Fuzzy Model for Assessing the Scope of Work of Railway Passanger Transport Undertaking

Aleksandar Blagojević[1], Iskra Stojanova[2], Marko Subotić[3], Veljko Radičević[4]

[1]Expert adviser, Ministry of Communications and Transport, Trg B&H 1, 71000 Sarajevo, Bosnia and Herzegovina; e-mail: aleksandar.blagojevic23@gmail.com

[2]Adviser, UN Environment, Key Dimitar Vlahov 4, 1000 Skopje, Macedonija, e-mail: iskrastojanova@gmail.com

[3]Assistant professor, Faculty of Transport and Traffic Engineering, University of East Sarajevo, Doboj Vojvode Misica 52, 74000 Doboj, Republic of Srpska, BiH; e-mail: msubota@gmail.com

[4]City Administration of Niš, 7. Jul 2, 18000 Niš, Serbia, e-mail: veljkoradi@gmail.com

Abstract: The main objective of the European policy of rail transport is the development of a single railway area. The opening of the railway sector to market competition impose that railway undertakings behave like any other modern enterprises in other markets and in other industries. It means, they must constantly develop and maintain competitive advantages, and be better than others. In today's very intense competition conditions, this is the most difficult to achieve. The railway undertakings are challenged to find optimal solutions to operate efficiently and effectively, in order not only to survive on the transport market, but also to develop and maintain a competitive advantage. The paper developed innovative model for the evaluation of efficiency of railway operators for passenger transport assessing the scope of work of railway undertakings that can greatly help to increase the competitive ability of railway undertakings in the single railway market. The developed models allow the integration of indicator groups (resources, operational, financial, quality and safety indicators) into a single assessment of the scope of work of railway undertakings and also allow the provision of information about the corrective actions that can improve the scope of work of the railway undertaking. The proposed model has been tested on actual examples, e.g. railway undertaking Railways of Republic of Srpska. The analysis of the results shows exceptional suitability for use of developed approach for assessing the scope of work of railway undertakings.

Key words: railway undertaking, efficiency, method, fuzzy logic, model.

INTRODUCTION

Today, modern business primarily involves a highly demanding market battle, regardless of whether it is production or providing transport services. Great competition requires that the organization of the company becomes a central determinant of business, while the activities that are being implemented are fully harmonized and financially cost-effective for both the carrier and the users of services. In order to survive on the market, companies are trying to find the optimal relationship between the resources invested and the achieved goals. The efficient railway transport is a very important component of the economic development on a global and national level. It is therefore of particular importance to rationally restructure the railways and develop their competitive capabilities. In a large number of countries in Europe, but also in other countries of the world, standards have been adopted regarding the restructuring of the railway system. Appropriate legal acts were adopted for the transformation of railways. The previous stages of restructuring did not allow complete liberalization of the railway transport market, the expected positive operation of the railway sector, fulfilment of the requirements of the transport market, raising the quality of railway services to the required level, interests of the community at national, regional and local levels and others. The restructuring of the railway system brought only partially positive business results in the main railways or pan-European corridors, mainly in transit traffic [15]. Although the quality of the services of the railway system has slightly increased, it is still far from the quality required by the transport market. In providing adequate quality of railway services, railway undertakings have a very important role in addition to railway infrastructure in terms of: reliability, frequency, timetable, traffic speed, safety, organization of work in railway stations, competitive prices in the transport market, etc. In the present conditions in a large number of countries, transport is mainly performed by national operators that have emerged from the transformation - a division of railway companies. Mostly these companies are managed by the state.

The complete liberalization of the railway transport market implies, above all, a free and non-discriminatory access to the railway infrastructure, with the fact that the transport function is performed by a larger number of operators on the appropriate national railway network. The effectiveness and efficiency of transport activities significantly affect the profitability of business of all entities involved in the process, but they cannot be provided without much effort in the process of quality management and transport activities.

The subject of this research paper stems from the needs of the countries of Europe, whether EU members or applying for membership, to establish the market principles of business in the railway sector. Primarily, this relates to the liberalization of the railway market and introduction of a larger number of railway undertakings, and in the context of its reforms, harmonized with integration into EU and a modern international transport market. In the narrower sense, the subject of the research focuses on the concept of a railway undertaking through the development of a model for assessing the scope of work of railway undertakings, in particular in the process of restructuring European railways, and then by testing on a concrete example. Using the Fuzzy Logic, a model for assessing the scope of work of railway undertakings has been developed.

MODEL FOR ASSESSING THE SCOPE OF WORK OF RAILWAY PASSENGER TRANSPORT UNDERTAKING

Fuzzy sets are sets whose elements have degrees of membership. In classical set theory, the membership of elements in a set is assessed in binary terms according to a bivalent condition — an element either belongs or does not belong to the set. By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set; this is described with the aid of a membership function valued in the real unit interval [0, 1].

The core technique of fuzzy logic is based on three basic concepts: (1) fuzzy set: unlike crisp sets, a fuzzy set has a smooth boundary, i.e. the elements of the fuzzy set can be partly within the set. Membership functions are employed to provide gradual transition from regions completely outside a set to regions completely in the set; (2) linguistic variables: variables that are qualitatively, as well as quantitatively, described by a fuzzy set. Similar to a conventional set, a fuzzy set can describe the value of a variable; (3) fuzzy "if-then" rules: a scheme, describing a functional mapping or a logic formula that generalizes an implication of two-valued logic. The main feature of the application of fuzzy "if-then" rules is its capability to perform inference under partial matching. It computes the degree the input data matches the condition of a rule. This matching degree is combined with the consequence of the rule to form a conclusion inferred by the fuzzy rule [13].

In assessing the scope of work of railway passenger transport undertakings, fuzzy input and output parameters have been defined. Fuzzy input parameters are the available number of rolling stock, the number of passengers carried, the costs for railway infrastructure charges, the Suitability - the ability of the offered services and the number of serious accidents. The Fuzzy output variable evaluates the operation of the railway undertaking. Rolling stock are the basic assets of railway undertakings that have the function of working means in the process of enabling transport services. It includes traction means i.e. locomotives and other self-propelled vehicles and tracked vehicles, i.e. all types of vehicles for transport of passengers.

It is of particular importance for a railway undertaking to achieve optimal capacity which implies such use of rolling stock, to achieve a relatively favorable relationship between the wearing of the useful properties, on one hand, and their productivity, on the other. The indicators of production, transport of passengers as the main activity of the railway undertakings is expressed through the number of passengers carried. The railway passengers transport undertaking collects certain revenues through the criteria that give the opportunity to see the amount of work done.

The cost for railway infrastructure charges directly affects the state of the railway undertaking in the transport market. When a domestic undertaking is able to provide the appropriate level of quality of the transport service, high charges will disincentive competition in the rail market. If the charges are high, there will be no interest from the private sector in the introduction of new operators. Also, no foreign operators will come to countries and railways where these charges are high. The number of serious accidents as an input for the model is very important for assessing the scope of work of the railway undertaking, as it affects the size of passenger transport and revenue, and affects as well the assessment of the scope of work of the undertaking, while railway accidents are damaging and destroying high value means of operation, cause large damage to property and traffic disruptions [3].The model proposed in this paper has been developed in a way that has not been used in the literature so far. The proposed model has been tested and verified through a survey conducted on the sample of the railway undertaking in BiH, i.e. the railways of Republic of Srpska. Figure 1 shows the layout of the model structure for assessing the scope of work (workload) of the railway passenger transport undertaking.

Figure 1. Structure of the model for assessing the scope of work of the railway passenger transport undertaking

DEFINING FUZZY VARIABLE

Fuzzy output variable A and fuzzy input variables B, C, D, E, and F are defined in the model for assessing the scope of work of the railway passenger transport undertaking. Fuzzy output variable A estimates the operator's scope of work. It is assumed that the grade can be: "BAD", "SATISFACTORY" or "GOOD", and that the quantification is from 1 to 10. The functions of belonging to the fuzzy sets A_{BAD}, $A_{SATISFACTORY}$ and A_{GOOD} are presented in Figure 2. Fuzzy input variable B is available number of rolling stock. It is assumed that the number of rolling stock can be "SMALL" (MBVS), "SATISFACTORY" (ZBVS) or "LARGE" (VBVS), and that the quantification of the scoring is from 120 to 180 rolling stock. Functions belong to fuzzy sets B_{MBVS}, B_{ZBVS} and B_{VBVS} are presented in Figure 3.
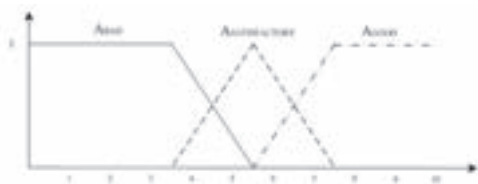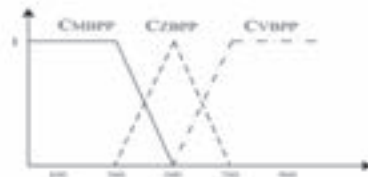

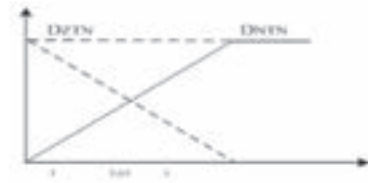**Figure 2.** Functions belong to fuzzy sets: A_l, A_z i A_D
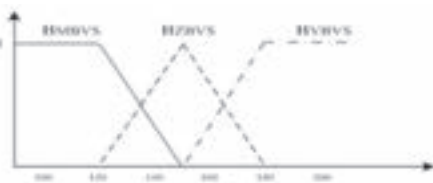
Figure 3. Functions belong to fuzzy sets

Fuzzy input variable C describes the work achieved by the undertaking through the number of passengers carried. It is assumed that the number of passengers carried can be: "SMALL" (MBPP), "SATISFACTORY" (ZBPP) or "LARGE" (VBPP), and the quantification of the estimated 300 to 700 thousand transported passengers. Functions belong to fuzzy sets C_MBPP, C_ZBPP and C_VBPP are shown in Figure 4. Fuzzy input variable D describes the cost of railway infrastructure charges.

It is assumed that these costs that reflect the operating costs of the operator can be: "SATISFACTORY" (ZTN), or "UNSATISFACTORY" (NTN). Functions belong to fuzzy sets D_{ZTN} and D_{NTN} are shown in Figure 5.
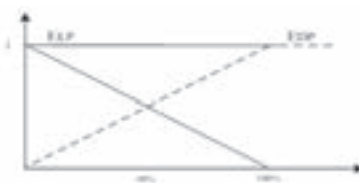

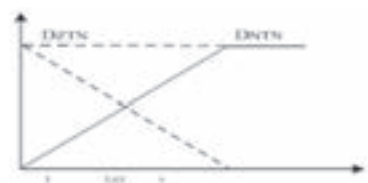**Figure 4.** Functions belong to fuzzy sets: C_{MBPP}, C_{ZBPP} i C_{VBPP}

Figure 5. Functions belong to fuzzy sets: D_{ZTN} i D_{NTN}.

The Fuzzy Input Variable E represents the Suitability - the ability of the offered services. This parameter represents a significant quality service evaluation. It is supposed to be "BAD" (LP) or "GOOD" (DP). Functions belong to the fuzzy sets ELP and EDP are presented in Figure 6. Fuzzy input variable F represents the number of serious accidents per driving kilometer. This parameter represents a significant quality service evaluation because safety is one of the most important quality elements. Based on the standards set by the European Safety Commission, it is assumed that the level of security can be "BAD" (LB) or "GOOD" (DB). Functions belong to fuzzy sets FLB and FDB are shown in Figure 7.

Figure 6. Functions belong to fuzzy sets: E_{LP} i E_{DP}.

Figure 7. Functions belong to fuzzy sets: F_{LB} i F_{DB}

Aleksandar Blagojević, et al.:
Fuzzy Model for Assessing the Scope of Work of Railway Passanger Transport Undertaking

TTTP (2018) **3**(1-2):15-21

FUZZY LOGIC

Fuzzy logic is the base of fuzzy system. It enables making decisions based on incomplete information, and models based on fuzzy logic consist the so-called "IF-THEN" rules. "IF-THEN" rules are interconnected with "ELSE" or "AND". When we assume that $x =[x_1, x_2, \ldots, x_n]$ is a vector of features describing any object or state and $y = [y_1, y_2, \ldots, y_m]$ is the vector of output values of a system, the rules are represented in the for

$$R^r : IF\ x_1\ is\ A_1^r\ AND\ x_2\ is\ A_2^r\ AND \ldots AND\ x_n\ is\ A_n^r\ THEN$$

$$y_1\ is\ B_1^r, y_2\ is\ B_2^r, \ldots, y_m\ is\ B_m^r.$$

where: $x \in X = X_1 \times X_2 \times \cdots \times X_n$, $y \in Y = Y_1 \times Y_2 \times \cdots \times Y_m$ i are the fuzzy sets [10]. Fuzzy logic is defined using algorithms for approximate reasoning. The special significance of fuzzy logic is in the possibility of its application for modeling complex systems in which is very difficult to determine the correlation of certain variables that exist in the model. Possible and logical rules are with weight 1, less possible 0.5. The approximate reasoning algorithm for evaluating the scope of work of railway undertakings for passenger transport, developed in this paper, consists of the following fuzzy rules [2]:

I. Available rolling stock "SMALL"   ≤ 120

Railway infrastructure charges	Suitability	Number of serious accidents	Assessment of the scope of work	Weight
Number of passengers carried SMALL				
satisfactory	good	bad	bad	1
satisfactory	good	good	satisfactory	0.5
unsatisfactory	bad	bad	bad	1
unsatisfactory	bad	good	bad	1
satisfactory	bad	bad	bad	1
satisfactory	bad	good	bad	1
unsatisfactory	good	bad	bad	1
unsatisfactory	good	good	satisfactory	1
Number of passengers carried SATISFACTORY				
satisfactory	good	bad	satisfactory	0.5
satisfactory	good	good	satisfactory	0.5
unsatisfactory	bad	bad	bad	1
unsatisfactory	bad	good	bad	1
satisfactory	bad	bad	bad	0.5
satisfactory	bad	good	bad	0.5
unsatisfactory	good	bad	satisfactory	0.5
unsatisfactory	good	good	satisfactory	0.5
Number of passengers carried LARGE				
satisfactory	good	bad	satisfactory	1
satisfactory	good	good	good	1
unsatisfactory	bad	bad	satisfactory	0.5
unsatisfactory	bad	good	satisfactory	0.5
satisfactory	bad	bad	bad	0.5
satisfactory	bad	good	bad	1
unsatisfactory	good	bad	satisfactory	0.5
unsatisfactory	good	good	good	0.5

II. Available rolling stock "SATISFACTORY" 120 do 180

Railway infrastructure charges	Suitability	Number of serious accidents	Assessment of the scope of work	Weight
Number of passengers carried SMALL				
satisfactory	good	bad	satisfactory	0.5
satisfactory	good	good	satisfactory	1
unsatisfactory	bad	bad	bad	1
unsatisfactory	bad	good	bad	0.5
satisfactory	bad	bad	bad	1
satisfactory	bad	good	satisfactory	0.5
unsatisfactory	good	bad	satisfactory	0.5
unsatisfactory	good	good	satisfactory	0.5
Number of passengers carried SATISFACTORY				
satisfactory	good	bad	good	0.5
satisfactory	good	good	good	0.5
unsatisfactory	bad	bad	bad	0.5
unsatisfactory	bad	good	satisfactory	0.5
satisfactory	bad	bad	satisfactory	0.5
satisfactory	bad	good	satisfactory	0.5
unsatisfactory	good	bad	satisfactory	0.5
unsatisfactory	good	good	good	0.5
Number of passengers carried LARGE				
satisfactory	good	bad	good	0.5
satisfactory	good	good	good	1
unsatisfactory	bad	bad	bad	0.5
unsatisfactory	bad	good	satisfactory	0.5
satisfactory	bad	bad	satisfactory	0.5
satisfactory	bad	good	satisfactory	0.5
unsatisfactory	good	bad	good	1
unsatisfactory	good	good	good	1

III. Available rolling stock "LARGE"   ≥ 180

Railway infrastructure charges	Suitability	Number of serious accidents	Assessment of the scope of work	Weight
Number of passengers carried SMALL				
satisfactory	good	bad	satisfactory	0.5
satisfactory	good	good	satisfactory	0.5
unsatisfactory	bad	bad	bad	1
unsatisfactory	bad	good	bad	1
satisfactory	bad	bad	bad	1
satisfactory	bad	good	satisfactory	0.5
unsatisfactory	good	bad	satisfactory	0.5
unsatisfactory	good	good	satisfactory	1
Number of passengers carried SATISFACTORY				
satisfactory	good	bad	good	1
satisfactory	good	good	good	1
unsatisfactory	bad	bad	bad	1
unsatisfactory	bad	good	satisfactory	0.5
satisfactory	bad	bad	satisfactory	1
satisfactory	bad	good	satisfactory	0.5
unsatisfactory	good	bad	satisfactory	0.5
unsatisfactory	good	good	good	0.5
Number of passengers carried LARGE				
satisfactory	good	bad	good	0.5
satisfactory	good	good	good	1
unsatisfactory	bad	bad	bad	1
unsatisfactory	bad	good	satisfactory	1
satisfactory	bad	bad	satisfactory	0.5
satisfactory	bad	good	satisfactory	1
unsatisfactory	good	bad	good	0.5
unsatisfactory	good	good	good	1

MODEL TESTING RESULTS FOR THE ASSESSMENT OF THE SCOPE OF WORK OF RAILWAY PASSANGER TRANSPORT UNDERTAKING

Input variables in fuzzy systems are the so-called linguistic variables that take different values, such as "available rolling stock", "number of passengers carried", "railway infrastructure charges", "suitability-ability of offered

Aleksandar Blagojević, et al.:
Fuzzy Model for Assessing the Scope of Work of Railway Passanger Transport Undertaking
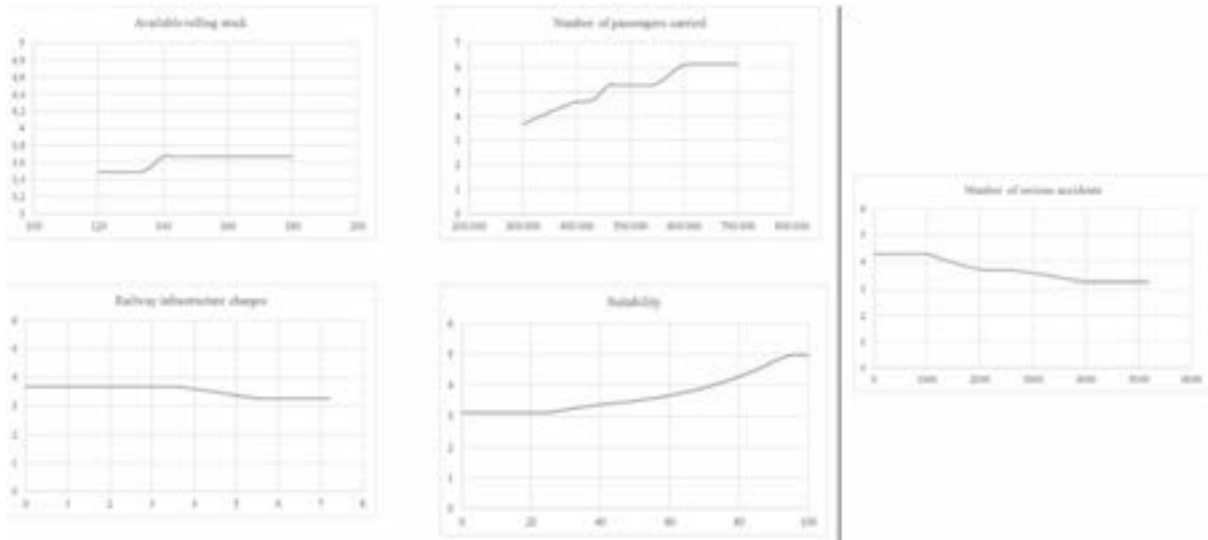
TTTP (2018) **3**(1-2):15-21

Figure 8. Assessment of the scope of work of railway passenger transport undertaking in the function of input parameters

services" and "number of serious accidents". The output is given in a continuous form. All possible values of the output variable are determined by the appropriate degree of belonging. After considering the degree of belonging of individual values of the output variable, defuzzification is performed. Defuzzification involves selection of one value of the output variable. The Centroid method (Center of gravity-COG or center of area-COA) is the basic defuzzification method that calculates the center of gravity of the function of belonging. The output value x*, which is the result of applying the Centroid method, is calculated according to the form (1).

$$x^* = \sum_{i=x_{\min}}^{x_{\max}} x_i \cdot \mu(x_i) \Big/ \sum_{i=x_{\min}}^{x_{\max}} \mu(x_i) \qquad (1)$$

where $\mu(x_i)$ has the belonging function. This paper uses the Mamdani fuzzy inference system (Centroid defuzzification), the minimization method for the operator

"AND" and the maximization method for the operator "OR". In accordance with the defined variable output function, the scope of work of the railway undertaking has been assessed. It should be noted that in such fuzzy models there is no possibility of strictly defining the interval limits. The obtained results on the assessment of the scope of work of the railway passenger transport undertaking on a randomly selected sample in the function of all 5 input parameters is presented in Figure 8 [2].

The graphical display of the output fuzzy variable A (assessment of the scope of work) in function of the input fuzzy variable B (available rolling stock), C (number of passengers carried), D (railway infrastructure charges), E (suitability) and F (number of serious accidents) is presented in Figure 9.

In order to examine the impact of the input variable on the evaluation of the scope of work of the railway undertaking, model testing was conducted, i.e. the answer
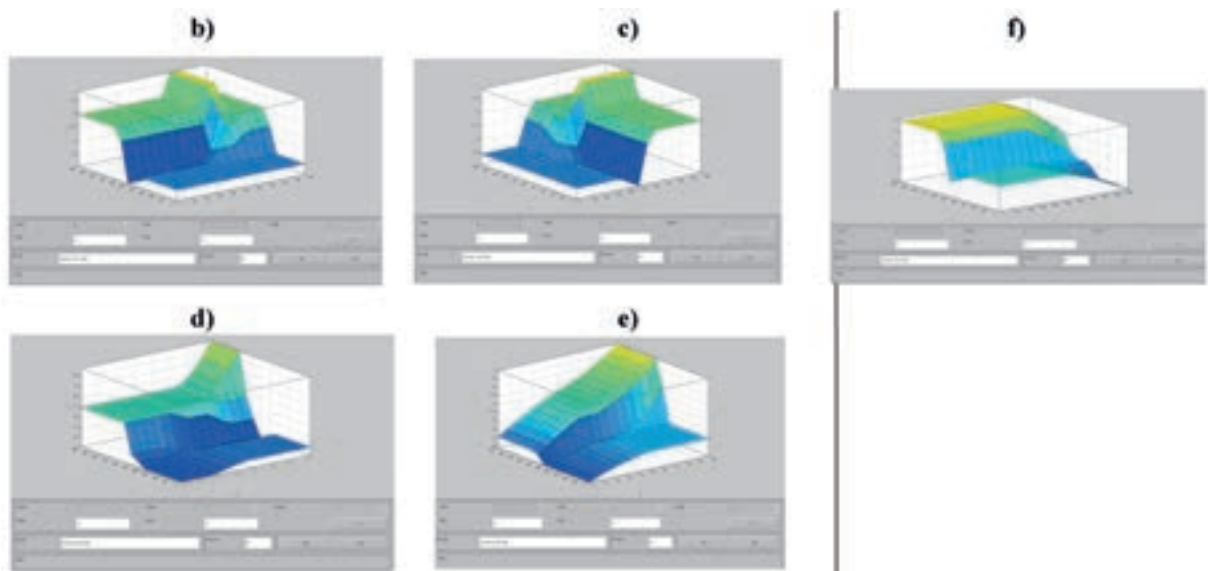

Figure 9. Output fuzzy variable A as a function of the input fuzzy variables B, C, D, E and F

to the question "WHAT-IF". For example, if the assessment of the scope of work in the function of the available number of rolling stock is observed with the constant values of other input variables, it is noticeable that the workload rating is rising to the level of 140 rolling stock. It should be noted that the function has no linear growth trend with an increase in the number of rolling stock and its value stagnates at an estimate of 3.67 for the number of rolling stock from 140 to 180. This can be explained by the fact that the operator has a surplus rolling stock for the volume of work that is currently performing (Figure 8). When it comes to the assessment of the scope of work of the undertaking in the function of the incoming variable number of passengers carried, provided that the other input quantities are constant, it is noticeable that the function has a growth trend by increasing the number of passengers carried. Changing the number of passengers carried in the range of 300,000 to 700,000, causes a change in the output variable to 67% (Figure 8). Observing the input variable costs of railway infrastructure charges, provided that the other input sizes are constant in the function of assessing the scope of work of the undertaking, it is noticeable that the value of the workload estimates ranges from 3 to 4. Changing the cost of railway infrastructure charges in the interval of 0 to 7, 2 causes a change in the output size to a maximum of 13%. This can be explained by the fact that the level of the railway infrastructure charges in BiH is among the lowest in the EU and the countries of the region (Figure 8). By analyzing the scope of work of the railway passenger transport undertaking when considering the incoming variable Suitability - the ability of offered services, provided that the other inputs are constant, it is noticeable that the function has a linear growth trend by increasing the undertaking benefits - Figure 8. If the input variable number of serious accidents is observed, provided that the other inputs are constant, it is noticeable that by de-

creasing this input variable in the range 0 to 5180 FWSIs, the workload rating is increased for 30% Figure 8.

Based on the results of the fuzzy model for the given values of the input variable, it can be concluded that the assessment of the scope of work (workload) of the railway undertaking railways of Republic of Srpska for passenger transport is poor. The definition of the fuzzy model for assessing the scope of work of the railway undertaking is shown in Figure 10.

CONCLUSION

Efficient railway transport is a very important component of economic development on a global and national level. It is therefore of particular importance to restructure the railways and develop their competitive capabilities. In order not only to survive on the transport market, but also to develop and maintain competitive advantages, they must operate effectively and efficiently. Effectiveness and efficiency of transport activities significantly affect the profitability of the business of all entities involved in the process, but they cannot be provided without much effort in the process of quality management and transport activities. Measuring the efficiency and effectiveness of railway undertakings inevitably becomes a condition for their survival in a unique transport sector. Efficiency and effectiveness have a positive impact on a number of other important indicators of functioning of railway undertakings, such as better use of resources, more rational energy consumption, increased security, increased quality of service, etc.

This paper has developed a fuzzy model based on which the management of railway undertakings can monitor the process of quality management and transport activities, and also define appropriate corrective actions. The developed model is tested on a realistic example, i.e. on railway undertaking ŽRS. The variable
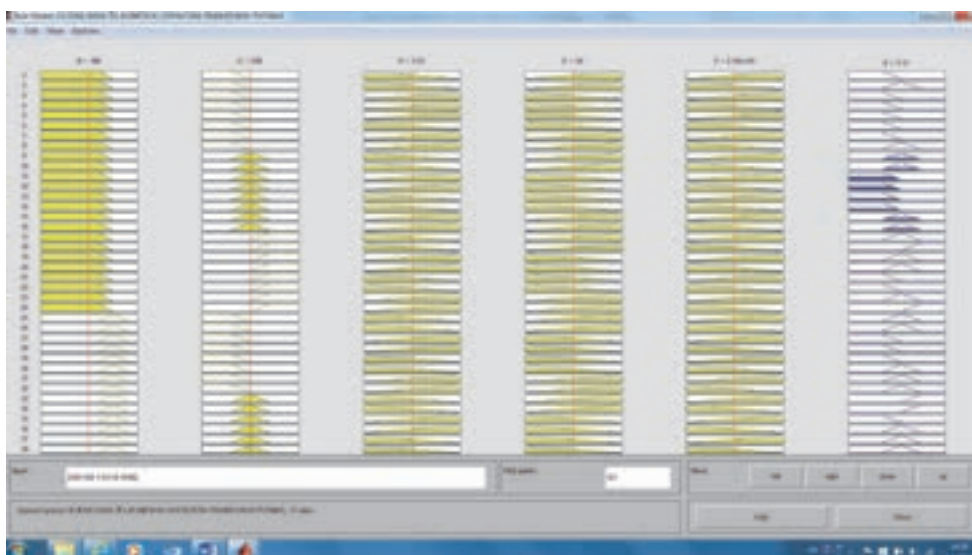

Figure 10. Defuzzification of the fuzzy model for assessing the scope of work of the railway passenger transport undertaking railways of Republic of Srpska

quantities and their values were identified based on the analysis of the railway undertaking ŽRS. The results obtained by testing this model for evaluating the scope of work of the railway passenger transport undertaking relate to the impact of the criteria on the output of the model. The criterion that most affects the output of the model for evaluating the scope of work of the railway passenger transport undertaking is the number of passengers carried. For the defined cases of testing the fuzzy model, the obtained results for evaluating the scope of work of the railway passenger transport undertaking are valid. In this way, the applied fuzzy model shows that the fuzzy logic technique can be applied efficiently and give good results in assessing the scope of work of railway undertakings. The universality of the developed model is reflected in its application to all railway undertakings.

This paper opens the possibility of further research to lead to development of new models that would combine the proposed approach with other approaches such as simulation, optimization models, etc. In this way, certain limitations would be exceeded and the process of evaluating the scope of work of railway operators would be improved.

REFERENCES

[1]   Azadeh A., Salehi V.: Modeling and optimizing efficiency gap between managers and operators in integrated resilient systems, Process Safety and Environmental Protection 92, 2014, pp 766-778.

[2]   Blagojević, A.: Modeling of the efficiency and effectiveness of railway undertakings, Doctoral thesis, Faculty of Technical Sciences, Novi Sad, Serbia, 2016.

[3]   Blagojević, A., Stojić, G., Kuravica M., Simić, S., Đorđević, Ž.: Defining and assessment of criteria for the evaluation of efficiency and effectiveness of railway undertaking, Proceedings VI International Symposium "Now Horizons2017", 2017, pp 360-368.

[4]   Blagojević A., Bošković B., Okolić S.: Simulation model of the company 's business balance when introducing the charges for use of railway infrastructure, Proceedings the first bh congress on railways, Sarajevo, CD Proceedings, pp. 59-65, Bosnia and Herzegovina, 2011.

[5]   Boender C.G.E., De Graan J.G., Lootsma F.A.: Multiple-criteria decision analysis with fuzzy pairwise comparisons, Fuzzy Sets and Systems 29, 1989, pp 133-143.

[6]   Bottani E., Rizzi A.: A fuzzy multi-attribute framework for supplier selection in an e-procurement environment. International Journal of Logistics Research and Applications, 8(3), 2005, 249-266.

[7]   Cantos P., Pastor J.M., Serrano L.: Vertical and Horizontal Separation in the European Railway Sector and its Effects on Productivity, Journal of Transport Economics and Policy 44, Part 2, 2010, pp 139-160.

[8]   Cebi F., Bayraktar D.: An integrated approach for supplier selection, Logistics Information Management, 16(6), 2003, pp 395-400.

[9]   Kilincci O., Onal S.: Fuzzy AHP approach for supplier selection in a washing machine company, Expert Systems with Applications 38, 2011, pp 9656-9664.

[10] Nowicki, R.: Nonlinear modelling and clas-sification based on the Ml-COG defuzzification. Nonlinear Analysis 71, 2009, ei033-ei047.

[11] Openshaw, S.: Fuzzy logic as a new scientific paradigm for doing geograph. Environment and Planning A 28, 1996, pp 761 - 768.

[12] Patel, A.V., Mohan, B.M.: Some numerical aspects of center of area defuzzification meth-od. Fuzzy Sets and Systems 132, 2002, pp 401-409.

[13] Qiao, Y., Kerenb, N., Mannan, M.S.: Utili-zation of accident databases and fuzzy sets to estimate frequency of HazMat transport ac-cidents. Journal of Hazardous Materials 167, 1-3, 2009, pp 374-382.

[14] Stojić G., Tanackov I., Vesković S., Milinković S., Simić D.: Modeling and evaluation of railway reform using fuzzy logic, IDEAL'09 Proceedings of the 10th international conference on Intelligent data engineering and automated learning, Springer-Verlag Berlin, Heidelberg 2009, pp 695-702.

[15] Stojić G., Vesković S., Tanackov, I., & Milinković S.: Model for railway infrastructure management organization, Promet – Traffic&Transportation, Vol. 24, No. 2, 2012, pp 99-107.

[16] Zadeh L.A.: Fuzzy sets, Information and Control 8(3), 1965, pp 338-353.