RAILWAY PROJECT EVALUATION WITH DYNAMIC PRIORITIES –SERBIA CASE STUDY

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ABSTRACT

Strategic decisions, such as transport investments, depend on a number of factors of different relevance that are often changeable over time. Evaluation of transport projects is a complex and difficult task, but also crucial for a company's success in the market. We assume that certain relations of the system elements are functions of time, and thus we apply a dynamic approach – dynamic priorities in multi-criteria decision making. The topic of this paper is time dependent multi-criteria decision making in a transport projects evaluation. The model is tested on real data from the Serbian railway network.

Keywords: transport projects, railway project evaluation, dynamic priorities

1. Introduction

Project evaluation is a very delicate, complex and difficult management task, with an aim to select and rank the considered projects. Evaluation of transport projects (including railway projects) has often been an essential step in the transport company's success. Decision making in investment planning is a very complicated process because of many relevant factors, such as: stakeholders (owners, regulators, market, politicians, etc.), system boundaries, transparency, and heterogeneous criteria (Jowitt, 2013).

Cost Benefit Analysis (CBA) is a well-known method in project evaluation. This traditional approach is the most used method in the transport sector. In the rail sector, CBA is applied 60% of the time for project evaluations. Multi-Criteria Approach (MCA)

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is applied in 14% of cases, and other methods are applied 26% of the time. In road projects, CBA is used in 56% of cases, and MCA is used in 20%. In internal waterway projects, the proportion of the methods used is 32% for CBA and 6% for MCA, and in sea transport projects evaluation the situation is very similar[2].

There are numerous approaches and methods in the evaluation of transport projects, such as CBA (Berechman and Paaswell, 2005, Van Wee 2007), MAUT - Multi Attribute Utility Theory (Tsamboulas, 2007), GP - Goal Programming (Ahern and Anandarajah, 2007), AHP - Analytic Hierarchy Process (Lee, 1998; Yedla and Shrestha, 2003; Ferrari, 2003; Gercek et al., 2004; Tudela et al.,2006; Caliskan, 2006), and ANP - Analytic Network Process (Shang et al., 2004; Piantanakulchai, 2005; Wey and Wu, 2007; Chang et al., 2009; Longo et al., 2009; Macura et al., 2011).

Shiftan et al. (2002) give a review of different methods and approaches to transport project evaluation with an emphasis on the specific features of CBA, and quantitative and qualitative multi-criteria analysis in this field. The majority of the mentioned references from the last decade critically analyzed the application of CBA in the evaluation of transport projects, and suggested applying the multi-criteria methods to solving the problems being considered.

The process of good decision making depends on conditions in the future which normally vary over time; thus, good decision making requires evaluation of likelihood and preference of conditions during different time periods. This is the primary reason for the use of the dynamic approach in the decision making process. There are situations in which changes occur in the structure of a problem, new criteria can be added, or old criteria replaced. Sometimes judgments on the criteria change, but the criteria remain the same. There are also cases where judgments on the criteria remain the same; however, judgments on the alternatives change over time. All these combinations are possible in practice (Saaty 2007a). Basic assumptions of the applied mathematical computation for this method are defined in Saaty's book (2007a).

The aim of this paper is to develop a model of an evaluation of railway projects as a support system to decision makers. The model has two parts, a static part and a dynamic part. The authors used the Analytic Hierarchy Process (AHP) approach for the static part of the model, and the Dynamic Hierarchy Process (DHP) approach to dynamic priorities in the dynamic part of the model. The model that was developed was tested on railway infrastructure projects in the Serbian railway network. In this model, the main decision maker was PE Serbian Railways.

This paper is organized as follows: it begins with the Introduction, then the next section is dedicated to the relevant literature review; next the basic assumptions of the applied approaches, AHP and DHP, are presented. The second part of this Section shows the dynamic model of the railway project evaluation, with all system elements and their

[2] http://heatco.ier.uni-stuttgart.de/hd1final.pdf

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mutual relations included. Next, results and a discussion are presented followed by some concluding remarks.

2. Literature review

The literature reviewed falls into three categories: applications of dynamic relations and the AHP approach; applications of the dynamic network process; and hybrid static-dynamic AHP models. This is the first application of dynamic priorities, as well as a dynamic hierarchy process, to this particular transport issue.

Boateng et al. (2012) analyzed risks in megaprojects, and focused on the dynamic relations in the model after having defined all the relevant risks. Researchers and project managers used this model in order to understand various social, economic and environmental systems within a holistic view. Tsamboulas et al. (2007) suggested a new multi-criteria analysis approach with the following characteristics: unification of the criteria and differentiation of the project performance over time, as a dynamic variable, and a new approach to transformation of the physical scales to artificial ones. The application of the proposed approach is demonstrated using transportation infrastructure investments. The dynamic hierarchy process was used in Gonzáleza et al. (2003) to help the product development team make effective decisions in satisfying customers' requirements with limited resources, in the case of school furniture design. A dynamic, cross-functional team organization was applied. A simple form of quality function deployment was used to identify the desirable product design, safety, and service features.

Numerous papers in the relevant literature deal with the dynamic network process. Dynamic models try to reflect changes in real or simulated time, taking into account that the network model components are constantly evolving. These models use concepts of state variables, flows, and feedback processes.

The network economy was discussed in Fiala (2006), referring to the global relationship between economic elements characterized by massive connectivity. The central act of the new era was to connect everything in deep web networks at a number of levels of mutually interdependent relations, where resources and activities were shared, markets enlarged and costs and risks reduced. For such a network, the ANP was used, as well as its extension, the Dynamic Network Process, which can deal with time dependent priorities in a networked economy. Fiala (2007) also applied the ANP approach to designing auctions, which requires a multidisciplinary effort consisting of contributions by economics, operation research, informatics, and other disciplines. The multiple evaluation criteria can be used. There is dependence between sellers, buyers, criteria and bundles of items. A variety of feedback processes create a complex system of items. The preferences of bundles of items can be evaluated by the ANP approach. In this paper, the Dynamic Network Process dealt with time dependent priorities in combinatorial auctions.

Market segmentation, as a critical point of business, was analyzed in Nasrabadi et al. (2013). This paper aimed to model a strategy-aligned fuzzy approach to market segment evaluation and selection. A modular decision making support system was developed to select an optimum segment with its appropriate strategies. The dynamic network process was applied to prioritize segment-strategies according to five competitive force factors.

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This model was supported by a case study on strategic priority difference within a short- and long-term consideration. Feglar and Levy (2003) applied dynamic ANP in order to improve decision making support in information and communication technology. They focused their attention on the classification of various ICT based innovations.

There are several papers in the relevant literature that mention the hybrid static dynamic AHP model. Wang et al. (2008) used hybrid AHP and the fuzzy mathematics method to deal with dynamic and static, and fixed and non-fixed quantified influence factors. According to the weight matrix and the matrix of the membership degrees, the fuzzy synthetic judge model was established, and the synthetic superior degree of the mining methods based on the influence factors was obtained by the numeration of the fuzzy mathematics methods.

In order to make decision-making more objective and accurate, based on the distinction between experts' static weights and experts' dynamic weights, Liu et al. (2007) researched a method to decide experts' dynamic weights in interactive decision-making and establish a definition of consensus degree. Based on the research of consistency and compatibility, the paper developed a framework of group decision-making for AHP based on experts' dynamic weights. Fang and Yang (2011) presented the defect of the traditional static AHP nets, and suggested the dynamic AHP net including correlative definitions and illustrations. Based on the net definitions, the dynamic AHP net formulas and evaluation node priority algorithm were proposed. A simulation verification example was given and the numeric evaluation result was analyzed. The result was compared with that calculated by the traditional AHP. The result showed that the proposed dynamic AHP net could resolve the uncertainty problem caused by simulation verification. Benítez et al. (2012) points out the weakness of static input mode in the AHP approach. They identify this weakness as the need for users to provide all the preference data at the same time, and have the criteria defined from the start. To overcome this weakness, they proposed a framework that allows users to provide partial and/or incomplete preference data at multiple times, i.e. they included the dynamic input mode assumption. An algorithm was developed to determine the new priority vector from the users' new input.

3. Model for railway project evaluation (static and dynamic approaches)

The model of railway project evaluation makes a rank list of the projects considered and priorities between them in an investment process. In this paper, the authors suggested improvement of the developed model presented for the first time in Macura et al. (2011). The model proposed in this paper extends the Macura model by including consideration of relevant external projects' influences and defining their dynamic priorities. The model has a static and dynamic part. The static part focuses on project evaluation based on the criteria which are constant through time, and the dynamic part presents project evaluation related to relevant external, time-changeable projects.

3.1 Applied approaches

The Analytical Hierarchy Process, developed by Thomas Saaty, is one of the most popular approaches to multi-criteria decision making (Saaty, 2007a). It is used in analyses of decision-making to solve complex problems, the elements of which are objectives, criteria, sub-criteria and alternatives. AHP is a very useful approach because

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of its ability to identify and analyze inconsistency of decision makers in the process of decompression and evaluation of the elements of the hierarchy. AHP mitigates this problem to some extent by measuring the level of inconsistency and gathers information from decision-makers. This is a static approach, which uses the fundamental Saaty scale to define priorities. By expanding the AHP approach, it is possible to cope with time - dependent priorities. This new approach is called Dynamic Hierarchy Process (DHP) (Saaty 2007b). Time-dependent decision-making, i.e. dynamic decision-making, is something that is often necessary. However, these alternatives may evolve over time, together with our preference for them, such as, stock market shares, the value of which constantly changes over time. Dynamic decision making is reality, not a theoretical concept which can be ignored. It is necessary for technical design problems, in which effects of several project factors change over time and a compromise between them must be made, to allow the system to react differently and continuously during its work time.

A typical appearance of the matrix in a dynamic form:

$$A(t) = \begin{bmatrix} a_{11}(t) & a_{12}(t) & \cdots & a_{1n}(t) \\ a_{21}(t) & a_{22}(t) & \cdots & a_{2n}(t) \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1}(t) & a_{n2}(t) & \cdots & a_{nn}(t) \end{bmatrix} \quad (1)$$

$a_{ij} > 0,\ a_{ji}(t) = a_{ij}^{-1}(t)$,

in a discrete situation, when $A(t)$ is consistent, we have $a_{ij}(t) = w_i(t) / w_j(t)$.

All relevant equations are developed in Saaty (2007b).

3.2 Elements of the model for railway project evaluation

The developed model has a network structure with four clusters (Figure 1). Each cluster has a certain number of elements which are explained in detail later in this section.

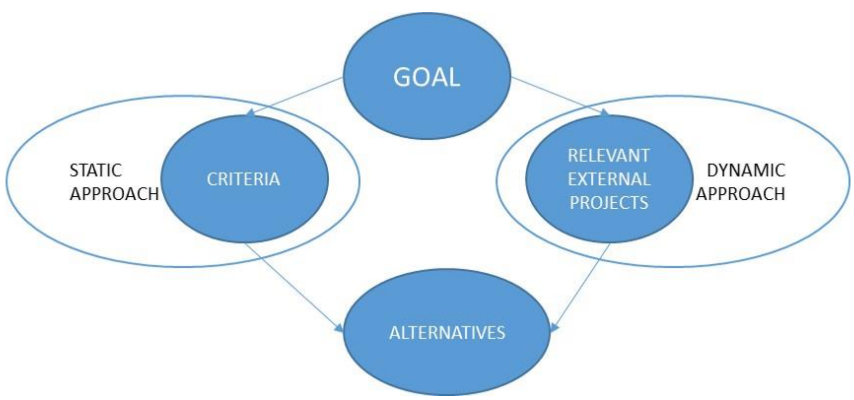

Figure 1. Proposed model

The sections being considered (Rail Corridor 10 in Serbia) are presented in Table 1.

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Table1
Considered alternatives

Section	*Alternative*	*Length of section (km)*	*Number of tracks*
A1	Šid-Stara Pazova	116	Double-track
A2	Subotica-Stara Pazova	153	Single-track
A3	Resnik-Mladenovac-Velika Plana	70	Single-track
A4	Velika Plana-Stalać	86	Double-track
A5	Stalać-Đunis	17	Single-track
A6	Đunis-Trupale	40	Double-track
A7	Niš-Preševo	173	Single-track
A8	Niš-Dimitrovgrad	104	Single-track

All the projects, the alternatives of the model, are already a part of the “Strategy for the development of railway, road, water, air and intermodal transport in the Republic of Serbia from 2008 to 2015”[3]. The purpose of the model in this paper is to rank rail investment projects, considering financial and operating aspects (Macura et al., 2011). Table 2 shows the considered criteria.

Table2
Considered criteria

	Criteria	*Measure*	*Type of criteria*
X_1	Cost-benefit ratio	/	⬂
X_2	Criteria of speed restriction	Travel time lost [train hours/km]	⬀
X_3	Criteria of rail infrastructure capacity utilization	The percent of rail line capacity utilization [%]	⬀
X_4	Criteria of inconsistency with AGC & AGTC	[%]	⬀
X_5	Criteria of traffic volume	[train/day]	⬀

Cost-benefit ratio criterion, X_1, represents the ratio between the benefit and the cost of a project. The benefit of a project is considered as a product of the average number of trains on the considered section, the expected increase of transport volume and average revenue per train. The assumption of increase in transport volume is based on the project “General Master Plan for Transport in Serbia”. The numerator of the Cost/Benefit ratio is actually the investment cost.

Criterion of speed restriction, X_2, gives priority to sections where the most time is lost due to reduced speed. Total loss of travel time for all trains on a part of line with

[3] www.mi.gov.rs

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temporary speed restrictions, which are the result of a poor state of substructure and superstructure, is calculated as follows:

$$\Delta t_{lv} = \sum_{i=1}^{n} \left(\frac{s_i}{v_{lvi}} - \frac{s_i}{v_{pri}} \right) \cdot N_{vi} \quad \text{[train hours]} \tag{2}$$

where

Δt_{lv} - is the total lost travel time on a part of rail line with temporary speed restriction, which is the result of poor state of substructure and superstructure [train hours];

s_i - is the total length of the i-th temporary speed restriction on a particular rail section [km];

i - is the number of temporary speed restrictions on a particular section;

v_{pri} - is the allowed speed according to the designed characteristics of a rail section with the i-th temporary speed restriction [km/h];

v_{lvi} - is the speed of the i-th temporary speed restriction [km/h];

N_{vi} - is the total annual number of trains on a line section during the temporary speed restriction [trains].

$X_{3,}$ criterion of rail infrastructure capacity utilization, represents the total number of trains that can operate on a rail section during a specified time period. It depends on the number of tracks, technical parameters of a rail line (plan, profile and characteristics of superstructure), existing equipment of a rail line, the characteristics of rolling stock and the actual system of traffic control on the line. Rail capacity utilization is the relationship of the relevant number of trains on a rail section and the line capacity. Relevant number of trains can be defined as the average daily number of trains increased by the coefficient of irregularity. Various approaches can be used for rail capacity calculation. The problem is that different approaches give significantly different values of capacity. In European terms the relevant method is recommended by a rail fiche No. 406 R of the International Railway Union (UIC), which is used in Macura et al. (2011). The rail section with less spare capacity will have a priority in this model.

The general formula for calculation of rail line capacity utilization is:

$$\alpha = \frac{N_v}{n} \quad [\%] \tag{3}$$

where

α - is rail capacity utilization [%];

N_v - is the relevant number of trains on a rail section [trains/day];

n - is rail line capacity [trains/day].

Inconsistency with International Agreements, X_4, is relevant due to the fact that Serbia is a signatory to two key European agreements (AGC and AGTC) and one regional agreement (SEECP) related to the parameters of railway infrastructure harmonization of the European network. According to the AGC and AGTC agreements, the relevant values for the considered Corridor 10 are given in Table 3. The rail sections with the worst parameters will have priority in this model.

The next criterion of traffic volume, X_5, represents the train traffic intensity on a rail section. Based on this criterion, a rail section with larger traffic volume will have priority. This criterion is calculated by the following equation:

$$N_v = N_p + N_t \text{ [train/day]} \quad (4)$$

where:

N_v - is the total average daily number of trains on a particular section [trains/day];

N_p - is the average daily number of passenger trains [train/day];

N_t - is the average daily number of freight trains [train/day].

The average numbers of freight and passenger trains are given in Table 3.

Based on the above explanation, all the defined criteria for the considered sections are calculated (Macura et al., 2011). The values are given in Table 3. By using these data, the pair-wise comparison matrices were developed. The alternative with which a higher effect can be achieved is better ranked. The matrix of a criteria comparison was made by transport expert's recommendations.

Table 3
Calculated values of the considered criteria for all alternatives

Alternative	*C1* *[%]*	*C2* *[train hours/km]*	*C3* *[%]*	*C4* *[%]*	*C5* *[train/day]*
A1	0.47	93	17/17	0.014	25
A2	0.45	24	75	0.084	48
A3	0.29	333	61	0.192	52
A4	0.07	31	23/23	0.048	40
A5	0.08	14	45	0.100	44
A6	0.05	14	23/23	0.010	44
A7	1.66	9	34	0.285	23
A8	2.84	12	36	0.267	16

The relevant external projects (Macura et al. 2012a, 2012b) can be international or domestic, infrastructure, ecological or social projects, etc. These projects are of great importance in transport project evaluation, since the transport networks are very dependent on their surroundings (including, not only the transport system in the considered country, but also in neighboring countries). It is possible to define the different relevance of these projects on the ranking of the projects. However, choosing the relevant external projects should be done by company management or by the experts.

External projects can have different influences depending on their importance in the network. The influence of an external project can be observed in terms of flow of goods

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(increased intensity of flow). This impact can be direct or indirect, by directly or indirectly increasing/decreasing the intensity of flow on the considered rail line.

Suggested relevant external projects in the model are:

- X – Vidin-Calafat Bridge - this project can take flow of goods and passengers from Corridor 10, and make better service quality on Corridor 4.
- Y – Rehabilitation of Corridor 4 – with this project, the competitive corridor, Corridor 4, becomes stronger in comparison to Corridor 10, with the aim of keeping the same freight transport volume on Corridor 10, the service quality should be improved.
- Z – Privatization of Port “Bar” - for the considered rail network in Serbia, one of the relevant external projects is the forthcoming privatization and improvement of the Port of Bar. Realization of this project would increase the volume of freight transport from Montenegro, through Serbia, to Hungary.

The authors suggested using the dynamic approach to define the priorities of relevant external projects, with respect to the effects on the alternatives. The following is an explanation of this proposal. One relevant external project has already been realized, Vidin-Calafat Bridge, project X (opened on June 14th, 2013). The end of the second project, the rehabilitation of Corridor 4, is planned for 2020. Project Z, privatization of Port “Bar”, will be realized in the near future, but its effects will become visible in the next few years. We assume that the relevant time horizon for consideration is from 2014 to 2020. In this period, the projects may change over time and all mentioned external projects will have been finished.

4. Results and discussion

The first part of the model, the static one, was developed using the Super Decisions software. Table 4 presents the alternatives’ weights relative to the criteria. All the calculations were performed using the well-known equations from the AHP approach (Bojkovic et al., 2011).

Table 4
Alternatives’ weights relative to criteria

Cj	*C1*	*C2*	*C3*	*C4*	*C5*	*Weights*
Ai	0.256	0.445	0.182	0.041	0.076	
A1	0.051	0.211	0.314	0.022	0.037	0.168
A2	0.237	0.113	0.132	0.044	0.097	0.144
A3	0.237	0.045	0.063	0.022	0.151	0.105
A4	0.051	0.075	0.021	0.083	0.220	0.070
A5	0.237	0.045	0.063	0.083	0.151	0.107
A6	0.026	0.028	0.314	0.286	0.037	0.091
A7	0.019	0.045	0.063	0.286	0.020	0.050
A8	0.142	0.437	0.030	0.173	0.287	0.265
Sum	1	1	1	1	1	1

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The authors assumed that relative priorities of relevant external projects were time-dependent values. Table 5 shows pair-wise comparison matrices for relevant external projects.

Table 5
Pair-wise matrices for relevant external projects

	2014			*2017*			*2020*		
	X	Y	Z	X	Y	Z	X	Y	Z
X	1	3	5	1	1	4	1	1	1
Y	0.333	1	4	1	1	3	1	1	1
Z	0.2	0.25	1	0.25	0.333	1	1	1	1

Based on the data from the previous table, the functions of priorities are defined in Table 6.

Table 6
Dynamic priorities of relevant external projects

	X	*Y*	*Z*
X	1	$2.857-0.643t$	$5.333-0.067t$
Y		1	$4.167-0.5t$
Z			1

According to the data from the table 6:

$$a_{12}=2.857-0.643t \quad (R^2=0.964) \tag{5}$$

$$a_{13}=5.333-0.067t \quad (R^2=0.92) \tag{6}$$

$$a_{23}=4.167-0.5t \quad (R^2=0.964) \tag{7}$$

Where:
R_2 – The *R* squared values, indicates how well data points fit in a statistical model
t – Time horizon: 2014 (t=1), 2017 (t=2) and 2020 (t=3)

Thereafter, using the following equations, the weights for relevant external projects can be obtained (Saaty, 2007b). All the computations have been done in Matlab.

$$\lambda_{\max}=(a_{13}/a_{12}a_{23})^{1/3}+(a_{12}a_{23}/a_{13})^{1/3}+1 \tag{8}$$

$$\Delta=a_{12}a_{23}+a_{13}(\lambda_{\max}-1) \tag{9}$$

$$D=a_{12}a_{23}+a_{13}(\lambda_{\max}-1)+(\lambda_{\max}-1)a_{23}+(a_{13}/a_{12})-1+(1-\lambda_{\max})^2 \tag{10}$$

$$w_{e_X}=\frac{\Delta}{D} \tag{11}$$

$$w_{e_Y}=\frac{(\lambda_{\max}-1)a_{23}+(a_{13}/a_{12})}{D} \tag{12}$$

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$$w_{e_Z} = \frac{-1+(1-\lambda_{\max})^2}{D} \tag{13}$$

Where:

$w_{e_X t}$, $w_{e_Y t}$, $w_{e_Z t}$ - weights of the relevant external projects, for X, Y, Z, $t = \overline{1,3}$

The following graphs (Figures 2a, b, c) show the changes of the relevant external projects weights, $w_{e_X t}$, $w_{e_Y t}$ and $w_{e_Z t}$, over time horizons. This time dependence of the weights was the main reason for using the dynamic approach, i.e. dynamic priorities, in this model. The considered time horizon from 2014 to 2020 is on the x axes. The *y* axes show the weight of relevant external projects; there are three graphs for each relevant external project, respectively.

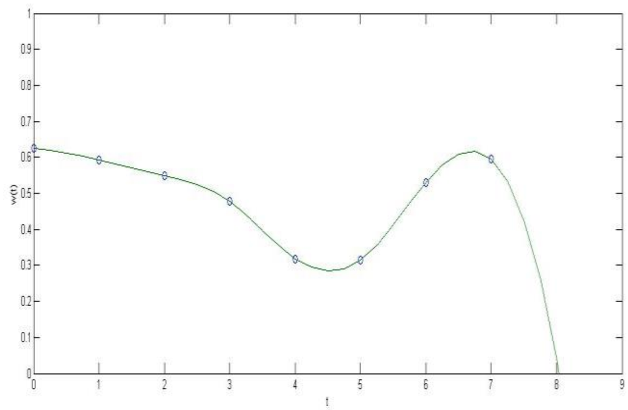

Figure 2a.

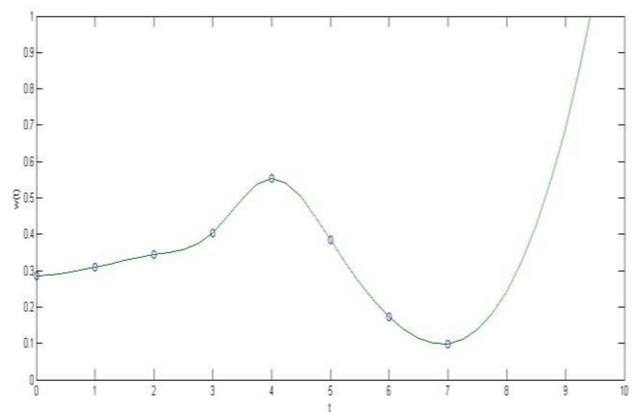

Figure 2b.

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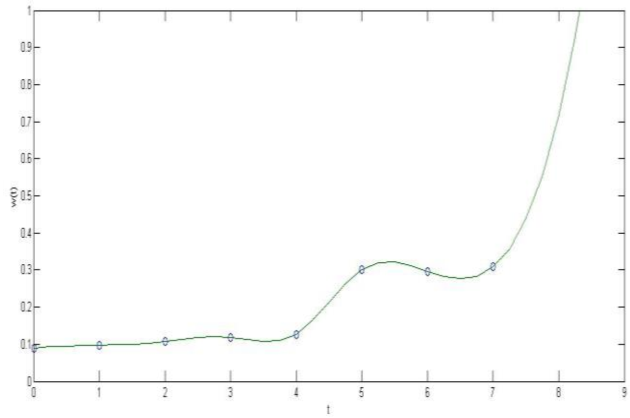

Figure 2c. Weights $w_{e_X t}$, $w_{e_Y t}$ and $w_{e_Z t}$ for relevant external projects X, Y and Z

The weights of the alternatives relative to criteria, w_{c_j}, are a constant value (Table 4), but the weights of the alternatives relative to external projects, $w_{e_m t}$, are time dependent. We assume that the criteria have the weight of 0.7, and the relevant external projects of 0.3 for the whole model. Final weights of the alternatives in the model should be calculated by the following equation (Table 7):

$$w_{A_i t} = 0.7 w_{c_j} + 0.3 w_{e_m t} \text{ , for } i = \overline{1,8} \text{ , } t = \overline{1,3} \text{ , } j = \overline{1,5} \tag{14}$$

Table 7
Alternatives weights relative to external projects and final results of the whole model through time horizons

	2014		*2017*		*2020*	
	$w_{e_m 1}$	$w_{A_i 1}$	$w_{e_m 2}$	$w_{A_i 2}$	$w_{e_m 3}$	$w_{A_i 3}$
A1	0.164	0.168	0.169	0.168	0.200	0.178
A2	0.145	0.144	0.144	0.144	0.133	0.141
A3	0.145	0.117	0.144	0.117	0.133	0.113
A4	0.145	0.092	0.144	0.092	0.133	0.089
A5	0.145	0.118	0.144	0.118	0.133	0.115
A6	0.145	0.107	0.144	0.107	0.133	0.104
A7	0.055	0.052	0.056	0.052	0.067	0.055
A8	0.055	0.202	0.056	0.202	0.067	0.206

The final rank of the alternatives is presented in the Figure 3. The evaluation of the process over time can be observed. The authors analyzed the relevant time period for the considered issue (2014-2020). Two different time windows are defined due to the following:

- The first relevant change should be realized about 2017 - the end of the external project "Privatization of Port Bar".

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- The second relevant change will occur in 2020 - the end of the external project "Rehabilitation of Corridor 4".

In this case study, the relative importance of the alternatives is not changeable over time. However, during time, some alternatives become more (A_1, A_7 and A_8) or less (A_2, A_3, A_4, A_5 and A_6) dominant.

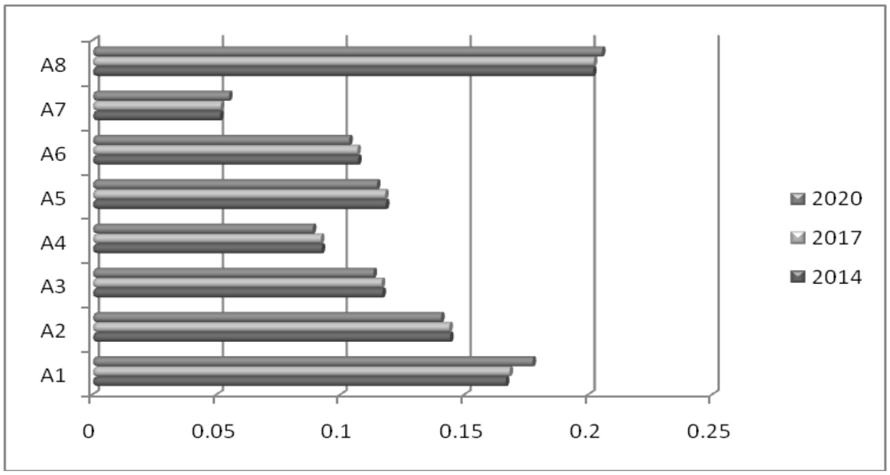

Figure 3. Final alternatives weights through time horizons

Sensitivity analysis

The assumption included in Equation 14, that the criteria weight is w_c=0.7, and for the relevant external projects weight is w_{rep}=0.3, can be modified in order to present a sensitivity analysis. The final results show that the relative project's rank is the same through the whole time horizon for the first case (w_c=0.7, w_{rep}=0.3). The project's rank is very similar in the second case (w_c=0.5, w_{rep}=0.5), the only difference is that the first and the second ranked alternatives, as well as the sixth and the seventh, change places. In the third case (w_c=0.3, w_{rep}=0.7), changes are the most evident, especially in the period after 2017. The following figure shows that the projects A_8, A_4 and A_6 are time sensitive, so the project A_8 changes even four positions, from the first, second, over the third to the seventh ranked project. The projects A_4 and A_6 in some cases are in the fifth, sixth or seventh ranked position.

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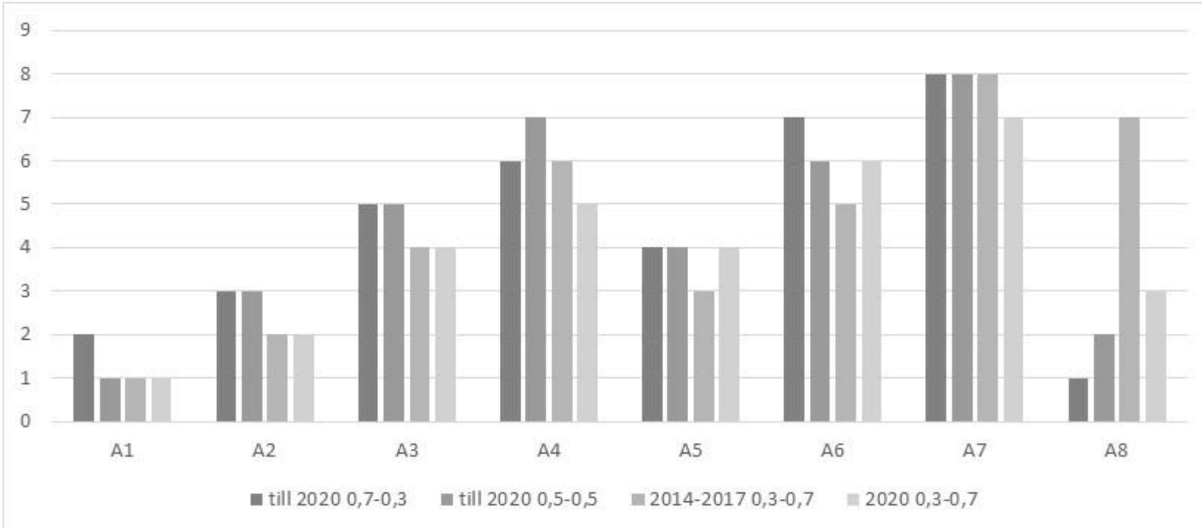

Figure 4. Final alternatives rank through time horizons with different criteria and relevant external projects weights

5. Conclusions

The evaluation of transport projects is a multi-criteria decision making process. This process is of great importance to a company's success, because very often it defines the company's share of the market. The model of decision making as a support system should have a flexible structure, suitable for potential modifications. Decision makers sometimes need a model which takes into account changes of the system elements, or changes in the system surroundings. This model describes results with all possible modifications and gives suggestions for all of them. The developed model involves changes in the system surroundings, with consideration of the relevant external projects; in addition, it includes changes of the element's priorities over time horizons, giving the final alternatives weights through time horizons.

The analyzed case study is Rail Corridor 10 in Serbia. The relative importance of the alternatives in this model is not significantly changeable over time. However, during time, some alternatives become more or less dominant.

With respect to future studies, we recommend analyzing relevant stakeholders and their influence on a decision making process. Very often, there are dynamic stakeholders' preferences which are changeable over time. Also, the relevant improvement of the model developed in this paper could consider the fact that some criteria are mutually interconnected, an aspect which can be elaborated by the Dynamic Network Process.

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