Transport Policy 36 (2014) 88–104

Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Two-phase model for multi-criteria project ranking: Serbian Railways case study

Dragomir Mandic, Predrag Jovanovic, Mirjana Bugarinovic *

Faculty of Transport and Traffic Engineering, University of Belgrade, Serbia

ARTICLE INFO

Keywords:
Two-phase ranking model
Multi-criteria ranking
Railway
Algorithm

ABSTRACT

An original two-phase model for ranking railway projects from different railway subsystems is presented. The model was developed for the purpose of ranking 75 Serbian Railways projects. The advantage of this model over existing one-phase models is that it allows for one to obtain not only a unique ranking list of all of the projects but also ranking lists for individual project clusters. The second essential advantage is that the application of this model eliminates the shortcoming of some of the high-ranked projects on the unique ranking list not being high-ranked on the cluster ranking list. Due to the frequency of situations in which projects contain a dualism of interests (e.g., local-global, individual-general, regional-national and national-European), based on the proposed model, a universal model for a two-phase ranking of projects was developed. The algorithm of the new model is presented herein.

1. Introduction

Serbian Railways, as well as the other railways in the region, was in a much worse situation after the war and other events that occurred in the Balkans region at the end of the 20th century than it was prior to these events. All segments of the railway system were in a notably poor state. Immediately after the war and the associated events, the first financial means of the International Financial Institutions (IFI) were used mainly to repair the most damaged structures (mainly infra-structural) to avoid the discontinuation of traffic.

Thereafter, the need to define the priorities of the development projects arose, as financial sources and the capability to take loans were limited. Thus, Serbian Railways asked for help from the Faculty of Transport and Traffic Engineering at the University of Belgrade to join experts from the railway company in performing a study that would define a list of priority development projects.

The additional reason for the creation of a unique list of priorities was the existing practice of financing individual projects based on criteria not consistent with the real needs of Serbian Railways but with the ability to provide a financial source. Typically, such financing was offered by different ministries (traffic, finance, infrastructure, etc.).

For this reason, at the outset of this study, Serbian Railways established the condition that the unique list of development projects had to be consistent with the priority lists of the individual organisational units of the company.

The challenge was that a large number of projects (75) from various areas (railway subsystems) had submitted applications. This large number of projects from various areas and a lack of similar examples in the scientific literature worldwide resulted in the definition of a new procedure for the evaluation and ranking of projects from different areas, with the potential for application to railway traffic.

The remainder of this paper is organised as follows. In Section 2, a description of the problem addressed is provided, followed by a literature review in Section 3 of multi-criteria analysis for the evaluation and ranking of projects in the area of traffic. In Section 4, the submission and grouping of projects as well as ranking within clusters is presented. Section 5 presents the proposed project ranking for a Serbian railway. Section 6 presents the results and discussion. These sections are followed by the description of a general model for the multi-criteria ranking of different project clusters. Possible directions of future research concerning similar problems are presented in the last section.

2. Description of the problem

As mentioned in Section 1, all Services and Organisational Units of Serbian Railways were asked to propose their priority projects. From seven organisational units of Serbian Railways, 75 proposals were obtained. The following areas were covered: railway infrastructure (25), transport (10), multimodal transport (13), control

* Corresponding author.

http://dx.doi.org/10.1016/j.tranpol.2014.08.002
0967-070X/

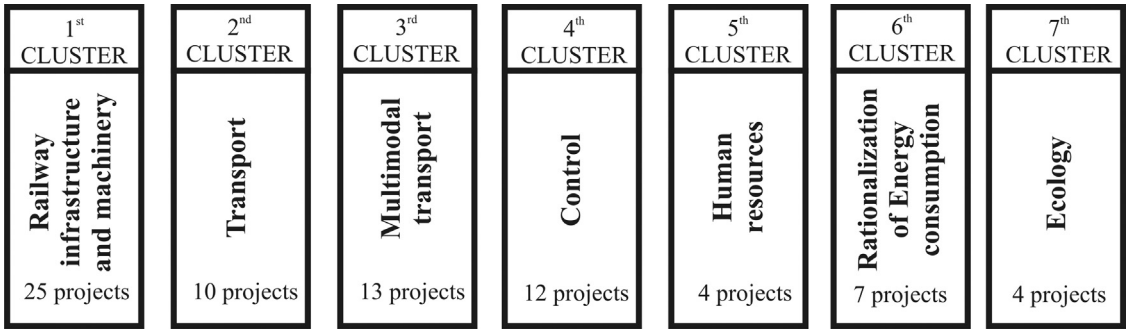

Fig. 1. Initial seven project clusters.

(12), human resources (4), rationalisation of energy consumption (7) and ecology (4), i.e., seven project clusters (Fig. 1).

It was immediately clear that the task could be solved by applying a multi-criteria evaluation and ranking method. However, the essence of multi-criteria evaluation and ranking is that it is applicable to projects of the same nature (or versions of the same projects) or to different projects but based on the same (common) criteria for all projects.

3. Literature review

Several groups of authors have applied multi-criteria analysis, as well as other analysis methods, in the evaluation and ranking of projects in the area of traffic.

Simulation techniques are widely applied. For example, by applying discrete optimisation and standard techniques such as Monte Carlo simulation, Bonnafous and Jensen (2005) created a model for identifying the most efficient program for investments, taking into account the partial incomes of individual projects. The paper presented a theoretical approach and an explanation of the method, but no application to specific problems was covered. Starting from the most frequent errors – overestimating profit and underestimating investment costs of traffic projects – Salling and Leleur (2012) used risk analysis and Monte Carlo simulation to facilitate the decision-making process in ranking projects in the area of transport and traffic (three alternative airports – one group of projects). In their study "Simulation-enhanced approach for ranking major transport projects", Su et al. (2006) modified their ranking model based on the Analytical Hierarchical Process (AHP) method to reduce subjective estimates of the criteria and alternatives. They extended the basic matrix of interactions and used Monte Carlo simulations to define the ranks of alternatives (one group of projects).

Most of the papers are based on the use of multi-criteria decision making and multi-criteria analysis. Buchanan and Vanderpooten (2007) used the ELimination and Choice Expressing REality (ELECTRE III) method to support the selection of power distribution network projects. Although the authors stressed that it is possible to use other methods of multi-criteria analysis, they highlighted the simplicity of their method in ranking and the advantages of alternatives within one group of projects. Eder et al. (1996) employed the Multi-Criteria Decision Making (MCDM) model to select ecologically justifiable projects concerning the hydro-regulation of the Danube, including several hydro-electric power station projects. The authors emphasised the mutually discriminating effect of some of the criteria. Furthermore, they used multi-criteria Q-analysis, which is based on a description of the geometric structure between two sets, alternatives and criteria (12 projects, hydro-electric power stations, one group of projects). De Brucker et al. (2011) demonstrated the need for and possibilities of using multi-criteria analysis models in an institutional approach for the evaluation of transport projects (18 generated projects in two areas – safety projects and post express – independently evaluated as case 1 and case 2). Macharis et al. (2009) presented a model of multi-criteria analysis by "several participants" (MAMCA) for the evaluation of transport projects. The estimate takes into account quantitative and qualitative criteria, each having its own significance defined by the participating party (one group of projects). In the study by Tsamboulas et al. (2007), multi-criteria analysis was applied for the evaluation of investment projects concerning traffic infrastructure. The authors' approach is characteristic in that they analysed criterion complexity ("width") separately and proved that individual simple criteria could be made complex and, as such, included in the analysis. Lee and Kim (2000) used the method of Analytical Network Process (ANP) and goal programming to define a model for selecting information systems. To address the inter-dependence of some of the alternatives and criteria, the authors used the opinions of experts obtained through interviews (one group of projects). In addition to those employed in the above-mentioned studies, other models involving the use of other tools, in addition to multi-criteria analysis, have been developed to obtain quality results. When evaluating transportation infrastructure projects Iniestra and Gutierrez (2009) was considered five criteria and 50 projects in the decision. They used multi-criteria techniques for the final selection of the projects portfolio, ELECTRE III, PROMETHEE and Weighting method, and including the decision makers' preferences based on the existing context. The use of the multi-criteria decision method ELECTRE III helped to incorporate the decision maker preferences, and to find the solution that represents the best compromise. The strength of this solution was measured in some way by comparing it against two other decision techniques PROMETHEE, and the classical Weighting method. Longo et al. (2009) combined AHP and ANP methods to select the best out of four infrastructural railway projects. In the first phase, by using the AHP method, the hierarchy and relative priority of the projects were defined; the ANP method was used to take explicit interactions between individual clusters into account (alternatives, participants in the process and criteria – four infrastructural projects – one group of projects). A study based on the application of multi-criteria analysis in the field of railway traffic by Chang et al. (2009) established a model for selecting strategic solutions for the revitalisation of the historic railway line in Taiwan. The model is based on the use of the ANP method together with the fuzzy Delphi method and goal programming. The proposed ANP model is based on a hierarchical network between clusters of alternatives, participants and criteria. The model includes strategic criteria for evaluating benefits, possibilities, costs and risks (revitalisation of the railway line – one group of project versions). In their paper entitled "One approach for road transport project selection", Ivanović et al. (2013) define a model for selecting projects concerning the reconstruction of a street mesh in a pedestrian zone by comparing the transport Master plan and the results obtained by multi-criteria analysis. The study also investigates whether ANP, as a method for multi-criteria decisions, can be of significant help in the evaluation and selection of infrastructural