Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 22 (2016) 1051 – 1058

Procedia Technology

9th International Conference Interdisciplinarity in Engineering, INTER-ENG 2015, 8-9 October 2015, Tirgu-Mures, Romania

Forming Set and Verification of Relevance Criteria on Evaluation of Alternative Corridors of the Infrastructure Facilities

Nazim Manic[a,]*, Izet Hot[a], Veis Šerifi[b]

[a]*State University of Novi Pazar, 36300 Novi Pazar, Serbia*
[b]*SaTCIP Publisher Ltd., 36210 Vrnjačka Banja, Serbia*

Abstract

Most of the models, which are already a small number, for selection of the optimal spatial solutions of the corridor of line infrastructure facilities are based on the criteria of evaluation whose relevance has not been verified. As a set of criteria is a starting basis for development of the hierarchical model of decision-making for the evaluation and selection of the optimum spatial solutions corridors, so is the relevance of the optimal solution of the selected model is based on selected criteria so much in question. This paper develops a model for the formation of a set of criteria of evaluation of alternative spatial solutions corridor of the line infrastructure facilities respectively their identification, derivation and grouping (clastering) and verification of their relevance. The model consists of two inter-related and complex steps. In the first step is formed a set of preliminary criteria of decision-making, in four also complex sub-steps. In the second step, with the help of statistical methods, such as surveys, descriptive statics and the most important, the factor analysis, verifies the relevance of each of the criteria from the preliminary set individually, and verifies (or does not verify) hierarchical model of decision-making, with the verification of its factors, formed on the basis of this set of criteria. In this way is obtained a finite set of relevant criteria of decision-making. The optimal solution selected through hierarchical model based on a set of relevant criteria has credible relevance.

Peer-review under responsibility of the “Petru Maior” University of Tirgu Mures, Faculty of Engineering

Keywords: Decision-making criteria; factor analysis; hierarchical model; optimal solution; line facilities.

* Corresponding author. Tel.: +381-65-8331332.
E-mail address: nmanic@np.ac.rs

Peer-review under responsibility of the “Petru Maior” University of Tirgu Mures, Faculty of Engineering
doi:10.1016/j.protcy.2016.01.149

1. Introduction

Management represents the continuous effect of management actions that affect the parameters of the system, and the system leads from one state to another. The inevitable follower of the management process is decision-making process. Decision-making is an integral part of everyday life of people and it can be said that the management and decision-making, as well as processes, are essential in every aspect of modern society. The results of decision-making are decisions which may vary from those that are vital to those that are made routinely and have relatively little significance. Before the multi-criteria analysis was developed the problems of selection and ranking of various decisions were usually reduced to the single criterion optimization tasks. However, in practice, most often are met tasks where alternatives need to be evaluated by several criteria which make the problem much more complex [1, 2]. Each phase of the planning and design determine the two parameters: the width of the approach to the problem and the level of detail analysis. Since the planning and design of infrastructure facilities are more plane arranged process, it fully requires to set aside as the most important steps of generating alternative solutions and their evaluation. Based on these activities, decisions are made on the transition to a new level (ie, the next stage of planning/design) with a degree of certainty that is proportional to the quality of research conducted while separating two basic task:

- decisions must be based on sufficiently detailed, impartial and reliable, that is, the relevant parameters and
- decisions to be verified by public and democratic decision-making as the infrastructure, most often, the public good, which is financed from the joint funds.

In this paper, attention is paid to the formation of a set of criteria (parameters) which would be the relevance and thoroughness, objectivity and reliability would be confirmed by scientifically acceptable methods.

2. Description of the problem

When designing line infrastructure facilities, before the designer is set the seemingly simple task of connecting the two nodal points along the route of the line facility. However, the problem is very complex because it needs to meet a variety of criteria (economic, functional, technical, environmental, social, etc.). Therefore, within the framework of the general project is done more possible solutions of corridor of the line facility and based on the values of their parameters, according to certain criteria will decide which of the offered alternatives provide the best possible (optimal) solution in the given circumstances. The decision making process, ie, the need for it, is constantly present in all areas of human activities regardless of whether it is an individual, group of people, companies, state and so on. It is therefore quite justified scientific study of decision-making, ie, the development of the theory of decision-making as separate scientific discipline [3, 4]. The decision-making implies selection of an alternative that solves a specific problem. In the problem of decision-making there are goals to be achieved by the decision, the criteria used to measure the achievement of these goals, the weight of those criteria that reflect their importance, and alternative solutions to problems. Data and information on the elements of decision problems summarize the relevant procedures in one number for each alternative, and on the basis of these values determines the ranking list of alternatives.

Behind every good and sustainable decision is a complex decision-making process which involves the synergy of action of the human mind, mathematical methods and computational tools, ie, a complex choice between the various alternatives that are under the influence of a smaller or larger number of factors. With the analysis of existing models in this field, it was concluded that in most models there are certain disadvantages that significantly affect the objectivity of the process of selecting the optimal solutions. If the defects would be remedied, respectively, performed an upgrade of some models, it would allow to obtain a clearer picture of interdependence criteria, depending on choice of alternatives of their importance, and vice versa, the effect of choice of alternative to the significance, that is, the weight of individual criteria. A large number of existing models, though is based to the analysis on more than one criterion, nevertheless, are essentially single criteria because an alternative evaluation is performed by each criterion separately. On the other hand, a certain number of models, though essentially are multi criteria, somewhat unjustifiably are forcing certain group of criteria (lately mostly environmental) [5, 6]. Analysis of existing models has been shown to be very common criteria (and subcriteria) evaluation are adopted without a valid explanation why they are particularly the relevant criteria for selecting the optimal solution.

An appropriate selection of certain criteria, even if they really were relevant individually, leading to wrong selection of certain alternative solutions as an optimal solution for a number of reasons: (i) they are not relevant evaluation criteria, (ii) they are relevant criteria for evaluation or are unreasonably excluded from the group of other relevant criteria, and therefore have obtained more importance (weight) than they really belong, (iii) and if all considered criteria are relevant, due to the wrong hierarchy among them (the wrong clustering, grouping) some criteria receive more, others less weight of really belonged one [7]. These problems are very often the cause of errors that occur when making planning and project documentation or the cause of wrong decisions made on the basis of insufficient or wrong collected information, scientifically insufficiently based analysis, wrong or insufficient responsibly conducted the process of making these important decisions. This is evidenced by many of the actions of infrastructure networks in the Republic of Serbia, but also elsewhere in the world.

3. Defining a set of relevant decision-making criteria

The criteria and sub-criteria are performance measures on which a decision will be made on the best alternative. "Added value", which brings with itself the VKA, is largely arising from the fact that it is based on a clearly defined set of criteria. Hence, there is the need for the criteria, first of all, must be operational, or, to use only the VKA. Measurement and evaluation of alternatives should show how the criteria have well defined all the possibilities for achieving the stated goal. Therefore, it is a very important question in practice: whether on the basis of specified criteria is really possible to be measured and evaluated how much an individual alternative can contribute to the objective function? Existing research criteria for the selection of optimal solutions of a corridor of the infrastructure facilities mainly are engaged in separating of several indicators and determining the intensity of their influence. Then, alternative solutions are compared according to these indicators and is adopted the solution with the best marks. This is the basic idea in a number of significant studies that have thus been realized.

Therefore, it is very difficult to make an universal model (a model that would fit to a large number of infrastructure systems) for defining the relative importance of criteria when selecting the optimal solution. There is made a question of changeability on importance of certain criteria, depending on a number of characteristics of the infrastructure system. Furthermore, if one takes into account that the infrastructure system by its nature is a dynamic system in which constantly occur numerous changes as well as changes in its environment, then, there is made the question on variability importance of particular criteria in time for one same system. Evaluation criteria of corridors of the line facilities derive from the objectives of the existence of infrastructure systems and specific objectives of building the facility which make the system. By means of criteria comprehensively and extensively are modeling the features of the problem, and adding adequate weight numerically are expressed preferences of decision-makers [8].

The criteria are also a measure of those features of the system (economy, efficiency, full capacity, functionality, etc.) that want to optimize to meet the set targets. In this paper is developed a complex model for the formation of a set of relevant criteria evaluation of alternative spatial solutions of corridor of the line infrastructural facility, as characterized by multiactor and multicriteria approach. The model consists of two complex steps (with a series of sub-steps) (Fig. 1).

A) Step 1: Defining a set of preliminary *decision-making* criteria

Alternative or outcomes of actions are displayed by a few, or a whole range of characteristics. Some of these characteristics can be accurately expressed in different units of measurement, while others are expressed descriptively. Attributes (criteria) are the characteristics of the alternatives that are relevant to the particular choice of the problem of decision-making. Unlike alternatives that are pre-defined, attributes are always self-selected and formulated. This means that their choice is subjective, as a set of attributes reflect the individual attitude of decision-makers, that is, reveals specific goals that he wants to achieve with the approved decision. Therefore, the sets of attributes will be different for each of the decision makers, and will vary in number and content or the importance that is attributed to them [9]. Identification of the appropriate set of criteria for a particular set of goals is the creative process. In some cases, there are objectives for which there are no clear criteria for the direct measurement of the level of achievement, but in this case for the achievement of the targets are used criteria that are suitable for measuring and indirectly reflect the achievement of the targets. In determining a set of criteria for a given target, which indicates the total criteria optimization problem, it is necessary to take into account that he should have met the following characteristics:

- measurability (criterion must be practically understandable to determine the value of a particular measurement scale for a given alternative) and
- easy perspicuity (value criteria must be sufficient to indicate a level that has met an objective).
- operational (used for problem of analysis),
- completeness (all aspects of the problem are given by criteria),
- no redundancy, mutual independence of criteria (even one aspect of the problem is not estimated using the criteria more than once),
- optimality of the set size (too many weighting makes analysis more difficult) and
- minimum (no finite set of criteria that represent the same problem but with a smaller number of elements).

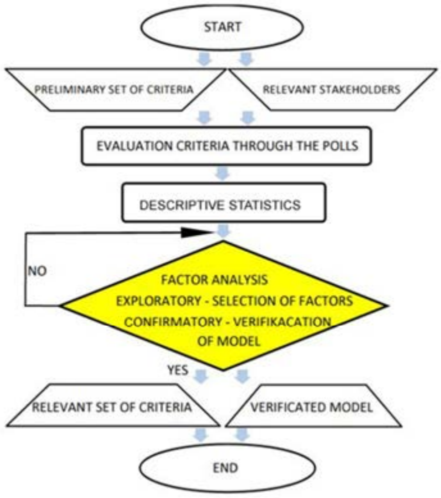

Fig. 1. General algorithm of defined model

a) Defining elements of the set

Whether the decision is made individually or in groups, an effective way of the began process of identifying criteria continue is obtaining answers to the question: "What will distinguish the good and the bad choice of alternatives to the problems of decision making?". The answer to this question should be given as accurately as possible [10-12]. Perspectives (view) of stakeholders (participants) play an important role. Therefore it is necessary to include the same in some or in all stages of the decision-making process. It is especially important to consider their perspective during the implementation of infrastructure projects, as well as the public, common good. One of the most effective ways to do this is a direct dialogue with all interested parties, where through interviews or surveys perceive their needs, requirements, concerns and interests. Analysis of the collected information will help the viewpoint of interested parties adequately injected into criteria for evaluating and ranking of variant solutions. When defining criteria a great assistance provides the so-called "target analysis", ie, the analysis of the objectives to be achieved by solving the defined problems. Of course, with the target analysis it is necessary to distinguish between the levels to which the model applies, especially due to the fact that at the higher (strategic) a part of the objectives are entered (comes) from the environment. Achieving of the given goals is a fundamental prerequisite of any decision-making process. Generally, there is a lack of a structured approach that would allow an efficient and fast system analysis of goals and the experience and teamwork, in addition to the methodology, the best guarantee of success. In practice is very often conflict of goals at the strategic level and usually happens that the goals coming from the environment are in conflict with the objectives of which are generated within the system. This contradiction is transmitted to the criteria, and the criteria most often are in conflict positions. The contradictory criteria are conditioned by the "poor structure" problem, and it can be concluded that the basic characteristics of "normal" (everyday) problems are contradiction to dominant criteria. Just contradiction criteria justify the use of multi-criteria analysis methods, because the "traditional" methods, including the intuitive decision-making, can not determine the optimal solution. In this way is identified a number of criteria, which become elements of the preliminary set of criteria. The second part of the preliminary set of criteria is identified on the basis of experience from similar projects, and conducted on the basis of scientific and practical research. In this part the largest role shall belong to "the creators of the project". The third part of the preliminary set of criteria defined in the model has been identified on the basis of past experience on similar projects, where these criteria proved its relevance.

The combination of these three approaches, you get the largest number of elements in a set of preliminary criteria for the evaluation of alternative solutions of corridor of the infrastructure facilities [14-16]. The fourth, and final, part of a set of preliminary criteria is defined on basis of the needs, expectations, interests and concerns by stakeholders through surveys or interviews. Although there is no clearly defined rule on the number of preliminary set of criteria, you still have to strive for it to be as small as possible. This number depends largely on the preferences of the analyst, the problem to be solved, but also on what the support system in decision-making is used. Financial significant or otherwise important decision, especially in systems with complex technical characteristics, can have hundreds of criteria (for example, decision-making where to build a nuclear power station). However, for better decision-making and optimal number of criteria is considered to be the range of 6-20 [17, 18].

b) *Grouping of criteria*

Grouping of attributes (criteria) in a number of subsets that are relevant to specific and identifiable components of the overall goal can be helpful in decision-making. Especially this applies to problems where thre is a large number of criteria. The main reasons for grouping of criteria are: (a) to assist the process of checking whether a set of criteria is adequately chosen with regard to the problem to be solved, (b) to facilitate the process of calculating the weight of criteria in certain methods for decision support, when first is determined the weight of sets of related criteria, and then is determined the weight of criteria within a set, and (c) for easier ways of perceiving on the basis of what criteria an individual alternative achieves bests functions of stated goal. For these reasons, the grouping of criteria (or "tree structuring values") is an important part of the VKA. There are few formal guidelines for determining whether a defined structure is good or bad. The most experienced analysts the problem of structuring see as a skill that is acquired primarily through practical experience. However, for most of the big problems, there is no unequivocal and unambiguous right structure or grouping of criteria. Eligible structure is simply one that reflects a clear, logical and common view of how the majority of the criteria which may be relevant for VKA be grouped into coherent sets, each of which will reflect the sets of one component of the overall problem.

B) Step 2: Determining the relevance and check *of* structure *set* of the preliminary decision-making criteria

In the process of determining the relevant indicators, Step 2 of the defined model provides application of the combined method of research, which includes:

- survey, which collect data from relevant stakeholders anketu,
- descriptive statistics, for data processing and
- factor analysis, to reduce the data set collected by the survey, and define a set of relevant criteria for evaluation and ranking of variant corridor.

The utilization of combined method in Step 2, integrate knowledge, skills and preferences of the relevant actors. Expressing preferences of actors through the evaluation criteria by closed survey, helps the decision makers to better understand the system itself, and thus contributes to making better decisions that will be a custom of all (or the vast majority) stakeholders [19, 20]. Questionnaire method is one of the most commonly used methods for data collection in social research, groups of relevant stakeholders (ie, their respective representatives). On the basis of their written replies data are researched and collected, information, views and opinions on the relevance of the criteria given in the preliminary set. Descriptive statistics describes, compare and analyze the mass appearance of the basic display and numeric processing of known data. Thereby a mass phenomenon is statistically homogeneous set of elements, that is, those elements that have the same characteristics. Statistical collection is defined conceptually, spatially and temporally. The statistical characteristics are the general properties of the elements of the statistical set at which the elements are defined as homogeneity or by them differ. Descriptive characteristics are expressed by words, respectively, sequenced rank, numerical number, and temporal at the moment. Description of mutual dependence of a large number of variables using a small number of basic, but not observable random variables known as factors, with the method of multidimensional (multivariate) analysis is called factor analysis.

Decision-making process in the factor analysis consists of six stages, plus an extra stage (stage 7):

- defining the objectives of factor analysis,
- designing of factor analysis,
- assumptions into factor analysis,
- performance of factors and assessment of the overall fit,
- interpreting of factors,
- confirmation of factor analysis and
- additional use of results of the factor analysis.

The general purpose of the factor-analytical techniques is finding a way to summarize the information contained in a large number of original variables into a smaller set of new, composite dimensions or variants (factor), with a minimum loss of information. Factor analysis as a set of statistical and mathematical methods suitable for the analysis of data on the interconnectedness of the analyzed phenomena, proved to be useful in all situations where in the researches at the same time experiencing a greater number of variables that are in mutual correlation and which requires determination of basic sources of the co-variation among data. In correlative connection of phenomena, changes in one and the other phenomena may occur in parallel, and that one is not the cause of others, unlike of the causal-consequential connection in which one pjenomena or event is a cause of the other phenomena of some other phenomena, events or changes. Factor analysis allows the calculation of correlation coefficient or coefficient of association between variables. The variables considered data obtained by measuring the change in the phenomena to be analyzed and studied. If the analyzed phenomena are mutually linked, then we can determine the size of each analyzed correlation phenomena. This means that as a result of such analysis to get symmetric matrices with a number of correlation coefficients. The number of these correlation coefficients is n (n-1) / 2, where n is the number of variables. The correlation coefficients show that the studied phenomenon related to the links between some are less, respectively, more. Factor analysis allows deeper penetration into the mutual dependencies and relationships between phenomena, and through a set of mathematical and statistical methods allows that through a larger number of variables, among which there is a connection, establishes a small number of variables that explain such interconnection. These basic variables are called factors. In Table 1 is presented the result of the research conducted during the audit functionality of the particular case. Variables analyzed in factor analysis are called manifest variables and factors that are determined on the basis of mutual relations manifest variables are called latent variables. Therefore, the main objective of factor analysis is that, instead of a large number of interconnected and dependent manifest variables that have resulted from another research, identify a small number of mutually independent latent variables that might explain the mutual relations of manifested variables. There are two basic strategies for the use of factor analysis: exploratory and confirmatory factor analysis.

Table 1. The percentage variance of the results of the factor analysis for the theoretical model criteria

Factors	Characteristic root (total)	Percentage of variance	Cumulative percentage of variance
F1: Socio-economic	3,967	14,694	14,694
F2: Traffic-exploitation	3,426	12,690	27,384
F3: Investment-construction	3,221	11,931	39,314
F4: Spatial-urban	2,641	9,782	49,097
F5: Ecological	2,457	9,101	58,197

Exploratory factor analysis establishes basic factors or sources of variation and covariation among the analyzed variables, and with a confirmatory factor analysis is carried out an objective test of a certain structural model or theory. Researcher are starting from pre-formulated model, hypotheses or theories about the structure of the main sources of variation and covariation between analyzed variables and test that model, a hypothesis or theory. For the purposes of this survey was used the method of confirmatory factor analysis. The term variable here means the criterion, sub-criterion or indicator. The main aim of the application of factor analysis is reflected in the verification and rationalization of the set of theoretical models of criteria/sub-criteria for the evaluation of alternative corridors of the infrastructure line facilities [21]. During the testing of models was conducted factor analysis by statistical program SPSS Statistic 20. In processing the results of the survey data were summarized by 60 respondents, N = 60. The preliminary set of criteria was analyzed with infrastructure elements determined in Step 1. During the analysis was performed the specification of a number of factors, and it was found that a number of factors accounted for five (Table 1). As an entry in a factor analysis was used the variables in the questionnaire, a total of 24 variables theoretical model criteria. With the method of factor analysis of principal components and application of orthogonal varimax rotation, were obtained factors almost identical to structure of the theoretical model. The results show a match for the most part of the structure, with which is verified the theoretical defined model. In order to determine the reliability of a defined theoretical model, using collected data was obtained by Cronbach's alpha coefficient for assessing the internal consistency of the results, which, for a complete model of 24 variables, was 0,828. Subsequently was made a factor analysis of the N=60 respondents. The principal component analysis, were extracted statistically significant factors in the space variables of the theoretical model with orthogonal rotation method and Varimax rotation criterion. During factor analysis is obtained the KMO index (Kaiser-Meyer-Olkin index, the index of sampling adequacy) K=0.704.Table I indicates the percentage of variance results obtained by the method of analysis for the defined theoretical model of decision-making criteria.

In the second column of Table 1 are shown the overall characteristic roots (ie. Lambda coefficients) which show the strength of each factor. The third column shows the percentage variance for that individual factors provide an explanation. In the fourth column are presented the percentages of given cumulative variance. On the basis of five factors cumulatively is explained 58.197% of the variance of results (first factor explains 14.694% of the variance of results, the second 12,690%, the third 11,931%, the fourth 9.782%, and the fifth factor of 9.101% of the total variance of the results).In Table 2 is shown the part of rotated components matrix showing the variables of theoretical models that have the highest projection of variance on several factors. On the basis of the criterion variable variance projections on several factors size of 0.519 and criteria of uneven projection variables on several factors, there were no variables that did not meet these two criteria, and there was no need to exclude any variables, ie, the need for reducing model. The result of the implementation of Step 2 is a set of relevant criteria (factors), as well as verification (or possible refutation) of the defined models.Based on the results of the factor analysis was confirmed all five factors given at the beginning of the analysis. Factor analysis has also confirmed the validity of the theoretical model of defined evaluation criteria. Hereby has been verified all criteria from a set of preliminary criteria and confirmed their relevance. The resulting set of relevant criteria can be used in the process of evaluating and ranking of variant solutions of corridor of the line infrastructural facilities as completely relevant, which will the obtained optimal solution will be considered fully relevant.

Table 2. The rotated matrix coefficients showing projections of the variance in the theoretical model

	F1	F2	F3	F4	F5
F1: Socio-economic criteria					
Exchange of real estate values	**0,869**	0,022	0,092	0,030	-0,046
Change in the dtructure of employment	**0,803**	0,031	0,106	0,095	0,113
Agriculture development	**0,783**	0,233	0,139	0,175	0,029
Increase quality of life	**0,766**	0,143	0,232	0,173	0,124
Tourism development	**0,729**	0,236	0,282	0,154	0,158
Increase of annuitant potential of the land	**0,578**	-0,126	0,217	0,189	0,068
Prevention of outflow of the population	**0,534**	0,087	0,112	0,034	-0,087
F2: Traffic-exploitation criteria					
Costs of accidents	-0,223	**0,879**	0,141	-0,014	0,110
Number of traffic accidents	-0,076	**0,803**	0,123	0,164	0,161
Annual operating costs of users	0,266	**0,753**	-0,051	0,142	0,154
Annual travel time of users	0,102	**0,733**	0,151	0,004	-0,030

4. Conclusion

Unlike alternatives that are pre-defined, attributes (criteria, sub-criteria, indicators) still are independently choosen and formulated. This means that their choice is subjective because the set of attributes reflect our individual attitude, repectively reveals our specific goals that we want to achieve with the decision-making. Therefore, the set of attributes will be different for each of us, and will vary in number and content, but also in importance that we attribute to them. Whether the decision is made individually or in groups, efficient way in the process of identification criteria is obtaining answers to the question: "What will distinguish the choice between good and bad alternatives to the problems of decision making?". Perspectives (view) of stakeholders (participants) play an important role. Therefore it is necessary to include the same in some or in all stages of the decision-making process. One of the most effective ways to do this is a direct dialogue with all interested parties, where through interviews or surveys anticipate their needs, requirements, concerns and interests. Analysis of the collected information will help that the view of stakeholders to be adequately injected into criteria for evaluating and ranking of variant solutions. When defining criteria a great assistance provides the so-called "target analysis". Methods of descriptive statistics and factor analysis proved to be an excellent mechanism for determining the relevance of the criteria and the validation structure formed by a set of criteria as described in the work. This method checks the relevancy of criteria that can be used in various fields of science and practice.

References

[1] Hot I., Management of conceptual designs creation in field of infrastructure by use of multi-criteria analysis, Ph.D. Thesis, Author's reprint, University of Novi Sad, Novi Sad, 2014. (in Serbian)
[2] Bairagi B., Dey B., Sarkar B., Sanyal S. K., A De Novo multi-approaches multi-criteria decision making technique with an application in performance evaluation of material handling device, Computers & Industrial Engineering, Volume 87, September 2015, pp. 267-282.
[3] Abramović I., Risk theory and decision-making methods, Faculty of Organization and Informatics, Varaždin, 1980. (in Croatian)
[4] Mardani A., Jusoh A., Zavadskas E.K., Fuzzy multiple criteria decision-making techniques and applications – Two decades review from 1994 to 2014, Expert Systems with Applications, Volume 42, Issue 8, 15 May 2015, pp. 4126-4148.
[5] Opricović S. Multidisciplinary optimization of systems in construction, Faculty of Civil Engineering, Belgrade, 1998. (in Serbian)
[6] Luo Chen L, et al., A hierarchical model for label constraint reachability computation, Neurocomputing, Vol. 162, 25 August 2015, pp. 67-84.
[7] Andrade A.R., Teixeira P.F., Statistical modelling of railway track geometry degradation using Hierarchical Bayesian models, Reliability Engineering & System Safety, Volume 142, October 2015, pp. 169-183.
[8] Brans J. P., A. New Family of Outranking Methods in Multicriteria Analysis, Operational Research '84, North Holland, 1984.
[9] Celik E., Gul M., Aydin N., Gumus A.T., Guneri A.F., A comprehensive review of multi criteria decision making approaches based on interval type-2 fuzzy sets, Knowledge-Based Systems, Volume 85, September 2015, pp. 329-341.
[10] Behmanesh I., Moaveni B., Lombaert G., Papadimitriou C., Hierarchical Bayesian model updating for structural identification, Mechanical Systems and Signal Processing, Volumes 64–65, December 2015, pp. 360-376.
[11] Forman, E., Peniwati, K. Aggregating individual judgments and priorities with the Analytic hierarchy process, European Journal of Research, Vol. 108, 1998.
[12] Aliakbarian N., Dehghanian F., Salari M., A bi-level programming model for protection of hierarchical facilities under imminent attacks, Computers & Operations Research, Volume 64, December 2015, pp. 210-224.
[13] Frei F., Kalakota R., Leone A., Marx L. Process Variation as a Determinant of the Bank Performance: Evidence from the Retail Banking Study, Management Science, Vol. 45, No 9, 1999.
[14] Piantanakulchai M.: Analytic Network Process Model For Highway Corridor, ISAHP 2005, Honolulu, Hawaii, July 8-10, 2005.
[15] Mittal J., Kashyap A., Real estate market led land development strategies for regional economic corridors – A tale of two mega projects, Habitat International, Volume 47, June 2015, pp. 205-217.
[16] Criqui L., Infrastructure urbanism: Roadmaps for servicing unplanned urbanisation in emerging cities, Habitat International, Volume 47, June 2015, pp. 93-102.
[17] Tepeš B., Descriptive statistics, lectures at the Faculty of Philosophy in Zagreb, (2004). (in Croatian)
[18] Fulgosi A., Factor Analysis, School book, Zagreb, (1988). (in Croatian)
[19] Saaty T. L., Özdemir, M. The Encyclicon; a Dictionary of Applications of Decision Making with Dependence and Feedback based on the Analytic Network Process, RWS Publications, (2005a).
[20] Begičević N., Multicriteria decision models in strategic planning of introducing e-learning, Ph.D. Thesis, Author's reprint, University of Varaždin, Varaždin, (2008). (in Croatian)
[21] Ouyang M., Wang Z., Resilience assessment of interdependent infrastructure systems: With a focus on joint restoration modeling and analysis, Reliability Engineering & System Safety, Volume 141, September 2015, pp. 74-82.