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Method and system for Multi-Attribute Market Value Assessment in analysis of construction and retrofit projects

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ABSTRACT

Multi-Attribute Decision-Making (MADM) methods prioritize the alternatives of comparative projects quite accurately. Problems arise when there is a need to determine the utility degrees and market values of the project alternatives. This becomes especially important for establishing the market value of real estate property in tender offers. However, the available MADM methods cannot accomplish this. Thus the authors of this article developed the MAMVA method, which permits determining the utility degrees and market values of project alternatives, and also developed a system on the basis of this developed method. This article presents the proposed Multi-Attribute Market Value Assessment (MAMVA) Method and the Decision Support System for Construction and Retrofit Projects (DSS-CRP). It also presents a case study to demonstrate the effectiveness of this method and system. The application of the MAMVA Method and DSS-CRP System for prioritizing and for determining the utility degrees and market values of construction and retrofit projects under consideration for financing by the European Economic Area (EEA) and Norway Financial Mechanism Grant made it possible to decrease the amount of requested support.

This article also presents the analysis and comprehensive assessment of the noted construction and retrofit projects. These were performed in consideration of the entire life cycle of a project and of needs satisfaction relevant to all the groups interested in a project. The developed MAMVA Method and DSS-CRP System permit assessing the appropriateness of projects under analysis in conceptual and qualitative forms. This method and system automatically submit the values of the project alternatives.

1. Introduction

More and more Decision Support Systems (DSS) are being developed for application in various areas over recent years (Asghar, 2008; Gao, Zhang, & Lu, 2009; Henriksen & Palocsay, 2008; Ramaseshan, Achuathan, & Collinson, 2008; Rigopoulos, Askounis, & Metaxiotis, 2010; Tchangani, 2009). Decision support systems for construction have been developed by Adeli (1988), Rodriguez-Martinez, Lopez-Arevalo, Banares-Alcantara, and Aldea (2004), Hajdasz (2008a, 2008b), Dedieu, Pibouleau, Azzaro-Pantel, and Domenech (2003), Alanne (2004), Zhao, Wu, and Zhu (2009), Pohekar and Ramachandran (2004), Roulet et al. (2002), Flourentzou and Roulet (2002), Mroz (2008), Diakaki, Grigoroudis, and Kolokotsa (2008) and Juan, Kimb, Roperc, and Castro-Lacouturec (2009). In Lithuania Zavadskas, Raslanas, Kaklauskas (2008), Kaklauskas, Gulbinas, Naimavičienė, and Kanapeckienė (2006), and Kaklauskas, Zavadskas, and Trinkunas (2007) have developed a number of multi-attribute decision support systems for use in construction.

Dedieu et al. (2003) addresses the development of a two-stage methodology for multi-objective batch plant design and retrofit according to multiple criteria. At the upper level (master problem), the Multi-Objective Genetic Algorithm (MOGA), which proposes several plant structures, is implemented for managing design or retrofit problems. At the inner level (slave problem), the Discrete Event Simulator (DES) evaluates the technical feasibility of the proposed configurations. First, basic DES principles are recalled. Then the following section develops MOGA based on the combined, single objective, genetic algorithm (SOGA) and Pareto Sort (PS) procedure. Finally a didactic example related to manufacturing four products using three types of equipment of discrete sizes illustrates this approach. Next, two criteria, investment cost and number of different plant unit sizes, are considered for designing a workshop. Then, starting from the best solution in terms of investment cost found in the design phase, a plant is retrofitted for double manufacturing. Finally the workshop is redesigned under the assumption of double production at the design phase. In terms of investment cost, this new solution yields a significant saving compared with what the retrofitted plant yields. In fact redesigning a new plant may challenge the retrofitting choice. Secondly an additional criterion is introduced concerning the number of production

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campaigns for reaching the steady-state or oscillatory regime, and the same approach (designing, retrofitting and redesigning) is performed which leads to the same conclusion as the bi-criteria case does.

Alanne (2004) proposed a multi-criteria "knapsack" model to help designers select the most feasible renovation actions during the conceptual phase of a renovation project. A case analysis concerning a real, Finnish apartment building was also presented. The primary aim of this case study was to test the applicability and functionality of the "knapsack" model in the context of these types of problems and to demonstrate the new model. For these reasons, as well as to avoid confusion, the simplified approach was applied. The results allowed to conclude that the method worked as had been expected. The analysis of this building case study led to the recommendation to adjust the radiator network by installing thermostatic valves. The most controversial factors regarding the evaluation of the model were the subjectivity feature of the multi-criteria assessment as well as the additive process of the model.

Based on the multi-index comprehensive evaluation method combined with the Life Cycle Assessment (LCA) Theory, Analytical Hierarchy Process (AHP) Method, post-evaluation thought and the successful degree evaluation method, a three-grade check and evaluation system was established on the heat metering and energy efficiency retrofit of existing residential buildings in northern heating areas of China. Zhao et al. (2009) also created a set of mathematical methods to evaluate the circumstances for implementing the heat metering and energy efficiency retrofit of these same buildings systematically, scientifically, comprehensively and objectively.

Within the framework of the European Joule-Thermie OFFICE Project, Roulet et al. (2002) developed the multi-criteria rating methodology based on a rating method that uses principal component analysis and a ranking method that uses a partial aggregation technique. This methodology rates or ranks office buildings and retrofit scenarios of that same building according to an extended list of parameters including energy usage for heating, cooling and other appliances, impact on the external environment, indoor environment quality and cost.

Flourentzou and Roulet (2002) described a systematic method based on multi-criteria analysis and a constructivist approach which helps an expert to design retrofit scenarios. This approach includes several steps that follow an iterative process. The associated computer tool takes charge of the tedious tasks such as calculating the associated costs, performing an energy balance and checking for coherence between actions and then it presents various viewpoints to an expert. It also helps the user by creating various scenarios quickly. The expert can then interact with this information and make the decision for selecting the final scenario. This interactive approach brings together expert intuition and rational systematic verification.

Mroz (2008) presented a new approach to community heating systems modernization and development planning process. It is based on the algorithm that aids general decision-making. The proposed algorithm takes into account both the demand and the supply side of the market for community heating modernization and development. To make the planning process more transparent and to increase the influence of decision-makers on the planning process, the ELECTRE III method was chosen as the tool to aid decision-making. The ELECTRE III method is based on the construction of an outranking relation and definition of a pseudo-criterion. The iteration mode of method application allows the decision-maker and analyst to investigate the sensitivity of the final solution to the changing preference model.

Diakaki et al. (2008) investigated the feasibility of applying multi-objective optimization techniques to the problem of energy efficiency improvement in buildings in order to consider the maximum number of possible alternative solutions and energy efficiency measures.

Juan et al. (2009) presented the Genetic, algorithm-based, online decision support system (DSS) to help residents easily conduct a housing condition assessment and offer optimal refurbishment actions considering the trade-off between cost and quality. Two refurbishment models were developed to explore the relationships among the life cycle cost, restoration cost and improved quality. The proposed DSS solves the problems arising from asymmetric information and conflicting interests between residents and contractors as well as improves the traditional housing condition assessment to be more effective and efficient.

Pohekar and Ramachandran (2004) reviewed the application of multi-criteria decision-making on sustainable energy planning. A review of more than 90 published papers was presented to analyze the applicability of the various methods discussed. The presented classification of application areas and the year of application highlighted the trends. One observation was that the Analytical Hierarchy Process is the most popular technique followed by the PROMETHEE and ELECTRE outranking techniques. Validation of results with multiple methods, development of interactive decision support systems and application of fuzzy methods to tackle uncertainties in the data were examined in the published literature.

Zavadskas et al. (2008) considered some of the problems associated with assessing the retrofit effectiveness of apartment buildings in urban areas. The retrofit of houses should be followed by the amelioration of their surroundings. The priority order of districts to be renovated depends on the condition of the buildings in a district and on strategic urban development programs. To determine the profitability of investments in housing retrofit, a number of retrofit scenarios need to be developed. The authors of this paper offer a new approach to determine the retrofit effectiveness of houses based both on expected energy savings and the increase in the market value of the renovated buildings. Retrofit scenarios for apartment buildings in Vilnius were developed in line with the proposed approach; i.e., retrofit investment packages for various districts were prepared and arranged in priority order for their application according to the geographical analysis method suggested by the authors.

Other authors applied the Method of Multiple Criteria Complex Proportional Evaluation (COPRAS) for various retrofit tasks (Kaklauskas, Zavadskas, & Raslanas, 2005; Kaklauskas et al., 2006; Zavadskas, Kaklauskas, Turskis, & Kalibatas, 2009 and others).

Upon analyzing the aforementioned scientific works, it can be asserted that those studies did not comprehensively analyze construction and retrofit project assessments since they did not take into consideration the entire life cycle of a project nor did they include all the groups interested in a project and their needs satisfaction.

Research shows that various scientists have specialized in depth the different and very important areas of multicriteria methodology and systems (Amiri, 2010; Dymova, Sevastianov, & Bartosiewicz, 2010; Fasanghari & Montazer, 2010; Kahraman & Kaya, 2010; Montazer, Saremi, & Ramezani, 2009; Xidonas et al., 2009). However, the current multicriteria methods and systems cannot to determine a utility degree and market value of alternatives (projects). In order to find what price will make a project being valuated competitive on the market a Method and System for Multi-Attribute Market Value Assessment determining the utility degree and market value of projects based on the complex analysis of all their benefits and drawbacks were developed by authors of the paper. According to this method the projects utility degree and the market value of a project being estimated are directly proportional to the system of the criteria adequately describing them and the values and weights of these criteria.

The structure of this paper is as follows: Section 2, which follows this introduction, presents Multi-Attribute Market Value Assessment