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Using ANP priorities with goal programming in resource allocation in transportation

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Abstract

Transportation Infrastructure (TI) project selection means identifying some alternative projects in order to maximize the net benefit to the organization and allocating resources only among those alternatives, within the given constraints on resources. To select the best set of proposed TI projects in an organization is difficult because there are lots of multiple factors such as project risk, corporate goals, limited availability of firm's TI resources, etc., in the candidate TI projects. The TI project selection problems are Multi-Criteria Decision Making (MCDM) problems. Prior project selection techniques are useful. However, they have restricted application because they generally depend on the assumption of independence among the candidate projects and criteria. In this paper, we suggest an improved TI project selection methodology which reflects interdependencies among evaluation criteria and candidate projects using analytic network process (ANP) within a zero–one goal programming (ZOGP) model. In order to provide a systematic approach to set priorities among multi-criteria and trade-off among objectives, ANP is suggested to be applied prior to GP formulation. Although goal programming incorporates multiple objectives and arrives at an optimal solution, its major drawback is that the decision maker(s) must specify goals and priorities a priori. In order to overcome this problem, group discussion is needed. In this research, we suggested an integrated approach for interdependent TI project selection problems using Fuzzy Delphi, Analytic Network Process concept and Zero-One Goal Programming.

Finally, in project selection, it is very important to consider the interdependent relationship among projects or criteria because of the characteristics of interdependence that exist in real problems. In addition, developing a methodology for considering interdependent factors is a very difficult problem. We introduce a method of solution through a real-world TI empirical example on an ongoing decision-making project in Taichung City, Taiwan using ANP/ZOGP. Using this method we solve problems having multiple criteria, interdependence and resource feasibility.
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Keywords: Transportation infrastructure project; Multi-criteria; Interdependence; Fuzzy Delphi; Analytic network process (ANP); Zero-one goal programming (ZOGP)

1. Introduction

Transportation Infrastructure (TI) project evaluation and selection is concerned with the allocation of scarce organizational resources. These TI project evaluation and selection problems are multi-criteria decision-making

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problems. Numerous methodologies for project or research and development projects selection have been developed and reported on, in the last two decades [1].

TI project selection means identifying some alternative projects in order to maximize the net benefit to the organization and allocating resources only among those alternatives, within the given constraints on resources. To select the best set of proposed TI projects in an organization is difficult because there are lots of multiple factors such as project risk, corporate goals, limited availability of firm's TI resources, etc., in the candidate TI projects. The TI project selection problems are Multi-Criteria Decision Making (MCDM) problems. When we evaluate project problems, we need to collect a group opinion because to know the interdependence relationship among criteria and criteria in the considered project problems is very important. In order to collect group opinions for interdependent project problems, we use expert interview. Keeney and Raiffa [2] propose a method to determine the utility function of the decision-maker in mathematical form. This utility function then represents a decision maker's level of satisfaction with different alternatives. Mathematical programming is basically a static optimization problem, consisting of different models such as linear programming, goal programming, dynamic programming, and game theory [3]. Goal Programming (GP) [4] is designed to deal with problems involving multiple conflicting objectives. However, to overcome the drawback of GP, decision makers must specify the goals and their priorities a priori. The result of problem formulation shows a great difference as the decision maker's judgements. Therefore, a systematic procedure is needed to determine the following factors in constructing the GP model through a group discussion: (1) objectives, (2) desired level of attainment for each objective, (3) a degree of interdependence relationship, and (4) penalty weights for over-achievement or under-achievement of each goal.

Another shortcoming of GP is the lack of a systematic approach to set priorities and trade-off among objectives and criteria [3]. This drawback is even more evident when both tangible and intangible factors need to be considered and when interdependent factors are involved and a number of people need to participate in the judgement process. In order to overcome this problem, analytic network process (ANP), developed by Saaty [5], is applied to set priorities for objectives and determines trade-off among them.

The fuzzy Delphi method [6,7] is a systematic procedure for evoking expert group opinion. To determine a degree of interdependence relationship also, the fuzzy Delphi method is used. The information obtained from the fuzzy Delphi method and ANP is then used to formulate a goal programming problem. The objective of this paper is to describe an integrated approach of interdependent TI project selection using fuzzy Delphi method, ANP, and GP. Thus, in this paper, we suggest an improved TI project selection methodology which reflects interdependencies among evaluation criteria and candidate projects using analytic network process (ANP) within a zero–one goal programming (ZOGP) model. In order to provide a systematic approach to set priorities among multi-criteria and trade-off among objectives, ANP is suggested to be applied prior to GP formulation.

Prior TI project selection techniques proposed are useful but have restricted application because they consider only independent TI projects or evaluation criteria. To consider project interdependent properties provides valuable cost savings and greater benefits to organizations. Unfortunately, there are many clearly interdependent cases in real-world subset selection problems. In other words, when we carried out some TI projects, there exists a great amount of sharing a variety of different resources among various transportation applications. However, TI project problems have an interdependence property. There exists a great amount of sharing of hardware and software resources as the result of executing various TI projects. For example, portions of transportation engineering shop drawings drawn for one application submitted to such as engineering consultants, construction departments, and owners are being reused as some requirements for several other application projects, providing substantial savings in developmental cost [8].

The objective of this paper is to suggest a solving methodology for TI project selection problems that have interdependence property among project or evaluation criteria. In order to reflect the interdependencies property in TI project selection in which exist multiple criteria, we used an analytic network process (ANP) [5] model and zero–one goal programming (ZOGP) [9] by group expert interview. Specifically, we demonstrated how a combined ANP and ZOGP model can be used as an aid in TI project selection problems.

2. Review of the project selection problem

Several methods have been proposed to help organizations make good project selection decisions [10–13]. The existing methodologies for project selection range from single-criteria cost/benefit analysis to multiple criteria scoring models and ranking methods, or subjective committee evaluation methods [14–16].

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