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A comprehensive model for selecting information system project under fuzzy environment

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Abstract

In general, the development of any information system (IS) project requires large investments of resources, such as human resources, computer software and hardware resources, operational procedures adjustments, and so on. However, IS project selection is difficult because there are lots of factors to be considered, such as business goals, benefits, project risks and limited available resources. In fact, IS project selection takes place in an incomplete, vague and uncertain information environment. The aim of this paper is to present a multiple-criteria decision-making method (MCDM) for selecting an information system project based on the fuzzy measure and the fuzzy integral. In this paper, the subjective opinions of decision makers are described in linguistic terms expressed in trapezoidal fuzzy numbers. After aggregating the fuzzy ratings of all decision makers, the vertex method is applied to transform the aggregated fuzzy rating into a crisp value. And then, a new algorithm is developed to deal with the IS projects selection problems. Finally, a numerical example is given to demonstrate the procedure for the proposed method.

Keywords: Multiple-criteria decision-making; Information system project selection; Linguistic variables; Trapezoidal fuzzy number; Fuzzy integral

1. Introduction

The problem of information system (IS) project selection is an important issue for any business [1–5]. Selecting the most suitable from a set of IS projects is a significant resource allocation decision that can enhance the operational competitive advantage of a business. However, IS project selection is difficult because there are lots of quantitative and qualitative factors to be considered in the candidate IS projects such as business goals, benefits, project risks and available resources.

Traditional project selection technology focused mainly on quantitative tools, such as discounted cash flow, net present value (NPV), return on investment (ROI) and payback period [6]. These approaches transformed all economic and non-economic factors into monetary values and then applied commercial estimation software to facilitate the evaluation process of cost-benefit analysis. The decision makers usually select the best IS project based on the estimation results. However, these approaches ignore multiple factors that impact project selection, and do not provide a useful transformative formula to combine all relevant criteria into a single decision-making model [7].

Therefore, multiple-criteria scoring methods [8–11] and ranking methods [12] are widely employed to improve project selection in businesses [5,13]. These methods are used to score projects with respect to each of the evaluation objectives. Each objective is assigned a weight, and each project is scored with respect to the objectives. The weighted scores are summed to give a total score. Finally, projects selection is conducted by scores ranking. Buss [12] attempted to provide alternative approach to project selection with the ranking technique. He indicated that projects can be ranked on a cost-benefit basis, followed

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by ranking according to intangible benefits, technical importance, and degree of compatibility with corporate objectives. Henriksen and Traynor [11] proposed an improved scoring tool for R&D project selection. The improved algorithm is based on incorporating tradeoffs among the evaluation criteria, and the project value is measured according to merit and cost. Then, project alternatives are ranked based on the criteria of relevance, risk, reasonableness and return.

Recently, the analytic hierarchy process (AHP) has been employed to guarantee that the assigned weights of each objective are suitable [14]. The design of the hierarchy involves structuring all the problem elements. Then, the elements on the same hierarchical level are compared in pair-wise comparisons with other elements. A relative ranking of priorities of the elements is yielded and aggregated to obtain the final ranking score. The AHP has been applied to solve unstructured problems ranging from simple personal decisions to complex IS project selection problems [3,15,16].

The limitation of scoring methods, ranking methods and AHP methods has a compensatory bias. For example, when one criterion has a low value other criteria may offset it, then a project with a high weighted score might be accepted even if it is inferior regarding one of its objectives. In order to overcome optimization problems, mathematical programming models have been proposed, such as multi-attribute decision-making [8], multi-objective decision-making [17–20], goal programming [21–24], dynamic programming [25,26], quadratic programming [27], and nonlinear programming [4]. These models consider multiple objectives, moreover, some of them also consider resources constraints. Firstly, the candidate projects are characterized by multiple objective functions, which are employed to integrate the multiple objectives into a single objective function. Then, the relative value of each project is calculated from the single objective function. Secondly, optimization process of these models is implemented based on the relative value of each project. Usually, decision makers refrain from such techniques, not only due to complex implementing processes, but also because mathematical programming methods need crisp data to get meaningful results. However, IS project selection takes place under an incomplete, vague (intangible), and uncertain information environment. For instance, some factors like "importance to user" are subjective and difficult to measure. Meanwhile, the linear combination form is used as the mathematical model to approximate the human decision process. This so-called linear model is obviously inadequate, since human subjective evaluation does not always hold linearity [28,29]. Bellman and Zadeh [30] question the assumption in decision theory that imprecision can be equated with randomness. In addition, environmental impact factors, such as project risk, organizational objectives, and degree of user support, are often omitted from direct consideration since they are difficult to measure quantitatively. Even systems that are considered technically sound may run a high risk of failure when the behavioral, political and other organizational concerns are overlooked [31,32]. Qualitative issues are becoming more critical to organization than ever before [33].

Fuzzy logic has been employed in handling inexact and vague information because of its ability to utilize natural language in terms of linguistic variables [34,35]. Many decision-making processes occur in an environment in which the goals, constraints and consequences of possible actions are not precisely known. Due to imprecise and subjective information that often appears in an IS project selection process, as already mentioned, crisp values are inadequate for solving the selection problems. A more realistic approach may be to use linguistic assessments instead of numerical values [30,35–40]. A set scale of linguistic variables can be presented to the decision makers, who can then use it to describe their opinions. Sugeno [41] presented the theory of fuzzy measures and fuzzy integrals as means to express fuzzy systems and further proposed to use his theory in modeling subjective human evaluation process. Hence, subjective human ratings can be better approximated using fuzzy measures than using the additive ones.

In addition, decision making by multiple decision makers is commonplace in most IS project selections. In short, such a project selection is a group multiple-criteria decision-making (GMCDM) problem. In this paper, the vertex method [36] was applied to calculate the distance between two fuzzy numbers. The vertex method is an effective and simple approach to calculate the distance between two trapezoidal fuzzy numbers. After calculating the aggregated fuzzy rating of all the decision makers, a distance value was calculated between the aggregated fuzzy rating and the fuzzy max rating. Then, a ranking index value was defined based on the two distance values to transform the aggregated fuzzy rating into a crisp value. And then, an IS project decision-making method was proposed based on fuzzy integral.

This paper is structured as follows: Section 2 introduces the basic definitions and notations of the fuzzy number, fuzzy measure and fuzzy integral. In Section 3, a systematic method based on fuzzy integral is presented to solve the IS projects selection. In Section 4, the proposed method is illustrated with an example. Finally, some conclusions are stated at the end of the paper.

2. Basic definitions and notations

A fuzzy set $\widetilde{A}$ in a universe of discourse X is characterized by a membership function $\mu_{\widetilde{A}}(x)$, which associates with each element x in X a real number in the interval [0,1]. The function value $\mu_{\widetilde{A}}(x)$ is termed the grade of membership of x in $\widetilde{A}$ [42]. A fuzzy number is a fuzzy subset in the universe of discourse X that is both convex and normal [43].

Definition 2.1. A positive trapezoidal fuzzy number (PTFN) $\tilde{n}$ can be defined as (n_1, n_2, n_3, n_4), shown in Fig. 1. The membership function, $\mu_{\tilde{n}}(x)$, is defined as [44]