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A fuzzy AHP application in government-sponsored R&D project selection☆

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Abstract

Due to the funding scale and complexity of technology, the selection of government sponsored technology development projects can be viewed as a multiple-attribute decision that is normally made by a review committee with experts from academia, industry, and the government. In this paper, we present a fuzzy analytic hierarchy process method and utilize crisp judgment matrix to evaluate subjective expert judgments made by the technical committee of the Industrial Technology Development Program in Taiwan. Our results indicate that the scientific and technological merit is the most important evaluation criterion considered in overall technical committees. We demonstrate how the relative importance of the evaluation criteria changes under various risk environments via simulation.

Keywords: Fuzzy analytic hierarchy process; Government sponsored R&D projects; Crisp judgment matrix; Simulation

1. Introduction

Technology is viewed as one of the major factors determining the competitiveness of an industry. Private firms may not pursue technology research and development (R&D) projects because: (1) R&D scientific and technical frontiers are risky and the chances of failure are high. (2) An individual firm may not have the capabilities required to develop the technology. And (3) private incentives may not be sufficient to induce a firm to undertake the project in the face of difficulties in appropriating the resulting benefits [1]. In many countries, government-sponsored R&D programs prove to be a useful strategy to encourage private firms to undertake R&D projects [2]. For example, the American government initiated the Advanced Technology Program (ATP) in 1990 to encourage industry to develop technology projects. ATP has approved 134 R&D projects and totally funds committed US$331 million between 2002 and 2004 [3]. Korea, Japan, China, and many other organization for economic cooperation and development (OECD) countries have all launched advanced technology programs to encourage private firms to develop core technologies and to secure cutting-edge technologies.

Taiwan launched similar government-sponsored technology development programs (TDP) in 1979, such as the Industrial Technology Development Program (ITDP), the Small Business Innovation Program

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(SBIR), etc. The research budget of the TDP has steadily increased [4]. For example, TDP's actual expenditure increased from NT$15.17 billion to NT$18.22 billion from 2001 to 2004. Also manpower devoted to the corporation increased from 5561.2 person/year in 1999 to 6644.9 person/year in 2003. The TDP produced 797 patents, 450 patent applications, 1061 technology transfers, 2190 technical papers, 622 subcontracted research projects, and 1595 contracts and industrial services in 2003 [5]. With respect to the benefits of R&D, the TDP also produced 618 enterprise investments [5].

As governments strive to become more efficient and reduce the costs of services in order to remain competitive, the choice of government-sponsored TDP projects has become increasingly important [6]. Due to the funding scale and complexity of technology, the selection of TDP projects can be viewed as a multiple-attribute decision that is normally made by a review committee with experts from academia, industry, and the government. However, these experts, who have a diversity of knowledge, often enter the group with different assumptions, viewpoints, and interpretations of the issues involved and often select proposed TDP projects based on evaluation criteria that are not clearly defined. Therefore, review committees tend to select projects with consensus. An effective mechanism to resolve this kind of cognitive conflict is necessary.

Many published studies on R&D portfolio selection have developed a wide variety of models related to experts' judgments [7–9]. Perrone [10] used the fuzzy multiple criteria decision model (fuzzy MCDM) to evaluate advanced manufacturing systems. Coffin and Taylor [11] first presented multiple criteria R&D project selection using fuzzy logic, then a few pioneering studies, e.g., Chan et al. [12] and Hsu et al. [6], formulated their theoretical frameworks based on fuzzy multiple criteria method[1] to analyze technology project selection. In this paper we integrate previous research findings and use a theoretical approach, which is based on a fuzzy version of analytic hierarchy process (fuzzy AHP) to help in government-sponsored R&D project selections.

Unlike R&D project selection in private firms, the selection process of government-sponsored R&D projects is less discussed [6]. Wang et al. [13] indicated that evaluation criteria at national level R&D project selection is difficult to find. Zhang et al. [14] also indicated that establishing a proper evaluation system of criteria is the basis for technology R&D projects. However, Bilalis et al. [15] indicated that certain objective goals and criteria are difficult to measure with distinct values in project selection. It is crucial to establish a proper system to identify criteria and find the relative importance of criteria for selecting government-sponsored R&D projects. As Henriksen and Traynor [16] noted, the purpose of weighting is not only to emphasize the most appropriate criteria, but also to facilitate self-selection of the optimal R&D portfolio. Thus, different from Hsu et al.'s approach, which employs a fuzzy number for scoring technology alternatives, we use fuzzy numbers to score judgments of evaluation criteria.

Computational steps of fuzzy AHP need to formulate a judgment matrix. Some studies [17,23,19] employed α-cuts and convex combinations to form a crisp judgment matrix and others [20,21,6] employed α-cuts to create a fuzzy judgment matrix. Unlike previous studies in government-sponsored R&D project selections [6,13], we use a crisp judgment matrix, incorporated with the index of optimism, to deal with criteria weighting and simulate important changes of criteria under various decision risks.

In order to put later discussions in perspective, we first offer a brief description of ITDP project selection in Taiwan. This includes challenges to R&D project selection decisions. We discuss a fuzzy AHP approach, which includes a group decision-making method to develop a hierarchical structure for ITDP project selection, in-depth interviews of the ITDP review committees to obtain their evaluating criteria, and a triangular fuzzy number for scoring these experts' judgments. We further detail the fuzzy AHP findings about the managerial perceptions by simulating the risk attitude of these committees. We then outline the policy implications of our findings, followed by conclusions.

2. ITDP project selection in Taiwan: a background

The ITDP, the emphasis of our research, is one of the major technology development programs in Taiwan. The aim of the ITDP is to encourage industries to take part in key innovative technologies and applied research. The ITDP supports industrial R&D projects in four main areas: telecommunication and electronics, mechanical engineering and aeronautics, materials and chemical engineering, and biotechnology and pharmaceuticals. According to official data, 588 applications have been filed and 259 (44%) of them have been approved since 1999. Table 1 shows ITDP investment from 1999 to 2004. Among the 259 sponsored projects, material and chemical engineering-based projects (38%) and machinery and aerospace-based projects (38%)

[1] There was considerable empirical support for fuzzy multiple criteria methods, and researchers have suggested various ways to broaden their applicability [17,20–24].