Journal of Scientific & Industrial Research
Vol. 75, August 2016, pp. 463-465

Evaluating the Commercial Potential of Original Technologies in Universities

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Received 20 July 2012; revised 24 August 2013; accepted 10 November 2014

Since 2010, Ministry of Science and Technology (MOST) and Academia Sinica in Taiwan have formulated the Germination Program to translate important scientific discoveries into innovative developments. Using actual cases, this study aimed to propose a technology evaluation framework consisting of a hybrid fuzzy multi-criteria decision making (fuzzy MCDM) approach to evaluate and prioritize the optimal alternatives with best commercial potential. The fuzzy Delphi method was first used to determine the three dimensions and nine important decision criteria. Next, the fuzzy analytic hierarchy process (fuzzy AHP) results indicated that the top three dimensions are accordingly ñtechnological innovationò, ñbusiness developmentò and ñoperating managementò. The top three important criteria are ñtechnological originsò, ñpotential impactò and ñtechnological competenceò respectively. Finally, the fuzzy technique for order preference by similarity to ideal solution (fuzzy TOPSIS) results revealed that T2 and T4 are the two optimal alternatives with best commercial potential for further funding and commercialization. The proposed technology evaluation framework could serve as a reference to both government administrative agencies and university practitioners for the future evaluation of commercializing original technologies.

Keywords: Original technology, Commercial potential, Technology evaluation, Fuzzy MCDM.

Introduction

In recent decades, universities worldwide have long been at the forefront of developing early-stage technologies that have a significant impact on society[1]. Since the mid-2000s, universities in Taiwan have also sought to commercialize these scientific discoveries that benefit society at large[2]. Both Ministry of Science and Technology (MOST) and Academia Sinica in Taiwan have actively established a mechanism to translate important scientific discoveries into innovative developments[3]. These scientific discoveries were defined as ñoriginal technologiesò that is waiting to be further evaluated for commercialization. This study aimed to propose a technology evaluation framework as shown in Fig. 1 consisting of a hybrid fuzzy multi-criteria decision making (fuzzy MCDM) approach toward a more effective evaluation on these original technologies.

The Origination of Germination Program in Taiwan

A project titled ñForesight Taiwanò was led by academician Dr. Eugene Wong and funded by the National Science Council (NSC, a former body of MOST) from 2007ï 2010 as part of an effort to offer solid guidance for Taiwanôs economic future and catalyze the development of new innovative industries[3]. Foresight Taiwan project was divided into a small internal part and a larger external part. The funding of the external project, referred to as the Germination Program, comes directly from NSC[4]. The Germination Program began with scientific discoveries that were defined as ñoriginal technologiesò. To carry out the mission of Germination Program, Germination Function Units among universities were thus established. The goal of Germination Function Units is to prospect and evaluate original technologies that originated in Taiwanôs universities, and to develop them to a point where they can be launched as businesses with conventional funding.

The Evaluation of Commercial Potential of Original Technologies

With the rapid development of science and technology, original technologies have sprung up in our society. Therefore, it is extremely important for both government administrative agencies and universities to identify and evaluate their commercial potential when facing stagnating economic growth today. Belina *et al.*[5] described that it is important to

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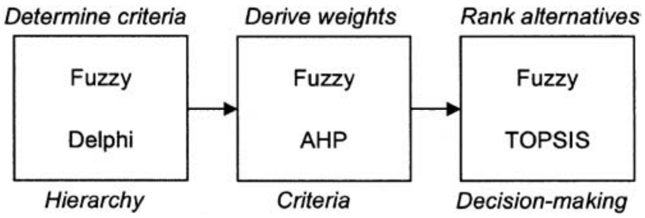

Fig.1ð The proposed technology evaluation framework

Table 1ð An example of original technologies

Code	Original technologies
T1	Electrically tunable focusing liquid crystal lenses
T2	Wireless electroencephalography (EEG) health care system
T3	Disposable breath sensor for liver disease monitoring
T4	Silicon quantum dot (SiQD) bio-probes for bio-imaging

Table 2ð The priority weights and ranks of dimensions and criteria

Dimensions	Weights	Ranks	Criteria	Local weights	Global weights	Global ranks
Technological innovation	0.425	1	Technological origins	0.387	0.164	1
			Technological competence	0.342	0.145	3
			Patent portfolio	0.271	0.115	4
Business development	0.364	2	Seamless pipelines	0.312	0.114	5
			Validity of business model	0.275	0.100	6
			Potential impact	0.413	0.150	2
Operating Management	0.211	3	Operating team	0.257	0.054	9
			Value proposition	0.454	0.096	7
			Logistics management	0.289	0.061	8

identify the commercial potential of original technologies despite the theory studied or the activity practiced. Wu *et al*.[6] described that the evaluation of commercial potential of original technologies is the study of the ñfuture stateò of themselves. Fiske[7] also described that scientists often conduct research to advance innovations, but most are still unsure of how to recognize the commercial potential of their discoveries.

One important thing is that identifying the commercial potential of original technologies in universities is a fuzzy MCDM process that involves early-stage technology evaluation and project prioritization. Therefore, using real examples, this research reveals how we applied and demonstrated our proposed methodologies to the evaluation and prioritization of original technologies with commercial potential in academic settings.

The hybrid fuzzy MCDM approach

The proposed technology evaluation framework as shown in Fig. 1 consists of a hybrid fuzzy MCDM approach that is composed of three methods including the fuzzy Delphi method, the fuzzy analytic hierarchy process (fuzzy AHP) method, and the fuzzy technique for order preference by similarity to ideal solution (fuzzy TOPSIS) method. The fuzzy Delphi method is a useful technique for aggregating expertsô opinions and reducing the uncertainty and ambiguity that exists in their judgments[8,9]. Hence, this study used fuzzy Delphi method to screen the important decision criteria. Next, the fuzzy AHP method can convert the opinions of experts from previous crisp values to fuzzy numbers and membership functions, so as to solve hierarchical fuzzy problems[10-12]. The fuzzy AHP method was therefore applied to determining the weights of criteria. Finally, this study deployed the fuzzy TOPSIS method to prioritize the alternatives. The logic of fuzzy TOPSIS is to calculate the distance of each alternative from both the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS), and then to obtain the closeness coefficients for achieving aspiration levels[13,14].

Empirical Analysis of Germination Program

Using real examples as shown in Table 1, this research demonstrated how we applied the proposed technology evaluation framework to the evaluation and prioritization of original technologies with commercial potential in universities.

Step 1: Determine the Important Criteria and Dimensions

This study first used fuzzy Delphi method to screen out nine important criteria from 15 ones, and then put them into three dimensions through expert interviews.

Step 2: Derive the Weights of Dimensions and Criteria

A typical AHP questionnaire for realizing 16 expertsô perceptions was designed in the form of pair wise comparisons. The crisp values sourced from the evaluation of relative importance between dimensions and criteria in pairs were converted to fuzzy numbers. The fuzzy judgment matrices for dimensions and criteria were then generated. The final priority weights of dimensions and criteria were calculated through fuzzy AHP method, and summarized in Table 2.

Table 3ð The closeness coefficients for the four alternatives

	$\tilde{d}_i^-$	$\tilde{d}_i^+$	Satisfaction degree of $\tilde{CC}_i^-$	Gap degree of $\tilde{CC}_i^+$	Rank
T1	0.498	0.381	0.567	0.433	3
T2	0.624	0.258	0.707	0.293	1
T3	0.289	0.601	0.325	0.675	4
T4	0.573	0.312	0.648	0.352	2

Step 3: Rate the Alternatives

16 experts were requested to express their perceptions about the rating of every original technology regarding each criterion in linguistic variables. Next, we used the approach of average value to integrate the fuzzy decision values of 16 experts with respect to each criterion. The weighted fuzzy normalized decision matrix was then established. The distances of each alternative to the FPIS and FNIS reference points were calculated, and the closeness coefficients of the four alternatives were thus obtained as shown in Table 3.

Conclusions

The successful exploration and commercialization of original technologies in universities contributes to sustainable development of the national economy. Therefore, this study aimed to propose a technology evaluation framework consisting of a hybrid fuzzy MCDM approach toward a more effective evaluation on these original technologies. The three dimensions and the nine important decision criteria were first determined by the fuzzy Delphi method. In view of the fuzzy AHP results, ñtechnological innovationò is the most important dimension and its defuzzified value is 0.425, followed by ñbusiness developmentò and ñoperating managementò. The top three important criteria are ñtechnological originsò, ñpotential impactò and ñtechnological competenceò respectively. Finally, the fuzzy TOPSIS results revealed that the satisfaction degree values of T1, T2, T3 and T4 are 0.567, 0.707, 0.325 and 0.648 respectively. Therefore, we considered that T2 and T4 are the two optimal alternatives with best commercial potential for further funding and commercialization. The proposed technology evaluation framework was designed to provide researchers with a fuzzy point of view to traditional evaluation model for dealing with imprecision. The hybrid fuzzy MCDM approach within this framework could further enable decision makers to better understand the complete evaluation process. Furthermore, this framework could serve as a reference for the future evaluation of commercializing original technologies in universities. It was suggested for future works to consider how different technological, economic, social, and environmental factors lead to corresponding commercialization success.

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