The Key Success Factors of Small Business Innovation and Research of Taiwan Automotive Electronics Industry

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***Abstract*—In recent years, Taiwan government provides incentive program, 50 million US Dollars annually, to encourage the risky and costly innovation and new technology development activities in small business. The key success factors of this SBIR program are the main issues in this research. They are investigated by Delphi method and Analytic Hierarchy Process (AHP). The important factors related to the successfulness of SBIR program were investigated by literature research in order to compile an expert questionnaire in Delphi method and AHP. The questionnaire is composed of four dimensions and sixteen factors of research and innovation. The questionnaire was distributed to R&D managers of the SBIR grant recipient companies. Through AHP survey, it is confirmed that the government supports and cooperation with academia is the most important key factor.**

***Index Terms*—Small and medium-sized enterprises (SMEs), Small Business Innovation Research (SBIR), Key Success Factors, Automotive Electronics, Delphi Method, Analytic Hierarchy Process (AHP).**

I. Introduction

Small and medium-sized enterprise (SME) covers a wide range of definitions and measures, varying from country to country and between the sources reporting SME statistics. Some of the commonly used criteria are the number of employees, total net assets, and sales and investment level. However, the most common definitional basis used is employment, and here again, there is variation in defining the upper and lower size limits of an SME. Despite this variance, a large number of sources define an SME to have a cut-off range of 0 - 250 employees [1].

Over the decades, governments around the world started to focus their research funding on small and medium businesses, recognizing the importance of these businesses in modern economies. For one thing, SMEs are an important driving force for innovation and they can be as innovative as larger enterprises [2]. In addition, for most countries, SMEs occupy the great majority of all economic business activities around the world. Taking Taiwan as an example, there were total of 1.23 million SMEs, or 97.68% of all enterprises, by the end of 2009 [3]. Other developed countries offer similar profiles. U.S. federal government created Small Business Innovation Research (SBIR), administered by the Small Business Administration (SBA), to provide funding to generate innovative hi-technology small firms and enhance U.S. competitiveness [2]. In the matter of how companies value this program or how critical is the support of the program toward the success of this small business innovation and research is the major purpose of this study. The automotive electronics industry is chosen for its infancy stage in Taiwan as compare to other electronics sector. This would be able to reveal the true value of program funding toward innovating small firms.

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II. SBIR in Taiwan

Small Business Innovation Research (SBIR) of Taiwan started in February, 1999 in Taiwan. The goal of this project is to drive and promote the innovation and research activities of small and medium enterprises in Taiwan economic development. As of 2008, the SMEA of Taiwan has passed research funding to over 2779 innovation research projects and an accumulation of 54.56 billion Taiwan dollars [3].

A. Qualification Requirement of SBIR

Firms established under company law and conform to the following are qualified to apply for the SBIR project:

- Paid-in capital $\leqq$ 80 million NT dollars
- Number of employees $\leqq$ 200
- No record of overdue tax payments
- No record of cancellation in participated governmental technological projects in the past 5 years

B. Types of SBIR Projects

The SBIR project is divided into 2 categories: Innovation Technology and Innovation Service. Several types of innovation and research activities are encouraged by the program including:

- Developing a brand new idea, concept or new technology
- Applying an existing technology to a new application
- Applying a new technology or business model to an existing application
- Improving an existing technology or product upon various aspects.

III. Literature Review

The research into entrepreneurship and the small and medium enterprise draw large amount of research activities since 1990s [4]. The issues of competitiveness and government supports for SMEs are the central theme [5], [6].

IV. Methodology

The main objective of this study the key success factors in SME R&D, especially in automotive electronics industry. This is not explicitly available in literature. Expert opinion

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will help establish the basis of the first systematic framework for decision making on R&D or innovation program of automotive electronics. This study will also help to validate the assumptions made on the availability of data, and contribute to the development of a framework that will assist engineers and managers in decision making on R&D or innovation program of automotive electronics. The Delphi technique is used to establish the validity and acceptability of the assumptions.

A. Delphi Method

This study utilized the Delphi method to achieve the consensus among experts on the R&D issues. Delphi method is a combination of quantitative and qualitative research methods of technology integration [7]. Delphi method collects opinion from a group of experts to obtain the most reliable consensus through a series of questionnaires. The facilitator invite a group of related experts and research scholars, on condition of anonymity in each other, to several individual questionnaires for each survey will be followed up the questionnaire results with the new study points to give experts and scholars, after repeated implementation, until the difference between the views of experts and scholars to minimize so far. Twenty experts are invited to participate in our Delphi study. The Standard deviation results of the second round reach convergence. Therefore, the Delphi study adopts the questionnaires of the two rounds.

B. The Analytic Hierarchy Process (AHP)

The AHP can be used to stimulate ideas for creative courses of action and to evaluate their effectiveness [8]. It helps leaders determine what information is worth acquiring to evaluate the impact of the participants' judgments and preferences, thereby enabling leaders to assess the quality of their assistants' knowledge and the stability of the solution. Here is what one can expect to gain by using it:

1) A practical way to deal quantitatively with different kinds of functional relations in a complex network.
2) A powerful tool for integrating forward (projected) and backward (desired) planning in an interactive manner that reflects the judgments of all relevant managerial personnel. The output of this process is explicit rules for allocating resources among current and new strategy offerings — or to satisfy a specific set of corporate objectives — or under alternative environmental scenarios.
3) A new way to:

- Integrate hard data with subjective judgments about intangible factors.
- Incorporate judgments of several people and resolve conflicts among them.
- Perform sensitivity analysis and revision at low cost.
- Use marginal as well as average priorities to guide allocation.
- Enhance the capacity of management to make tradeoffs explicitly.

4) A technique complementing other ones (benefit/cost, priority, risk minimization) for selecting projects or activities.
5) A single replacement for a variety of schemes for projecting the future and protecting against risk and uncertainty.
6) A vehicle for monitoring and guiding organizational performance toward a dynamic set of goals [8].

A decision-making approach should have the following characteristics:

- be simple in construct,
- be adaptable to both groups and individuals,
- be natural to our intuition and general thinking,
- encourage compromise and consensus building, and
- Not require inordinate specialization to master and communicate.

Briefly, decision making as a process that involves the following steps:

- Structure a problem with a model that shows the problem's key elements and their relationships.
- Elicit judgments that reflect knowledge, feelings, or emotions.
- Represent those judgments with meaningful numbers.
- Use these numbers to calculate the priorities of the elements of the hierarchy.
- Synthesize these results to determine an overall outcome.
- Analyze sensitivity to changes in judgment [9].

V. Empirical Case Study

With the continuously increasing utilization of electronic equipments to improve the performance and compliance of environment and other regulations, the automotive electron has become newly developed market of the electronic industry beyond 3C (Computer, Communication, and Consumer Electronics) in recently years. Managers in charge of R&D division in SBIR program participating companies, which involved in automotive electronics, are invited as experts of this study. The Delphi method was utilized first to investigate the key success factors in SBIR program of automotive industry. These factors were then used as the key attributes in AHP study to explore the some of the most critical factors.

A. Delphi Survey

The result of the first round survey is shown in Table I. After reassemble the result from first round survey, the second round survey was issued to the same group of experts. The result of second round reached the converge criterion [7], as shown in Table II. The 16 key success factors from the survey are:

1) Average firm size
2) Type of opportunities and the relationship to type of innovation
3) Globalization of the automotive industry supply and demand-driven factors
4) Government promote the SBIR
5) Industrial innovation act legislation
6) Political and regulatory-industry-academia, government cooperation program
7) Capital intensity
8) Advertising intensity
9) Development of product features
10) Resource management
11) Predictive produce capacity
12) Knowledge acquisition

13) Knowledge innovation
14) Knowledge protection
15) Knowledge share and integration
16) Diffusion of knowledge

Although the priority of these factors may be reveal from the average of the Delphi survey, the real importance may be different if we as the questions in different way. Therefore, AHP survey was conducted after these important factors been decided by Delphi survey.

TABLE I: DESCRIPTIVE STATISTICS (DELPHI –FIRST ROUND)

Key success factors	Sample size	Minimum	Maximum	Average	Standard deviation
Industry Structure-Average firm size	20	3	4	3.60	.503
Industry Structure-Type of opportunities and the relationship to type of innovation	20	3	5	4.35	.671
Industry Structure-Globalization of the automotive industry supply and demand-driven factors	20	3	5	4.30	.865
Political and Regulatory-Government to promote the SBIR	20	3	5	4.40	.598
Political and Regulatory-Industrial innovation Act legislation	20	3	5	3.80	.523
Political and Regulatory-Industry-Academia, government cooperation program	20	3	5	3.65	.671
Industry/Product life cycles-Capital intensity	20	3	5	4.50	.607
Industry/Product life cycles-Advertising intensity	20	3	5	4.25	.639
Industry/Product life cycles-Development of product features	20	3	5	4.50	.607
Industry/Product life cycles-Resource management	20	4	5	4.80	.410
Industry/Product life cycles-Predictive power capacity	20	2	5	4.00	.858
Knowledge Conditions-Knowledge acquisition	20	4	5	4.55	.510
Knowledge Conditions-Knowledge innovation	20	3	5	4.50	.607
Knowledge Conditions-Knowledge protection	20	3	5	3.90	.553
Knowledge Conditions-Knowledge sharing and integration	20	3	5	4.55	.605
Knowledge Conditions-Diffusion of knowledge	20	4	5	4.50	.513

TABLE II: DESCRIPTIVE STATISTICS (DELPHI –SECOND ROUND)

Key success factors	Sample size	Minimum	Maximum	Average	Standard deviation
Industry Structure-Average firm size	20	3	4	3.80	.410
Industry Structure-Type of opportunities and the relationship to type of innovation	20	3	5	4.55	.605
Industry Structure-Globalization of the automotive industry supply and demand-driven factors	20	3	5	4.55	.605
Political and Regulatory-Government to promote the SBIR	20	3	5	4.40	.598
Political and Regulatory-Industrial innovation Act legislation	20	3	5	4.20	.523
Political and Regulatory-Industry-Academia, government cooperation program	20	3	5	4.00	.562
Industry/Product life cycles-Capital intensity	20	3	5	4.50	.607
Industry/Product life cycles-Advertising intensity	20	3	5	4.40	.598
Industry/Product life cycles-Development of product features	20	3	5	4.55	.605
Industry/Product life cycles-Resource management	20	4	5	4.80	.410
Industry/Product life cycles-Predictive power capacity	20	3	5	4.20	.616
Knowledge Conditions-Knowledge acquisition	20	4	5	4.60	.503
Knowledge Conditions-Knowledge innovation	20	3	5	4.55	.605
Knowledge Conditions-Knowledge protection	20	3	5	4.10	.553
Knowledge Conditions-Knowledge share and integration	20	3	5	4.60	.598
Knowledge Conditions-Diffusion of knowledge	20	4	5	4.55	.510

TABLE III: AHP WEIGHT ANALYSIS

Dimensions	Ratio	R&D key success factors	Ratio
Industry Structure	21%	Average firm size	16.90%
		Type of opportunities and the relationship to type of innovation	38.70%
		Globalization of the automotive industry supply and demand-driven factors	44.30%
Political and regulatory	24.6%	Government promote the SBIR	25%
		Industrial innovation Act legislation	25%
		Political and Regulatory-Industry-Academia, government cooperation program	50%
Industry/Product life cycles	24.6%	Capital intensity	14.10%
		Advertising intensity	19.70%
		Development of product features	10.70%
		Resource management	34%
		Predictive produce capacity	21.60%
Knowledge conditions	29.8%	Knowledge acquisition	16.90%
		Knowledge innovation	25.70%
		Knowledge protection	24.60%
		Knowledge share and integration	22.20%
		Diffusion of knowledge	10.70%

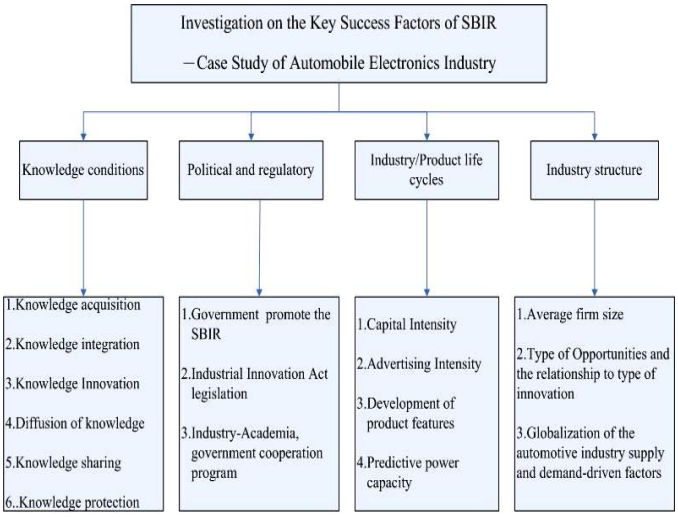

Fig. 1. Construction of key success factors index dimensions.

B. AHP Survey

The 16 key success factors from Delphi survey were categorized into 4 dimensions. The importance of these 4 dimensions were pair-wise compared first. These the factors within these dimensions were also pair-wise compared. The computed result are shown in Table III. From the AHP result, the knowledge condition is the most important among these 4 dimension. This can be understood by the fact that innovation and research are knowledge intensive. Among the key success factors, knowledge innovation is the most important factor in the knowledge condition. Other important factors among rest of the dimensions are resource management, political and regulatory-industry-academia, government cooperation program, globalization of the automotive industry supply and demand-driven factors.

VI. Concluding Remarks

In this paper, we sought to explore the level of complementarities between the firm's technological competences, derived from in-house R&D activities, and the technological opportunities available from cooperation with external agents, to develop new products. The results show that the higher the firm's technological competences, the higher the level of cooperation with scientific agents. This result supports the idea that in-house R&D activities not only generate new knowledge, but also promote the use of external sources of scientific knowledge. Nevertheless, when we analyzed the joint effect that such factors exercise on the firm's innovation output, rather than being complementary, they function as substitutes. This unexpected result leads us to an important conclusion. In the case of automotive electronics firms, cooperation with scientific agents does not constitute a key factor to develop new products, especially when firms put a lot of effort into developing in-house R&D activities.

The research method of this study is based on arranging the related literature that explored the key success factors of research and innovation of small and medium enterprises. With the use of Delphi Method, expert questionnaire was designed with the hierarchy framework for key success factors. This framework is composed of four dimensions and sixteen factors of research and innovation.

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