Expanded Perspective on the Biotech Industry: Qualitative Research for Assisting in Establishing Sustainable Competitive Advantages

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ABSTRACT

The biotechnology industry currently is developing rapidly and expanding into multitudinous fields. Consequently, this investigation examines the case of the Taiwanese biotechnology industry to understand how different strategies can be applied by industries to create competitive advantage. This study performs the value chain construct (Porter, 1985) to devise concept indicators, and implements the Fuzzy Delphi Method expert questionnaire (FDM) for drafting strategic hierarchy structure. Next, this study uses the Fuzzy Analytic Hierarchy Process (FAHP) to derive “the key success factors for biotechnology industry competition advantages in Taiwan”. Finally, this study treats the most important and critical development strategy of the biotechnology industry in Taiwan based on the research results.

Key Words: Biotechnology Industry; Competitive Advantage; Strategy; Key Success Factors

RESEARCH MOTIVATION

Porter (1990) once observed that national economic success derives not from individual industries, but rather from the combined influences of numerous industries. Therefore, ‘industry’ rather than ‘country’ may be the best basic unit for analyzing national competitive advantage. To maximize benefits from international specialization and regional competitiveness, particularly for developed countries, the industry structure adjusting vigorously in their countries under the new world industry.

The “biotechnology industry” developed out of the life sciences. The global research and development direction of the life sciences will significantly impact the humanity in the future. Furthermore, following the decoding of the human genome, life sciences will become the most significant technology industry of the 21\textsuperscript{st} century with all nations striving to include it in their information technology development. It will have astonishing growth in this century. Regarding the Taiwanese biotechnology industry, it not only ranks among “top ten emerging industries” promoted by the government, but is also the key industry in developing Taiwan into an Asia-Pacific Regional Operations Center.

Aaker (1984) once pointed out that a business can only establish sustainable competitive advantage by mastering key success factors in its industry. The development of the biotechnology industry as a star industry in Taiwan results from the current economic power, the intention to promote or develop the knowledge economy and the biotechnology industry. Furthermore, the biotechnology industry has attracted heavy investment from government, academia, and researchers. Nevertheless, the biotechnology industry how to plan, how to promote and develop, and how to harness the relationship between the government and the people to build a successful cluster effect is important absolutely? These issues, as well as their future development, deserve consideration and deserve careful consideration.

The technology of the Taiwanese biotechnology industry is currently developing rapidly. Biotechnology itself has an extremely high degree of “inter-disciplinary integration” and “scientific linkage”. Therefore, how industry uses different strategies to create advantageous conditions for business success is an important area for directing future efforts in the biotechnology industry. Numerous scholars and experts have also proposed various suggestions regarding the development direction for the biotechnology industry. This study thus takes the Taiwan biotechnology industry as an example, and adopts the concept of value chain proposed by Porter (1985) to analyze the key success factors that may influence the competitive advantage of the biotechnology industry,
and further examine the development strategies corresponding to the various key success factors to provide a reference for industry groups, government departments, and other relevant institutions in decision-making.

LITERATURE REVIEW

This investigation uses the literature on biotechnology, competitive advantage, value chain and key success factors (KSFs) to understand the research motivation and analytical methods, as follows:

**Biotechnology**

This norm has frequently been used to label a broad range of technologies and commercial activities. In fact, various opinions exist regarding the exact definition of biotechnology, and as yet there is no conclusion. This situation applies even in technologically advanced western countries, such as those in Europe, and the United States. However, a review of the related literature reveals that biotechnology is broadly defined as referring to the application of the basic life sciences, including recombinant DNA, cell integration and culture, fermentation engineering, enzyme transformation, and so on, for research and development, or manufacturing and production, with the aim of improving human life.

**Key Success Factors and Develop Strategy in Biotechnology Industry**

Owing to investment in the biotechnology industry being extremely high risk and resource intensive, this industry requires long-term and stable financial support and the integration of cross-domain knowledge (Robert & Mizouchi, 1989). Small and newly formed biotechnology firms may require on marketing function supporting promoting their products successfully. The key success factors in the biotechnology industry can be divided into two types internal and external. Internal factors include human resources, production strategy, industry cluster; external factors include cluster effect, infrastructure, and national policy (Arojarvi, 2001). On the other hand, success factors in biotechnology medical industry include production quality, staff competition, risk management ability in new medicine development, product commercialization ability and takeover planning ability.

Löffler (2002) indicated that the structure of the pharmaceutical industry has transformed vertical integration into horizontal integration and its business model will completely control its customers in future. Those phenomenons will transfer medicine production which concentrated on mass population into mass medicine production into personalized medical treatment; customers will then be able to transfer their attitudes regarding seeking hospital treatment when got sick to health protection in advance. Furthermore, Sun et al, (2005) employed the fuzzy multi-criterion decision model (FMCDM) and expert conferences to agglomerate every biotech professional field opinions to create a common consensus. Based on upon development directions for agricultural biotechnology are determined which fit the development goals of Taiwan.

**Competitive advantages and Value chain**

Aaker (1984) proposes that if a business wants to build up its competitive advantages, it needs to build up its sustainable competitive advantages in order to be truly meaningful. These “sustainable competitive advantages” (SCAs) have to possess the following three characteristics: (1) sustainable competitive advantages need to include the key success factors of the industry (2) sustainable competitive advantage is a kind of competitive advantage that clearly differentiates the business from its competitors (3) sustainable competitive advantages need to respond to changes in the environment and competitors’ actions.

Porter (1985) further pointed out that the competitive advantage originating from the value created by the enterprise for the clients, and the basic tool with which the enterprise would diagnose the competitive advantage and seek the improvement was the “value chain model”. The overall value presented by the value chain is composed of various “value activities” and “margin”. The so-called value activities refer to the detailed activities that are conducted on the layers of material and technique by the enterprise, and also the foundation for the enterprise to create valuable products for the clients.

Porter (1985) believed that the content of the value activities distinguished by value chains could be revised in accordance with the industrial characteristics. Therefore, this research tends to introduce the characteristics of the ecotourism industry and develop a value chain suitable for ecotourism on the basis of Porter’s concept of value chain. On the aspects of primary activities, this study constructs the value activities by taking ecotourism as the basis of the final product. These value activities are slightly different from the original ones. The differences lie in how to deliver the products or services directly or indirectly to the clients. (Figure 1)

**Strategy**

Porter (1980) highlighted that the essence of strategy is about adaptation to the competition of environment, and its core topics include industrial analysis, competitor analysis, strategy orientation, etc. Matsuno and Mentzer (2000) believed that the relationship between the market-oriented achievement and company
performance were presented differently under the different strategies. Therefore, to choose a strategy suitable for the company becomes rather important.

**Definitions and Confirmed methods of Key Success Factors**

Daniel (1961) pointed out that most industries contain three to six factors that can determine success. Rockart (1979) feels that any company shall identify these factors if it expects success. These key areas are the key success factors. Boynton and Zmud (1984) point out that key success factors are matters that managers or businesses need to pay special and continuous attention to if they wish to succeed or obtain excellent results. Thompson and Strickland (2002) considered key success factors to be related to the product property, assets, competitiveness, and market benefits, and also to be closely connected to the profitability of the company. In their view, key success factors were the ones that each person engaged in each industry must possess if he wants to obtain a strong competitive power.

This research has used the expert questionnaire survey to integrate the points of view of many scholars, including Hsu (1998) and Chen (2002) who pointed out that when solving the problems about group consensus decision-making. This research has utilized the fuzzy Delphi method and the fuzzy hierarchical analysis to analyze the data and handle the problems on fuzziness resulted from the process of criterion measurement and judgment.

**METHODOLOGY**

**Development and Establishment of a Hierarchy Framework**

This research has applied Porter’s (1985) concept of value chain and established a primary hierarchy framework for “the key success factors of the competitive advantage of the biotechnology industry” through the exploration of preceding literature, and has taken it as the basis for design of a questionnaire by means of the fuzzy Delphi method and as the basis for selection of assessment criteria to facilitate the subsequent empirical study. The framework takes the “key success factors of the competitive advantage of the biotechnology industry” as the final objective, and can be divided into three hierarchies in turn: the main objective, the secondary objective, and 37 assessed items, as shown in Figure 2.

**Questionnaire Design and Survey Objects**

In the first stage of the questionnaire design, the expert questionnaire adopting Fuzzy Delphi method has been designed on the basis of the primary hierarchy framework developed in Figure 2 to evaluate the appropriateness and importance of each measurement dimension and assessment index. The questionnaire is composed of the following three parts: instruction for filling in, content of questionnaire, and basic information. The assessment includes 0~10 grades. The higher the score, the more important it is. In each assessed item on the questionnaire, the acceptable scope and the measurement of the single value of the degree of importance shall be filled in, and the open questions shall be listed after each item. In this way, the experts could fill in the score in the form of an integral value for each strategy factor and index in full accordance with their personal determination, and offer their valuable experiences.

In the second stage of the questionnaire design, the authors use the success factors screened out from the foregoing questionnaire survey to establish a complete hierarchy framework which can then facilitate the design of the questionnaire by means of fuzzy hierarchical analysis. The questionnaire is mainly composed of the two following parts: sequence of importance of assessment criteria and paired comparison of relative importance of assessment criteria. The assessment mode takes 1~9 as the assessment scale, adopt the paired comparison method, and require experts to fill in the questionnaire.
This research takes the expert questionnaires as the foundation for research and analysis. Robbins (1994) once pointed out that the optimal number of experts required by the group decision-making was 5~7. In order to make the dimensions more objective, the research has adopted the purposive sampling method in the first stage. A total of 20 expert questionnaires were distributed and 16 were returned. The survey objects are the relevant administrators from the publicly operated units, relevant practitioners engaged in tourism, persons in relevant organizations or institutions, or professors in universities of relevant fields and so on. In the second stage, it bases on the sampling from the logging 59 factories in public information observation center. The research still used purposive sampling method. Of the 20 expert questionnaires being distributed, 18 were returned. The survey objects are also the relevant administrators as described above.

Figure 2 primary hierarchy frameworks

DATA ANALYSIS

Analysis of Stage One Fuzzy Delphi Questionnaire Survey—Establishment of the Hierarchical Framework Agreed on by the Experts

In this study, by use of the Excel, the threshold value 7.3 is calculated from the above mentioned Fuzzy Delphi Method as the screening standard of assessment criteria. Totally, 14 assessment criteria are deleted and 23 are retained as possible success factors, about 62.2% of total. Based on above screening result, this study
builds the strategic hierarchy framework of possible success factors that influence “ecotourism industry’s competitive advantage”, as detailed in Figure 3, on such a basis “FHAP Expert Questionnaire in the Second Stage” is designed.

Figure 3 strategic hierarchy structures of “KSFs weight analysis of Taiwan’s biotechnology industry”
Source: Sorted out by this research

Analysis of Fuzzy Analytic Hierarchical Process Questionnaire Survey—Selection of Key Success Factors for Improving Competitive Advantage

This research applies the fuzzy analytic hierarchical Process and designs the program by our self, then utilizes EXCEL to analyze the expert questionnaires in stage two. Based on the formula in abovementioned FHAP, this study has analyzed the second stage expert questionnaire. At first, this study uses the triangular fuzzy number to establish the fuzzy positive reciprocal matrix as the basis for calculation of fuzzy weight values and verifies the matrix’s consistency based on definite values specified by experts. The result indicates that C.I. and C.R. values are all $\leq 0.1$, which have met the acceptable deviation scope recommended by Saaty (1980). This means that previous and subsequent judgments of experts at all levels are consistent. Also examined from the overall assessment and analysis, the overall consistency ratio (C.R.H) of the hierarchy framework of “Key Success Factors in Competitive Advantages of Ecotourism Industry” established by our research is 0.044, within the scope of C.R.H<0.1. This indicates that the relevance of inter-levels within the hierarchy framework established by our research is appropriate and that the consistency of entire hierarchy is satisfactory.

Hence, the relevant weight of various assessed elements in their respective levels could be analyzed, called as Local Priority, and then the overall value of priority weight is further calculated to understand the Global Priority of various elements in the entire hierarchy. Finally, the priority values are sorted based on Global Weight calculated to find out assessed elements focused on by experts under the major target of “Key Success Factors in Competitive Advantages of Biotechnology Industry”. The analytical result is as shown in Table 1.
### Table 1  Weight Analysis of Key Success Factors in Biotechnology Industry

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<th>Dimension</th>
<th>Weight</th>
<th>1st level</th>
<th>2nd level</th>
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<th>Importance sequence</th>
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<td><strong>Primary activities</strong></td>
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<td><strong>Manufactured cost controlling</strong></td>
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<td><strong>Promoted marketing capability</strong></td>
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<td><strong>Molded brand imagination capability</strong></td>
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<td><strong>Command trends of market needs</strong></td>
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<td><strong>Product service after-selling capacity</strong></td>
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<td><strong>Customer education capability</strong></td>
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<td><strong>Support activities</strong></td>
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<td><strong>Trained up technology &amp; R&amp;D members’ quality</strong></td>
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<td><strong>Procurement &amp; firm infrastructure</strong></td>
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<td><strong>Acquired factory buildings capability</strong></td>
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Source: Sorted out by this research

The column of importance sequence in Table 1 shows. The first ten evaluation items are five items each for primary and support activities. In the research finding that both the primary and support activities are close to 50%, and so on indicates that although experts feel primary activities are more important than support activities, in practice, to maximize enterprise profit, primary activities and support activities are both necessary to create and sustain competitive advantage.

Regarding to the number of key success factors, this study consults the perspective of Daniel (1961) regarding key success factors in “Management Information Crisis”: Most industries usually have 3 to 6 key factors underpinning their success. In recent years, most scholars studying key success factors have identified set 4 to 6 key success factors. This study thus selects top six factors and lists them in the last column of Table 1, ranked in order of importance, as the “key success factors for improving the competitive advantage of the Taiwanese biotechnology industry”. Finally, the most important factors include “R&D innovation capability in manufacturing processes”, “Quality control capability of manufacturing processes”, “Technological training, and R&D member talent”, “Top management characteristics”, “Product commercialization capability”, and “R&D and innovation capability”. These six key success factors are consistent with the emphasis on R&D and technology innovation, market marketing, professional talents, and respect for product quality of the biotechnology industry.

**Development Strategies for the Taiwanese Biotechnology Industry**

This section draws up specific development strategies for the Taiwanese biotechnology industry where key success factors are based on the research results. This study hopes that these development strategies can facilitate the development of the Taiwanese biotechnology industry.
Development Focused on “Innovative Research and Development” and establishing “Niche Advantages”.

In the era of the knowledge economy, using innovative inventions and intellectual property rights to obtain revenue has become the main focus of development in the emerging global biotechnology industry. The patents and intellectual property rights generated from innovative research and development can not only create new value for the industry, they are also crucial to business competitive advantage and survival. Therefore, although Taiwanese industry was initially focused on manufacturing as the main activity, to secure the future prosperity of Taiwan it is necessary to develop a biotechnology industry focused on innovative research and development. Biotechnology industry research and development is characterized by long product development time and huge capital investment. Consequently, Taiwan should harness its niche advantages in precision manufacturing and engineering applications to rapidly enter the biotechnology value chain.

Select the Promising Areas as Key Development Areas.

Taiwan possesses limited natural resources. Therefore, the development of the biotechnology industry in Taiwan must focus on a few areas of excellence to maximize the chances of success. Examples of such areas include biotechnology medical treatment related to regional diseases in Asia, biomedical technology integrating opt-electronics and information engineering, and scientific application of Chinese herbal medicines.

Use Knowledge Management to Boost Innovativeness.

The government plans to invest 50-60 billion capitals to develop the biotechnology industry over the next five years. The Taiwanese biotech industry hopes to establish over 500 biotechnology companies by 2011. Consequently, to permit the industry flourishes and develops, that the knowledge management concepts must be used for data searching, gathering, and creation, or for organizational restructuring and to create a new organizational culture.

Strengthen Cooperation between Industry and Academia and Create Industry Alliances.

Industry is typically focused on profits, and hence its research goals are highly focused. Meanwhile, academic research and development typically does not much consider risk, and the research scope is broader and deeper. The likelihood of more in-depth research is thus increased. Therefore, if academic research can obtain financial support from industry, the results will have higher added value and will be able to be applied in the market. Consequently, whether in the process of knowledge exchange or the ultimate goal of economic benefits, cooperation between academia and industry is mutually beneficial. Owing to the limited capability of individual enterprises, organizational operators can use cooperative alliances with a product orientation to complement one another.

Nurture Professional and Management Talent in the Biotechnology Industry.

Long-term planning is important in biotechnology industry research. Long-term nurturing is required for talent in many areas, including interdisciplinary talent. Furthermore, talent must be connected with the world to adopt an international outlook. Furthermore, it is necessary to develop an improved environment to attract foreign professional talents to Taiwan to harness their industry experience and solve the problem of talent displacement and shortage in Taiwan.

Otherwise, regardless of whether the biotech industry cooperation between the industry and the academia or bringing in technology or strategic alliance, technology evaluation ability is necessary. Furthermore, every segment of the biotech industry value chain in patent application is extremely important. Professionals with both legal and biotechnology qualifications should be nurtured to handle patent issues. The above concepts are extremely important to linking the Taiwanese biotechnology industry with the rest of the world.

Strengthen the Commercialization Capability of the Product.

Currently, biotechnology manufacturers must learn to package manufactured products into commodities and sell them on the market to develop product functionality and characteristics and maximize product benefits. Following products have become commodities, the next task is to create a brand image, establish a good impression of the product in the minds of customers, understand market and customer demands to increase product added value.

CONCLUSIONS AND SUGGESTIONS

Conclusions

This investigation uses the value chain concept of Porter (1985) to collate preliminary dimensions of possible success factors in the Taiwanese biotechnology industry. These dimensions are used to establish the preliminary hierarchical framework. The stage one fuzzy Delphi expert questionnaire is then designed based on this hierarchical framework based on this hierarchical framework, the stage one fuzzy Delphi expert
questionnaire is designed. Six evaluation factors and 23 evaluation criteria agreed upon by the experts are then selected after completing the indicated calculations.

Based on the possible success factors in the biotechnology industry identified above, six key success factors for improving the competitive advantage of Taiwan’s biotechnology industry are chosen through fuzzy analytical hierarchical process. The most important factors include “R&D innovating capability in manufacturing processes”, “Quality control capability of manufacturing processes”, “Technological training, and R&D member talent”, “Top management characteristics”, “Product commercialization capability”, and “R&D and innovation capability”. These factors are equally divided between primary and supported activities. Clearly, every segment in the value chain, regardless of whether it is a primary or a support activity, is a source of added value and profits and added value and profits biotechnology industry development.

To improve the competitive advantage of the Taiwanese biotechnology industry and its development into an internationally competitive industry, this investigation devises the following specific development policies in response to the key success factors for the Taiwanese biotechnology industry. This study hopes that these development strategies can facilitate the development of the Taiwanese biotechnology industry. These strategies include: 1. Development focused on “innovative research and development” and “niche advantages”, 2. Select of promising areas as key development areas, 3.Use knowledge management to boost innovativeness, 4. Strengthen cooperation between industry and academia and create industry alliances, 5. Nurture professional and management talent in the biotechnology industry and 6. Strengthen the commercialization capability of the product.

Suggestions

The notion of cooperation between industry and academia is not yet prevalent in the Taiwanese biotechnology industry. Enhancing cooperation between industry and academia, and establishing mechanisms for such cooperation, can significantly facilitate the development of the Taiwanese biotechnology industry. Currently, most Taiwanese biotechnology companies are small and medium enterprises. It is difficult for a single one of these small/medium companies to be as strong as a large foreign company. Besides producing synergy, strategic alliances between biotechnology manufacturers can also combine research areas in which each has expertise. Such alliances can produce groundbreaking progress developing of biotechnology products and technologies.

REFERENCE