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Based on Analytic Hierarchy Process to Discuss Key Factors in High-tech Industrial Ecology Development

Kaijun Yu [1], Ruiyi Gong [1], Shanshan Hu [1], Yuzhou Luo [2*]

[1] Library, Shanghai University of Medicine & Health Sciences, Shanghai, CHINA

[2] School of Medical Instruments, Shanghai University of Medicine & Health Sciences, Shanghai, CHINA

[*] Corresponding author: luoyuzhouluo@126.com

Abstract

The excellent performance of high-tech industry in past years maintains the continuous growth of national economy; and, the strong profitability potential attracts the investment of more businesses. The development of high-tech industry has various countries and regions expand the research & development and capital investment so that high-tech industry gradually becomes the head of the industry. Nonetheless, in the era with diverse products, product life cycle is shortened and the expansion of new production lines is accelerated to result in unprecedented opportunities and new challenges for high-tech industry. In addition to the distribution of production capacity and technology development at current stage, the extension of competitiveness to cope with the rapid change in industry is worth considerations. Aiming at supervisors and employees of high-tech industry in Hubei Province, 250 copies of questionnaire are distributed and 211 valid copies are retrieved, with the retrieval rate 84%. The research results show 1. "technological change" as the most emphasized dimension in Hierarchy 2, followed by "capital motivation", "personnel growth", and "business growth" and 2.top five indices, among 14 evaluation indices, as product innovation, cost & exchange rate, knowledge dissemination, industry structure, and experience accumulation. Finally, suggestions are proposed according to the results, expecting to extend the competitiveness of domestic high-tech industrial ecology development and achieve the goal of sustainable management.

Keywords: high-tech industry, environment development, critical factor, industrial ecology

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INTRODUCTION

The increasing emphasis on high-tech industry allows high-growth opportunities and even explosive growth of high-tech companies. The high performance of high-tech industry maintains the growth of national economy, and the strong profitability potential attracts the investment of more businesses. High-tech industry presents excellent performance on revenue growth, profitability, or output value per person. It becomes the fact that high-tech industry would be the mainstream of national industry. In spite of global recession, high-tech industry has moved against the tide and experienced growing sales to become the highlighted and rapidly developing industry. The prospect of development in high-tech industry has various countries and regions expand the research & development and capital investment that high-tech industry gradually becomes the head of industry. Along with the rapid emergence of the Internet as well as the continuous breakthrough and innovation of technology in high-tech industry, the related application markets are constantly developed to drive the excellent performance of high-tech industry. The positive investment of relevant businesses lays good foundation of the development of domestic high-tech industry.

Going through the promotion and development in past years, high-tech industry gradually plays the critical role in the economic system. Nevertheless, the growth rate slows down with the saturation of personal computer related industries. To maintain the industria dynamic and continuous growth, seeking new products and developing new needs are urgent in the entire industry. The approach of digital era rapidly changes industries. From the aspects of broad application and market growth, high-tech industry satisfies human demands and technology development. Products applying technology development are commonly applied to various fields, while more convenient, high-quality, and high-effectiveness technologies are still developed to replace traditional product market and create a larger consumption market. In such an era with diverse products, product life cycle is shortened and the

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expansion of new production lines is accelerated that high-tech industry is facing unprecedented opportunities and new challenges. In addition to the distribution of production capacity and technology development at current stage, the extension of competitiveness to cope with the rapid change in industry is worth considering.

LITERATURE REVIEW

Industrial Ecology

Da et al. (2014) indicated that changes in biological ecosystems was proceeded with different time courses; for many organisms, ecological changes were experienced to the end of life; and, evolution changes required several centuries to be completed. However, such two time courses were integrated in business ecology, as a business, different from biology, could guide the evolution and form major evolution in the life cycle. Liu and Wang (2017) mentioned that, in comparison with species in biological ecosystems, leaders in business ecology presented an important advantage as the ability to look at the whole world and understand the interactive operation in the entire ecology. Sadeghi (2018) explained that it allowed a business changing the characteristics and adapting to the ecology. Moreover, a business could pre-judge the future change of the ecology and make evolution at the time to be ready for future challenges (Fernandez and Pallis 2014).

Zhou et al. (2017) mentioned that "industrial ecology" was used for observing the interactive relationship among businesses and between businesses and environment as well as exploring the development track. Taddeo et al. (2017) regarded the observation of industrial ecology as a science, while it was "social science". When comparing the development of such social science with the development of engineering science, social science was still at the stage of observation and experience accumulation. Nonetheless, Aab et al. (2014) stated that the impact of science and engineering technology accelerated the cycle of industry changes. The observable phenomena and experience accumulation were therefore increased. Some "theorems" to affect business management and economic development started to manifest, e.g. displays in electro-optical industry. After several computer generations, from original CRT monitors to LCD monitors, the industrial ecology was still rapidly changing and advancing. Liu et al. (2014) pointed out industrial ecology as the state of an industry presenting upstream/downstream correlated businesses and environment for the survival; and, along with changes of people, time, affairs, objects, and locations, the points of industrial ecology and business development would be the pursuit of high value added. A complete value added chain was necessary in industrial ecology, and a business should specialize in at least an item, but not all.

Content of Industrial Ecology Development

In the observation of Hwang et al. (2016), businesses, people, technology, and capitals were four major motives to induce growth.

(1) **Business growth:** Business growth could be the source of ecology changes. In the growth motive of high-tech industrial ecology, the growth and the change of growth cycle of a business would be discussed.

(2) **Personnel growth:** People organize a business to become a part of the organizational structure, but it is difficult to see the growth and change of people from the organizational structure. However, to view people's growth from the viewpoint of ecology, it does not simply release the constraint on thinking, but helps people deeply understand business changes (Kim and Ko 2014).

(3) **Technological change:** Technological change is the major motive to affect high-tech industrial ecology. The emergence of a new technology or application would mess up the originally orderly management as well as have the leading company lose the competitive status or reorganize the technology to lead the market.

(4) **Capital motivation:** Capitals are the motive and resources for high-tech businesses, as the industry would be motivated with capitals. Although it is borderless, it is a limited resource that a business has to face the competition of such a resource (Huang and Lin 2014).

Hu et al. (2017) regarded industrial ecology development as the movement caused by some forces to result in evolutionary incentive or pressure, which could be called "evolutionary process". Although there were different evolution directions and speed among industries, any industries had the predictable dynamic process. The evolution process or dynamic of such ecological development are described as below.

(1) **Growth change:** The long-term change in industry growth rate is the common motive of the structure change. Industry growth becomes a

major variable to decide the resistance strength in the industry as well as the consideration of a business maintaining the market share and expanding the output capacity. Long-term change in industry growth therefore would affect the supply-demand balance and might attract new entrants (Kim and Mauborgne 2015)

(2) **Customer change:** The meaning of new customer segmentation for industry evolution lies in the service of new customer segmentation appearing fundamental impact on industry structure.

(3) **Purchaser learning:** A purchaser could accumulate the use experience in products and the knowledge of competitors' products through repeated purchase. A purchaser, when becoming smarter, would make the purchase decisions with more information as the purchaser's enhancing product knowledge would promote the quality of products and service.

(4) **Uncertainty reduction:** The reduction of uncertainties is a learning pattern to affect industry structure. Indicators of practicability of technology and market potential could be acquired in the industry growth process, and the way to eliminate uncertainties is the learning process to imitate success strategies.

(5) **Knowledge dissemination:** A business developing new products and manufacturing technology would be diffused. A technology would become perfect along with time, and the relevant knowledge would be diffused.

(6) **Experience accumulation:** Keeping the uniqueness of experience accumulation might become the strong motive of industry changes. A business, without being the first to gain experiences, has to be strategically well prepared for imitation.

(7) **Scale change:** A growing industry would gradually increase the size; on the contrary, it would reduce the size.

(8) **Cost & exchange rate:** The investment costs (including salary, material costs, capital structure, communication costs, and transportation costs) and exchange rate fluctuation would largely affect the competition structure of industry.

(9) **Product innovation:** Product innovation could enlarge market coverage, enhance industry growth, or reinforce product differentiation.

(10) **Marketing innovation:** New marketing patterns would enlarge or shrink economic scales to further affect motility disorder.

(11) **Process innovation:** Process innovation would affect capital intensive level, economic scale, fixed cost ratio, vertical integration, and experience accumulation process to further influence industry structure.

(12) **Industry structure:** The industry structure of suppliers and purchasers would affect the bargaining power that their structure changes would result in major influence on industry evolution (Marshall et al. 2015).

(13) **Government policy:** The system power of governmental regulations and policies would majorly change industry structure.

(14) **Access & withdrawal:** The access and withdrawal of businesses in an industry would obviously affect the industry structure.

Critical Success Factor

Li et al. (2014) stated that "critical success factor" (CSF; or Key Success Factor, KSF), promoted by Massachusetts Institute of Technology, was an analysis method to define organizational information needs. Berdonosov et al. (2015) mentioned that Daiel considered that the information system of a company should be distinguished and selected; meanwhile, success factors in industry should be concentrated; most industries presented 3-6 critical success factors. More research on critical success factors was done after 1979 to result in gradually consistent opinions about critical success factors. Most researchers advocated that critical success factors were assets, technologies, resources, activities, and managers' performance and presented uniqueness; to succeed in the industry, a manager should present such conditions to be more competitive and acquire permanent advantages than other businesses. Chou (2014) indicated that the characteristics of critical success factors should be concerned when taking critical success factors into account. For this reason, the common basic characteristics, according to researchers' analyses, are organized as below.

(1) Critical success factors would change with time.

(2) Critical success factors would change with industry, product, and market.

(3) Critical success factors would change with changing life cycle of an industry.

(4) Future development trend should be taken into account of critical success factors.

(5) Hasty investment before understanding the critical success factors of an industry would result in failure.

(6) A manager should stress on specific affairs or critical work to determine critical success factors.

(7) A manager should focus the management on critical success factors.

(8) A manager should deeply understand critical success factors and used them as the basis for making strategies.

RESEARCH DESIGN AND METHOD

Delphi Method

The AHP dimensions are established according to Delphi Method. Delphi Method, also named expert survey, separately sends questions to various experts through mails for inquiring the opinions, which are collected and organized the comprehensive opinions. The comprehensive opinions and predicted questions are further mailed to the experts for further opinions; the experts would revise the original opinions according to the comprehensive opinions. By repeating the inquiries for several times, a more consistent prediction result is acquired step by step.

Delphi Method, according to the system program, applies anonymous opinion announcement, i.e. no mutual discussion among experts, but simply horizontal contact with researchers. With several runs of expert surveys and repeated inquiry, induction, and revision, the basically consistent opinions of experts are organized as the prediction result. Such a method presents broad representativeness and is more reliable.

Establishment of Evaluation Indicator

The research questionnaire is emailed to experts in various fields. The first-time feedback is organized the considerations of high-tech industrial ecology development. Such factors with similar properties are classified in the same category and sent back to the experts for opinions. With several runs of inquiry through email, the final consistence is achieved. An expert conference is further called to set the critical factors in high-tech industrial ecology development, as business growth, personnel growth, technological change, and capital motivation. Such factors are used as the AHP dimensions and the correspondent classifications are applied to establish the AHP questionnaire. The research criteria, after the revision with Delphi Method, cover the followings.

(1) **Business growth:** growth change, industry structure, uncertainty reduction, and scale change.

(2) **Personnel growth:** purchaser learning, customer change, knowledge dissemination, and marketing innovation.

(3) **Technological change:** product innovation, process innovation, and experience accumulation.

(4) **Capital motivation:** cost & exchange rate, government policy, and access & withdrawal.

Research Object

High-tech industry is selected as the research object that high-tech industry in Hubei Province is sampled and the supervisors and employees are proceeded the questionnaire analysis. Total 250 copies of questionnaire are distributed, and 211 valid copies are retrieved, with the retrieval rate 84%.

DATA ANALYSIS RESULT

After completing all hierarchical weights, the relative importance is distributed to show the importance of factors in the entire evaluation system as well as to generate the overall weight of factors in high-tech industrial ecology development, **Table 1**.

Table 1. Overall weights of factors in high-tech industrial ecology development

Dimension	Hierarchy 2 weight	Hierarchy 2 sequence	index	overall weight	overall sequence
Business growth	0.208	4	growth change	0.035	13
			industry structure	0.097	4
			uncertainty reduction	0.064	8
			scale change	0.047	11
Personnel growth	0.231	3	purchaser learning	0.038	12
			customer change	0.071	7
			knowledge dissemination	0.102	3
			marketing innovation	0.028	14
Technological change	0.288	1	product innovation	0.123	1
			process innovation	0.060	9
			experience accumulation	0.086	5
Capital motivation	0.273	2	cost & exchange rate	0.115	2
			government policy	0.078	6
			access & withdrawal	0.056	10

CONCLUSION

According to the research results, the following conclusions are summarized.

Among evaluation dimensions in Hierarchy 2, "technological change", weighted 0.288, is mostly emphasized, about 28.8% of overall weight, followed by "capital motivation" (weighted 0.273), "personnel growth" (weighted 0.231), and "business growth" (weighted 0.208). Such a result reveals that technological change is the mostly emphasized dimension in high-tech industrial ecology development.

Among the evaluation indicators in Hierarchy 3, the weights are sequenced as below.

1. The evaluation indicators under business growth are sequenced industry structure, uncertainty reduction, scale change, and growth change.
2. The evaluation indicators under personnel growth are sequenced knowledge dissemination, customer change, purchaser learning, and marketing innovation.
3. The evaluation indicators under technological change are sequenced product innovation, experience accumulation, and process innovation.
4. The evaluation indicators under capital motivation are sequenced cost & exchange rate, government policy, and access & withdrawal.

By organizing the overall weights of critical factors in high-tech industrial ecology development, top five indicators, among 14 evaluation indicators, are sequenced product innovation, cost & exchange rate, knowledge dissemination, industry structure, and experience accumulation.

SUGGESTION

Based on the research conclusion, the following suggestions are proposed in this study, expecting to provide definite directions for high-tech industrial ecology development.

1. High-tech industry should actively turn to offshore sourcing and development to achieve the cost benefit of manufacturers. Besides, research & development innovative technology should be started or existing technology should be improved to develop and design new products, e.g. power saving, low radiation, no pollution, and recyclable products, for the continuous survival and development in the market.
2. It should work hard towards rich capitals, highly self-produced components, broad marketing channels, private brand, and good after-sales service in order to establish competitive advantages for the continuous development of high-tech industry.
3. To have high-tech industry compete with famous brands in the international market, high-tech industry should actively establish private brands for higher marketing profits, positively develop towards regional clusters and global manufacturing, develop towards professional division of labor, and step to the development trend of "the big becomes larger and the small accelerates the elimination speed".

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