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Construction of index weight for organizational innovation in Taiwanese high-tech enterprises

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The objective of this research is to construct Taiwan's high-tech industries organizational innovation evaluation index weight, in order to evaluate Taiwan's current level of ability in this area, and to be a guideline for business. In addition, an organizational innovation model was also constructed to act as a foundation for innovation theory. The research methods being employed included literature review, in-depth interview and small group technique, which were used as a first step in constructing an organizational innovation measurement model. Before constructing the organizational innovation measurement model for the present study, a weighted measurement index was created through integrating the subjective and objective weight restriction to create. After finishing the construct of organizational innovation model, the empirical studies conclude that the most important dimension to measure organizational innovation including: product innovation, process innovation and organizational structure and climate innovation.

Key words: High-tech enterprises, organizational innovation, index weight

INTRODUCTION

The 1990s have seen the world entering an era of global competition, where national borders no longer act as barriers. Meanwhile, the economy in Taiwan had also experienced the impact from liberalization and internationalization during the transition. Due to the diminished competitiveness of local labor-intensive industries, a steadily shift to brain-power-intensive industries took place in Taiwan during the transition, and the development of knowledge-based technology intensive industries has become the only direction for Taiwan to remain competitive.

The high risk, rapid change in business environment, short product life cycle nature associated with high-tech industries often demand those enterprises involved to have even faster response capability for survival. As the thinking of management should also be adjusted according to the change in mode of competition, a key issue for the present day high-tech enterprise is to establish the learning capability of its organization, so as to effectively nurture and accumulate the ability to adapt to changes and challenges. Nonaka (1991) discovered

that the key factor for the success of well known corporations like Honda Motors, Cannon and Matsushita, was their way to manage the success of new knowledge, thus calling them knowledge-creating company, very similar to the intelligent enterprise as promoted by Quinn (1992), both of which stressed the use of knowledge as foundation to establish core advantage. Therefore, under such new competing environment, the mode of competition will be on how an organization structure can innovate, shape, accumulate, utilize and spread knowledge. Implying that the root of attaining competitive advantage for future enterprise will be on continuous knowledge innovation and the ability to create new technology, product and management style, by the assimilation of external knowledge and integrate it with in-house knowledge and creativity. Thus, organization innovation (OI) is set as the theme to be investigated in the present study.

The word "innovation" is frequently found in the literature, with technology improvements or breakthroughs being the main subject of investigation in related studies. As "innovation" and "technical innovation" were used to describe the same thing in most cases, a large number of studies were addressed at innovations on technological research and development. With relatively fewer studies were conducted on organizational

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innovation based on the viewpoint of an organization as a whole, it is of importance to make in-depth explorations on the context of organizational innovation and further theoretical supplements. Most past studies on organizational theory were concerned with the performance improvements, with how these targets could be achieved through better technological ability being subjects of interest, but less were proposed on organizational innovation concept and on how related factors could be coordinated to improve the performance of an organization. The dimensions of organizational innovation is extremely complex, Tsai (1997) employed the view of multiple indexing to define innovative capability as the breadth and depth of innovation, expressed by technological products or management measures, generated in-house or purchased from outside, within the past three years. The breadth of innovation includes equipment, system, policy, resolution, process, product and service etc. The depth of innovation includes the importance, degree of influence and effect on long-term profitability etc. of each innovation. The present study, is addressed at the most needy enterprises, viz. the high-tech businesses, that require cultivating its innovative capability, and attempts to make in-depth explorations on the context, the influencing factors and dimensions of OI. By adopting a rigorous methodology, the organization innovative measurement model is developed and used to establish the foundation of a more complete theory on OI.

This paper is structured as follows. Section 1 is the Introduction. Section 2 separately describes the subjective, objective approaches and proposes an integrated approach to determine weights. Section 3 describes the application of the proposed approach. Section 4 concludes the paper.

APPROACHES TO DETERMINE WEIGHTS

Several approaches have been proposed to determine weights (Hwang, 1987, Saaty, 1980). Most Majorities of them can be classified as subjective and objective approaches depending on the information provided. The subjective approaches include the Analytic Hierarchy Process (Saaty, 1980), Delphi method (Hwang, 1987), and weighted least square method (Chu, 1979) etc. The objective approaches include Data Envelopment Analysis (Charnes, 1978), principal component analysis (Fan, 1996), the entropy method (Hwang, 1981) and the multiple objective programming model (Choo, 1985, and Fan, 1996) etc. Subjective approaches determine weights that reflect subjective judgment, but those weights can be influenced by the decision making units (DMUs). Objective approaches determine weights by making use of mathematical models, but they neglect subjective judgment.

This study applies both the subjective weight restriction

method and the objective weight restriction method (Liu, 2006) to evaluate the index weight.

Subjective weight restriction method

Several types of subjective weight restrict methods (such as Analytic Hierarchy Process, Delphi, and multiple criteria decision making) are currently used. These methods are characterized by the subjective setting of weights in the evaluation index, by experts, based on their own experience. Different scholars may give different weights and thus, subjectivity is the major drawback. Remedial measures such as increasing the numbers of experts, properly selecting experts, and so on, can diminish this drawback; however, subjectivity remains. The advantage of the subjective weight restrict method is that experts can reasonably identify the weight index that corresponds to the actual problems. Thus, despite the different placement of weights on the index, the method can still determine the order of priority and avoid conflicts between the reality and the index weights, as can occur in the objective weight restrict method. This study uses AHP, which process is described as follows.

The strongest function of AHP is to simplify a complicated system into a hierarchy of processes, each including simple but essential elements. In short, the procedure affects the incentives of each decision making point and the pair-wise comparisons between the nominal scales. After the process of quantification, a comparison matrix is established to obtain the Eigenvector, representing the weight of each hierarchy, and the Eigenvalue. From the above, the corresponding strength and weakness of the individual pair-wise comparison used as information for decision-making. In addition, if factors of AHP are interrelated in many hierarchies, the priority and then the connection are determined to obtain the combined weight of factors in the lowest hierarchy. Combining the consistency indices in all the comparison matrices, provides each consistency index and ratio to evaluate on the common recognition of the entire hierarchy.

Objective weight restriction method

Researchers have been working on objective weight restriction method (DEA, Gray prediction, Composition analysis) to avoid the shortcomings of the subjective weight restriction method. The primary data of the objective weight restrict method are the actual figures used in the matrix for evaluation to avoid subjective sources and ensure the weights are objectively given. Yet, sometimes, inevitably the subjective weight may correspond to fact. The least important index could theoretically have the largest weighting and the most important index may not be the case. Examples can be

seen in many DEA analyses.

Accordingly, the subjective weight restriction method has its advantages, and the objective method also has some advantages if the practical situation is neglected. In the real situation, where weights are obtained through either the subjective or the objective method, the difference between the methods tends to be ignored and, therefore, their reliability becomes doubtful.

This study concentrates on the advantage of the integration and objectification of the weight restriction method to offer more reliable information for decision-making.

Integrating subjective and objective weight restriction methods

Basic assumption: Assume that a_i is the subjective weight of I_i , and b_i is the objective weight. The final weight is given by the following equation:

$$W_i = \alpha a_i + (1-\alpha)b_i \quad [0 \leq \alpha \leq 1]$$

In multiple criteria decision-making, the relevant importance of each index is different. According to the basic concepts of multiple criteria decision-making, decision makers can categorize an index according to important, determined by various criteria, and may or may not show their preference. If the evaluation indexes are V_1, V_2, \dots, V_n and the index criteria are R_1, R_2, \dots, R_k ; then importance is in the order, $R_1 > R_2 > \dots > R_k$ that R_1 is more important than R_2 and R_2 is more important than R_3 and so on.

Analysis model: If there is no difference between the evaluation indexes, that is, the indexes are located at the level of the same significance, and the weight priority obtained from the objective weight restriction and the priority obtained by the subjective weight restriction is identical, then $\alpha = 0$. The weight calculated by the objective restriction method is used as the weight of the index.

i) If there is no difference between the evaluation indexes, that is, the indexes are located at the level of the same significance, and the weight priority obtained from the objective weight restriction and the priority obtained by the subjective weight restriction is not identical, then $\alpha = 0.5$. The weighted average of the weight obtained by the subjective and objective weight restriction methods is used as the weight of the index, or the optimal weight is obtained by trial and error until it is accepted by the decision maker.

ii) If each evaluation index is located at different level of significance, but the weight priority obtained from the objective weight restriction and the weight priority obtained by the subjective weight restriction is identical,

then it illustrates that the more important index has a larger weight. To eliminate the human subjective factor, only the weight obtained by the objective weight restriction method is used as the weight of the index, and then $\alpha = 0$.

iii) If each evaluation index is located at a different level of significance, the weight priority obtained from the objective weight restriction and the weight priority obtained by the subjective weight restriction is not identical, but the priorities of indexes according to the significance level are identical, then $\alpha = 0.5$. The weighted average of the weight obtained by the subjective and objective weight restriction methods is used as the weight of the index, or the optimal weight is obtained by trial and error until it is accepted by the decision maker.

iv) If each evaluation index is located at a different level of significance, the weight priority obtained from the objective weight restriction and the weight priority obtained by the subjective weight restriction is not identical, but the priorities of indexes according to the significance level are not identical, then it shows that the weight obtained from the subjective weight restriction method is no longer calculated from the significance level of the index itself. Therefore, the weight obtained by the objective weight restriction method gives no reference value to the determination of the index weight, and only the weight obtained by the subjective weight restriction method is used as the weight of the index, and then $\alpha = 1$.

v) Here is a special situation. If the value of one or K of the weight(s) obtained from the objective weight restriction method is zero (commonly happens in the DEA analysis), it shows that the attributive of each solution for such indexes is the same, and such indexes will not affect the decision of the priority. Then, such kind of indexes should be eliminated from the evaluation indexes. The indexes remaining should be processed according to each of the aforementioned situations.

vi) From the above analysis, if the weight priorities obtained from the subjective and objective weight restriction methods are identical, then the weight obtained by the objective weight restriction method is used as the final weight of each weight, effectively eliminating the subjectivity of the index weight. If the priorities of the weights obtained from these two methods according to the significance of the weight are not consistent, the weight obtained from the subjective weight restriction method is used as the final weight for each index. It can eliminate the mistake of the conflict between the weight determined by the objective weight restriction method and the actual significance of the weight of the index.

ESTABLISHMENT OF OI INDEX WEIGHT

The foundation of the OI measurement model being developed in the present study is mainly based on the OI structure factors proposed by Liu (2001). The preliminary measurement model was established through literature

study, in-depth interview with experts, assessors and assessed, together with small group techniques (SGT) to compile the views and opinions on the dimensions and measurement index for the OI of high-tech enterprises. In addition, other than subjective indicators, objective indicators were also included. The preliminary measurement model was first designed in the form of a questionnaire and sent to the middle to higher management in the production or research and development departments of 150 information technology and electronics related companies, located in the Hsin Chu Science Based Industrial Park and the Nan Tze Industrial District. Two sets of questionnaires were sent to each company, that is, a total of 300 questionnaires dispatched, and 209 (70%) valid returns were collected. Base on the results of factors analysis, different dimensions were identified and named accordingly. A total of two system dimensions, five measurement dimensions and twenty secondary dimensions were obtained, thus completing the construction of preliminary measurement model. The dimensions and indicators of the measurement are shown in Figure 1. The details of the whole construction process is given below:

Measurement model exploration stage

Literature review and analysis: The first stage of OI hierarchy and indicators for high-tech enterprises in Taiwan was constructed through the collection, collation, analysis, followed by appropriate induction and comparison of related literature results.

In-depth interview and small group technique (SGT): After the first stage hierarchy and indicators was established, views and opinions on the OI hierarchical structure and measurement index on Taiwan's high-tech enterprises were sought from experts and scholars, in order to modify the initial model and set up a more rigorous analytical structure for subsequent study. Ten experts from related area in Taiwan were consulted; five of them were academicians with innovation management as major research interests, whilst the remaining five were middle to higher management from the research departments of high-tech industrial companies. The consultation, carried out at Taipei and Kaohsiung, used in-depth interview and small group technique, lasted from 2 to 3 h.

Exploratory factor analysis: A pre-measurement table that contained 34 questions was prepared according to the measurement dimensions and indicators. 300 sets of the table were sent to 150 high-tech companies and 209 valid returns collected. Using principal component analysis method and setting an Eigen value of greater than 1.0 as selection criteria, common factors were extracted from the returned questionnaires. The common factors were then subjected to orthogonal rotation treatment, using varimax solution method, so that after the rotation, the greatest difference between the maximum

and minimum factor loading of the same factor in each question will be obtained, to facilitate the identification and naming of common factors. The hierarchy and naming of the final measurement structure obtained after factor analysis is shown in Figure 1.

Dimensions and indicator weight establishment

According to integrate subjective and objective weight restriction, so as to obtain the relative weights of the hierarchy and indicator, the order of importance of Taiwan's high-tech enterprise OI system dimension is TI (0.516) and then AI (0.484); the ranking of important dimensions is: product innovation (0.288), process innovation (0.228), organization structure and climate innovation (0.206), staff innovation (0.158), sales and marketing innovation (0.120). From these results, it can be concluded that the display of innovations in product, process together with organization structure and climate innovation are more important dimensions for evaluating the organizational innovative capability of an enterprise. The most important activities or criteria for these dimensions are patent and new product development, manufacturing procedure, together with innovative management techniques and specialization, for product innovation, process innovation, together with organization structure and climate innovation, respectively.

Conclusion

An OI evaluation model for high-tech enterprises in Taiwan has been established, using a rigorous method that involved continuous challenges and modifications. The method combined the orientations of process theory and organizational innovativeness. The study employed multiple viewpoints to define OI, and in agreement with many contemporary researchers view, attempted to incorporate AI, as well as TI into the definition of OI. Since the present model has incorporated the views and opinions from numerous experts and literature, it displayed general agreement with past studies. The major theoretical contribution of the present study is its supplement to existing OI theory, with the dimensions and indicators weight used to evaluate the OI of high-tech enterprises being developed not only explained the context of OI, but also formed a platform for studying OI measuring model and applications. In practical terms, results from the present study should be useful guidelines and reference for corporations to improve organization innovation capabilities.

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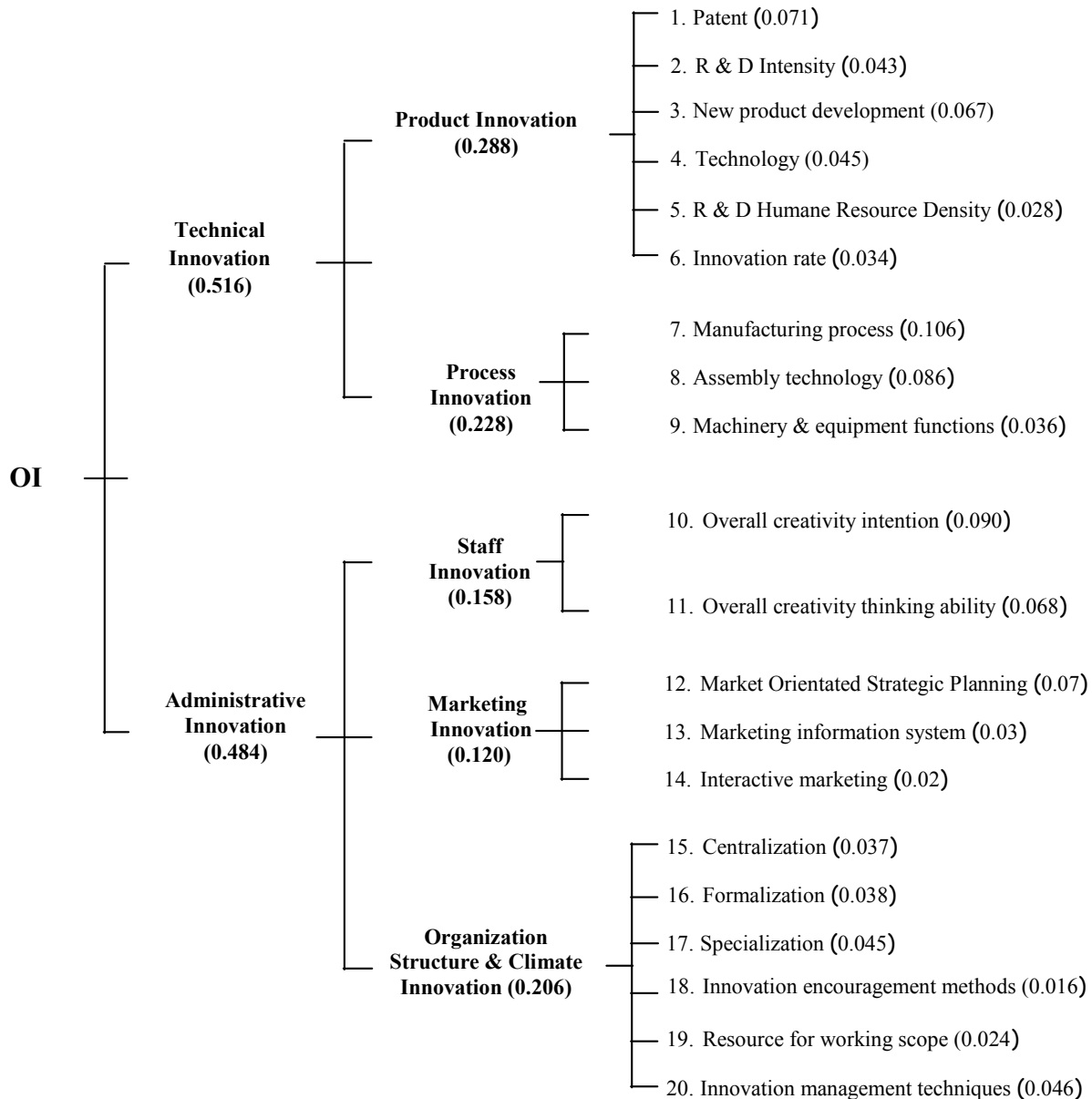


Figure 1. Hierarchical structure and indicators weight.

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REFERENCES

- Charnes A, Cooper WW, Rhodes E (1978). Measuring the Efficiency of Decision Making Units, *Eur. J. Oper. Res.* 12(6): 429-444.
- Chu ATW, Kalaba RE, Spingarn K (1979). A comparison of two methods for determining the weights of belonging to fuzzy sets, *J. Optim. Theory Appl.* 27: 531-538.
- Fan ZP (1996). Complicated Multiple Attribute Decision Making: Theory and Applications, Ph.D. Dissertation, North-eastern University, Shenyang, PRC.
- Hwang CL, Lin MJ (1987). Group decision making under multiple criteria: method and application, Springer Berlin.
- Hwang CL, Yoon K (1981). Multiple Attribute Decision Making: Methods and Applications, Springer, Berlin.
- Liu CC, Tsai MT, Chuang LM (2001). An Empirical Study on the Construction of Measuring Model for Organizational Innovation in Taiwanese High-tech Enterprises, *J. Hum. Res. Manage.* 1(1): 53-71.
- Liu CC (2006). Simulating Weights Restrictions in Data Envelopment Analysis Using a Subjective and Objective Integrated Approach, *Appl. Econ.* 38(21): 2545-2552.
- Nonaka I (1991). The Knowledge-creating Company, *Harv. Bus. Rev.* 96-104.
- Quinn JB (1992). The Intelligent Enterprise a New Paradigm, *Acad. Manage. Exec.* 6(4): 48-63.
- Saaty TL (1980). A scaling method for priorities in hierarchical structures, *J. Math. Psychol.* 15: 234-281.
- Tsai ST (1997). Organizational Factors, Creativity of Organizational Members and Organizational Innovation, Ph. D. Thesis, National Taiwan University.