Using Analytic Network Process to Establish Performance Evaluation Indicators for the R&D Management Department in Taiwan's High-tech Industry

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Abstract

The high-tech industry is the economic lifeline for Taiwan. Its characteristics are short product life cycle, rapid changes in the market, and a high obsolescence rate for new products. Under globalization, the high-tech industry has adopted Information Technology (IT) to shorten the manufacturing process, reduce costs and conduct product research and development (R&D) to increase the core competence of enterprises and achieve the goal of sustainable operations. Enterprises should actively strengthen their integration with internal and external resources and lead in R&D management to increase industrial operating performance. Effectively managing operations and R&D management evaluation in Taiwan's High-tech Industry has become a critical subject. This study adopted 4 major Balanced Scorecard (BSC) perspectives to establish the Total Performance Evaluation Indicators for the R&D management department in Taiwan's High-tech Industry. The Analytic Network Process (ANP) was applied to evaluate the overall performance of the R&D management department. The research framework is divided into 2 phases. The first phase is combined with the 4 major perspectives, Financial, Customer, Internal Business Process and Learning and Growth, as the related indicators for each measurement perspective. The Key Performance Indicators (KPI) were selected using Factor Analysis to identify the key factor from the complicated indicators. The relationship between the characteristics of each BSC's evaluation perspective is dependence and feedback. This study applied ANP to conduct the calculation and adjustment of correlation between each KPI, and determine on their relative weights for the objective KPI. The "Financial Perspective" for R&D management department in Taiwan's High-tech Industry focused on the budget achievement rate of R&D management. The weight indicator value is (0.05863). The "Customer Perspective" focused on problem-solving satisfaction. The weight value of this indicator is (0.17549). The "Internal Business Process Perspective" focused on the quantity and quality of R&D. The weight value of this indicator is (0.13506). The "Learning and Growth Perspective" focused on improving competence in

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the research personnel's professional techniques. The weight value of this indicator is (0.02789). From the total weighting indicators, the order of the Performance Indicators for the R&D management department in Taiwan's High-tech Industry is: (1) Customer Perspective; (2) Internal Business Process Perspective; (3) Financial Perspective; and (4) Learning and Growth Perspective.

Key Words: R&D Management, Performance Evaluation, BSC, ANP

1. Introduction

In recent years, many enterprises have realized the importance of R&D management, thus they are have begun promoting R&D management. The current R&D departments are different than the previous operations. Supervisors from many enterprises have found that R&D management could be a competitive weapon for enterprises. The R&D department is a key link in the organization and its performance greatly influences the overall organizational achievement. Effectively managing R&D has become a critical subject. The Performance Evaluation is very important. The main purpose of an enterprise is to continuously seek its' economic goal. Through performance evaluation results, an enterprise is able to understand its' own efficiency and effectiveness in resource utilization. The performance evaluation is a reference indicators for R&D management to produce future strategies. The Balanced Scorecard (BSC) system proposed by Kaplan and Norton (1996) translates strategy into action and integrates all units/departments of a company to cohere to a common consensus, developing synergy towards the strategic direction to achieve the company's goal. This has become the strategic management system in which many companies are extremely interested. Brewer *et al.* (2004) pointed out that it is very important to convert the company's conceptual viewpoints, "Goal" and "Strategy," into tangible evaluation indicators that can be practically implemented. However, currently, there is no set of modes or a mechanism for weight determination of the objective Performance Evaluation Indicators for BSC theory. There is still a need to conduct further discussion aiming at determining a weight determination for the critical evaluation indicators.

The relationship between the BSC evaluation perspectives and indicators is dependence and feedback. A simple hierarchical relationship is not present; thus, in the Analytic Network Process (ANP) model proposed by Saaty (1996, 2001), the criteria are independent from each other. As a result, determining the weight value between the perspectives and indicators may be achieved using the ANP method (Lin *et al.*, 2008). The purpose of this study is: (1) Conduct an analysis considering the characteristics of the R&D department to produce performance evaluation indicators using 4 perspectives: financial, customer, internal business

process, and learning and growth; (2) Apply Factor Analysis and determine the effective evaluation indicators; and (3) Apply ANP to determine the weight and priority of each indicator as the important referential basis for the R&D department.

2. Literature Review

This study establishes Performance Evaluation Indicators for the R&D management department in Taiwan's High-tech Industry. Thus, this study conducts the analysis using the related literature and documents from Taiwan's High-tech Industry, R&D management, BSC, Performance Evaluation, ANP, etc.

2.1 Definition and Characteristics of High-tech Industry

Bleicher & Paul (1983) discussed that the high-tech industry is a capital and technology-intensive industry that is particular about professional knowledge, emphasizes R&D and science and technology talent incubation, a large-scale economy, high risk and high reward. Gould and Keeble (1984) thought that the high-tech industry should be measured using three indicators: the ratio of R&D expenses to yield; the speed of technological innovation; and the weight of the number of management, technical and R&D personnel. Shanklin and Ryans (1984) thought that an enterprise should possess a powerful science and technology foundation, producing new technologies that rapidly replace existing technology, and establishes or alters markets and demands following the application of new technology. Chiu (2002) pointed out that the characteristics of Taiwan's High-tech Industry included: (1) Talent-intensive; (2) Capital-intensive; (3) High technical level and complicate manufacturing process; (4) High market concentration ratio; and (5) Short product lifecycle. Hence, this study integrated and organized the abovementioned literature and document to divide the characteristics of Taiwan's high-tech industry into 6 major categories: (1) Integrated Circuit (IC) industry; (2) Computer and Peripheral Industry; (3) Communication Industry; (4) Optoelectronics Industry; (5) Precision Machinery Industry; and (6) Biotechnology Industry.

2.2 R&D Management

Data organized by the US based Arthur D. Little Company in 1991 showed that R&D management can be divided into 3 eras since 1959 to date: (1) 1st Generation R&D Management (1950~1960): its goal lacks a strategic framework that regarded R&D as a cost center or as a source that produced expenses. The supervisors were seldom involved in or directed R&D. (2) 2nd Generation R&D Management (1970~1980) possessed a partial strategic framework, which, as for the projects, may consider cooperating with the enterprise's integrated development strategy. (3) 3rd Generation R&D Management (after 1980) has an integrated

strategic framework. The main characteristics are: (1) R&D and High-level supervisors adopted the spirit of partnership to jointly draft and plan cooperation between the inter-business units and enterprise R&D; (2) Understanding the enterprise's demand, R&D should discuss with the opportunity for the new business; (3) High-level management strove for establishing a partnership between R&D and other departments; (4) Whether implementing the project or not is only adopted the investment portfolio but the individual project. The studies of Youssef (1994) pointed out: DFM (Designing for Manufacturing) is not only able to achieve the advantage of differentiation and low cost, but, through DFM, it also can reach the rapid delivery, high quality and the flexible product types to achieve low cost advantages. In addition, this may reduce discards and rework to create purchase, assembly and inventory efficiency and accelerate the learning effectiveness.

A comparison between the automobile industries in Japan, US and Europe through the process of literature review, Cusumano and Nobeoka (1992) pointed out that automobile manufactures with higher ranking in manufacturing productivity, designing productivity, total quality and the design for manufacturability, will always adopt the following measures: an overlapping development phase, multifunctional teams, effective communication and coordination mechanism, while they're in the process of new product development. The studies of Karagozoglu and Brown (1993) pointed out: in the early stage of new product development, if related marketing approaches can be applied to customers' participation, then it may help not only to succeed in new product development, but also shorten the R&D duration. Battelle and other companies emphasized research and development. Millett (1990) pointed out 4 important factors that will influence whether R&D management will succeed. The response to customer's demand, the regularly upward and downward communication, technology, really not the practical products and technology but might deeply influence on the R&D competence. Ellis and Curtis (1995) indicated that Managers of R&D units should know that R&D activities do influence customer satisfaction. Among which, how much time the managers spent to understand and which measuring method they used was very important. In a thesis of Total Quality Development, Clausing (1994) which pointed out that the contents of total quality development are included whether products can sufficiently respond to customer demand, feasibility of design, powerful function, successful integration, reusability and strategic influence.

The R&D of McDonough (1993) pointed out: lead the external technology into will save the time of internal self-R&D. The studies of Karagozoglu (1993) indicated that if enterprise is able to be well-used the external technology, it may help to shorten the duration of R&D. According to the 5 types of industries that divided by Lawrence, Chakrabarti (1991) researched and indicated that there's the significant positive correlation existed among the high tech, capital-intensive and labor-intensive industries, and R&D investing and operating growth rates. The company, DeMott (1990) in order to obtain the competing advantage, it

can be strategically allied with other companies for sharing their facilities and exchanging information. In addition, the US-based small and medium sized businesses are frequently composed of the network with vertically integrating with the upstream and downstream work teams to obtain the competing advantage that only for the large-scale enterprise before. Rosenau (1998) thought that the participation of high-level managers could help with providing and supporting resources, could increase the encouraging degree for personnel with engaging in new product R&D, and could help with purchasing and training for the equipment that may increase the productivity. The researches of Mabert *et al.* (1992) pointed out: it may help to shorten the duration of R&D while R&D team experiencing the competitive threat from its competitor. After interviewed with 3 major automobile manufacturers and tens of auto part suppliers in Japan and sent out the questionnaire to more than 300 auto companies in US and Japan, Kamath and Liker (1994) indicated that if enterprises allow suppliers participating in developing process of new products, then it may effectively help enterprises with shortening the lead time, reducing the production cost and accelerating the design procedure. After reviewed and organized the literature and document, this study has listed 5 items to measure the R&D management in Taiwan's high-tech industry, as described below:

(1) Customer Participation Degree in Early New Products R&D, Karagozoglu and Brown (1993) indicated that customer participation in new product development may timely allow R&D department to effectively solve customer's demand and question, and, at the same time, the added value may increase with following the early customer participation in the new product R&D. Moreover, in the future, the user-demand-oriented design will lead a company to success or failure. Kamath and Liker (1994) indicated if enterprises allow suppliers participating in developing process of new products, then it may effectively help enterprises with shortening the lead time, reduce the manufacturing cost and accelerate the design procedure.

(2) Cooperative Degree between R&D Projects and External Technologies: Karagozoglu (1993) pointed out if an enterprise is able to apply external technology, it may help enterprises to shorten the duration of R&D and reduce the cost.

(3) Cooperative Degree between R&D Projects and External Funds/Capitals: Chakrabarti (1991) indicated there is a significant positive correlation existed among the high tech, capital-intensive and labor-intensive industries, and R&D investing and operating growth rates.

(4) Interdepartmental Degree of R&D Plans: Youssef (1994) indicated through the early participation in design, the adjustment among the trial duration, design and manufacturing, may be substantially reduced. Through the integration with R&D and manufacturing, long-term and short-term competitive advantages could be obtained for the company. Cusumano and Nobeoka (1992) pointed out adopting multifunctional teams in new product development may have better performance in manufacturing productivity,

designing productivity, total quality and the design for manufacturability.

(5) Degree of Investing in R&D Plans by High-level Managers: Rosenau (1998) pointed out that the participation of high-level managers can help with provide supporting resources and increase personnel motivation while engaged in new product R&D. Karagozoglu and Brown (1993) indicated the participation of high-level managers in new products R&D may accelerate the R&D schedule and speed up cooperation, making the performance of multifunctional teams more efficient.

2.3 BSC

Kaplan and Norton proposed the BSC concept (Balanced Scorecard) in 1996. Its main function is to performance measurements to supplement evaluating the financial measurements of previous performance. In addition, they thought that the BSC system was a performance evaluation tool and also an indicator of the organization's future success. The researches of Chow and Haddad (1997) indicated: the main characteristics of BSC depend on its competence in integrating organizational strategy, framework and vision to help enterprises with converting long-term strategy and customer value into action both internally and externally. Therefore, BSC is not only a performance evaluation tool, but also a core system that directly entered to the business administration. Through these 4 perspectives of financial, customer, internal business process and learning and growth, enterprises accepted the diversified viewpoint of the new competitive environment by taking the future success factors in organization as a motive to closely connect with strategy, and, moreover, through the strategic reward system and the setup of departmental and individual vision with adopting the method of strategic implementation feedback and learning to establish a complete strategic management mechanism.

2.4 Performance Evaluation

Within enterprises, to understand daily operating activity performance, the Performance Measurement or Performance Evaluation is indicated as a system that enterprises may use a quantification criterion or subjective judgment to measure or evaluate. In addition, the evaluation of operation performance is able to help the strategy and organizational structure that adopted by enterprises with achieving the set goal or not. Venkatraman and Ramanujam (1986) proposed 3 types of performance with conceptual scope for the business performance:

(1) Financial Performance: it indicated that has achieved the economic goal of enterprise, and the common indicators are: profit after tax, operating revenue, operating growth rate, return on capital and profit rate.

(2) Operating Performance: it combined the financial performance with operating performance to be the business performance, such as market share, product quality, rate of

added-value, marketing efficiency etc., non-financial indicators.

(3) Organizational Effectiveness: it is the most comprehensive business performance that, except for these 2 abovementioned performances, also included the conflict solving, satisfaction of the goal for each related person, and employees' morale. Ven De Ven and Ferry (1980) thought that the traditional financial performance is the most common indicator that researchers used to evaluate the result among organizations, such as investment return, sales revenue, and profit rate, etc. Among which, in general, the common researches are prefer to use the sales revenue.

Chakravarthy (1986) mainly divided the categorizing and operating performance measurement methods into 4 classifications: (1) Operating Goal: it indicated the operating plan for enterprise, such as the achieving degree in annual budget, capital increase, expansion of factory, joint venture, and merge; (2) Productivity: it indicated the use situation of factory and facility; (3) Profit: it indicated the well-arranged capital for enterprise with performing at the return on investment which could obtain from the calculation of the profit growth ratio; and (4) Long-term Advantageous Resource: it indicated the basis of sustainable operation and continuous growth for enterprises. De Brentani (1989) combined the literature of product innovation and service marketing, and along with 115 types of Canada-based enterprises as the research object; in addition, the research results found that the differentiating characteristics between service and product were somewhat different to the performance measurement. Kaufman (1988) thought that the performance indicators are the measuring methods that used to differentiate and prove whether achieved the pre-planned goal or not. And, the measuring or evaluating criteria are also known as the Performance Criteria. Fortuin (1988) regarded the Performance Indicator as a type of variable to measure the efficiency or effectiveness in whole or partial system of organization in order to understand whether the operating procedures conformed to the set goal or not.

2.5 Analytic Network Process (ANP)

2.5.1 Characteristics of ANP

In real life, since mutual interaction and dependence exists between top and bottom hierarchies, and its relationship is not the simple linear relationship from the top to bottom but is more likely similar to the relationship framework of network, thus there're many problems in making decision that are not able to be clearly expressed by structured hierarchy. The researches of Saaty (1980a/1980b) pointed out: the interaction of dependence that formed between the Clusters and Element is able to be analytically illustrated with figures, and every element of each figure should be linked to each other, but divided into 2 or more than 2 un-linked figures. ANP not only allows the Inner Dependence within clusters, but also the Outer Dependence between clusters. It provides a complete framework which including the link between cluster and element, and to study the whole question procedure using the ex-

pected methods of the decision-makers. ANP researchers are able to sort out the interaction between each element and cluster, and then figure out the priority and scale for each solution. As a result, this study has induced the ANP characteristics as follows: (1) Possessed the model of network framework; (2) Possessed interrelation between factors; (3) The most significant characteristic of ANP is that it possessed the "Feedback Relationship"; and (4) Utilizing the calculation of Supermatrix.

2.5.2 Basic Assumption of ANP

The ANP is the expansion of the Analytical Hierarchy Process (AHP), and there're still existed some similarities between these 2 methods. As for the AHP, many assumptions proposed by Saaty (1977/1980a) are still tenable, and the basic assumptions of ANP are as follows:

(1) A system that can be decomposed into many Classes or Components, and to form the hierarchical structure of directed network.
(2) Within the hierarchical structure, each hierarchical element will be assumed that it possesses independence.
(3) Element in each hierarchy is able to use some or all elements of the previous element as the basis of conducting the evaluating operation.
(4) It is able to change the Absolute and Numerical Scales into the Ratio Scale while conducting the comparing evaluation.
(5) After conducting the Pair or Pair-wise comparison, it is able to use the Positive Reciprocal Matrix to handle the follow-up process.
(6) The preference relations conform to the Transitivity, it is not only the relations between strength and weakness that meet the principle of the Transitivity (A is better than B, B is better than C, then A is better than C), but also the advantageous degree of element can be obtained by the Weighting Principle; meanwhile, the strength relations also conform to the Transitivity (i.e., A is two times better than B, B is three-fold better than C, then A is six-fold better than C).
(7) It is very difficult to completely possess the Transitivity, thus it allows the existence of the Incomplete Transitivity, but it needs to examine the degree of Consistency.
(8) Every element that showed in the hierarchical framework, no matter its advantageous degree is small or not, it will be regarded as relating to the whole evaluation framework but the independence of non-check hierarchical structure.

3. Research Methodology

3.1 Research Procedure

The research framework of this study is divided into 2 phases. The first phase is the se-

lection of Performance Evaluation Indicators. Firstly, used the related literature and expert opinion as the basis of categorizing the Primary Indicators of Performance Evaluation, and then adopted the questionnaire survey to understand the importance recognition of indicators from the R&D department supervisors, scholars and experts; in addition, analyzed the collected data and sieved out Key Performance Indicator (KPI) through the Factor Analysis. The second phase is, through the expert questionnaire survey, used the ANP technique to investigate the interrelations between each KPI and define relative weights to make the final conclusion and suggestion.

3.2 Use ANP to Confirm the Weight of Key Performance Evaluation Indicators

The main calculating steps of ANP technique are described as follows:

(1) Establish the hierarchical framework of network for BSC: this study is applied the Analytic Network Process to calculate the entire relative weight of the evaluation indicators under the interaction between each performance evaluation perspective, thus used the Critical Performance Evaluation Indicators of BSC's Financial, Internal Business Process, Learning and Growth and Customer Perspectives to establish the hierarchical framework of network of ANP; moreover, to set the indicator(s) under each evaluation perspective will all interact with other perspective indicators.

(2) Design and Fill-in of ANP Questionnaire: this questionnaire used each Performance Evaluation Indicator as the influential criteria of evaluation, and then conducted the pair-wise importance evaluation to each perspective. The questionnaire uses 1 to 9 levels and 17 ratios to carry out the comparison of the relative importance among operating elements.

(3) Establish Pair-wise Comparison Matrix: this is the first step of the questionnaire analysis, and converts the integrated results of this questionnaire into the Pair-wise Comparison Matrix with aiming at integrating and standardizing the ANP questionnaire.

(4) Integration of Expert Preference: When there is only one decision-maker, his/her adjudged results may not involve in preferential integration. However, if applied the decision-making clusters to conduct the evaluation, since every person who filled in the questionnaire is different from each other for question recognition as well as the different adjudged values of pair-wise comparison. In addition, the degree of importance for the operating performance evaluation indicators that obtained in the end should be different also, thus it needs to carry out the integration with expert preference. There're many methods of the preference integration, according to the consideration for easier determination and simple calculation, this study used the mean value of the decision-making clusters data to conduct the integration of expert preference. The calculating methods of the mean value include 2 methods: Arithmetic Mean and Geometric

Mean, and according to the suggestion of Saaty (2001), the Geometric Mean is a better method than another. This step will integrate and standardize the pair-wise matrix for each expert to establish the pair-wise comparison matrix.

(5) Eigenvalue and Eigenvector Calculation: After completing the pair-wise comparison, through calculating the eigenvalue and eigenvector of pair-wise comparison matrix, then it is able to figure out the relative weight of element. However, when the order number of matrix is bigger, the calculation will be more complicated; therefore, it is able to use the similar eigenvalue solution to sort out the eigenvalue and eigenvector with simple calculating process and similar value to the precision value.

Set if the pair-wise comparison matrix of n items ($A_1, \cdots, A_i, \cdots, A_n$) is $A = [a_{ij}]$, then first calculate the sum of column vectors, T_i:

$$T_i = \sum_{j=1}^{n} a_{ij}, \quad i = 1, 2, \cdots, n$$

then calculate the total sum of column vectors T:

$$T = \sum_{i=1}^{n} T_i = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}$$

next, use the following normalization to calculate the weight W_i of A_i item:

$$W_i = \frac{T_i}{T} = \frac{\sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}}, \quad i = 1, 2, \cdots, n$$

and then according the following formula to figure out the maximum eigen-value, λ_{max}.

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}$$

(6) Consistency Test: Aiming for inconsistent contradiction generated by the decision-makers or experts that answered the questionnaire, unclear answers to the questions or non-answered, it is very difficult to obtain full consistency. After collecting the ANP questionnaire, a consistency test was carried out to guarantee the usability of the questionnaire.

(7) Supermatrix Calculation: In order to handle the correlation relationships between ele-

ments in the problem structure, the ANP technique adopted a specific matrix structure, called the Supermatrix, to calculate the relative weight of the elements. Supermatrix is composed of many sub-matrixes. If there are no relationships existing between elements, the pair comparison value of the Submatrix is 0, as shown in Figure 1. A and B Perspectives showed an external dependence relationship between them, and A Perspective and B Perspective showed an internal dependence relationship individually, the matrix can be expressed as follows:

$$M' = \begin{array}{c} \\ \text{Perspective A indicator} \\ \text{Perspective B indicator} \end{array} \begin{array}{c} \begin{array}{cc} \text{Perspective A indicator} & \text{Perspective B indicator} \end{array} \\ \begin{bmatrix} X & Z \\ Y & W \end{bmatrix} \end{array}$$

Figure 1. Illustration of supermatrix

Matrix *X*: indicated that under the influence of A Perspective, the pair comparison matrix of each indicator within the A Perspective.

Matrix *Y*: indicated that under the influence of A Perspective, the pair comparison matrix of each indicator of A Perspective and B Perspective.

Matrix *Z*: indicated that under the influence of B Perspective, the pair comparison matrix of each indicator of A Perspective and B Perspective.

Matrix *W*: indicated that under the influence of B Perspective, the pair comparison matrix of each indicator within the B Perspective.

Among which, the M' "Unweighted" Supermatrix, since the matrix column value may not conform to randomization (such as the sum of column values is not equal to 1), thus it has to undergo specific procedures to convert. Next, the maximum eigenvalue sorted out from the evaluation perspective is multiplied to carry out the matrix multiplication to obtain the weighted supermatrix, which expressed as M. Through the abovementioned transforming procedure, and conducted the limiting multiplication process, which multiplied M' by M to power $2^k + 1$ (where k is the value that determined subjectively), and then the dependence relationship will be converged gradually to obtain the relative weight between elements.

4. Research Result and Analysis

4.1 First Phase Questionnaire Survey and Data analysis

The BSC adopted 4 perspectives to evaluate the operating performance of enterprises. In

terms of these 4 perspectives: financial, customer, internal business process and learning and growth, if each main element has been sieved out more than 2 evaluation factors under each perspective, the number of sieving indicators is 8 and that will not reach BSC's suggestion of 3 to 5 KPI for each perspective. To avoid the questionnaire of "Apply ANP to Establish KPI Weight" too complicated that caused by too many indicators in the next phase, thus this study sieved out 16 key performance evaluation indicators in principle; as a result, it only sieved one previous key factor in the main elements for each perspective.

4.2 Establish Network Hierarchical Framework of Question

According to BSC's Financial, Customer, Internal Business Process and Learning and Growth perspectives to establish the Hierarchical Framework of Network, in this figure, indicators that under each evaluation perspective will be influenced by the interaction from its own perspective and other perspective indicators. This study applied the Super Decision software to build up the ANP model, as shown in Figure 2.

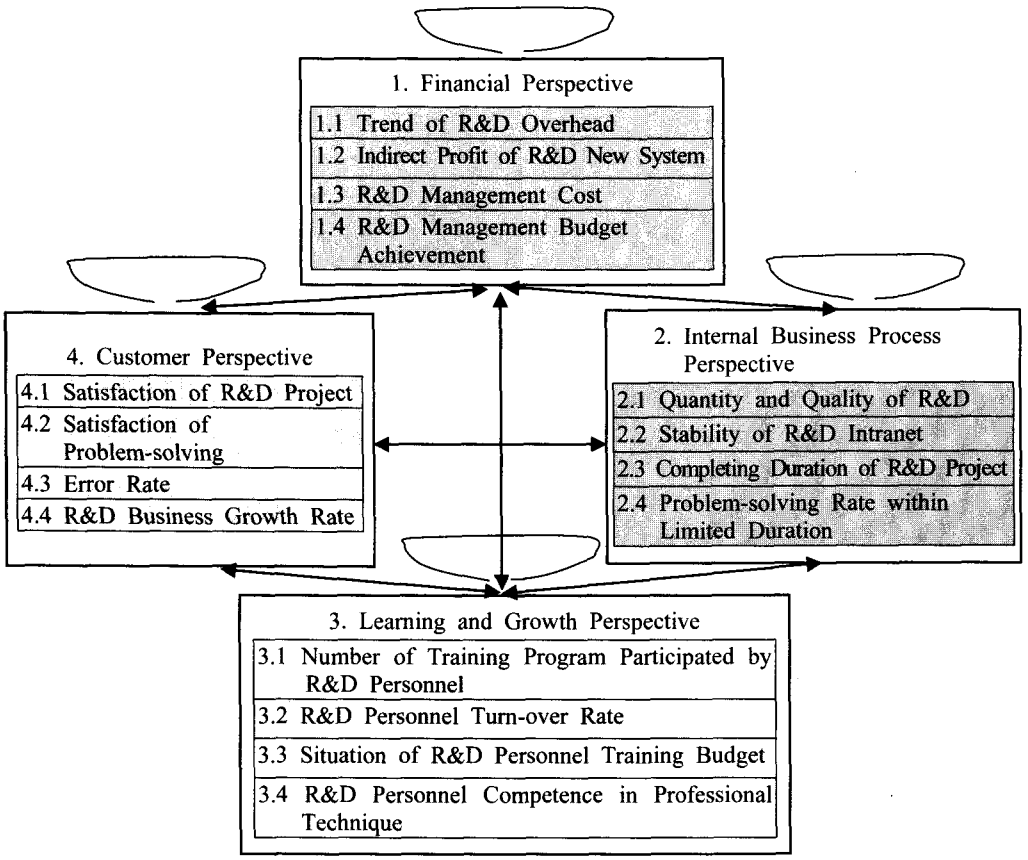

Figure 2. ANP model of decision-making software in this study

4.3 The Second Phase Applied ANP Technique to Confirm the Results Analysis of Performance Evaluation Indicators Weight

At last, this study categorized the relative weights of each key performance evaluation indicator for the R&D department, as shown in Table 1.

Table 1. Relative weight of R&D department KPI

Perspective	Evaluation Indicators	Advantageous Vector of All Elements	Priority	Ratio of Each Perspective	Priority
Financial Perspective	Trend of R&D Overhead	(0.02871)	2	11.83%	3
	Indirect Profit of R&D New System	(0.01209)	4		
	R&D Management Cost	(0.01974)	3		
	R&D Management Budget Achievement	(0.05863)	1		
Internal Business Process Perspective	Quantity and Quality of R&D	(0.04297)	3	25.47%	2
	Stability of R&D Intranet	(0.13506)	1		
	Completing Duration of R&D Project	(0.04745)	2		
	Problem-solving Rate within Limited Duration	(0.03942)	4		
Learning and Growth Perspective	Number of Training Program Participated by R&D Personnel	(0.01038)	2	6.50%	4
	R&D Personnel Turn-over Rate	(0.00925)	3		
	Situation of R&D Personnel Training Budget	(0.00803)	4		
	R&D Personnel Competence in Professional Technique	(0.02789)	1		
Customer Perspective	Satisfaction of R&D Project	(0.15508)	3	56.17%	1
	Satisfaction of Problem-solving	(0.17549)	1		
	Error Rate	(0.16826)	2		
	R&D Business Growth Rate	(0.07245)	4		

5. Conclusion

In this study, the sorting result for each criterion's dominance obtained by applying the Super Decision showed, among these 4 major BSC perspectives, the weights of the "Customer Perspective" and "Internal Business Process Perspective" were higher. As a result, it may express that the R&D department of enterprises is regarded as providing users with services but also promoting improvement in the internal business process. The weights of the "internal business process" and "customer" perspectives are higher than the other 2 perspectives;

as a result, after evaluated by experts and supervisors, as for "customer" perspective, they thought that how R&D department improve the relationship between itself and users to carry out the R&D personnel service measures, and upgrade the trust and satisfaction of customer is very important. In terms of the "internal business process" perspective, they thought that the R&D department shall improve the related R&D business procedures to ensure the effectiveness and rationality of the internal management procedures to increase the total performance for the organization. Such outcomes were also responded the R&D department, under the current environment, to the direction of its total performance evaluation as focusing on the orientation towards the customer and internal business process.

As for the "Financial Perspective Indicator," the importance degree of indicators is: R&D Management Budget Achievement, Trend of R&D Overhead, Purchasing Cost of Information, and the Indirect Profit that caused by the Development of New System; in addition, the weight value of R&D Management Budget Achievement (weight 0.05863) and Trend of R&D Overhead (weight 0.02871) are more higher than others. Thus, the results of the integration with expert opinions expressed that the financial budget of the information department mainly included the personnel costs, information soft/hardware, and expenses of project implementation, and their source is depended on the budget distribution that planned annually and the implementation in the project application. Therefore, the information department is focused on budget and expense control goals. In terms of the "Internal Business Process Perspective Indicator", the importance degree order of its indicators is the Network Stability, Completing Duration of Project, Simplified Quantity and Quality of Internal Procedure, and Problem-solving Rate within Limited Duration. The weight of "Network Stability" is the highest (weight 0.13506), which expressed it is an important and indispensable indicator to maintain the normal operation of the information system network after integrating with experts' opinions; in addition, the "Completing Duration of Project" (weight 0.04745) and "Simplified Quantity and Quality of Internal Procedure" (weight 0.04297) are also the important evaluation items that represent the internal information department is focused on the proper working procedures of systems or services, such as project management, operation demand management, problem management, control and management of the system version, document quality management, etc. In addition, the information department is also emphasized the respondent time and operating efficiency.

As for the "Learning and Growth Perspective Indicator," the importance degree order of its indicators is the Employees' Competence in Professional Technique, Number of Training Program Participated by Information Personnel, Employees' Turn-over Rate, and the Budget Situation of Annual Education Training Plan. Among which, the degree of Employee Competence in Professional Technique (weight 0.02789), Number of Training Program Participated by Information Personnel (weight 0.01038) and Employee Turn-over Rate (weight

0.00925) are higher, which showed that the information personnel need to use continuous further education and learning to upgrade their own competence in professional technique is the important direction of goal. Moreover, experts are agreed unanimously on the competence in continuously learning and accepting new knowledge is a very important measuring indicator, and, as a result, only employees who possessed good competence in professional techniques are able to ensure the system quality and promptly complete the demand of users. As for the "Customer Perspective Indicator," the importance degree order of its indicators is the Satisfaction of Problem-solving (weight 0.17549), Error Rate (weight 0.16826), Satisfaction at Project Support (weight 0.15508) and New Business Growth Rate. This outcome is responded to the unanimous agreement of experts on considering the increase of customer "Satisfaction" and the decrease in "Error Rate" are important indicators, services that provided by the information department for customers included various types of business application system or software. From the viewpoint of providing service quality to measure and divide into the information and system quality, the system quality includes safety, error rate and the degree of easy-to-use, etc. Therefore, through this, the information department wishes to provide services with high quality and efficiency and reduce customer complaints in order to build up its own value.

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