Constructing a Cost-benefit Decision Supporting Prediction Model with Considering Organizational Structure

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Abstract: - Cost Benefit Analysis (CBA) is frequently employed to evaluate the feasibility of project or plan. Most of costs and benefits are quantization items. However, we were gradually met the situation that the evaluated items can not be quantized and it had make the bother for system modeling. Besides, the characteristics of organizational structure (e.g. the viewpoint of the organizational employees) should be also taken into consideration since performing the necessary analysis. Hence, in this article, we will employ the artificial neural networks (ANNs) to construct the procedure of the cost-benefit decision supporting model with taking the consideration of employee' viewpoints. Besides, we will also apply an illustrative example to demonstrate the rationality and the feasibility for the proposed procedure.

Key-Words: - Artificial Neural Networks, Cost-Benefit Analysis, Decision Supporting Model

1. Introduction

Cost Benefit Analysis (CBA) is frequently employed to evaluate the feasibility of project or plan (Vining et al., 2001; Durairaj et al., 2002; Fuguitt & Wilcox, 1999; Murphy & Simon, 2001; Zerbe & Dively, 1994). We have to define essential items of cost and benefit in detail while the CBA is applied. And then we quantify these items by money for the procedure of estimating follow-up designate economic indicators. These items we estimated are usually intangible and difficult to quantify by money under the positive and complex environment. Only the parts are quantified by money can be analyzed while directly use various developed CBA models to treat, and the parts are difficult to quantify by money can be neglected. These results may lead to analyze individually while we made final decision, and some useful references will be given up. On the presented characteristics of organizational construction, the internal members can be considered a fundamental element of characteristics of linkage architecture. If the suggestions and opinions of internal members should be aptly taken into analytic procedures since performing valuation, the more information can be provided by performing modeling of organizational structure. In addition, how to take the opinions of members into the CBA procedure to develop an appropriate modeling will be a significant issue. System modeling is a manner that can be considered as the general traditional manufacturing industry commonly used to employ in structural analysis or manufacturing procedure analysis (Su & Hsieh, 1998; Tong & Hsieh, 2000). The information of rational concept will be a valuable reference for decision makers to employ in decision. The traditional systemic structure is to use theoretical function formula to define or structure by statistic regression. However, both manners possess some limited conditions and inconvenience while we applied. Accordingly, another new modeling technology has been highly respected by industrial and academic circles and succeeded in several domains in recent year.. That is artificial neural networks (ANNs), and one part of artificial intelligence (AI). It outlines a structural procedure of cost-benefit decision supporting model based on organizational structural characteristic. In this study, we will illustrate how to practice the constructing produce of CBA model with ANNs as mentioned above and demonstrate its practicability by leading a information system into the traditional industry in Taitung area.

2. Literature Review

2.1 CBA

According to the CBA literatures in the past, the foundation of CBA was applied to estimate the investment program since 1894. The cosumer's surplus was addressed. Nevertheless, an Act in the early twentieth century such as the river and harbor Act asking government to separately quantify and aptly analyze the economic benefit and expenses that developed a river and harbor was the first to concretize and develop the concept. That was the primary attempt on cost-benefit concept. Reputedly, CBA was formally applied by the united states flood control act in 1936. Although it defined the estimative benefit of program was more than estimative cost of program, it has never been made a rules of estimating CBA. All the analytic frameworks are basis on this foundation. After confirming what items attach to cost or benefit, the items can be available for quantification, calculation, and so much as comparison. There are also available to build up models or perform another analysis (Vining et al., 2001; Fuguitt & Wilcox, 1999; Zerbe & Dively, 1994; Boardman, 1996).

Although CBA we used in the past is available, there are some limitation and defects in CBA to perform as follows:

1. It is difficult to accurately define cost and benefit, and number of variables we input is limited.
2. The results of CBA are not the only factor the decision maker considered.
3. It is difficult to apply CBA in a fateful decision of investment.
4. The problems that incomplete information has caused.

The scope of application of CBA is very generally. As a result of the ranges of different investment projects are not all the same, the resources necessary to input and the effect of projects are also all different. The tolerable differences in the procedure of establish experimental model and quantification are due to the difference of respect or scope considered in CBA. In the primary stage of development of CBA, it mostly aimed at tangible or determinate effect of project to analyze while it is applied in experimental analysis as a result of the quantitative technology has not yet been mature. In the subsequently sustained development, the declarative account is gradually introduced into the intangible effect of project for remaining decision maker of paying attention to the importance and understanding it. A model of analytic procedure with five steps was advanced by the strategic program units of the social safety administration of United State in 1991. The purpose is to solve little to middle limited problem of budge. It means CBA is to let decision maker to know what essential factor he have to consider and what essential information he needs. In addition, it also can provide decision maker for relevant data to avoid the decision to be a subjective judgment. However, it is used to provide decision maker for more information to refer and then it make CBA to be completely.

2.2 Backpropagation neural network

Among the several conventional supervised learning neural models including the perceptron, backpropagation neural network (BPNN), learning vector quantization (LVQ), and counter propagation network (CPN), the BPNN model is frequently used (Ko *et al.*, 1998; Neural Ware, 1990; Hsieh, 2001; Hsieh, 2006) and, therefore, it will be selected herein. A BPNN consists of three or more layers, including an input layer, one or more hidden layers, and an output layer. Detailed descriptions of the algorithm can be found in various sources (Neural Ware, 1990; Rumelhart *et al*., 1986). To develop a backpropagation neural network, the training and testing data set are firstly collected. The data sets consist of both the input parameters and the resulting output parameters. The backpropagation learning algorithm employs a gradient- or steepest- heuristic that enables a network to self organize in ways that improve its performance over time. The network first uses the input data set to produces its own output. This forward pass through the backpropagation network begins as the input layer receive the input data pattern and passes it to the hidden layer. Each processing element (PE) calculates an activation function in first summing the weighted inputs. This sun is then used by an activation function in each node to determine the activity level of the processing node. The output generated by the network is compared to the known target value. If there is no difference, no learning takes place. If a difference exists, the resulting error term is propagated back through the network, using a gradient- or steepest- descent heuristic to minimize the error term by adjusting the connection weights.

The equation (Neural Ware, 1990; Rumelhart *et al*., 1986) utilized to adjust the weights following the presentation of an input/output pair for the output layer k is:

$$\Delta W_{kj} = \eta \delta_k O_j \quad (1)$$

where

ΔW_{kj} =the change to be made in the weight from the j-th to k-th unit following the presentation of an input pattern,

δ_k =the error signal for unit k after the presentation of an input pattern,

O_j =the j-th element of the output pattern produced by the presentation of an input pattern,

η =the learning rate that governs how fast the network will encode a set of input/output patterns.

The backpropagation rule for changing weights following the presentation of an input/output pair for the hidden layer j is

$$\Delta W_{ji} = \eta \delta_j O_i \quad (2)$$

where

ΔW_{ji} =the change to be made in the weight from the j-th to i-th unit following the presentation of an input pattern,

δ_j =the error signal for unit j after the presentation of an input pattern,

O_i =the i-th element of the output pattern produced by the presentation of an input pattern,

η =the learning rate that governs how fast the network will encode a set of input/output patterns.

As for the training phase, a signal input pattern is presented and the network adjusts the set of weights in all the connecting links such that the desired output is obtained at the output node. On accomplishing the adjustment, the next pair of input and output target value is presented and the network learns that association.

3. Procedure of modeling construction

3.1 The concept of system modeling construction

The system modeling is the method that commonly employed in structural analysis or processing analysis for general traditional industry (Su & Hsieh, 1998Tong & Hsieh, 2000). The primary option is the objects that we considered are regarded as Figure 1 system. Furthermore, all the information pertinent to system will be separated input system from output system depending on their unique attributes, and then it will be employed in the system modeling by the correlation between input system and output system (Tszeng, 2002). Generally, input system was categorized two types. One could be control and the other failed to control (e.g. the error terms). The effect of interruption is not generally considered in optimal system while performing in system modeling construction. Therefore, it will make the procedure of system modeling construction and the modeling analysis more easily. On the contrary, it is more distinct from practical construction of system. For the system with more indeterminate information, it doesn't only attempt to completely control all the information of practical system, but also explore the reasonable conspectus of practical system by modeling construction. The information of reasonable conspectus for decision maker will be a valuable reference.

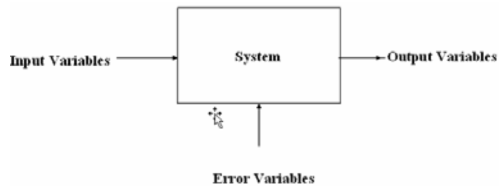

Figure 1. The conceptual diagram of a system.

3.2 Method and Procedure

There are two types of traditional construction of modeling system. One is to define by the formulation of theoretical function, and the other is to structure by statistic regressive analysis. There are some limitation existed in two manners while it is adopted. There are limitations in applying theoretical formulation. Substantially, it has to be tie-in academic theory first to control the due construction of theoretical formulation. Relative to the dynamic system, there are many limitations to apply. As for the utility of statistic regressive method to structure modeling system, it isn't necessary to completely realize the theoretical formulation of system first. However, there are some limitations in hypothesis to apply the procedure of mathematical formulation. For example, the data of modeling construction must confirm to the normality, independent character and so on. Besides, it has to past through approvable procedure with the compatibility of model after structuring model. Generally, there has some limitations of adopting statistic method in construction of model such as non-linear model, it is more likely to face the problem of selecting reasonable construction. As a result of these limitations and inconvenience, several domains have attached great importance to the new modeling technology in recent years and succeed in many applied domains. The modeling technology is namely ANNS (Hsieh, 2005; Hsieh & Tong, 2001). Subsequently, we will aim at the new modeling technology to give conceptual interpretation. As for ANNs applied in system modeling, academics such as Su & Hsieh (1998), Hsieh & Tong (2000, 2001), Hsieh (2005) had applied such option in the research on modeling construction of system.

Furthermore, it can be used by collected data from questionnaire to complete the modeling construction of system, and then provide a method and a reasonable evidence of applied procedure. Therefore, an applied ANNs was advanced in this research to structure the procedure of cost-benefit decision supporting model. The model that we structured in this research is a mode for predicting the benefit by cost input. Short for benefit gained by decision supporting model. The main thought on logistic concept is represented as Figure 2.

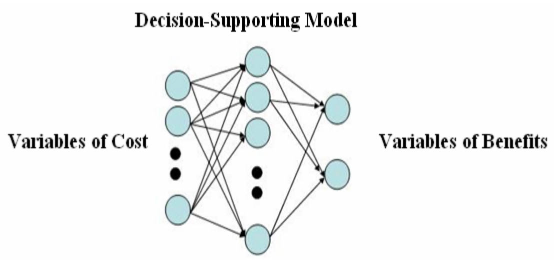

Figure 2. The conceptual diagram of decision-supporting model.

Step 1. Select variables of cost and benefit of decision-supporting model.

The essential cost and benefit items are selected to be used in case study. In order to sufficiently control relevant information of modeling construction of system, we can aptly adopt various useful references to cost according to the situation of case study, e.g. the maximum of budge, discount rate, etc.

Step 2. Collect data to construct the model.

It is necessary to collect data to construct the model after confirming the cost and benefit variables of modeling construction. To allow the construction of cost-benefit data, the useful parts are generally little. We will adopt the variables of sensitive cost items to obtain useful data to construe the model. Only one sensitive cost variable can be changed every time in practice. According to the actual demand, each changeable level of variant sensitive cost item can be selected. Naturally the more changeable level have, the more data will be obtained. It will obtain tangible effect of corresponding estimate with monetary value according to the variance of each cost item. As for intangible effect, it will be divided into two types: one is the effect to be estimated by analysts of CBA, and the other is the estimated effect of general users after introducing such a mechanism (or a system) with adjustable cost items, and therefore can lead to double effect on data of modeling construction. That is, the combination of identical cost item corresponds to the different estimated effect. In addition, that will be a reference for modeling construction because of representing the organizational construction of system in practical.

Step 3. The modeling construction of ANNs

It major purpose is to structure a BPNN network by using relative data of modeling construction in this stage. That is, it is used to find an apt model of network through try-and-error way. In this model, the cost variables will be selected for the input information and the benefit variables will be selected for the output information. It can be trained for a relational decision model that cost responds to benefit by using data. The primary parameters include:

1. The unit number of ANNs is corresponded to the layer such as input layer, hidden layer and output layer
2. The transfer functions are adopted in the construction of network
3. The network parameters such as learning rate, learning frequency, etc.

As for the model construction by using BPNN, the indicators are used to estimate the network construction. Several parameters will be taken into consideration since taking BPNN to construct model. The first part will be the parameters about the network architecture, e.g. the number of PEs for input, hidden and output layer; and the second part will be the parameters about the algorithm, e.g. the learning rate, learning count, the transfer function, etc. Hence, try-and-error way will be used at this phase. After constructing the decision-supporting model, the practitioners can input the different conditions or combination of input variables to the constructed model. Then, the predicted result can be then obtained. It will provide more information to the practitioners or managers since making the decision.

4. Illustrative example

We applied a case owing to a conventional manufacturer at Taiwan to demonstrate the rationality and feasibility of the proposed approach. In this case, the manufacturer would like to make a decision about the issue of the introduction of information strategy. Next, we will apply our proposed procedure to it.

Step 1. Determine the items to be considered.

After discussing with the managers, we also take the maximum budget, the discount rate, the initial cost and the average annual cost to be the cost items. Hence, twenty-two items of cost and eighteen items of benefits including fifteen intangible items and three tangible items were be taken into analysis.

Step 2. Collect the related data.

According to the definition of the cost-benefit, we collect the related data from the enterprise and totally have one hundred and eight data. Each data will include two parts: (1) There are eighteen statuses for the cost combination due to the level setting of the adjustable items. Those statuses will have the corresponding tangible benefits. And, the intangible benefits will be evaluated via five members who can familiar with the cost-benefit analysis in this enterprise. Hence, ninety data can be obtained including the cost combination and the corresponding intangible and tangible benefits ($(6\times3)\times5=90$). This part can be viewed as the reacted information to introduce system or strategy to the current organization; (2) We also collect the reacted information of the intangible benefit from fifteen common users via using a fixed cost combination. This part can be viewed as the information from common users to response the introduction of system or strategy. Finally, we will obtain one hundred and five data to perform the model construction.

Table 1. The evaluation table for the intangible benefits.

Item	Sub-item	option
procedure	Shorten work procedure	VG G C B VB
	Shorten management procedure	VG G C B VB
	Enhance productivity	VG G C B VB
	Shorten time	VG G C B VB
standardization	Set up work standardization	VG G C B VB
	Set up rational standardization	VG G C B VB
quality	Enhance job quality	VG G C B VB
	Beautify job result	VG G C B VB
	Enhance service quality	VG G C B VB
	Improve business image	VG G C B VB
development	Match job development	VG G C B VB
	Make rational preparation	VG G C B VB
control	Increase data link	VG G C B VB
	Provide decision information	VG G C B VB
	Enhance job safety	VG G C B VB

Herein, VG will denote the linguistic term of very good and give score of 5, G will denote the linguistic term of good and give score of 4, C will denote the linguistic term of common and give score of 3, B will denote the linguistic term of bad and give score of 2, VB will denote the linguistic term of very bad and give score of 1.

Step 3. Performing the model construction.
To simplify the operation, we take a software package, Neural Professional Plus II, to aid our model construction. After performing the necessary operations, Figure will represent the comparison diagram for the RMSE of training and testing. From Figure 3, we can obtain the optimum number of PEs to be determined as 24 due to s the RMSE of training and testing were the minimum values. The final network architecture will be set as 22-24-18, and the corresponding relation diagram can be graphically depicted as Figure 4.

The managers input the related cost items of the four candidates into our constructed model, and the corresponding benefit items can be predicted in Table 2. In order to make a simple decision, we design a comparison procedure as:

1. For the tangible benefit items: we will transfer the value into score 1~4 by comparing the four candidates: the maximum value will set as 4 and the minimum value will set as 1.
2. To sum all benefit values for each candidates, the recommendation of priority for the four candidates can be determined.

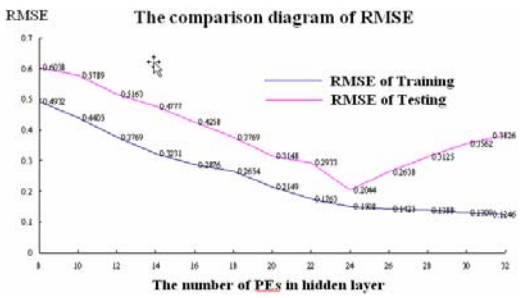

Figure 3. The comparison diagram for RMSE value of training and testing data.

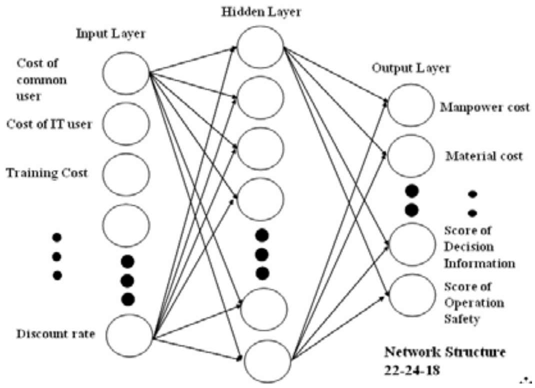

Figure 4. The constructed decision-supporting BPNN model.

Table 2. The comparison table of the predicted benefit for all candidate.

Items	Candidate 1	Candidate 2	Candidate 3	Candidate 4
Reduce manpower cost*	1	3	2	4
Reduce material cost*	3	4	2	1
Reduce space cost*	4	2	1	3
Shorten work procedur	4.32	2.92	5.01	3.01
Shorten management procedure	3.08	5.02	4.12	4.12
Enhance productivity	3.26	1.93	2.94	2.08
Shorten time	5.25	3.12	4.02	3.15
Set up work standardization	2.14	4.08	3.12	2.95
Set up rational standardization	3.22	1.88	3.25	4.08
Enhance job quality	2.03	3.12	5.13	2.25
Beautify job result	1.36	0.95	3.89	2.89
Enhance service quality	3.23	1.96	3.92	3.12
Improve business image	2.25	3.22	4.95	4.12
Match job development	1.83	1.08	4.11	3.08
Make rational preparation	3.85	1.94	2.08	1.92
Increase data link	2.87	3.11	3.21	3.92
Provide decision information	4.11	0.92	2.89	3.16
Enhance job safety	3.15	2.08	3.02	2.93
Sum	53.95	46.33	60.66	54.78
Rank	3	4	1	2

* will denote the numerical item

After performing the necessary analysis, we obtain the priority to be (candidate 3□candidate 4□candidate 1□candidate 2) in Table 2. The managers can hold more information since making the decision.

5 Concluding Remarks

In this study, we proposed a decision-supporting model to address the issue of cost-benefit with considering the characteristics of enterprise's architecture involving the viewpoint of employee. This model can include the variables with qualitative or quantitative characteristics to model construction. It will provide the opportunity to make the initial evaluation for most enterprises. The managers can rapidly obtain the related information about introducing a system, a project or a strategy to their enterprise. In this study, we also apply a case owing to a conventional manufacturer at Taiwan to demonstrating the rationality and feasibility of our proposed decision-supporting model.

References:

[1]Bhatia,Anil (1999), Customer Relationship Management, 1st ed. U.S.A.;Don Hull.

[2]Boardman, Anthony E. et al. (1996) , Cost-Benefit Analysis: Concepts and Practice, NJ: Prentice Hall.

[3]Durairaj, S. K., Ong, S. K., Tan, R. B. H, Nee, A. Y. C. (2002) , "Evaluation of life cycle cost analysis methodologies," Corporate Environmental Strategy, 9**,** 1, 30-39.

[4]Fuguitt, D. and Wilcox, S.J. (1999) , Cost-Benefit Analysis for Public Sector Decision Makers, New York: Quorum Books.

[5]Hsieh, K. L. (2005), "Parameter Optimization of a Multi-response Process for Lead frame Manufacturing by Employing Artificial Neural Networks," International Journal of Advanced Manufacturing Technology. (forthcoming)

[6]Hsieh, K. L. and Tong, L. I. (2001) , "Applying artificial neural networks to optimize the multiple quality responses mixing qualitative and quantitative characteristic," Computers in Industry, 46**,** 1, 1-12.

[7]Leavitt, H.J. (1965) , Applying Organizational Changes in Industry, Chicago: Rand McNally.

[8]Murphy, K. E. and Simon, S. J. (2001) , "Using Cost Benefit Analysis for Enterprise Resource Planning Project Evaluation: A case for Including Intangibles," Proceedings of the 34th Hawaii International Conference on System Sciences, 1-11.

[9]Su, C.-T. and Hsieh, K.-L. (1998) , "Applying Neural Network to Achieve Robust Design for Dynamic Quality Characteristics," International Journal of Quality & Reliability Management, 15, 5, 509-519.

[10]Tong, L.-I. and Hsieh, K.-L. (2000) , "A novel means of applying neural networks to optimize the multi-response problem," Quality Engineering, 16, 2, 312-320.

[11]Vining, A., Boardman, A., Greenberg, D., and Weimer, D. (2001) , Cost-Benefit Analysis: Concepts and Practice, New York: Prentice-Hall Publishing.

[12]Zerbe, R. O. J. and Dively, D. D. (1994) , Benefit-Cost Analysis: In Theory and Practice, NY: Harper Collins.