Construction of Cost Prediction Model in CBA by Using BPNN

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Abstract: - Cost Benefit Analysis (CBA) had been viewed as a technique to evaluate the performance for different systems, different projects or different strategies. However, the pratitioners will gradually meet the situation that the evaluated items can not be quantized and limit the analysis especial for model construction. Besides, the characteristics of organizational structure (e.g. the viewpoint of the organizational employees or members) should be also taken into consideration since performing the CBA analysis. Hence, in this article, we will employ the backpropagation neural network (BPNN) to construct the cost prediction 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: - Cost-Benefit Analysis, Cost Prediction Model, Backpropagation Neural Network (BPNN)

1. Introduction

Cost Benefit Analysis (CBA) is frequently employed to evaluate the feasibility or the rationality of a system, a project or a plan (Vining et al., 2001； Durairaj et al., 2002；Fuguitt & Wilcox, 1999； Murphy & Simon, 2001；Zerbe & Dively, 1994). As for the applications of CBA, we must define essential items (variables) of cost and benefit. Then, we will quantify these variables by designating economic indicators. However, those variables may have intangible form and it will be difficult to quantify by money under the positive and complex environment. For example, the method with the qualitative semantic manner will be commonly used to gain the estimate of the benefit. Only quantified parts from the viewpoint of money can be analyzed while directly use various developed CBA models. These results may lead to analyze individually while we made final decision, and some useful references will be given up. CBA procedure is the more commonly essential manner for general organizations to employ in several projects and strategies or systems. However, the findings are more likely based on the structural characteristics of organizations. On the other words, it is necessary to present useful information through analyzing several internal data or potential organizational characteristics. 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.

As a result of considering cost or benefit items, there are likely to possess the characteristic of quantification and non-quantification. 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 and used for most traditional manufacturing industries in structural analysis or manufacturing procedure analysis （Su & Hsieh, 1998；Tong & Hsieh, 2000）. For the system with more indeterminate information, completely controlling all the information of practical system does not the primary attemption. Especially, exploring the reasonable conspectus of practical system by modeling construction will be the important attemption. The information obtained from the reasonable conspectus will be a valuable reference for decision maker. 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, artificial neural networks (ANNs), has been highly respected by industrial and academic circles and succeeded in several domains in recent years. In this study, we will illustrate how to incorportae the ANNs and CBA model to address the cost-benefit analysis and to verify the rationality and feasibility by demonstrating a case which it will introduce a IT system into the traditional manufacturer at Taitung area in Taiwan.

2. Literature Review

2.1 The foundation of 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.

After World War II, the practicable scope of CBA was expended. The military expenses and the other various expenses were the appropriate objects. From 1980 to date, CBA was wildly applied to the estimate of fateful program case of investment. There have been wildly applied to various domains such as education, science research, national defense, forest, institution, city development, transports, common administration and so on. In generally, to define cost and benefit are the foundation of 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.

2.2 The application of CBA

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.

2.3 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. 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 frequently employed to achieving structural analysis or processing analysis for most industries (Su & Hsieh, 1998；Tong & Hsieh, 2000). Herein, all the information pertinent to system will be separated into input and output parts depending on their unique attributes. Then, the system can be modelled accoring to the hidden correlation among those input and output signals. Generally, two types can be formed to the input signals: one could be control and the other failed to control (e.g. the error terms). The effect of interruption is generally omitted while performing model construction. Hence, it will make the procedure of model construction and the modeling analysis more easily. On the contrary, it is more distinct from practical system. For the system with more indeterminate information, completely controlling all the information of practical system does not the primary attemption. Especially, exploring the reasonable conspectus of practical system by modeling construction will be the important attemption. The information obtained from the reasonable conspectus will be a valuable reference for decision maker.

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. Howver, some limitations will exist in two manners while they were adopted. As for the limitations in applying theoretical formulation, it has to be tie-in academic theory and the philosophy to achieve the applications. Relative to the dynamic system, there are many limitations to make it is hard to apply. As for the utility of statistic regressive method to model a system, it is not necessary to completely realize the theoretical formulation of system. However, there are some limitations in hypothesis to apply the procedure of mathematical formulation. For example, the data of model 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 modeling. Generally, there has some limitations of adopting statistic method in model construction, e.g. non-linear model is more likely to meet the problem of selecting reasonable construction. As a result of these limitations and inconvenience, several domains have attached great importance to the new modeling technologies 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 technologies to give conceptual interpretation. As for applying ANNs in system modeling, Su & Hsieh (1998), Hsieh & Tong (2000, 2001), Hsieh (2005) had applied such viewpoints in their studies. Furthermore, collecting data from questionnaire will be viewed as another way to achive the model construction. Hence, incoporating ANNs technique and questionnaire into the model construction will be a feasible way to construct a system model. The model that we structured in this study is a mode for predicting the possible cost requirement from the expected benefit. Such consideration would like to provide the decision-maker more information since evaluating the cost-benefit analysis at the initial stage. The logistic concept is represented as Figure 1.

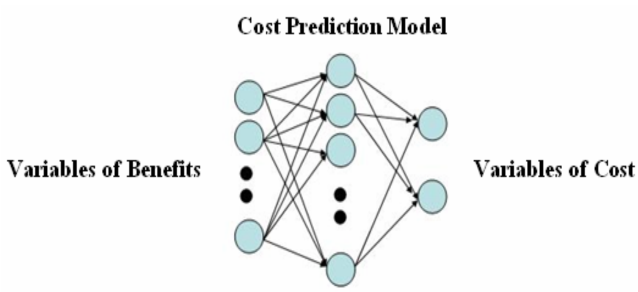

Figure 1. The conceptual diagram of cost prediction model.

Step 1. Select the considered variables of cost and benefit.

The essential cost and benefit items can be selected according to the considerations or the real requirements of managers or practitioners. 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 useful data.

It is necessary to collect data to construct the model after confirming the cost and benefit variables of model construction. However, at the initial stage, only less information can be obtained since making the cost-benefit analysis. We will adopt the sensitive cost variables to create useful data. But, 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 different combination of icost variables corresponds to the different benefit results. In addition, that will be a reference for model construction due to the potential organizational construction of system will be included into analysis.

Step 3. Model construction by using ANNs.
To structure a BPNN network by using relative data will be an the purpose of model construction. That is, it is used to find an apt architecture of network through try-and-error way. In this model, the benefit variables will be selected for the input signals and the corresponding cost variables will be selected for the output signals. 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 Taitung area in 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 IT strategy. Howvwer, only less information were provided to aid the decision-making. It will lead the managers to be a hard work. Next, we will apply our proposed procedure to solve it.

Step 1. Select the considered variables of cost and benefit.
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 useful 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 ((6×3) ×5□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. Model construction by using ANNs.
To simplify the operation, we take a software package, Neural Professional Plus II, to aid our model construction. After performing the necessary operations, Figure 4 will represent the comparison diagram for the RMSE of training and testing. From Figure 2, we can obtain the optimum number of PEs to be determined as 28 due to s the RMSE of training and testing were the minimum values. The final network architecture (i.e. the cost prediction model

based on the benefit considerations) will be set as 18-28-22.

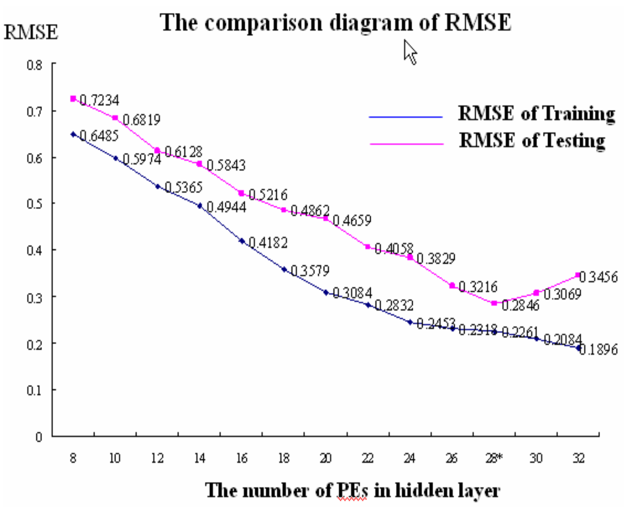

Figure 2. The comparison diagram for RMSE value of training and testing data.

After constructing the cost prediction model, the manufacturers can obtain the reference information from their expection of benefit. Such constructed model will rationally react the characteristics of enterprise architecture with the consideration of including the viewpoints of the enterprise members due to the data will react from them. The hidden information for such model will provide the reference direction to managers, avoid the managers lying in the confuse and reduce the probability of risk. Leavitt (1965) had pointed out that the architectures of enterprise will be frequently adjusted when introducing a new system or strategy due to making the perfect diamond structure. Hence, the constructed model will suitably denote the characteristics. Besides, such model can dynamically re-constructed via including the new data. Because there is less information to aid the managers making decision at the initial stages. Hence, the managers can obtain a reference infotmation by inputting their expected benefit into the cost prediction model, and the recommended costs can be predicted.

In this case, the managers provide their expected benefit and the predicted cost items will be also listed in Table 2 (in this study, we also take an example). The managers can take the predicted result to be reference information since performing the cost-benefit analysis. Hence, several possible combinations of the expected beneits can be formed according to the real considerations of managers. Then, the managers can input them into the cost prediction model and the corresponding cost terms can be obtained. Next, the managers can take them to the reference information to make their final decision.

Table 2. The result of the predicted cost terms with respect to the expected benefits..

Benefit terms	Expected benefit	Cost terms	Predicted costs
Reduce manpower cost*	60	Cost for general user*	64.2
Reduce material cost*	200	Cost for IT user*	124.3
Reduce space cost*	100	Training cost*	36.8
Shorten work procedur	5	Administration cost*	73.5
Shorten management procedure	5	Planning cost*	48.9
Enhance productivity	4	Cost for primary system*	312.5
Shorten time	4	Cost for workstation*	100.6
Set up work standardization	4	Cost for network devices *	152.8
Set up rational standardization	4	Cost for communication devices*	221.5
Enhance job quality	5	Cost of setup*	18.2
Beautify job result	4	Cost of consumables*	269.8
Enhance service quality	5	Cost for procurement*	295
Improve business image	4	Cost for system development*	112.8
Match job development	5	Cost for system usage *	66.9
Make rational preparation	5	Cost for system maintain*	156.2
Increase data link	5	Cost for setup control room *	52.5
Provide decision information	4	Cost for peripheral equipments*	63.7
Enhance job safety	4	Cost for preservation*	33.8
		Cost for maximum allowable budget *	722.5
		Cost for the first investment*	187.3
		Average annual cost*	653.8
		Discount rate	0.05

* will denote the numerical item

5 Concluding Remarks

In this study, we proposed a cost prediction model to address the issue of cost-benefit with considering the characteristics of enterprise's architecture involving the viewpoint of enterprise's members. This model can include the variables with qualitative or quantitative characteristics to model construction. It will provide the opportunity to make the initial evaluation since making the cost-benefit analysis for most enterprises. The managers can rapidly obtain some reference 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 Taitung area in Taiwan to demonstrating the rationality and feasibility of our proposed cost prediction model.

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