The Construction of Cost-Benefit System via ANNs Technique

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Abstract: - As we known, the technique of cost Benefit Analysis (CBA) had been frequently employed to evaluate the project plan for most enterprises until now. However, the organization architecture is seldom been mentioned since performing CBA technique. However, the modelling applications will not include all information. Besdies, for most managers, if they can early obatin more information about the cost investment or if they can predict the possible benefit at the initial stage of analysis, they can make the suitable decision-making. In this article, we will employ the artificial intelligence (AI) technique to construct a cost/benefit and benefit/cost prediction model. An illustrative example is then employed to demonstrate the rationality and the feasibility for the proposed procedure.

Key-Words: - Cost-Benefit Analysis, Cost Prediction Model, Benefit 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.

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）. 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 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). 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.

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). 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.

3. Procedure of modeling construction

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.

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. As for cost prediction 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.

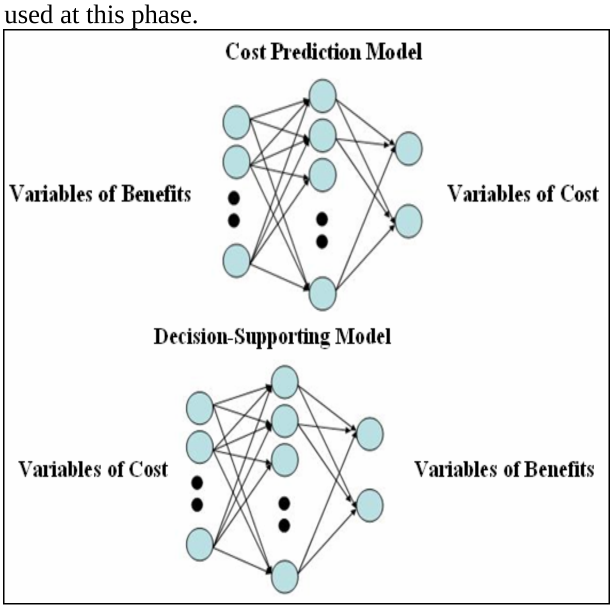

Figure 1. The conceptual diagram of benefit prediction model and cost prediction model.

Next, as for the benefit prediction model, the benefit variables will be selected for the output signals and the corresponding cost variables will be selected for the input signals. The procedure of model construction will be same as the model construction of cost prediction. After constructing those two models, a decision-supporting step will be made, the practitioners can input the expected benefits to the cost prediction model. The predicted cost terms of the ideal condition will be obtained. Next, the practitioners can make comparison to determine the one with the similar cost terms. Then, inputting the cost terms of this cadidate into the benefit prediction model to verify if the result of predicted benefits are similar as the expected benefits. If the difference can be accepted by practitioners, the corresponded project can be then determined as the optimial choice. Otherwise, the model will be necessary to re-constructed or the cost/benefit terms will be also re-evaluated.

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 ($(6\times3)\times5=90$). 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. As for the intangible benefits, we will evaluate it by using scoring technique. 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.

Fisrtly, we will construct the cost benefit model. The related parameters about BPNN will be given as follows:

1. Processing elements of input layer: It includes 18 variables and the number of PEs will be set as 18.
2. As for the hidden layer, we will choose one hidden layer due to that it is the sutiable decision after pilot

run.

3. The ratio of traing and testing data is set as 4:1, that is, there are 84 training data and 21 training data.
4. The learning rate will be set as 0.15 and the momentum will be set as 0.8 after performing several pilot runs.
5. The transfer function will be determined as Sigmoid function.
6. The stopping criterion, i.e. training epoch, will be set as 10000.
7. The number of PEs of the output layer will be set as 22 due to that there are twenty-two benefit items.
8. We will initially set the average PEs of the input and output layer (20) to the number of PEs in hidden layer. Then, try-and-error method will aid us making the finally decision to it.

To simplify the operation, we take a software package, Neural Professional Plus II, to aid our model construction. After performing the necessary operations, Figure 2 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.

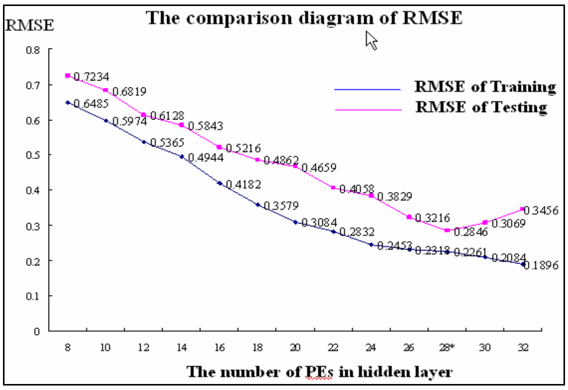

Figure 2. The comparison diagram for RMSE value of training and testing data.

Next, we will constrcut the benefit model by using BPNN. And, the construction procedure is the same as the procedure of cost prediction model. Figure 3 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.

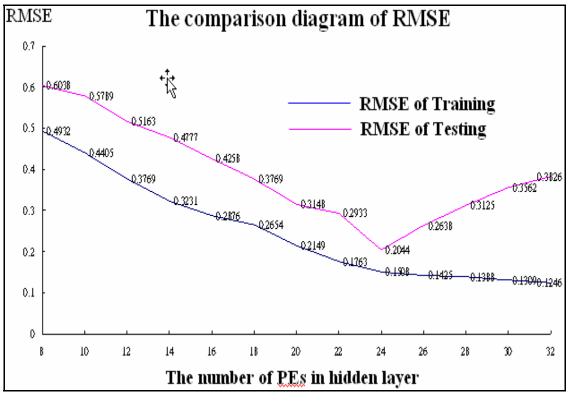

Figure 3. The comparison diagram for RMSE value of training and testing data.

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 1 (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.

Table 1. 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

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. Next, the managers will apply the constructed model into analyzing the procurement of IT systems. Four IT systems will be included into the final decision-making and the corresponding cost terms of those four candidates will be listed in Table 2. After making the comparison of cost terms for those four cases to the predicted coste we obtained, we can find out that the cadidate 3 has the similar cost terms. Then, we will input the actual cost terms of candidate 3 into the benefit prediction model to verify the if the predicted benefit terms is the same as the expected results. The results of the predicted benefit terms will be listed in Table 3. From Table 3, we can verify the result is very close to the practitioners' expected benefit. Hence, candidate 3 will be the optimal choice in this case.

Table 2. The costs of the four candidates.

Cost terms	Cost of candidate 1	Cost of candidate 2	Cost of candidate 3	Cost of candidate 4
Cost for general user*	60.5	62.5	**68.5**	81.2
Cost for IT user*	164	115.2	**108.4**	162.3
Training cost*	45	32.7	**45.2**	51.2
Administration cost*	96	81	**79.5**	76.9
Planning cost*	64.8	63.9	**51.2**	62.4
Cost for primary system*	325	360	**308.8**	320
Cost for workstation*	96.6	125	**103.2**	112
Cost for network devices *	177.5	142	**156.2**	164
Cost for communication devices*	250	268	**230.5**	240.5
Cost of setup*	24	30	**24.3**	20.5
Cost of consumables*	260.5	306	**275.4**	275
Cost for procurement*	280	310	**302.5**	310
Cost for system development*	145	125	**116.2**	112
Cost for system usage *	83	72.5	**73.8**	80
Cost for system maintain*	183.5	163	**162.9**	142
Cost for setup control room *	66.3	50.6	**56.8**	52
Cost for peripheral equipments*	76.8	65.2	**66.2**	74
Cost for preservation*	42.5	34.8	**36.2**	45
Cost for maximum allowable budget *	764	767	**736.9**	768
Cost for the first investment*	212	204	**192.5**	200.5
Average annual cost*	792	712.5	**680.2**	763
Discount rate	0.04	0.06	**0.063**	0.04

Table 3. The predicted benefit of the candidate 3.

Cost terms	Predicted costs	Benefit terms	Expected benefit
Cost for general user*	68.5	Reduce manpower cost*	54.8
Cost for IT user*	108.4	Reduce material cost*	192.6
Training cost*	45.2	Reduce space cost*	95
Administration cost*	79.5	Shorten work procedur	4.63
Planning cost*	51.2	Shorten management procedure	4.42
Cost for primary system*	308.8	Enhance productivity	3.87
Cost for workstation*	103.2	Shorten time	3.48
Cost for network devices *	156.2	Set up work standardization	3.62
Cost for communication devices*	230.5	Set up rational standardization	4.18
Cost of setup*	24.3	Enhance job quality	4.59
Cost of consumables*	275.4	Beautify job result	4.22
Cost for procurement*	302.5	Enhance service quality	4.69
Cost for system development*	116.2	Improve business image	3.86
Cost for system usage *	73.8	Match job development	4.77
Cost for system maintain*	162.9	Make rational preparation	4.59
Cost for setup control room *	56.8	Increase data link	4.88
Cost for peripheral equipments*	66.2	Provide decision information	3.62
Cost for preservation*	36.2	Enhance job safety	4.18
Cost for maximum allowable budget *	736.9		
Cost for the first investment*	192.5		
Average annual cost*	680.2		
Discount rate	0.063		

5 Concluding Remarks

In this study, we proposed a prediction system to address the issue of cost-benefit analysis with considering the characteristics of enterprise's architecture involving the viewpoint of enterprise's members. Two models will be included in this system, the variables with qualitative or quantitative characteristics can also be constructed. 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. However, there are several remarks will be made in this study:

1. We only take the viewpoint of employee to analyze the cost-benefit and it will be not enough to the real analysis. Hence, it will be necessary to find out more variables from the related theories to aid the decision-making.
2. At this time, those variables including the cost terms or benefit terms will be set as the same weight. In the future, taking different weight will be a suitable study direction to improve the performance.

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