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Artificial Neural Network Modeling in Forecasting Successful Implementation of ERP Systems

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***Abstract*: Artificial Neural Network (ANN) is widely used in business forecasting. ANN is a powerful forecasting tool. It is suitable for solving complex problems. Recently, ANN has been applied in many varieties of business decision making, such as bankruptcy forecasting, customer churning prediction, stock price forecasting, business process innovations, and systems development. In this study, we investigated the usefulness of the ANN model in forecasting success when implementing Enterprise Resource Planning (ERP) systems. We used an ANN method to compare the performance of three different models: ANN, Multivariable Discriminant Analysis (MDA), and Case-based Reasoning (CBR). Experimental results show that the ANN approach is a promising method for forecasting successful ERP implementation.**

***Keywords*: ERP, ANN, MDA, CBR, forecasting, decision making.**

I. INTRODUCTION

In order to forecast problems more accurately in management, an Artificial Neural Network (ANN) model has been applied in many varieties of business decision making [5], [8], [9], [12], [13], [15]. For example, ANN is widely used by companies for forecasting bankruptcy, customer churning, and/or stock price forecasting. In this study, ANN is applied for solving problems in forecasting a successful implementation of Enterprise Resource Planning (ERP) systems.

We have developed a template for the performance measurement of an ERP systems implementation based on prior studies of related ERP systems [1], [2], [3], [4], [8], [13]. The template is composed of the following four components: that project planning, AS IS process design and analysis, TO BE process design and analysis, and ERP systems development and operation.

In developing the best prediction model for ERP systems implementation success, this study applied the ANN model. We used an ANN method to compare the performance of three different models: ANN, Multivariable Discriminant Analysis (MDA), and Case-based Reasoning (CBR). The result of this research showed a more accurate forecasting model of the ERP systems operation for a company. In this result, guidelines for successful ERP system implementation and operation are indicated for ERP project managers and CEOs.

This paper consists of five sections, including the introduction. Section II introduces the basic concept and business application of ANN. Section III proposes the ANN approach for forecasting a successful implementation of ERP systems and describes the research design and experiments. Section IV summarizes and discusses the results. In the final section, conclusions and limitations of this research are presented.

II. Research Background

ANN is widely used in business forecasting. ANN is a powerful forecasting tool. It is suitable for solving complex problems. ANN consists of an input layer, a hidden layer, and an output layer. It has a processing element, which is modeled on neuron function as a basis. Linkage weighting between the processing elements can be calculated through the circulation of the input layer, the hidden layer, and the output layer.

The most frequently used activation function is the sigmoid function in ANN. The advantage of using ANN is that it provides the best result for defining the relationship between independent variables and dependent variables.

ANN is an algorithmic theory of machine learning imitating human brain activity based on its experiences and knowledge. In 1943, McCulloch and Pitts presented the first neuron model. In 1949, the Canadian psychologist Hebb suggested systematic rules in controlling linkage intensity.

ANN was then applied in diverse fields. In 1958, Rosenblatt showed the ANN algorithm.

Although problems in systematically determining the hidden layer, the learning rate, and over fitting and under fitting exist with ANN [3], despite these minor problems, ANN seems to offer superior performances over the logistic regression analysis or MDA [8], [11]. Therefore, ANN is applied in many varieties of business decision making, such as bankruptcy forecasting, customer churning prediction, and stock price forecasting. Application research using ANN has been diverse for a long time.

For example, Fletcher and Coss [5] who used ANN in forecasting a bankruptcy of a corporation proved that ANN performed better in forecasting than logistic regression analysis did. Tam, Kiang [9] also verified that ANN is superior in forecasting the bankruptcy of a bank. Recently, many research studies are in the process of using ANN to improve the performance of forecasting with fuzzy membership function, genetic algorithms, and case-based reasoning. Yang et al. [12] have proved that probabilistic neural networks using neural networks in forecasting a bankruptcy are more useful than the existing simple back propagation neural network or MDA. Roy [16] proposed a stock classification model using neural networks. Lam [17] demonstrated the usefulness of neural networks as a post-processing model for improving forecasting performance and for explaining the performance logic to managers. Walczak [18] applied a neural network in the prediction of future currency exchange rates.

In this study, we applied the ANN model for predicting the successful implementation of ERP systems.

III. The Research Design and Experiments

A. Research Data

In this research, we analyzed ERP system articles, and then found relevant research variables [1], [2], [3], [4], [8], [13]. The 13 independent variables were established as the ERP systems implementation process using the Critical Success Factors (CSF) method through in-depth interviews with 15 ERP specialists [14]. The ERP systems implementation process is comprised of the following 13 variables grouped in 4 component parts <Tables 1, 2, 3, and 4>:

Factors of ERP Systems implementations	Feature Name of CSF
project purpose, project period, project scope, project method definition, performance planning, budget planning, project resource allocated role, project team setting, project schedule planning, team leader quality, project step output, seminar and reporting, consultant practice, ERP expert practice etc	1. project purpose and scope 2. project period and budget planning 3. project team and allocated role 4. project output reporting and control

Table 1. CSF of ERP planning

Factors of ERP Systems implementations	Feature Name of CSF
AS IS process definition, AS IS process analysis, task and business problem analysis and design, task standardization level measurement, AS IS application analysis, D/B, S/W, H/W, N/W analysis, AS IS organization and task analysis, culture analysis, best practice benchmarking	5. AS IS process analysis 6. AS IS system analysis 7. AS IS organization analysis

Table 2. CSF of AS IS process

Factors of ERP Systems implementations	Feature Name of CSF
gap analysis of AS IS process and TO BE process, TO BE process definition. TO BE data model definition, TO BE application system definition, TO BE infrastructure definition, TO BE organization structure definition, TO BE task definition, TO BE performance definition	8. TO BE process analysis 9. TO BE systems analysis 10. TO BE organization analysis

Table 3. CSF of TO BE process

Factors of ERP Systems implementations	Feature Name of CSF
IT structure detail design and analysis, level setting of business supporting system, database, interface, data transformation, add-on program, back up of data and database, recovery strategy, manual, test of module function, interaction test among modules, integrated testing of total system, real time service system, new system monitoring, operation authority planning about multi users, cost and profit analysis of systems operation, education of maintain, repaired etc	11. ERP systems design and programming 12. ERP systems testing 13. ERP systems operation and maintaining.

Table 4. CSF of ERP development

The first component, ERP project planning, is composed of project purpose and scope, project period and budget planning, project team and properly allocated role, and project output reporting and control. The second component,

AS IS process design and analysis, is composed of AS IS process analysis, AS IS system analysis, and AS IS organization analysis. The third component, TO BE process design and analysis, is composed of TO BE process analysis, TO BE systems analysis, and TO BE organization analysis. The fourth component, ERP systems development and operation, is composed of ERP systems design and programming, ERP systems testing, and ERP systems operation and maintaining.

Feature	Data	Mean	S.D.
1	108	3.4259	.90898
2	108	3.3148	.97298
3	108	3.4167	.98707
4	108	3.3333	.93729
5	108	3.3611	.93187
6	108	3.3704	.91297
7	108	3.4074	.92763
8	108	3.3981	.95643
9	108	3.5000	.94226
10	108	3.2407	.91580
11	108	3.3519	.98886
12	108	3.3426	1.04266
13	108	3.3056	.99022

Table 5. Descriptive Statistics

Survey questionnaires to measure the independent and dependent variable were employed to target Small and Medium sized Enterprises (SMEs) using ERP systems. Each independent and dependent variable question was assessed using a 5-point Likert-scale format. The dependant variables measured Information System (IS) quality, information quality, task efficiency, and decision support. For forecasting purposes, the dependent variable was set at '1' for the success of ERP implementation and '0' for the failure of ERP implementation .

This survey was administered from August through September 2002 to ERP systems managers of SMEs. The surveys were collected on-line from a survey website supported by the Small Business Corporation (SBC) of Korea, a national organization. Of the 174 surveys collected, data from 108 were used for analysis after discarding insufficiently answered surveys. The forecasting model used 13 meaningful variables <see Table 5 for descriptive statistics>.

B. Research Methods

This research has compared the performance of forecasting a successful implementation of ERP systems using ANN, CBR, or MDA models, as mentioned earlier. The ratio for the training data set and holdout data set is 80:20 for the test. The results consist of 86 of the training data set and 22 of the holdout data set. This research did not employ linear scaling because the research data were already normalized by the five-point Likert type scale.

C. CBR

CBR has some characteristics that distinguishes it from the other Artificial Intelligence (AI) techniques. CBR is able to modify or adapt a retrieved solution when applied in a different problem-solving context. CBR uses the k-Nearest Neighbor (k-NN) method for finding similar cases. The popular method [formula?] of k-NN is Euclidean distance, as follows.

$$d(X, Y) = \sqrt{\sum_{i=1}^{p} w_i (x_i - y_i)^2}$$

Where d (X, Y) is a distance X and Y, I and j are the values for attributes *x* and *y* in the input and retrieved cases, p is the number of attributes, w_i is the importance weighting of the attributes *x* and *y*. In this study, CBR uses 1-NN algorithm for the total holdout data set.

D. MDA

In this study, an MDA model is used as a benchmark. In building the MDA model for predicting successful ERP systems implementations, we need to forecast a precise cut-off value showing a clear distinction between samples. An MDA is a useful technique for forecasting ERP systems implementations. An MDA function is represented as follows.

$$Z = W_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_i X_i$$

Where Z-scores refer to a discriminant score, and W represents cut-off values. Z and Xs indicate dependent and independent variables respectively. Statistical analyses were done using SPSS version 11.0.

E. ANN

This study compares the performance of ANN and those of CBR and MDA methods. ANN uses various components such as input layers, hidden layers, and output layers. Since the design of ANN is rather close to an art, its performance is dependent on the levels of hidden layer numbers, hidden node numbers, learning rate, and momentum.

According to Hornik [7], controlling only a hidden layer number and hidden node number, we can have satisfactory results on the classification problem. Due to the small data set, we control the hidden layer number of ANN as 1 in our experiment (hidden node numbers are 8, 16, 32, and 64). In addition, we use the basic option of Neuron Intelligence software, online back propagation algorithm, the learning rate is 0.1, and momentum is 0.1.

Hidden Node	8	16	32	64
Training Data	98.65%	98.65%	98.65%	98.65%

Holdout Data	94.12%	94.12%	94.12%	94.12%

Table 6. Forecasting performance of ANN

IV. Result

The prediction performances of ANN, CBR and MDA models are compared in this section. As shown in Table 7, ANN achieves higher prediction accuracy than MDA by 21.42% for the holdout data. ANN achieves higher prediction accuracy than CBR by 16.85% for the holdout data. According to this experimental result, the forecasting performances of our ANN model outperform CBR and MDA models.

Model	CBR	ANN	MDA
Training Data	-	98.65%	88.40%
Holdout Data	77.27%	94.12%	72.70%

Table 7. Best forecasting performance of CBR, ANN, MDA

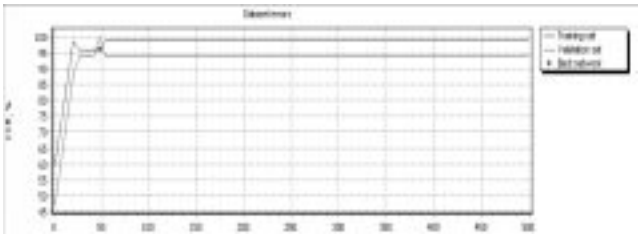

Figure 1. Hit ratio of ANN after 500 training iterations

According to this research outcome, using ANN to forecast a successful implementation of ERP systems is the best choice. The order of outstanding performances of forecasting is the following: MDA < CBR < ANN.

V. Conclusion

In this research, we suggested an ANN model to forecast a successful implementation of ERP systems. The result showed that our proposed model, the ANN model, outperforms CBR and MDA models. The result is very significant in that ERP project managers can better control ERP system projects with this model.

However, this research has some limitations. First, the experimental data sample is small. Therefore it is necessary to collect more samples from various-sized companies using ERP systems. Second, the variables for measuring the implementation of ERP systems were used with restricted ERP project variables. Therefore, it is necessary to conduct more studies using a greater variety of variables for more applicability.

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