A Hybrid Method using Analytic Hierarchical Process and Artificial Neural Network for Supplier Selection

S. H. Tang, N. Hakim, W. Khaksar, M. K. A. Ariffin, S. Sulaiman, and P. S. Pah

***Abstract*—A hybrid approach between the Analytic Hierarchical Process (AHP) and Artificial Neural Network (ANN) has been developed to evaluate and select the best supplier for shoes manufacturing. Firstly, questionnaire was setup based on previous study to obtain supplier selection criteria for shoes manufacturing. The proposed hybrid methodology uses the AHP to determine the local and global weights of criteria, and the ANN method to select the best supplier. In order to grasp this evaluation and selection, result calculated by AHP is compared to the result of ANN.**

***Index Terms*—Supplier selection, shoes manufacturing, analytic hierarchical process, artificial neural network.**

I. Introduction

Supplier selection has always been a complicated problem that undoubtedly concerned a lot of academics and practitioners to scrutinize the subject matter. Although being characterized as one of the most discussed subject in many publications, most of the theoretical selection methods available in the literatures are actually not being employed in the real industrial world [1]. The possible reason is stand alone supplier selection methods have reliability issue in solving the real supplier selection problem.

Most of the literatures agreed that supplier selection problem is a multiple criteria decision making (MCDM) problem which includes both quantitative and qualitative factors. The supplier selection process would be simple if only one criteria were used in the decision making process. Though in many situations, purchasers have to take account of a range of criteria in making their decisions [2]. However, the risk in selection process is unable to be fully satisfied by using the MCDM methods alone. This is where another method must be integrated. The Analytic Hierarchal Process (AHP) was found widespread application in decision making problems, involving multiple criteria in systems of many levels [3]. Though, AHP depends on human intuition, especially in method of pair wise comparison [4], and any lack of information regarding the supplier selection criteria may disturb the evaluation process. To overcome this difficulty, we combine the AHP with Artificial Neural Network (ANN) and propose a hybrid AHP-ANN methodology in this paper. Integrating the AHP and ANN could compensate on each other's drawback in satisfying the requirements of the supplier selection process. The effectiveness of our approach is demonstrated through the example of shoes manufacturing that finds the related criteria, evaluate and select the best supplier.

There is a numerous research on the supplier selection criteria since 1960's which initiated by an extensive research by Dickson (1966) [5]. Almost 57 percent (42 out of 74 articles) of the articles regarding the supplier selection criteria have appeared since 1985 [6]. Dickson's (1966) [7] work is considered the pioneer in the area of supplier selection criteria. Generally, the 23 criteria presented by Dickson (1966) still cover the majority of those presented in the literature until today which are quality, delivery, and performance history is on the top of criteria [7]. Reflect to evolution of the industrial environment such as Just-In-Time (JIT) environment, the degree of importance has been changed. For example, the importance of geographical position changed whereas this criterion appeared in the 20th position in Dickson's (1966) study [6]. Currently, net price is the most important criteria, followed by quality and delivery [8]. While some of the criteria have changed, the major criteria have remained the same, which strengthens their significance. In order to decide the supplier selection method, the consideration needs to be emphasized on the sourcing method either it is single sourcing (total demand is purchased from the best supplier) or multiple sourcing (total demand is purchased from several suppliers) [9].

AHP had widely been in use for solving multi-level criteria for supplier selection despite its time consumption to finish the process. To ease the process, a web-based AHP system had been developed [10] which the decision maker needs to determine the relative importance weighting for the criteria and the supplier need to fill their specification information into the system [11]. Data Envelopment Analysis (DEA) is integrated to AHP due to the AHP method can only compare a very limited number of decision alternatives [12]. On other study, DEA was integrated into AHP to solve various problems [13]-[15], and Fuzzy AHP had been used to represent decision makers comparison judgment and decide the final priority of different criteria [16].

ANN is known for its ability through learning process [17] and claimed to be helpful for practical industrial applications especially for dynamic situations [11]. Many papers used the ANN with other methods, such as ANN-DEA [18]. Genetic Algorithm (GA) also had been integrated with ANN, where the ANN was responsible for benchmarking the potential suppliers with respect to four evaluating criteria, and GA was used to determine the best combination of suppliers [19].

The hybrid model of AHP and ANN with four supplier selection criteria for manufacturing organization was introduced [11]. Two modules were used; module 1 applied

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AHP to calculate the weight of each criterion and module 2 used ANN to select the best supplier. They claimed to be first one that jointly AHP and ANN methods.

II. Methodology

The methodology consists of three modules; module 1 develops the questionnaire from previous study and send to the shoes manufacturing company. Module 2 applies AHP to calculate the local and global weights of criteria. Module 3 utilizes the ANN to select the best supplier.

A. Module 1: Develop the questionnaire

Supplier selection criteria from previous study [8] had been used to develop the questionnaire. The weights of criteria in this questionnaire are in the range of 1 to 9. Three respondents from selected company filled the questionnaire by comparing the importance between each criterion on every level (six criteria, sixteen sub-criteria, and thirty six sub-sub criteria).

B. Module 2: Develop the AHP

Based on the results of questionnaire, AHP had been developed. The process will be through a pair-wise comparison to determine the local weights of each criterion. Normal procedure in AHP had been followed accordingly. In this step, average result from three respondents is determined and undergoes the pair wise comparison. Consistency Ratio (CR) for every obtained local weights is calculated to measure how consistent the judgment of the respondents. CR value less than 0.1 will be accepted. Then, value of global weights is calculated by multiplying local weights of criteria to local weight of sub-criteria, and to local weight of sub-sub criteria. The example of calculation is *Trust (0.427) x Inter personal trust (0.753) x Trust between key men (1.00) = 0.3217*. Global weight for every supplier taken from previous study [8] is multiple with global weight weights of criteria which result to total score.

C. Module 3: Develop the ANN

In this step, 168 ANN networks are developed that consist of fourteen different training algorithms and twelve different configurations for each training algorithm. Thirty five inputs (number of sub-sub criteria) and one output are used. The network had been developed using MATLAB Toolbox: Neural Network Toolbox (R2008a). Information from previous study [8] has been used as a training data. During training, value of Mean Square Error (MSE) for each network is determined, and the lowest value of MSE indicates the best training performance. For testing process, results from AHP are used to as testing data. Only the best network within each training algorithm had been tested, and their performance was measured with coefficient of determination (B). Network that has $B \geq 0.9$ is considered the best network. Prediction of best supplier by the ANN is compared to the result calculated from AHP.

III. Results and Conclusion

Trust becomes the most supplier selection criteria for shoes manufacturing, followed by cost, and quality. Certainly, in challenging business world, trust issue is more important, that lead the mutual partnership between the manufacturer and the supplier. The proposed hybrid AHP-ANN with $35\text{-}[15\text{-}5]_2\text{-}1$ configuration and Levenberg-Marquardt (trainlm) training algorithm gave the best prediction quality with B = 0.86071. It shows a good prediction result against the result calculated by AHP as illustrated in Table 1 and Fig. 1.

TABLE I: Total Score by Method

Supplier/ Method	AHP	ANN	Difference |AHP-ANN|
Supplier A	0.288191	0.281888	0.006303
Supplier B	0.179896	0.184882	0.004985
Supplier C	0.385212	0.413936	0.028724
Supplier D	0.129136	0.196727	0.067590

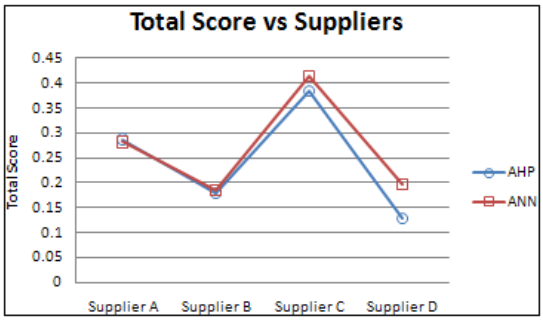

Fig. 1. Total score vs supplier

The main contribution of this paper was in integrating the using of AHP method with ANN method, later known as an AHP-ANN hybrid method. It is very attractive to develop a hybrid model, which involves the advantages of both.

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