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AN APPROACH TO USING THE GREY- ANALYTIC HIERARCHY PROCESS (G-AHP) FOR SUPPLIER PERFORMANCE MEASUREMENT

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ABSTRACT

In this paper, we present a procedure for assessing supplier's performance, which is an extension of the Analytic Hierarchy Process, which its integrated to Grey Theory methods. Reseachers use different methodologies of MCDM to solve supplier evaluation and selection problems. Integrated AHP, which it is implemented in the software package Expert Choice. The rangking of supplier's perfomance is calculated with grey theory methods after its calculated by AHP procedure. Some specific criteria for measure the performance of the chemical suppliers, among others: guarantee product quality, the accuracy of product delivery to the laboratory suppliers, communication between laboratories and suppliers, after sales service, handling of complaints by suppliers and prices of products. The data obtained are primary data obtained from questionnaires and performance measurement Chemical Supplier Paiton Unit 9 at the laboratory of water later on though the method of Grey- Analytic Hierarchy Process (G-AHP). We present a procedure for supplier performance measurement using G-AHP.Value weighting of votes chemicals supplier performance in PT. PJB UBJ O & M by the method of Grey- Analytic Hierarchy Process (G-AHP) is the weight values for Supplier "A" against the criteria of 0,498, weight values for Supplier "B" against the criteria of 0,942, weight values for Supplier "C" against the criteria of 0,908, and weight values for Supplier "D" against the criteria of 0,711. So, the best chemical supplier, which its calculated by G-AHP is Supplier A.

KEYWORDS : Supplier performance, Analytic Hierarchy Process, Grey Theory, Expert Choice

1. INTRODUCTION.

Supplier selection is an issue of strategic importance for any company. Since by deciding the best supplier, companies can save material cost and increase competitive advantage. Supplier evaluation is necessary to know what the supplier is doing well in each area of action. There are several evaluation models for supplier selection and evaluation in the literature (Chaharsooghi and Ashrafi, 2014; N. Aissaoul, et al., 2007; I. de Boer et al., 2001). Measuring supplier performance, which includes multi criteria and multiple conflicting objectives, can be defined as the process of finding the right suppliers. Since this selection process mainly involves the evaluation of different criteria and various supplier attributes, it can be considered as a multiple criteria decision making (MCDM).

The Analytic Hierarchy Process (AHP) has been used in various setting to make decisions and solving multiple criteria decision making problems. Several papers have compiled the AHP succes in very different fields (Ishizaka Alessio and Labib ashraf, 2009; Ayhan M.B., 2013). Multiple criteria has led to AHP applications in conjunction with many other decision support tools and methodologies, recent years, many researchers using fuzzy AHP applications for supplier selection problem, but some negative comment or criticism on Fuzzy theory have been subject too for some researchers (Abdullah Lazim, 2013). Although many authors have expressed critisms of AHP, but the popularity of AHP for solving problem MCDM is a fact (Whitaker, 2007). The Grey Theory method is a method for decision making characterized by incompplete information under the multi-dimensional decision circumstance, providing a flexible approach using different weighting coefficients. Since the AHP have some criticism because of weaknesses and have been subject of substantial debate among specialis in MCDM metods, we interest to integreted AHP and Grey theory for supplier performance evaluation. The Grey-AHP is expected to fit the best supplier performance evaluation, providing a simple and straightforward method. The purpose of this paper is to present a procedure for assessing supplier's performance, which is an extension of the Analytic Hierarchy Process, which its integrated to Grey Theory methods.

2. METHODOLOGY

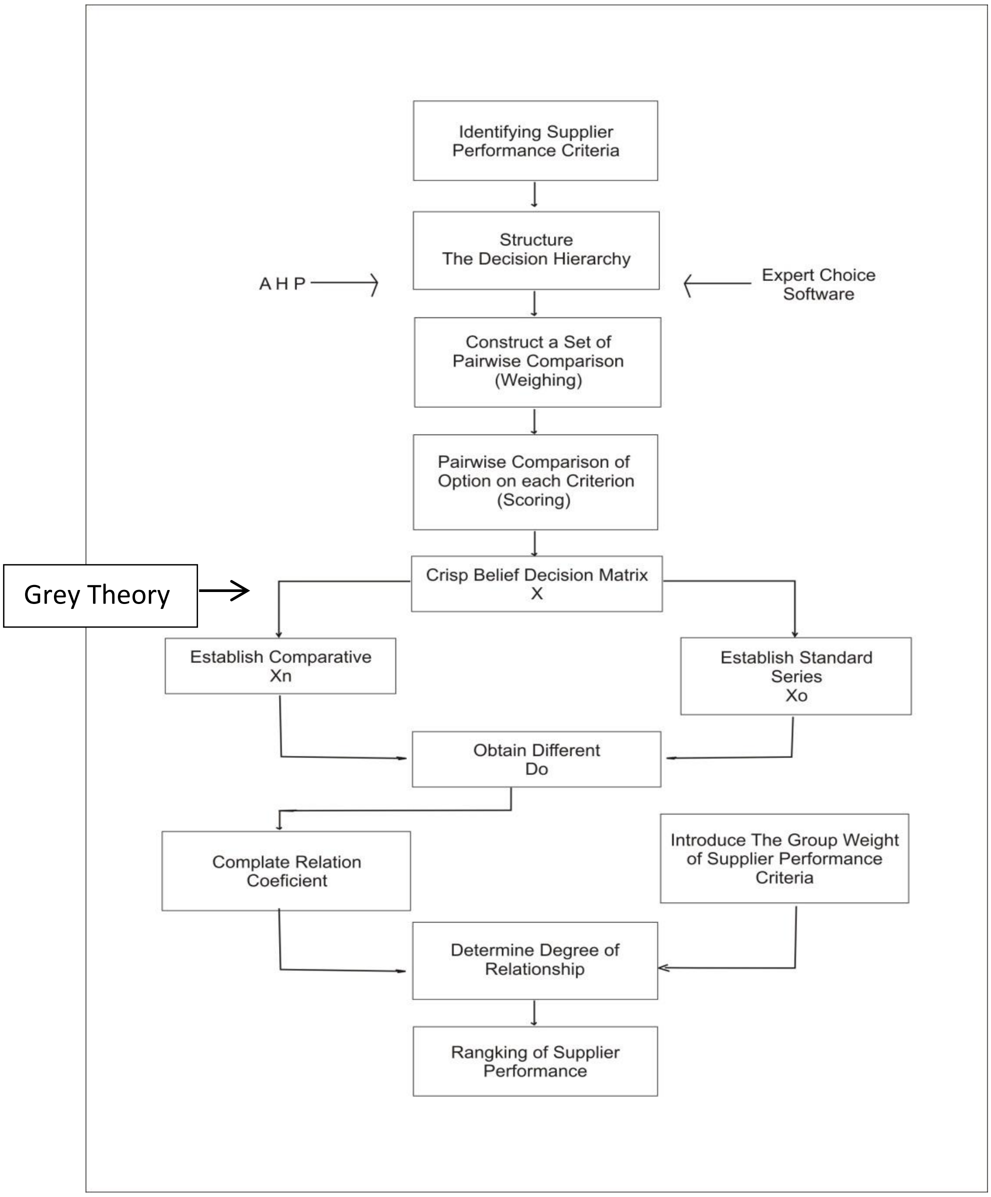


Fig. 1 The G-AHP for Supplier Performance Measurement

2.1 Supplier Performance Evaluation

Supplier Performance Evaluation has been studied extensively in the literature. The majority of supplier evaluations consist of only three factors : price, quality and delivery (Hirakubo and Kublin,1998) and early researches showed special emphasis mainly on cost and then on reliability, responsiveness, safety, and environtmental (Huang and Keskar, 2007). In this paper, we used six criteria for supplier performance evaluation for measure the performance of suppliers, among others: guarantee product quality, the accuracy of product delivery to the laboratory suppliers, communication between laboratories and suppliers, after sales service, handling of complaints by suppliers and prices of products.

2.2 The Analytic Hierarchy Process

The Analytic Hierarchy Processs (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. (Saaty, T.L.,2008). To make a decision in an organised way to generate priorities we need to decompose the decision into the following steps.

a. Define the problem and determine the kind of knowledge sought.

b. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

c. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

d. Use the priorities obtained from the comparisons to weight the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority.

e. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

2.3 Expert Choice

In 1983, Dr. Saaty joined Dr. Ernest Forman, a professor of management science at George Washington University, to co-found Expert Choice. The AHP and Expert Choice software engage decision makers in structuring a decision into smaller parts, proceeding from the goal to objectives to sub-objectives down to the alternative courses of action. Decision makers then make simple pairwise comparison judgments throughout the hierarchy to arrive at overall priorities for the alternatives. Expert Choice is intuitive, graphically based and structured in a user-friendly fashion so as to be valuable for conceptual and analytical thinkers, novices and category experts. Because the criteria are presented in a hierarchical structure, decision makers are able to drill down to their level of expertise, and apply judgments to the objectives deemed important to achieving their goals. At the end of the process, decision makers are fully cognizant of how and why the decision was made, with results that are meaningful, easy to communicate, and actionable. The expert choice steps will explored in the next section in case study.

2.4 Grey Theory

Grey theory, proposed by Julong Deng (1989), deals with decisions characterized by incomplete information, and explores system behavior using relational analysis and model construction (Shih et al., 1996; Wu et al., 1984; Chang et al., 2001; Liu et al., 2011; Geum et al., 2011). Grey theory provides a measure to analyze relathionship between discrete quantitative and qualitative series, and all components in the series shall conform to the following characteristics :

existent, countable, extensible and independend. The construction of grey model is describe as below: (Chang et al., 2001; Liu et al.,2011)

(1) Establish comparative series

An information series with n components or decision factors, such as some specific criteria for measure factors of the supplier's performance can be expressed as,

$X'_i = \left(X'_i(1), X'_i(2), \ldots, X'_i(K)\right) \in X,$, where $x'_i(k)$ denotes the the kth factors of x_i. If all information series are comparable, the n information series can be described as the following matrix :

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} = \begin{bmatrix} X_1(1) & X_1(2) & \cdots & X_1(k) \\ X_2(1) & X_2(2) & \cdots & X_2(k) \\ \vdots & \vdots & & \vdots \\ X_n(1) & X_n(2) & \cdots & X_n(k) \end{bmatrix} \quad (1)$$

(2) Establish the standard series

Degree of relation can describe the relationship of two series, thus, an objetive series called the standard series shall be established, and expressed as $X_0 = X_0(1), X_0(2), \ldots, X_0(k))$. When conducting the performance of the supplier, the smaller the score, therefore the standard series can be the lowest level of all the performance of the supplier.(Pillay & Wang, 2003)

$$X_0 = X_0(1),\ X_0(2), \ldots, X_0(k)) = (0,0, \ldots, 0) \quad (2)$$

(3) Obtain the difference between comparative series and standard series

To discover the degree of grey relationship, the difference between the comparative and standard series, D_0, is calculated and reflected in a form of a matrix as seen below :

$$D_0 = \begin{bmatrix} \Delta_{01}(1) & \Delta_{01}(2) & \Delta_{01}(3) & \ldots & \Delta_{01}(k) \\ \Delta_{02}(1) & \Delta_{02}(2) & \Delta_{02}(3) & \ldots & \Delta_{02}(k) \\ \vdots & \vdots & \vdots & & \vdots \\ \vdots & \vdots & \vdots & & \vdots \\ \Delta_{0m}(1) & \Delta_{0m}(2) & \Delta_{0m}(3) & \cdots & \Delta_{0m}(k) \end{bmatrix} \quad (3)$$

Where $\Delta_{0j}(k) = \|X_0(k) - X_j(k)\|$, $X_0(k)$ is the standard series and $X_j(k)$ is the comparative series.

(4) Compute the grey relational coefficient

To compute the relational coefficient, the decision factors of the supplier's performance model are compared with the standard series. The grey relation coefficient, $\gamma(X_0(k), X_i(k)$, is expressed as :

$$\gamma(X_0(k), X_i(k)) = \frac{\Delta_{min} + \varsigma\Delta_{max}}{\Delta_{0j}(k) + \varsigma\Delta_{max}} \quad (4)$$

Where

J = 1,…….., m k = 1, ………, n

$X_0(k)$ is the standard series and $X_j(k)$ is the comparative series.

$\Delta_{0j} = \|X_0 - X_j(k)\|$

$\Delta_{min} = \min_{\forall j \in i} \min_{\forall k} \|X_0(k) - X_j(k)\|$

$\Delta_{max} = \max_{\forall j \in i} \max_{\forall k} \|X_0(k) - X_j(k)\|$

ς is an identifier, $\varsigma \in (0,1)$, only affecting the relative value of risk without changing the priority. Generally, ς can be 0,5.

(5) Determine the degree of relation

Before finding the degree of relation, the relative weight of the decision factors shall be first decided in order to be used in the following formulation,

$$\Gamma(X_i, X_j) = \sum_{k=1}^{n} \beta_k \gamma(X_i(k), X_j(k) \quad (5)$$

where β_k is the weighting coefficient of factors, and $\sum_{k=1}^{n} \beta_k = 1$

if all factors are equally important, the above formulation can be modified as:

$$\Gamma(X_i, X_j) = \frac{1}{n}\sum_{k=1}^{n} \gamma(X_i(k), X_j(k)) \quad (6)$$

(6) Rank the factors of the supplier's performance

Based on the degree of relation between comparative series and standard series, a relational series can be constructed. If $\gamma(X_0, X_i) \geq \gamma(X_0, X_j)$, which indicates the degree of relation between X_i dan X_0 is greater than that between X_j dan X_0.

3. AN ILLUSTRATIVE CASE STUDY.

One of the existing power plants in Indonesia, Paiton Unit 9 is a capacity of 660 MW. Viewing of how important this power plant in Indonesia it can be said that the power plant is a vital tool of the state, then there is need for maintenance, protection and reliable operation. The main ingredient is water for generating steam, the water used must meet the parameters have been specified by the manufacturer listed in the manual book. To support this required technical chemicals and chemical analyst who used to perform water quality analysis process. Chemicals used by the laboratory of water contained in the Paiton power plant also has a standard 9-standard, therefore the supplier selection must be precise so that the chemicals that come in accordance with the specifications desired by the laboratory.

3.1 By using expert choice, The AHP consists of follows steps : (Ishizaka and Ashraf Labib, 2009)

3.1.1 Problem modelling

Breaking dawn the problem in hierarchy, which can be devided into three parts : goal (The best supplier performance), criteria (1. Guarantee product quality, 2. The accuracy of product delivery to the laboratory suppliers, 3. Communication between laboratories and suppliers, 4. After sales service, 5 . Handling of complaints by suppliers; and 6. Prices of products) and alternatives (Supplier A, Supplier B, Supplier C, and Supplier D).

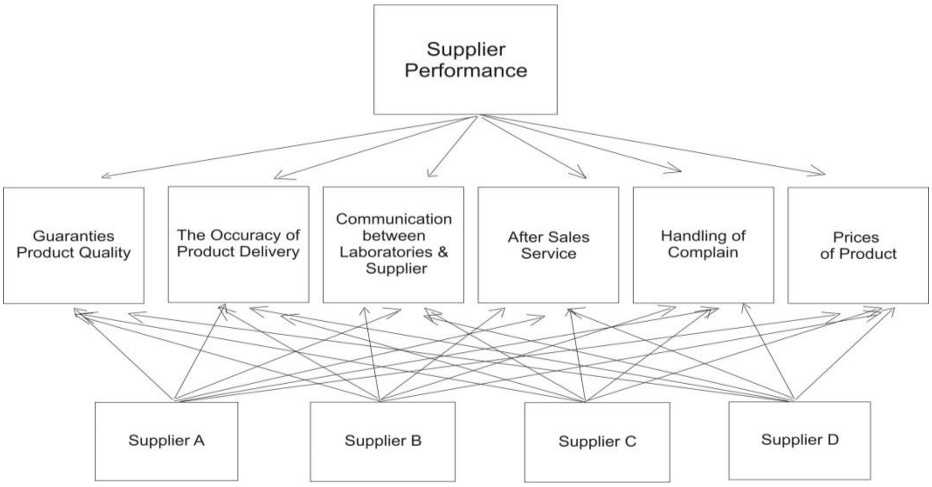


Fig. 2. Hierarchy of supplier performance evaluation

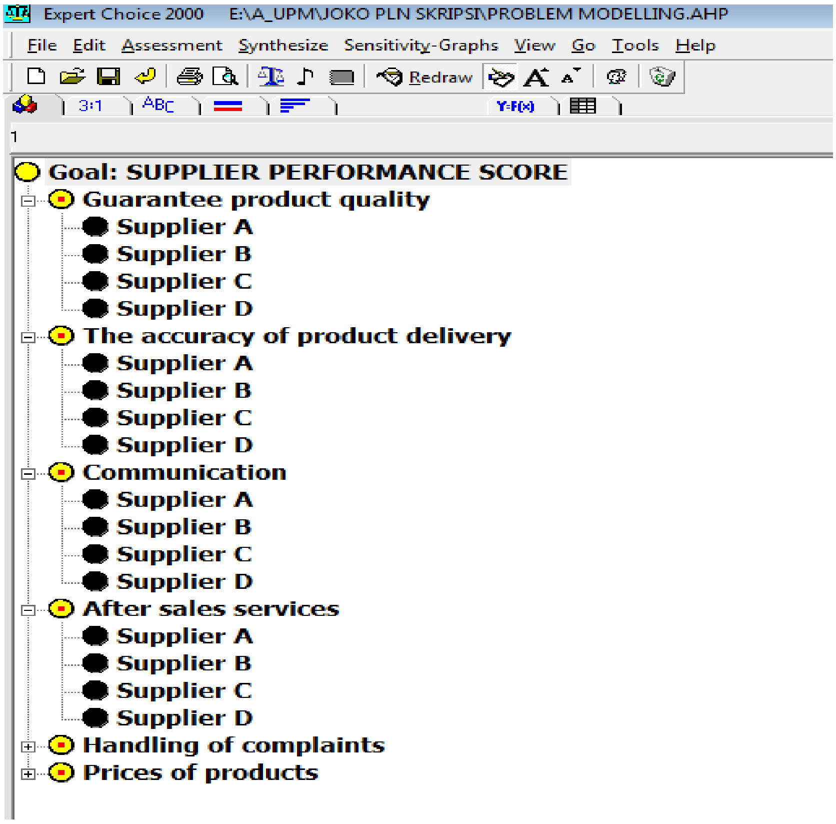
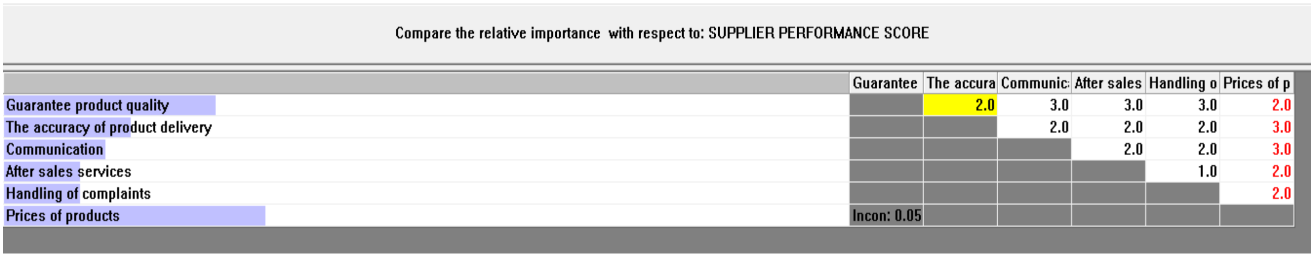


Fig 3 . Hierarchy of supplier performance evaluation, **** which Expert Choice soft ware

3.1.2 Pairwise comparisons

At each node of the hierarchy, a matrix will collect the pairwise comparisons of the decision-maker (e.g. figure 3)



Compare the relative importance with respect to: SUPPLIER PERFORMANCE SCORE

	Guarantee	The accura	Communic	After sales	Handling o	Prices of p
Guarantee product quality		2.0	3.0	3.0	3.0	2.0
The accuracy of product delivery			2.0	2.0	2.0	3.0
Communication				2.0	2.0	3.0
After sales services					1.0	2.0
Handling of complaints						2.0
Prices of products	Incon: 0.05					

Fig. 4 . Comparison matrix of supplier performance criteria

3.1.3 Judgement scales

One of AHP's strengths is the possibility to evaluate quantitative as well as qualitative criteria and alternative on the same preference scale of nine levels. These can be numerical, verbal or graphical.

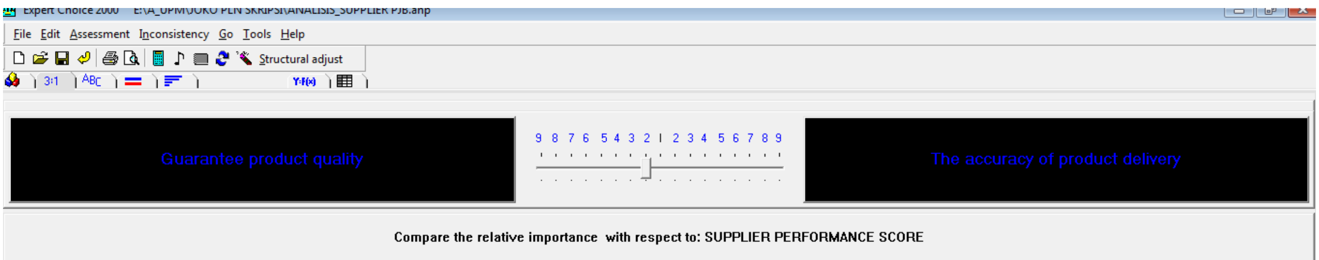


Fig. 5 . Numerical scale

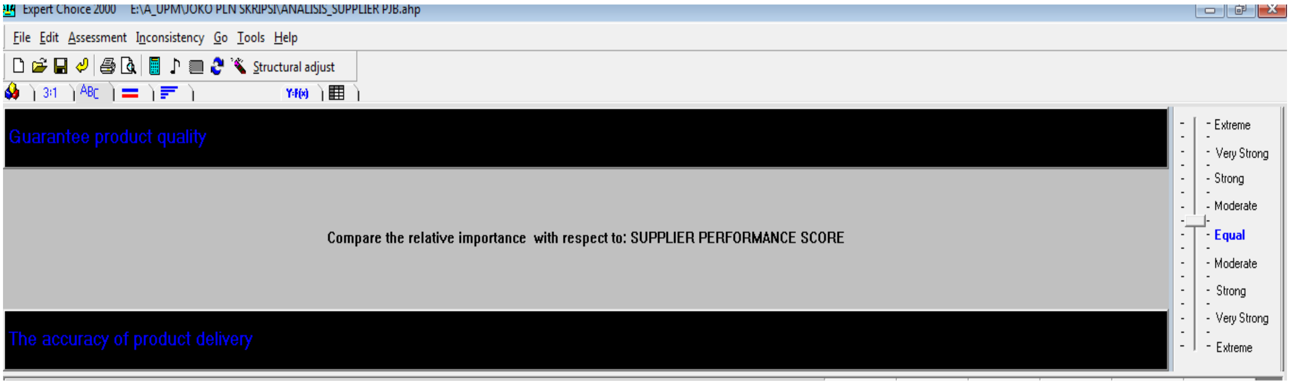


Fig. 6 . Verbal scale

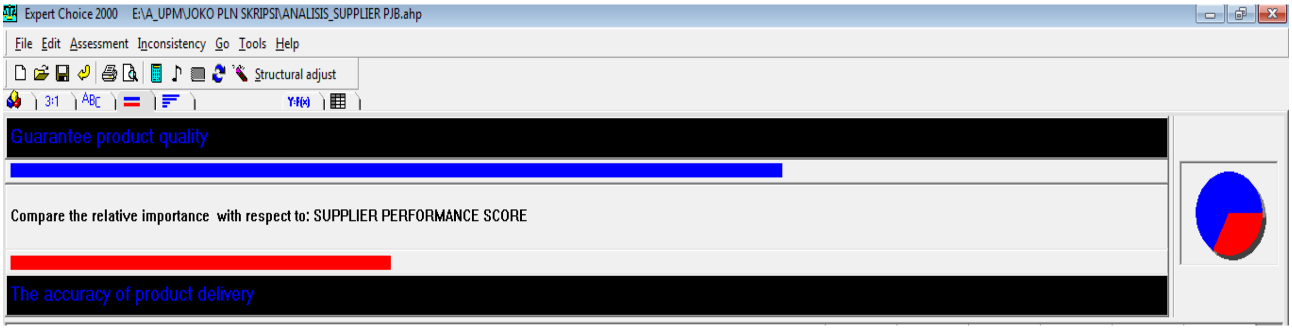


Fig. 7 . Graphical scale

3.1.4 Priorities derivation

Once the comparisons matrices are filled, can be calculated. The traditional AHP uses the eigenvalue method. We start from the case of a consistent matrix with known priorities w_i. In the chase, comparison of alternatives i and j is given by $\frac{w_i}{w_j}$, which multiplied by the priority vector w results in:

$$A = \begin{bmatrix} \frac{w_i}{w_j} & \frac{w_i}{w_j} & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \frac{w_i}{w_j} & \frac{w_i}{w_j} & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \frac{w_i}{w_j} & \frac{w_i}{w_j} & \frac{w_i}{w_j} & \cdots & \frac{w_i}{w_n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ \frac{w_n}{w_j} & \frac{w_n}{w_j} & \frac{w_n}{w_j} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix} \quad (7)$$

Or grouped : $\boldsymbol{A}\,\overline{w} = n\,\overline{w}$ (8)

Where w : vector of priorities

n : dimension of the matrix

$\boldsymbol{A}$: comparison matrix

Equation (8) is the formulation an eigenvector problem. The calculated priorities are exact for a consistent matrix. When slight inconsistencies are introduced, priorities should vary only slightly according to the perturbation theory (Saaty, 2003).

3.1.5 Consistensy

As priorities make sense only if derived from consistent or near consistent matrices, a consistency check must be applied. Saaty (1997) has proposed a consistency index (CI), which is related to the eigentvalue method:

$$CI = \frac{\lambda\, max - n}{n-1} \quad (9)$$

$where\ \lambda\ max$ = maximal eigenvalue

The consistensi ratio, the ratio CI and RI,is given by :

$$CI = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (10)$$

Where RI is the random index (the average CI of 500 randomly filled matrices.

If CR is les than 10%, then the matrix can be considered as having an acceptable consistensy.

The ideal mode uses a normalisation by deviding the score of each alternative only by the score of the best alternative under each criterion.

3.1.6 Aggregation

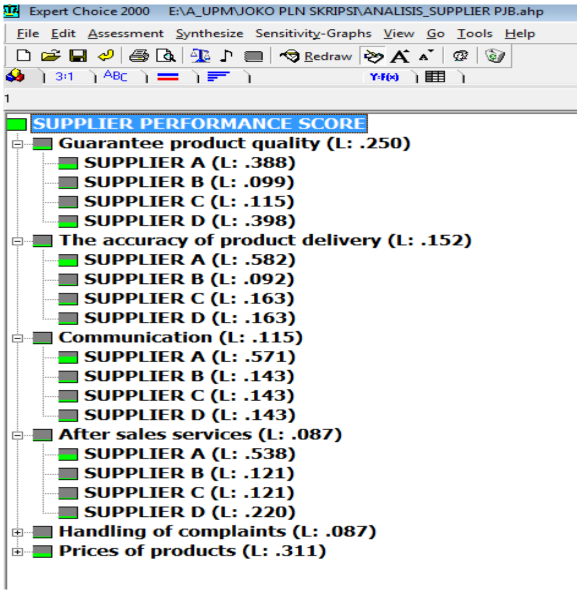


Fig. 8 Priorities with the distribitive mode of supplier performance

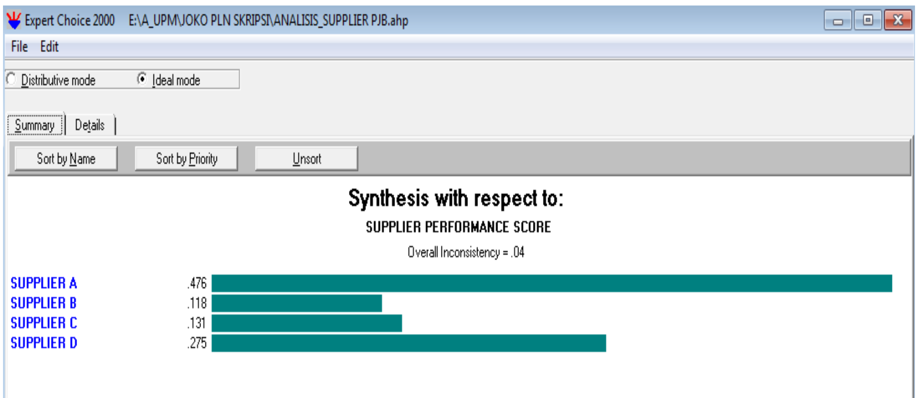


Fig. 9 Synthesis of Supplier performance evaluation

3.1.7 Sensitivity analysis

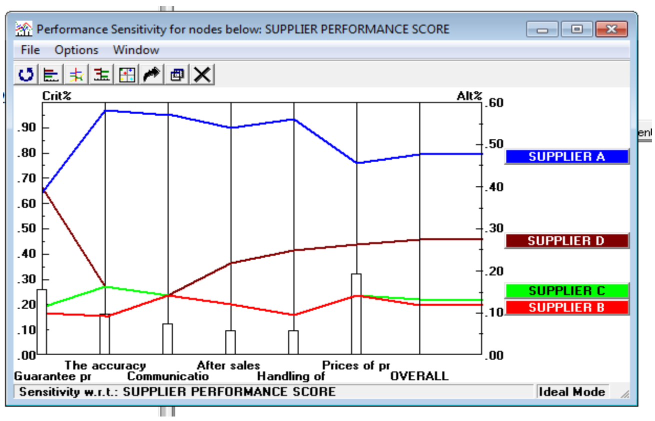


Fig. 10 Graphical sensitivity analyses of Supplier Performance

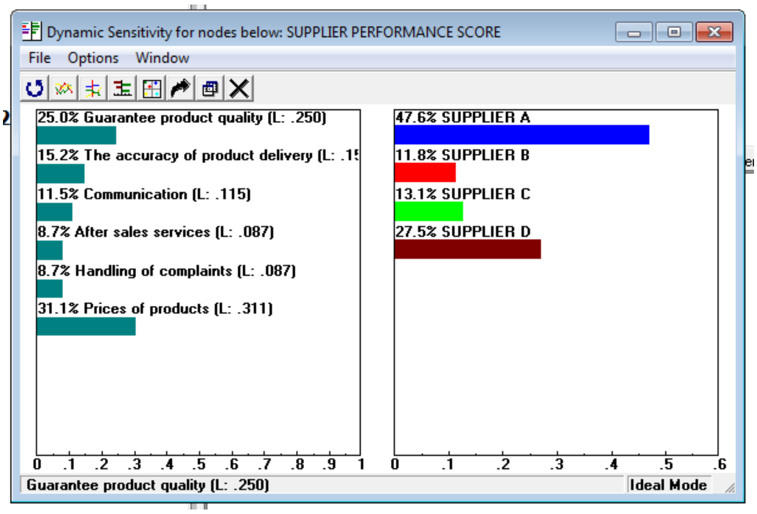


Fig. 11 Dynamic Sensitivity analyses of Supplier performance

3.2 Grey Theory

In order to determine better solution for the alternatives for supplier evaluation proses, the data from AHP analysis is calculated with Grey Theory procedure as follow :

3.2.1 Establish comparative series

An information series with criteria for measure factors of the supplier's performance can be expressed as the following matrix :

$$X = \begin{bmatrix} 0,388 & 0,582 & 0,571 & 0,538 & 0,560 & 0,455 \\ 0,099 & 0,092 & 0,143 & 0,121 & 0,095 & 0,141 \\ 0,115 & 0,163 & 0,143 & 0,121 & 0,095 & 0,141 \\ 0,398 & 0,163 & 0,143 & 0,220 & 0,249 & 0,263 \end{bmatrix}$$

The standard series is taken to be lowest possible value, as such the value 0 .(Pillay & Wang, 2003)

$$X_0 = (X_0(1),\ X_0(2), X_0(3), X_0(4), X_0(5), X_0(6)) = (0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0)$$

3.2.3 Obtain the difference between comparative series and standard series.

The difference between the comparative and standard series, D_0, is calculated and reflected in a matrix as seen below :

3.2.2 Establish the standard series

$$D_0 = \begin{bmatrix} \Delta_{01}(1) = 0,388 & \Delta_{01}(2) = 0,582 & \Delta_{01}(3) = 0,571 & \Delta_{01}(4) = 0,538 & \Delta_{01}(5) = 0,560 & \Delta_{01}(6) = 0,455 \\ \Delta_{02}(1) = 0,099 & \Delta_{02}(2) = 0,092 & \Delta_{01}(3) = 0,143 & \Delta_{02}(4) = 0,121 & \Delta_{01}(5) = 0,095 & \Delta_{01}(6) = 0,141 \\ \Delta_{03}(1) = 0,115 & \Delta_{03}(2) = 0,163 & \Delta_{01}(3) = 0,143 & \Delta_{03}(4) = 0,121 & \Delta_{01}(5) = 0,095 & \Delta_{01}(6) = 0,141 \\ \Delta_{04}(1) = 0,398 & \Delta_{04}(2) = 0,163 & \Delta_{01}(4) = 0,143 & \Delta_{04}(4) = 0,220 & \Delta_{01}(5) = 0,249 & \Delta_{01}(6) = 0,263 \end{bmatrix}$$

3.2.4 Compute the grey relational coefficient

The grey relation coefficient is calculated as shown here :

$\Delta_{min} = 0,092$ $\Delta_{max=}$ $0,582$

$$\gamma(X_0(k), X_i(k)) = \frac{\Delta_{min} + \varsigma\Delta_{max}}{\Delta_{0j}(k) + \varsigma\Delta_{max}}$$

$$\gamma(X_0(1), X_1 1) = \frac{0,092 + 0,5\ x\ 0,582}{0,388 + 0,5\ x\ 0,582} = 0,564$$

$$\gamma(X_0(1), X_1 1) = \frac{0,092 + 0,5\ x\ 0,582}{0,099 + 0,5\ x\ 0,582} = 0,982$$

Similarly, the grey relation coefficient for all supplier performance criteria can be calculated in the same way as shown in the matrix below :

$$\gamma(X_0(k), X_i(k)) = \begin{bmatrix} 0,564 & 0,439 & 0,444 & 0,462 & 0,450 & 0,513 \\ 0,982 & 1,000 & 0,882 & 0,930 & 0,992 & 0,887 \\ 0,943 & 0,844 & 0,882 & 0,930 & 0,992 & 0,887 \\ 0,556 & 0,844 & 0,882 & 0,750 & 0,709 & 0,691 \end{bmatrix}$$

3.2.5 Determine the degree of relation

The relative weight of the decision factors as shown here:

Guarantee product quality	:	0,250
The accuracy of product delivery	:	0,152
Communication	:	0,115
After salesservices	:	0,086
Handling of complaints	:	0,086
Prices of products	:	0,311
Total	:	1,000

Substituting the grey relation coefficient and group weights of supplier performance criteria will give the degree of relation for the first supplier performance score as seen here :

$\Gamma(X_0, X_1)$ = (0,564 x 0,250) + (0,439x0,152)+(0,444x0,115)+(0,462x0,086)+

(0,450x0,086)+(0,513x0,311)

= 0,498

In the same way, the degree of relation is calculated for all the supplier performance evaluation and the results are shown as bellow :

	Grey Relation	Rangking
SUPPLIER A	0,498	1
SUPPLIER B	0,942	3
SUPPLIER C	0,908	4
SUPPLIER D	0,711	2

The degree of relation of the five supplier performance give the rangking of the five suppliers as supplier 1>supplier 4 > supplier 2> supplier 3. So, the final conclusion for the supplier performance measurement is that supplier 1 is given the best supplier , following by supplier 4, 2 and 3.

Results should be clear and concise.

Discussion must explore the significance of the results of the work, often in the concluding paragraph, not repeat them. Avoid extensive citations and discussion of published literature. A combined Results and Discussion section is often appropriate.

4. CONCLUSION.

Thera are many different methods to problem solving of supplier performance measurement, the proposed model was used to evaluation of supplier performance in PT PJB UBJ O & M, Probolinggo, Indonesia. After analysing all alternative, which G-AHP as problem solving method, The best supplier with total score 0,498 had been chosen, its Supplier A.

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