Supplier Selection based on the Performance by using PROMETHEE Method

T S Sinaga*, K Siregar

1,2Industrial Engineering Department, Faculty of Engineering, University of Sumatera Utara Almamater street, Campuss USU, Medan 20155, Indonesia
2Head of Industrial Engineering, Department, University of Sumatera Utara, Indonesia

* Tutil@usu.ac.id

Abstract. Generally, companies faced problem to identify vendors that can provide excellent service in availability raw material and on time delivery. The performance of suppliers in a company have to be monitored to ensure the availability to fulfill the company needs. This research is intended to explain how to assess suppliers to improve manufacturing performance. The criteria that considered in evaluating suppliers is criteria of Dickson. There are four main criteria which further split into seven sub-criteria, namely compliance with accuracy, consistency, on-time delivery, right quantity order, flexibility and negotiation, timely of order confirmation, and responsiveness. This research uses PROMETHEE methodology in assessing the supplier performances and obtaining a selected supplier as the best one that shown from the degree of alternative comparison preference between suppliers.

1. Introduction
Supplier performance must be monitored continuously. The performance assessment is important as the evaluation that will be used to selection the supplier alternative and improvement so could ensure the raw material availability. In a situation where the company has more suppliers for a particular item, the results of the evaluation can also be used as a basis for selecting suppliers that will be allocated to the order in the next period or as consideration to look for alternative suppliers. It can avoid the disruption of production due to inventory issues.

Supplier selection is decision-making problems including both qualitative and quantitative factors to identify suppliers with the highest potential for meeting a firm’s needs consistently and at an acceptable cost [1]. Manufacturing needs to involve suppliers in improving corporate performance, particularly in terms of product design and continuous improvement activities by considering criteria for supplier selection [2]. Wu et al mention there are 23 basic criteria for the supplier assessment according to Dickson, including quality, delivery, and performance history as the three most important criteria [3]. Actually, there are difference evolution paths for each supplier selection stream and demonstrate the problem from a mathematical perspective with a focus on technical modelling aspects. Moreover, a study has reviewed a total of 221 academic journals in the last 26 years regarding on the selection of suppliers explain about identify, classify, and examine supplier selection problems systematically [4]. Promethee has applicated in several areas include the papers on the topics of
Supplier assessment issue is a multi-criteria problem. The multi-criteria approach has been tried to look at the risk of river flood in Germany by developing a framework for GIS-based MCA [6]. This methodology is called the AHP methodology in the human resource selection process in academic applicants [7]. Using this method can reduce subjectivity and increase the ratings across raters (inter-rater reliability). It should better define and streamline the selection process by saving time and producing more accurate results. The other case, integrating the proposed product bundle determination model into supplier selection process can provide the purchasing company and cooperative suppliers efficiently [8]. Four computer component suppliers were selected based on four criteria when used interval type-2 fuzzy TOPSIS to solve supplier selection problem [9].

PROMETHEE method is proposed for rank technique in the organization [10]. Supplier assessment for the cement industry using MHSP method; an integration of the F-AHP and F-Promethee and actually more effective from other techniques such as TOPSIS, ANP, DEA or by integrating any of such techniques [11]. Various supplier selection models have examined and obtained a framework of multiple perspectives decision making for supplier selection [12].

This study focused on the concrete industry which has 5 suppliers. This assessment importantly to support government project, especially provision of the pole. It is faced the arrival of materials that is not timely and quality of raw materials is not accordance with the specification desired. It could result in disruption of the company's production process. The industry estimates that number of consumer demand will increase in the future. Therefore, it must be supported by the best performance of suppliers to ensure the ability to meet consumer demand. Although over the years, management has made penalty for suppliers with poor performance, but it seems there is no significant improvement in supplier performance. So, it is necessary to measure the performance of suppliers with the right method for determining the best supplier that suitable and meet the criteria established by the industry. Weighting among criteria uses AHP method and suppliers ranking use PROMETHEE method. This study is expected to recommend the best suppliers as an alternative to cooperate in fulfill the customer demand.

2. Methodology
Type of this research is descriptive research and the aim is to explain the facts and the properties of the object systematically. The survey conducted on ten respondents regarding the performance of suppliers who cooperate with the company by using a questionnaire instrument. The selected respondents are the staff who handling the company's cooperation with suppliers.

The independent variable in this research is the supplier's performance attributes according to Dickson theory such as quality, delivery, price, and warranty and service complaints [3]. The dependent variable in this study was the determination of the best suppliers. There are four main criteria which further split into seven sub-criteria, namely compliance with accuracy, consistency, on-time delivery, right quantity order, flexibility, and negotiation, also warranty and service complaints. Stages of the research process presented are presented in Figure 1.
The questionnaire was developed based on the level of interest and pair-wise comparisons among criteria and sub-criteria. Finally, each rating scale option had to be attributed a value in order to obtain the score of a supplier. One option proposed by Saaty is to rate each option on a scale from one to hundred according to their value. Scores are then normalized in order to obtain the value of 1.00 for the best option [13]. Suitable questions in questionnaire were made in 9 points Likert scale and developed based on the level of interest and pairwise comparisons between criteria and sub-criteria. Questionnaire made in 9-point likert scale and addressed directly to the respondents that responsibility in purchasing.

### 2.1. AHP Methodology

Analytical Hierarchy Process is a methodology which in multi-criteria decision model has been used to derive weight or scores for the object in a multi-attribute space [14]. A hierarchy consists of a minimum of three levels where the first level consists of the objective of the problem, while then last level consists of the alternatives. Between these two levels exists one or various levels of criteria and sub-criteria [11]. In this research, the hierarchy to supplier selection in concrete industry is presented Figure 2.

![Figure 1. Stage of the research](image-url)
Based on AHP calculation of priority weight on level 2 are quality with weight 0.5319, consisting of elements K1 (conformity with quality standards of raw materials are determined by the company) with a weight 0.3477, and K2 (consistency of quality) with a weight of 0.1832. This means that the sub-criteria are considered to have an influence to the performance of supplier. Calculation of priority weight on level 3 is presented in Table 1.

| Sub-criteria | Weight of Priority |
|--------------|--------------------|
| K1           | 0.3477             |
| K2           | 0.1832             |
| K3           | 0.0949             |
| K4           | 0.0745             |
| K5           | 0.1043             |
| K6           | 0.1185             |
| K7           | 0.0759             |

2.2. PROMETHEE Analysis

The PROMETHEE method is considered to developed multiple criteria decision-making methods. It is an outranking method for a finite set of alternative actions to be selected and ranked among a set of criteria [15]. We describe the procedure of implementation PROMETHEE I and II as follow: We consider a multi-attribute decision-making problem with a set of possible alternatives which is evaluated on a set of criteria. Without loss of generality, suppose that all the criteria have to be maximized. The problem can be represented as [16]:

$$\max \{ g_1(a_i), \ldots, g_j(a_i), \ldots, g_n(a_i) | a_i \in A \} \quad (1)$$

Where $A = \{a_i | i = 1, 2, \ldots, m \}$ is a set of possible alternatives and $g = \{g_j | j = 1, 2, \ldots, n \}$ is a set of considered criteria, $g_j(a_i)$ represents performance of alternative $a_i$ with respect to the $j$th criterion. A decision-maker expresses his preference of alternative $a$ over alternative $b$ considering the criterion $g_j$ by computing a single-criterion preference degree $p_j(a, b)$ which is in function of $d_j(a, b) = g_j(a) - g_j(b)$. The value of this preference function $p_j(a, b)$ is included between 0 and 1. If $a$ is better than $b$, then $p_j(a, b) > 0$; otherwise, $p_j(a, b) = 0$.

PROMETHEE analysis consists of two steps. The basic steps of the Promethee algorithm by Brans [10]. It can be outlined as described by PROMETHEE I analysis calculates the positive outranking
flow (leaving flow) and negative outranking flow (entering flow) based on the value of the preference index. Furthermore PROMETHEE II is calculates net flow to gain ranking supplier. Net flow obtained from the reduction of flow leaving and entering flow. There are 5 (five) suppliers alternative observed in this study. Net flow and rank of the suppliers are presented in Table 2.

| Supplier alternative | Leaving Flow | Entering Flow | Net Flow | Rank |
|----------------------|--------------|---------------|----------|------|
| S1                   | 1,0000       | 0,0000        | 1,0000   | 1    |
| S2                   | 0,2240       | 0,7760        | -0,5520  | 5    |
| S3                   | 0,4583       | 0,5418        | -0,0835  | 3    |
| S4                   | 0,3574       | 0,6427        | -0,2853  | 4    |
| S5                   | 0,4604       | 0,5396        | -0,0792  | 2    |

3. Result and Discussion
In this paper, the first is explain the meaning of the problem and measure performance of supplier is formulated by integration AHP and Promethee method. AHP methodology can be a very useful tool in aiding organizations in selecting appropriate criteria can significantly and increase the structure of the process and reduce subjectivity [7]. In this research, it is properly designed and implemented, so can assist organizations in meeting many of the goals of the selection process. Promethee is a set of outranking methods, including the PROMETHEE I for partial ranking of the alternatives and the PROMETHEE II for the complete ranking of the alternatives. The rankings are influenced by the weights allocated to the criteria and criterion quality got the highest weight will be the best alternative [11]. A supplier performance measurement with the PROMETHEE successfully sequenced five suppliers based on supplier performance results to cooperate with the company. Supplier with the best performance was followed by supplier S1, S5 as the second and S3 as the third. Strengths and weaknesses of the criteria that selected can looks from the degree of alternative comparison preference between suppliers are presented in Table 3.

| Supplier | Strength | Weakness |
|----------|----------|----------|
| S1 between S5 and S3 | K1, K2, K3, K4, K5, K6 and K7 | - |
| S5 between S3 | K2, K3, and K6 | K1, K4, K5, and K7 |
| S3 between S5 | K1, K4, K5, and K7 | K2, K3, and K6 |

The results of the assessment by the PROMETHEE, S1 is selected supplier as the best supplier because it has greatest weight than others. It needs corrective action on any weakness of S5 and S3 to improve performance in production of concrete company.

4. Conclusions
The numerous benefits that could result when using the AHP to select criteria of supplier performance. Seven sub criteria have found by AHP and to be considered to make rank of the suppliers. PROMETHEE method has obtained supplier S1 as the best supplier from five suppliers that cooperate with the concrete company. outrank by PROMETHEE has successfully applied to address the issue of supplier selection researched. This stage can be applied in finding the best solution in select and rank a set of alternatives related to manufacturing performance.
Acknowledgments
The authors gratefully acknowledge that the present research is supported by Ministry of Research and Technology and Higher Education Republic of Indonesia. The support is under the research grant BP-PTN USU of Year 2016 Contract Number 67/UN5.2.3.1/PPM/SP/2016.

References
[1] Safari, Hossein, Maryam Sadat Fagheyi, Saadeh Sadat Ahangari and Mohammad Reza Fathi 2012 Applying PROMETHEE Method Based On Entropy Weigh For Supplier Selection, Business management and strategy, Macrothink Institute ISSN 2157-6068 Vol.3 No.1 97-106
[2] Vonderebse, Mark A and Michael Tracey 1999 The Impact of Supplier Selection Criteria and Supplier Involvement on Manufacturing Performance, Journal Of Supply Chain Management Summer 35 3 ABI/INFORM Collection 33
[3] Patil, Amol Nayakapp 2014 Modern Evolution In Supplier Selection Criteria And Methods, International Journal of Management Research & Review Vol.4 Issue 5/Article No-8/616-623, ISSN 2249-7196
[4] Wetzstein, Anton., Evi Hartmann, W.C. Benton and Nils-Ole Hohenstein 2016 A Systematic Assessment Of Supplier Selection Literature State-Of-The-Art And Future Scope, Int. J. Production Economics 182 304–323
[5] Behzadian, Majid, R.B. Kazemzadeh A. Albadvi and M. Aghdasi 2010 Promethee: A Comprehensive Literature Review On Methodologies And Applications European Journal Of Operational Research Vol.200 Issue 1 198-215
[6] Meyer, Volker, Sebastian Scheuer, and Dagmar Haase 2009 A Multi Criteria Approach For Flood Risk Mapping Exemplified At The Mulde River, Germany, Nat Hazards 48:17–39 DOI 10.1007/S11069-008-9244-4
[7] Rahal, Ahmad D., and Larry H. Faulk I 2011 A collaborative Decision Making Framework For Human Resource Selection, The Case of Academic Applicants The Journal of Management and Engineering Integration Vol.4 No.2 66-74
[8] Yu, Chunxia., T. N. Wong 2015 A product bundle determination model for multi-product supplier selection J Intell Manuf 26 DOI 10.1007/s10845-013-0790-6 369–385
[9] Otheman, Adawiya., Ahmad Termimi Ab Ghani and Lazim Abdullah 2014 The Use of Interval Type-2 Fuzzy TOPSIS in Supplier Selection Applied Mechanics and Materials, Vol.548-549 1954-1958
[10] Brans, J.P. and PH Vincke, 1985, A Preference Ranking Organization Method (The Promethee Method For Multi-criteria Decision Making) Management Science Vol.3 No.6, 647-
[11] Gupta, Rajesh, Anish Sachdeva and Arvind Bhardwaj 2012 Selection Of Logistic Service Provider Using Fuzzy Promethee For A Cement Industry, Journal of Manufacturing Technology Management Vol.23 No.7 899-921
[12] Ordoobadi, Sharon and Shouhong Wang 2011 A Multiple Perspectives Approach To Supplier Selection Industrial Management & Data Systems Vol.111 No.4 629-648
[13] Saaty, T.L 2008 Decision making with the analytic hierarchy process Int.Journal Services Sciences Vol.1 No.1 83–98
[14] Zahir, Sajjad 2002 Using The Analytic Hierarchy Process For Quantifying And Classifying Objects With Multiple attributes Infom 40,2 Proquest 149-172
[15] Rostam, Sarkawt 2015 Decision Making Model Based on PROMETHEE For Manufacturing Strategy Direction and Performance Improvement in Manufacturing SMEs American Journal of Science and Technology. Vol.2 No.5 251-257
[16] Mahmoudi, Amin, Soheil Sadi-Nezhad and Ahmad Makui 2015 An Extended Fuzzy PROMETHEE based on Fuzzy Rule based System for Supplier Selection Problem Indian Journal of Science and Technology, Vol.8(31) DOI: 10.17485/ijst/2015/v8i31/84225 1-11