

Performance Assessment of Hardboard Material's Supplier in PT. Nutech Pundi Artha using Analytic Network Process (ANP) Methods

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Abstract

PT. Nutech Pundi Arta is a company engaged in automotive interior industry. This company deals directly with some suppliers on hardboard material. During this companies often experience problems related to the performance of suppliers such as delivery delays and quality mismatches that have been agreed by the company. Assessment of supplier performance is important to do in PT. NPA so that supplier performance can be controlled and improved so it doesn't disrupt the continuity of the company's production. The purpose of this research is to identify and determine the weight of criteria and subcriteria of supplier performance and to get supplier performance rating using Analytic Network Process (ANP) method. The result of the criteria weight were quality (0.20402), cost (0.15984), delivery (0.20764), flexibility (0.13405), responsiveness (0.15272). The result of subcriteria weight were the amount of Goods Reject (0.10741), Provide Guarantee (0.09663), Price Comparable to Quality (0.08226), Payment Method (0.07757), Accuracy of Delivery Schedule (0.10348), Accuracy of Goods Sent (0.10415), Change of Order Volume (0.07058), Change of Delivery Time (0.06347), Response Speed to Complaint (0.07947), Ease of Contact (0.07324). The results of performance assessment of hardboard material suppliers that obtained from the highest order to the lowest are PT. RMA (0.050053), PT. A (0.047198), PT. GCI (0.04444).

Keywords:

Supply Chain, Supplier Performance, ANP, Hardboard

1. Introduction

Supply Chain Management (SCM) is a complete relationship of activities starting from the procurement of goods and services by suppliers (suppliers), converting raw materials into goods in process and manufactured goods, distribution to wholesalers, to arrived at retailers and consumers. In the supply chain concept, suppliers are one of the most important parts and influence the survival of a factory. A healthy and efficient company does not mean much if the supplier is not able to produce raw materials that are of high quality or unable to meet the delivery on time. If the supplier is not responsible and the response to the fulfillment of the request is not good, it will cause problems with the continuity of the company's production. Therefore companies need to evaluate suppliers carefully and sustainably (Mauidzoh and Zabidi, 2007).

PT. Nutech Pundi Arta is one of the companies engaged in manufacturing. The products produced are requests from customers in the form of car interior products such as hardboards, carpets, plastic silencers and felt. PT. NPA has three suppliers that supply hardboard material. The problems found in the three suppliers are incompatibility of material specifications provided by suppliers with specifications set by the company. This can hamper the smooth production at PT. NPA. Companies in producing production need to get a smooth supply of material so that the performance of suppliers needs to be assessed. Continuity of cooperation with suppliers depends on the assessment of supplier performance. So far, the company does not have a performance appraisal system for its suppliers so that the company cannot determine suppliers that really have the best performance and suppliers that have less optimal performance.

In assessing supplier performance, influential factors not only involve company data, but performance criteria must be set. Supplier performance is assessed based on multicriteria QCDFR (Quality, Cost, Delivery, Flexibility, Responsiveness). Some decision-making methods (multi criteria decision making) include the AHP (Analytic Hierarchy Process) method, the Promethee method (Preference Ranking Organization Method for Enrichment Evaluation) and ANP method. AHP method can solve the problem complex multicriteria into a hierarchy (Kholil et al. 2015) Promethee method is a method of determining sequence (priority) in multicriteria

analysis. The dominance of the criteria used is the use of values in outranking relationships. The ANP method is the development of the AHP method, interaction and feedback from elements in the cluster (inner dependence) and between clusters (outer dependence) (Iriani, 2012). However, in assessing supplier performance it is possible to have decision problems that cannot be hierarchically structured because they involve interactions and dependencies of elements of higher level in the hierarchy. In the lower level elements, the ANP method can be used in this study.

This study aims to determine the weight values of criteria and subcriteria to measure supplier performance and determine the level of performance of each hardboard material supplier at PT NPA.

2. Literature Review

2.1 Supply Chain Management

Supply Chain Management (SCM) has the main activities, namely, designing new products, planning production and inventory, carrying out production, shipping activities and also procurement of raw materials. The main objective of each supply chain is to meet consumer needs and generate profits (Chopra and Meindl, 2007).

The aim of SCM is to build a supplier chain that focuses on maximizing value for customers. Competition is no longer between companies, but between supply chains. In addition, the supply chain is global.

2.2 Purchasing

Purchasing is one of the important functions in the successful operation of a company. This function is burdened with the responsibility of getting the quantity and quality of the materials available at the time needed at prices that are in accordance with the prevailing prices (Assauri, 2008). According to Heizer and Render (2009), the objectives of purchasing activities are:

1. Helps identify products or services that can be obtained externally.
2. Developing, evaluating, and determining suppliers, prices, and delivery of the best for the goods or services.

2.3 Supplier

Supplier is the source that provides the first material, where the chain of distribution of goods will begin. This first material can be in the form of raw materials, raw materials, auxiliary materials, merchandise, subassemblies, spare parts, etc. (Indrajit and Djokopranoto, 2006). Every company needs suppliers to supply material needed to produce the final product. Suppliers play an upstream role and are very important in their position in the industry (Yuliandono et al, 2010).

Supplier is one part of the supply chain that is very important and influences the survival of a company. Onut et al in Paramita et al (2011) explained that improper supplier selection can disrupt the company's operations, while the right supplier can significantly reduce purchasing costs, increase market competitiveness and increase product end-user satisfaction.

2.4 Supplier Evaluation

Based on ISO 9001: 2000, evaluation is a way of evaluating the performance of suppliers to determine the rank of suppliers that meet the requirements as selected suppliers capable of producing or delivering the products needed by the company. Supplier evaluation is an assessment carried out to determine the supplier's ability to provide certain quality materials and also produce evidence that supports the decision to accept the supplier's product. The main reason for evaluating suppliers is because the evaluation can describe the supplier's performance that has been achieved.

Integrated with other operating functions, supplier evaluation can bring great benefits which include monitoring quality costs to investigating the accuracy of material delivery.

Carr and Pearson in Amran (2014) stated that generally vendor evaluations "help the company's purchasing department better understand the vendors that are performing well and who are not performing well". Through evaluation, companies hope to gain an understanding of suppliers and the capabilities they have that will benefit the company. Evaluation of supplier performance is carried out with different periods according to the policies and needs of each company. The selection of the evaluation period is very important and must be adjusted specifically to the actual condition. Evaluation periods that are too short can

be ineffective because they make suppliers uncomfortable and easily lose suppliers. While the evaluation period that is too long can be punitive and blaming.

2.5 Vendor Performance Indicator (VPI)

The supplier evaluation and the selected criteria used in this study refer to the research conducted by Maudzoh and Zabidi (2007), which uses multi criteria (financial and non-financial) that refer to the QCDFR model, where there are five criteria: quality, cost, delivery, flexibility, responsiveness.

1. **Quality.** This criterion assesses suppliers in terms of quality of products produced by suppliers. Raw materials are one of the inputs for manufacturing companies that are absolutely necessary. For a factory that does not make its own raw materials in terms of raw materials obtained from a third party (supplier), then the material quality of the supplier must be the main supervision in order to produce quality products.
2. **Cost.** The criteria for material costs supplied by suppliers are financial criteria that are the main consideration of each factory in choosing suppliers.
3. **Delivery.** This criterion assesses suppliers in terms of service delivery of raw materials.
4. **Flexibility.** This criterion assesses suppliers in terms of the ability of suppliers to meet demand for changes in quantity and time.
5. **Responsiveness.** This criterion has suppliers in terms of the supplier's ability to respond to problems and requests.

2.6 Analytic Network Process (ANP)

Analytic Network Process or ANP is a mathematical theory that allows one decision maker to face interrelated factors (dependence) and systematic feedback. This method is a new approach to qualitative methods which is a further development of the previous method namely Analytic Hierarchy Process (AHP) (Yulianti, 2013).

ANP method provides a general framework for dealing with decision problems without making assumptions about the dependence of higher level elements in the hierarchy, on lower level elements. Therefore, ANP is represented by a network, not a hierarchy, can overcome this problem. ANP is a logical way to deal with dependence (Saaty, 2004). The difference between hierarchy and network is illustrated in Figure 1. Hierarchy has a destination or source node or cluster. Hierarchy also has a sink node or cluster known as probability theory as a absorbing state that represents an alternative decision. This is a linear top down structure without feedback from lower levels to a higher level. However, it has a circle at the lower level to show that each alternative at that level depends only on itself and thus these elements are considered independent of each other. Unlike hierarchies, networks spread in all directions and groups of elements are not arranged in a certain order. The feedback network consists of interactions and dependencies between elements at a lower level. The feedback structure does not have a linear shape from top to bottom, but it looks like a cycle network in each cluster of each element and can be in the form of a loop on the cluster itself. Alternative network groups may or may not have feedback on other groups.

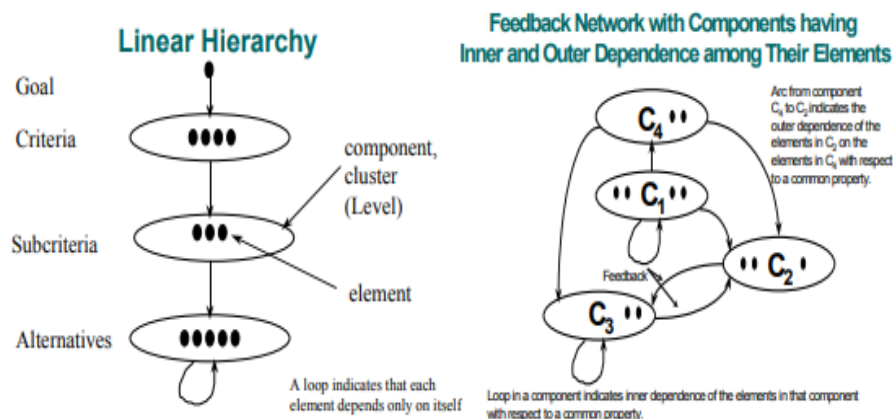
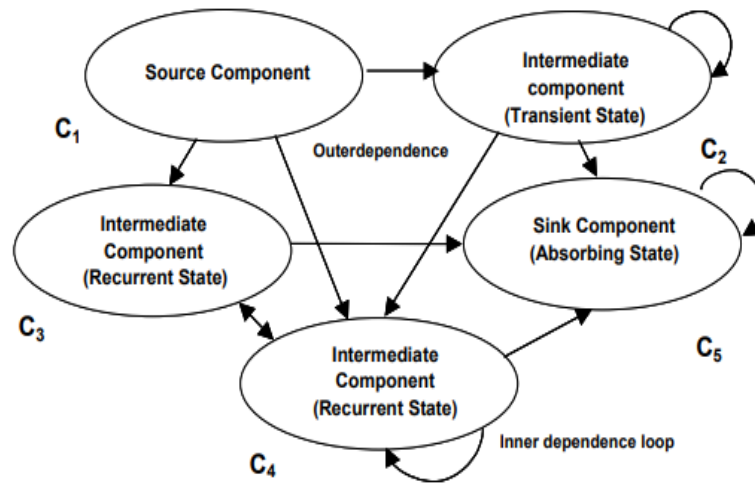


Figure 1. Hierarchy and Network Differences (Saaty, 2004)

The model of the ANP method is in the form of a network so that it can be seen the interrelationships between each element that exists on the same criteria, or on different elements of criteria. The ANP model as shown in Figure 2.



Gambar 2.2 Model ANP (Saaty, 2004)

Comparison of the level of interest in each element and cluster is presented in a matrix by providing a ratio scale with pairwise comparisons. Pairwise comparisons use the ratio of pair dominance using actual measurements. One of the advantages of using the ANP model in the supplier performance appraisal process is that it can be accommodated in the relationship between the criteria and the subcriteria assessment of supplier performance in the problem at hand. Based on the sub-criteria that have been identified, it is found that the linkages between these sub-criteria are found. This attachment can be divided into 2, namely inner dependence and outer dependence). Inner dependence is the relationship that occurs between criteria in the same criteria. While the outer dependence is the relationship that occurs between the criteria in different criteria (Sena, 2015).

According to Ascarya in Rusdyana and Dewi (2013), there are 3 basic principles of ANP namely decomposition, comparative judgment, and hierarchical composition or synthesis of priorities:

1. The principle of decomposition, which is applied to structure complex problems into a hierarchical framework or ANP framework consisting of cluster networks.
2. The principle of comparative assessment is applied to construct pairing comparisons of all elemental combinations in the cluster seen from the parent cluster. This pairing comparison is used to get local priorities from the elements in a cluster seen from the parent cluster.
3. The principle of hierarchical composition or synthesis is applied to multiplying local priorities from elements in a cluster with a 'global' priority from the parent element, which will generate the global priority of the entire hierarchy and add them to produce global priorities for the lowest level elements (usually alternatives).

In general, the steps to work on the ANP method according to Onut et al in Govindaraju and Sinulingga (2017) are as follows:

1. Comparison of pairs and estimates of relative weights
2. Initial supermatrix formation
3. Formation of supermatrix weight

After the paired comparison is complete, supermatrix is calculated in 3 steps:

1. Unweighted Supermatrix, made directly from all local priorities derived from pair comparisons between elements that influence each other.
2. Weighted Supermatrix, calculated by multiplying the value of the weightless supermatrix with the corresponding cluster weights.

The composition of the limited Supermatrix (Supermatrix Limiting), made by raising the weight of the supermatrix until stable. Stabilization is achieved when all columns in the supermatrixes that are appropriate for each node have the same value, namely one. For each subnetwork, the same procedure is applied and

alternatives are ranked. These steps are carried out in the Super Decisions software, which is a software package developed for ANP applications.

3. Weight of Interest from Klusters and Nodes

To determine the weight of the alternatives, a supermatrix limit is used from the ANP model. The overall priority of each alternative is calculated through the synthesis process. The results obtained from each subnetwork are synthesized to obtain the overall priority of the alternatives.

3. RESEARCH METHODS

The systematic steps that play an important role as a guide in resolving and providing solutions to problems that arise in this study. The data used in analyzing data is from questionnaires that have been distributed to decision makers. The steps in processing data are as follows:

1. Identify decision makers who know the characteristics of each supplier and the product criteria meet the requirements at PT. Nutech Pundi Artha.
2. Identify criteria and subcriteria to evaluate supplier performance which is carried out by interviewing the decision maker.
3. Together with decision makers, identify how relationships occur between criteria and subcriteria that might occur when assessing supplier performance.
4. Describe the structure of ANP model using Super Decision software.
5. Based on the ANP model, Collection of criteria-subcriteria assessment data, by the decision makers used to assess existing suppliers.
6. Data processing of assessment results are then processed using the ANP concept to obtain a weighted value that can help make decisions in assessing supplier performance.
7. Perform consistency test to find out whether a questionnaire has been used to check whether the results of the answers have been consistent or not. It is stated to be consistent with the value of $CR < 0.1$. if it is declared consistent, then it is continued with the supplier performance assessment stage. Whereas if the data is declared inconsistent, it is necessary to do the distribution of questionnaires again.
8. Supermatrix Calculation
Superweighted Supermatrix, Weighted Supermatrix, and Supermatrix Limiting calculations on the ANP method were processed using Super Decision software. The results of the Supermatrix Limiting are global weights of criteria and subcriteria as well as the overall alternative.
9. Analysis and conclusion of supplier performance appraisal are carried out after obtaining the value of weight for suppliers to find out the highest weight value among these suppliers and the highest supplier rank is set.

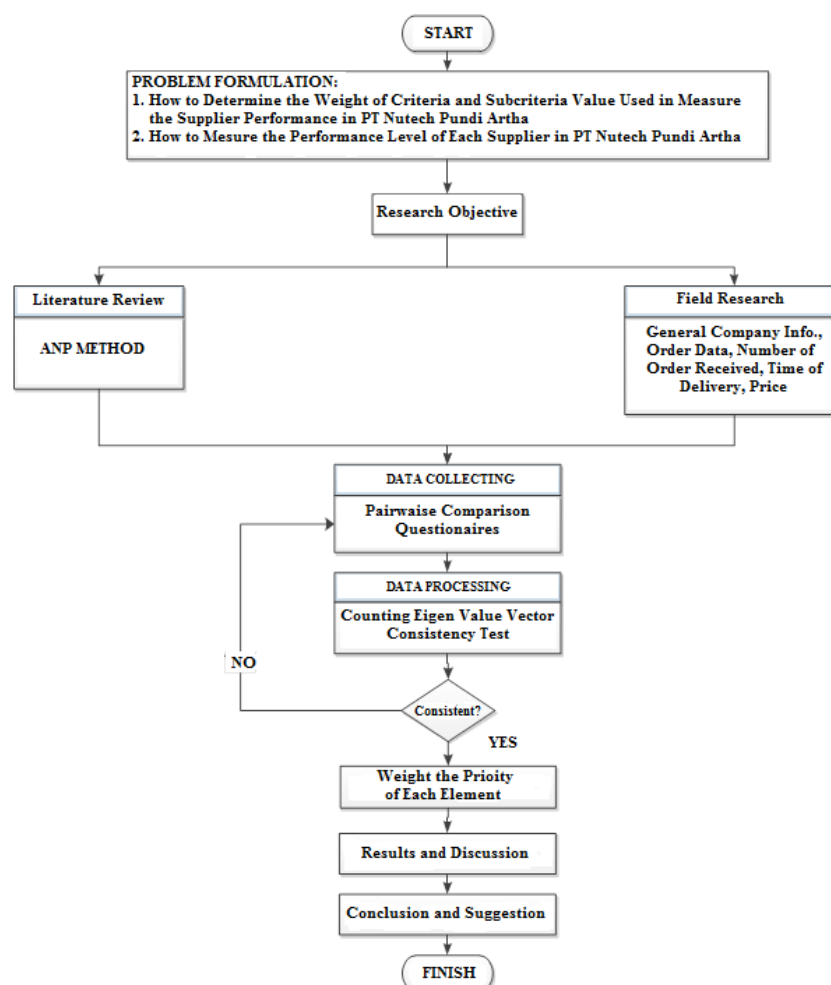


Figure 3. Research Flow Chart

4. Results and Discussion

PT. Nutech Pundi Arta is one of the companies engaged in general trade and services. PT. Nutech Pundi Arta was established in 2004 under the name BMK, then in 2008 changing its name to PT. Nutech Pundi Arta. PT. Nutech Pundi Artha production is based on the request of customers who have cooperated with the company. The products produced by the company include hardboards, carpets, plastic dampers and Felto. Currently PT. Nutech Pundi Arta is located in Palmerah, West Jakarta for head office and factory 1, while factory 2 is located in Kebon Jeruk, West Jakarta and factory 3 is located in Purwakarta, West Java. Customer at PT. Nutech Pundi Arta include Inoac, Toyota, Honda, Nissin, KICI, PT. AAA, and PT. Toyo Denso Indonesia.

4.1 Determination of Criteria and Sub-criteria

Criteria and subcriteria in this study is based on the discussions and interviews with experts related to suppliers using multi-criteria QCDFR (quality, cost, delivery, flexibility, and responsiveness) which has 5 criteria, 10 sub criteria, and 3 alternatives used in evaluating the performance of suppliers for hardboard material which can be seen in table 1 and table 2.

Table 1. Criteria and Sub-criteria

Criteria	SubCriteria	Description	Sources
Quality (Q)	Number of reject items (Q1)	The number of reject goods / materials received by the company from the supplier	Paramita (2012)
	Guarantee (Q2)	Provision of warranty or replacement of rejected material by the supplier	

Cost (C)	Payment method (C1)	Prices provided by suppliers are proportional to the quality of the goods	Iriani dan Herawan, (2010)
	Price Comparable to Quality (C2)	Ease of payment provided by suppliers	
Delivery (D)	Accuracy of Delivery Schedule (D1)	Schedule of arrival of goods according to company request	Pujotomo, Puspitasari, dan Rizkiyani (2016)
	Accuracy of Goods Delivered (D2)	The amount of goods purchased is in accordance with the amount of goods received by the company	
Flexibility (F)	Change in Order Volume (F1)	Fulfillment of changes in volume of goods ordered by suppliers	Iriani dan Herawan (2010)
	Changes in Delivery Time (F2)	Fulfillment of changes in shipping times by suppliers	
Responsiveness (R)	Response Speed Against Complaints (R1)	The length of time the supplier responds to complaints received by the company	Paramita (2012)
	Ease of Contact (R2)	Ease of ordering goods with suppliers	

Table 2. Alternative Suppliers

Alternatives	PT. A
	PT. GCI
	PT. RMA

Furthermore, respondents in this study related to supplier performance appraisal can be seen in Table 3 below.

Table 3. Research Respondents

No	Division	Position	Number of Respondents
1	<i>General Affair</i>	<i>General Manager</i>	1 person
2	Purchasing	<i>Supervisor</i>	1 person
3	<i>Quality Control</i>	<i>Supervisor</i>	1 person
4	Warehouse	<i>Supervisor</i>	1 person
5	PPIC	<i>Supervisor</i>	1 person

Making network structures is a very important stage in the process of Analytic Network Process (ANP). At this stage, each criterion and subcriteria will be determined whether it affects one another. Determination of the influence relationship between these subcriteria is done by interviewing the experts in supplier performance appraisal. Furthermore, structuring the network (network) based on the relationship between subcriteria is made using Super Decision software which can be seen in Figure 4.

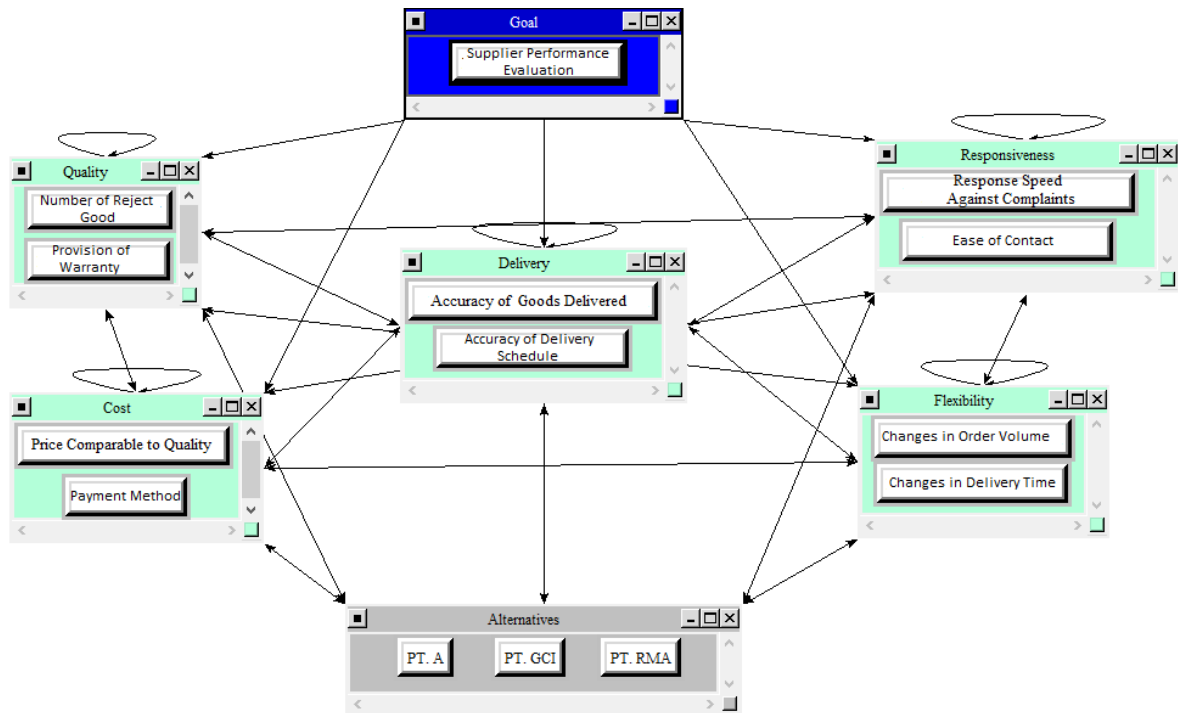


Figure 4. ANP Network Structure

Relationship between subcriteria and criteria is the basis for the formation of a network structure, which is the main and important part of the ANP. In this section there are two types of relationships that appear, namely inner dependence and outer dependence. The inner dependence relationship is found in all cluster criteria used. This shows that each subcriteria that exists in each cluster of criteria influences each other. The level of influence given can be seen in the Unweighted Supermatrix produced.

Likewise with the outer dependence relationship. This relationship also exists in all existing subcriteria. This shows that each subcriteria that exists in each cluster of criteria influences each other despite its small effect. The level of the relationship can also be seen in the Unweighted Supermatrix generated.

After collecting supplier questionnaire data and criteria-sub-criteria data, then processing the data using the ANP method. The supplier performance assessment questionnaire results obtained from 5 respondents were then averaged using geometric mean. Then the Mean Geometric results will be processed with Super Decision to obtain the value of Unweighted Supermatrix, Weighted Supermatrix and Limiting Matrix. The results of Unweighted Supermatrix, Weighted Supermatrix, and Limiting Supermatrix can be seen in table 4, table 5, and table 6 below.

Tabel 4. Unweighted Supermatrix

		Alternatives			Cost		Delivery		Flexibility		Goals	Quality		Responsiveness	
		PT. A	PT. GCI	PT. RMA	C-1	C-2	D-1	D-2	F-1	F-2	Pembelian Koneksi Supplier	Q-1	Q-2	R-1	R-2
Alternatives	PT. A	0	0	0	0.26897	0.2944	0.4	0.41851	0.33333	0.3333	0.33333	0.3028	0.3333	0.29615	0.31662
	PT. GCI	0	0	0	0.44735	0.2452	0.2	0.29575	0.33333	0.3333	0.33333	0.232	0.3333	0.251	0.3807
	PT. RMA	0	0	0	0.2836	0.4602	0.4	0.28572	0.33333	0.3333	0.33333	0.4651	0.3333	0.45284	0.30267
Cost	C-1	0.42196	0.60474	0.4273	0	1	0.5	0.44751	0.48186	0.5	0.25	0.387	0.49	0.48186	0.59514
	C-2	0.57803	0.39525	0.5726	1	0	0.5	0.55248	0.51813	0.5	0.75	0.612	0.509	0.51813	0.40485
Delivery	D-1	0.5	0.51813	0.5169	0.5	0.5	0	1	0.38461	0.5951	0.5	0.4818	0.5	0.5	0.5
	D-2	0.5	0.48186	0.48309	0.5	0.5	1	0	0.61538	0.4048	0.5	0.5181	0.5	0.5	0.5
Flexibility	F-1	0.5	0.5	0.5	0.5	0.5	0.63291	0.63397	0	1	0.5	0.5	0.5	0.5	0.5
	F-2	0.5	0.5	0.5	0.5	0.5	0.36708	0.34602	1	0	0.5	0.5	0.5	0.5	0.5
Goals	Supplier Performance Evaluation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quality	Q-1	0.57805	0.5169	0.63099	0.59839	0.6153	0.56896	0.5515	0.5	0.5	0.75	0	1	0.3865	0.5
	Q-2	0.42194	0.48309	0.369	0.4016	0.3846	0.43103	0.4484	0.5	0.5	0.25	1	0	0.61349	0.5
Responsiveness	R-1	0.5988	0.39393	0.57142	0.50761	0.5	0.66666	0.5169	0.43181	0.3333	0.33333	0.5951	0.5454	0	1
	R-2	0.40119	0.60606	0.42857	0.49238	0.5	0.33333	0.48309	0.56818	0.6666	0.66667	0.4048	0.4545	1	0

Tabel 5. Weighted Supermatrix

		Alternatives			Cost		Delivery		Flexibility		Goals	Quality		Responsiveness	
		PT. A	PT. GCI	PT. RMA	C-1	C-2	D-1	D-2	F-1	F-2	Pembelian Koneksi Supplier	Q-1	Q-2	R-1	R-2
Alternatives	PT. A	0	0	0	0.04413	0.04831	0.06928	0.06929	0.05306	0.05306	0.03488	0.04993	0.05098	0.04909	0.05245
	PT. GCI	0	0	0	0.07339	0.04024	0.04672	0.04897	0.05306	0.05306	0.03488	0.03826	0.06286	0.04172	0.06307
	PT. RMA	0	0	0	0.04654	0.07551	0.04956	0.04731	0.05306	0.05306	0.03488	0.0767	0.05105	0.07486	0.05014
Cost	C-1	0.09218	0.13211	0.09336	0	0.16394	0.07038	0.06299	0.0684	0.07097	0.01454	0.06015	0.07608	0.07183	0.08871
	C-2	0.12628	0.08635	0.1251	0.16394	0	0.07038	0.07776	0.07355	0.07097	0.04361	0.09504	0.07912	0.07723	0.06035
Delivery	D-1	0.13323	0.13807	0.13774	0.09527	0.09527	0	0.19806	0.08113	0.12553	0.05233	0.09804	0.10173	0.09335	0.09335
	D-2	0.13323	0.1284	0.12873	0.09527	0.09527	0.19806	0	0.1298	0.0854	0.05233	0.10542	0.10173	0.09335	0.09335
Flexibility	F-1	0.06166	0.06166	0.06166	0.06922	0.06922	0.08695	0.08984	0	0.15078	0.05233	0.06016	0.06016	0.06929	0.06929
	F-2	0.06166	0.06166	0.06166	0.06922	0.06922	0.05043	0.04754	0.15078	0	0.05233	0.06016	0.06016	0.06929	0.06929
Goals	Supplier Performance Evaluation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quality	Q-1	0.12567	0.11237	0.13718	0.11658	0.11989	0.11649	0.11292	0.09854	0.09854	0.39244	0	0.21405	0.07464	0.09656
	Q-2	0.09173	0.10502	0.08022	0.07824	0.07493	0.08825	0.09181	0.09854	0.09854	0.13081	0.21405	0	0.11848	0.09656
Responsiveness	R-1	0.10441	0.06869	0.09964	0.07523	0.0741	0.10234	0.07935	0.0579	0.0447	0.03488	0.08456	0.0775	0	0.16687
	R-2	0.06995	0.10568	0.07473	0.07297	0.0741	0.05117	0.07416	0.07619	0.08939	0.06977	0.05752	0.06458	0.16687	0

Tabel 6. Limiting Supermatrix

		Alternatives			Cost		Delivery		Flexibility		Goals	Quality		Responsiveness	
		PT. A	PT. GCI	PT. RMA	C-1	C-2	D-1	D-2	F-1	F-2	Pembelian Koneksi Supplier	Q-1	Q-2	R-1	R-2
Alternatives	PT. A	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472
	PT. GCI	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444
	PT. RMA	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005	0.05005
Cost	C-1	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758	0.07758
	C-2	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227	0.08227
Delivery	D-1	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349	0.10349
	D-2	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416	0.10416
Flexibility	F-1	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058	0.07058
	F-2	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347	0.06347
Goals	Supplier Performance Evaluation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quality	Q-1	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741	0.10741
	Q-2	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663	0.09663
Responsiveness	R-1	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947	0.07947
	R-2	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325	0.07325

Based on the results of data processing, priority can be obtained for all the following sub-criteria and alternatives in Table 7,

Table 7. Priorities of All Sub-Criteria and Alternatives

Name	Normalized By Kluster	Limiting
PT. A	0.33311	0.047198
PT. GCI	0.31364	0.04444
PT. RMA	0.35325	0.050053
Payment method	0.48533	0.077577
Price Comparable to Quality	0.51467	0.082268
Accuracy of Delivery Schedule	0.49839	0.103488
The Accuracy of the Amount of Goods Sent	0.50161	0.104156
Change in Order Volume	0.52653	0.070584
Changes in Delivery Time	0.47347	0.063471
Amount of Reject Goods	0.52642	0.107413
Provision of warranty	0.47358	0.096631
Response Speed Against Complaints	0.52038	0.079474
Ease of Contact	0.47962	0.073248
Total	6.0000	1.0000

Based on the results above, it can be seen that the limiting weight is the weight obtained from the supermatrix limit while the normalized by cluster weight is the local weight or the division between the weight limiting element and the number of limiting elements in one component. The biggest weight is the sub-number of reject items with global weight of 0.107413 or 10.74%. The weights for each alternative can be seen in Table 8 below.

Table 8. Priority for Synthesis for Alternatives

Alternatif	Ideals	Normals	Raw
PT. A	0.942973	0.333108	0.047198
PT. G	0.887858	0.313639	0.04444
PT. RAP	1	0.353253	0.050053

Based on the results above, it can be seen that there are weights in the form of ideals, raw, and normal. Normal weight is the result of alternative weights such as in the normalized by cluster priority weights. Raw weight is the result of alternative weights such as the weight limiting priority or limit matrix. Ideal weights are bobo obtained from the division between normal weights for each alternative with the greatest normal weight among these alternatives. These results indicate that PT. RMA gets the highest weight, which is 0.3533, followed by PT. A amounting to 0.3331 and third place, namely PT. GCI is 0.3136. So, in evaluating the performance of suppliers for hardboard materials of PT. RPA is the most optimal supplier.

5. Conclusion

Based on the results of data processing and analysis carried out by the Analytic Network Process (ANP) method in terms of supplier performance appraisal, it can be concluded that:

1. Quality criteria value is 0.2040 with sub-criteria value of reject (Q1) items of 0.1074 and provide a guarantee of 0.0966, Cost criteria value is 0.1598 with subcriteria value comparable price with quality of 0.0822 and payment method of 0.0775, Delivery criteria value is 0.2076 with sub-criteria for the accuracy of the number of items sent at 0.10415 and delivery schedule of 0.10348, Flexibility criteria value is 0.1340 with subcriteria changes in order volume of 0.0705 and subcriteria changes in delivery time of 0.0635, Responsiveness criteria value of 0.1527 with the values of sub-criteria for response to complaints

were 0.0794 and the ease of contacting was 0.0732. This shows that the quality criteria have the greatest influence on supplier performance appraisal.

2. Hardboard material suppliers that have the most optimal performance are PT. RMA with a global value of 0.050053, followed by PT. A with a value of 0.047198 and the lowest is PT. GCI is 0.04444.

6. Suggestion

Based on the results of the analysis and conclusions above, the researcher advised the company and related parties, namely:

1. Measurement of supplier performance carried out by PT. Nutech Pundi Artha can still be maintained as a partner of the company especially as a supplier of hardboard materials at PT. NPA. The results of this supplier's performance assessment should be informed to the supplier as a performance report in order to establish openness and it is expected that the supplier can maintain and improve its performance, it would be better if it is implemented in making the Company Operational Standards or Work Instructions in supplier evaluation.
2. For companies in the future, if there are new criteria or sub-criteria relevant to the company or in accordance with the new company policy, then the company can replace the criteria and subcriteria used in this study.

REFERENCES

- Akman, G., & Piskin, H. 2013. Evaluating Green Performance of Suppliers via Analytic Network Process and TOPSIS. *Journal of Industrial Engineering*, 1-13.
- Amran, T. G., Wulandari, S. T., & Prasyudi, O. 2014. Model Evaluasi Vendor. *Jurnal Teknik Industri ISSN: 1411-6340*, 65-85.
- Assauri, S. 2008. *Manajemen Produksi dan Operasi*. Jakarta: LPFEUI.
- Chopra, S., & Meindl, P. 2007. *Supply Chain Management: Strategy, Planning, and Operation*. New Jersey: Pearson.
- Govindaraju, R., & Sinulingga, J. P. (2017). Pengambilan Keputusan Pemilihan Pemasok di Perusahaan Manufaktur dengan Metode Fuzzy ANP. *Jurnal Manajemen Teknologi, Vol. 16, No. 1*, 1-16.
- Hariwan, P., Kholil, M., & Gadissa, A. 2015. Analisa Pengambilan Keputusan pada Penentuan Cairan Antiseptik Tangan yang Terbaik dengan Metode Analytical Hierarchy Process (AHP). *Jurnal PASTI Volume IX No 2*, 203-219.
- Heizer, J., & Render, B. 2009. *Manajemen Operasi (Buku 1)*. Jakarta: Salemba Empat.
- Indrajit, R. E., & Djokopranoto, R. 2006. *Konsep Manajemen Supply Chain*. Jakarta: PT Grasindo.
- Iriani, Y., & Herawan, T. 2012. Pemilihan Supplier Bahan Baku Benang dengan Menggunakan Metode Analytic Network Process (ANP). *Symposium Nasional RAPI XI FT UMS*.
- Kurniawati, D., Yuliando, H., & Widodo, K. H. 2013. Kriteria Pemilihan Pemasok Menggunakan Analytical Network Process. *Jurnal Teknik Industri Vol. 15 No. 1*, 25-32.
- Mauidzoh, U. 2007. Perancangan Sistem Penilaian dan Seleksi *Supplier* Menggunakan Multi Kriteria. *Jurnal Ilmiah Teknik Industri Vol. 5 No. 3*, 113-122.
- Musyaffak, H., Astuti, R., & Effendi, M. 2012. Penilaian Kinerja Supplier Pakan Ternak Menggunakan Metode Analytic Network Process (ANP) dan Rating Scale (STudi Kasus P DMC Malang-Jawa Timur). *Jurnal Industri Vol 2 No 3*, 153-160.
- Paramita, S., Effendi, U., & Dewi, I. A. 2012. Penilaian Kinerja Supplier Kemasan Produk "Fruit Tea" Menggunakan Metode FANP (Fuzzy Analytic Network Process) (Studi Kasus di PT Sinar Sosro Gresik). *Jurnal Industri Vol 1 No 3*, 159-171.
- Pujotomo, D., Puspitasari, N. B., & Rizkiyanti, D. 2016. Integrasi Metode ANP Dan TOPSIS Dalam Evaluasi Kinerja Supplier Dan Penentuan Prioritas Supplier Bahan Baku Utama Cetak Koran Pada PT Masscom Graphy Semarang. *Jurnal Teknik Industri, Vol. XI, No. 3*, 151-160.
- Rusydiana, A. S., & Devi, A. (2013). *Analytic Network Process: Pengantar Teori dan Aplikasi*. Bogor: SMART Publishing.

- Saaty, T. L. (2004). Fundamentals of The Analytic Network Process - Dependence and Feedback in Decision Making With A Single Network. *Journal of System Science and Systems Engineering*, 129-157.
- Sena, M. D. (2015). Penerapan Metode Analytic Network Process Untuk Menentukan Prioritas Perbaikan Jalan. *Jurnal Manajemen Informatika dan Teknik Komputer Vol. 1 No. 2*, 102-107.
- Tahriri, M. R., Osman, A. R., & Esfandiary, A. (2008). ANP approach for *supplier* evaluation and selection in a steel manufacturing company. *Journal of Industrial Engineering and Management Vol. 01 No. 02*, 54-76.
- Vanany, I. 2003. Aplikasi Analytic Network Process (ANP) Pada Perancangan Sistem Pengukuran Kinerja. *Jurnal Teknik Industri Vol. 5, No. 1*, 50-62.
- Vinodh, S., Ramiya, R. A., & Gautham, S. 2011. Application of Fuzzy Anytical Network Process For Supplier Selection in a Manufacturing Organisation. *Expert Systems with Applications 38*, 272-280.

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