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SUPPLIER SELECTION USING ANALYTICAL HIERARCHY PROCESS (AHP) AND TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS)

Aulia Ishak[1, a], Syafiah Khairunnisa Parinduri[2,b]
[1, 2] Industrial Engineering Department, Faculty of Engineering, Universitas Sumatera Utara, Medan, Indonesia
[a]aulia.ishak@gmail.com, [b]syafiahk@gmail.com

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Abstract. *Supplier selection is an important issue in decision making. In the manufacturing industry, one of the important activities is the procurement of raw materials by suppliers This Study Case which is a company engaged in the field of building materials with the main product in the form of nails with raw materials in the form of wire rod. In this research, some problems related to wire rod supplier that is not the right way used in supplier selection and delay of acceptance of raw materials, and less according to raw materials with quality and price of different raw materials from each supplier. This study aims to determine the best wire rod suppliers based on the weight of criteria and subcriteria and to rank on each supplier alternative. The method used in this research is AHP-TOPSIS method that will determine supplier priority. Determination of criteria and subcriteria is built on expert answers with closed and semi-open questionnaires. AHP method is used to obtain the weight of each criteria and subcriteria available and the weight is used in TOPSIS method to obtain the preference value of each supplier alternative which will determine the priority of the supplier. The research results show that there are 5 criteria with 15 subcriteria, where the quality weight has the biggest weight 0.5095, subcriteria The quality of service provided has the greatest weight of 0.2951 and PT. Master Steel has the greatest weight of 0.4589. Based on the preference value of PT. Master steel has the greatest preference value of 0.867. This shows that PT. Master Steel is in the order of the most important to become the best supplier prioritized in the fulfillment of wire rod supply to Company.*

Introduction

Nails are a product that is widely used as building material. Nail products are manufacturing products (semi-commodities) that depend on low cost operation. National Nail Needs according to data from the Indonesian Nail and Wire Factory Association (IPPAKI) are 120,000 tons per year or an average of 10,000 tons per month. . The installed capacity of Nail factory production in Indonesia under normal conditions is an average of 130,000 tons per year.

Along with the development of the manufacturing industry today, the industry is required to compete. In facing the competition, the industry must optimize every activity carried out, starting from the procurement of raw materials, production processes to finished goods. The thing that needs to be considered is the procurement of raw materials from suppliers (suppliers) that will be used in the production process.

This Research there are several obstacles faced in fulfilling the supply of raw materials by suppliers, namely the absence of the right method used in supplier selection and the delay in receipt of raw materials, and lack of conformity of raw materials with quality and prices of different raw materials from each supplier .

Therefore, we need a method that can be used in supplier selection by considering the criteria and order of priority in order to obtain the best suppliers who are able to meet the needs of the company. Supplier selection in this study by combining Analytical Hierarchy Process (AHP) and Technique For Order Preference By Similarity To Ideal Solution (TOPSIS) methods.

Literature References

Nail

In general, wire and nail products come from wire rods or Wire Rods (HS 7213.91.00.99; 7213.99.00.99) which are processed into various types of wire or Wire (HS. 7217.10.10.00; 7217.10.22.90; 7217.10.29.00) and finally produced as nails or Wire Nails (HS 7317.00.10.00). The nail production process in detail is nail wire processed as a material input feeder to the nail making machine and produced wire nails of various sizes ranging from 0.5 to 6 inches, the next step is to pack the nails into wooden boxes and pallets. Import and local nail and wire products have been standardized with SNI (Indonesian National Standard) which has been equated with the JIS (Japan Industrial Standard) standard. Domestic industrial nails and wires investigated have the same physical and technical characteristics and directly compete with imported nails and wires investigated [1].

Supplier

Selection and evaluation of suppliers has become one of the main topics in the production and operations management literature, especially in advanced technology and manufacturing environments. Supplier selection is a strategic process to mitigate the risk of partial upstream supply chains, if not fully implemented. Better relationships between sellers and buyers can increase supply chain visibility and the ability to overcome high demand volatility. Thus, the selection of suppliers is an integral part of any business[2].

Selection of the right supplier can minimize external risk. Supplier selection can be a single source or multiple sources. In a single source, all supplies come from one supplier. In some sources, on the other hand, all supplies come from a group of suppliers. Risks in the supply chain can be minimized by internal integration and external integration of supply chain sources. External integration strongly encourages single procurement by strengthening buyer-supplier relationships. Selection of suppliers is a process where suppliers are reviewed, evaluated and selected to be part of the company's supply chain[3]. The objectives of supplier selection are as follows:

1. To reduce the risk of procurement
2. To maximize the overall value of sales
3. To build a close relationship and long-term relationship between customers and suppliers.

Selection of suppliers is a strategic problem of various types of business because several things, namely, procurement is considered as a process of adding value to the supply chain, active supplier involvement can improve the efficiency and effectiveness of the supply chain. A brief product life cycle and rapid product innovation give more emphasis to the integration of material and information flows, both internally and externally[4].

According to, the results of research from Dickson became a reference for research that discussed suppliers or vendors. Dikcson research is based on a questionnaire sent to 273 agents and purchasing managers selected from members of the National Association of Purchasing Managers. Members of this association are sales agents and managers in the US and Canada. From the results of the study there were 23 important criteria for the supplier selection process which were sorted from the highest to lowest mean rating. The highest mean rating can be concluded as the most significant and most important criterion. In that year, the most significant criteria were product quality, delivery time, historical performance data, and warranty policies used by suppliers.[5]. These criteria can be seen in Table 1.

Table 1. Dickson Supplier or Vendor Selection Criteria

Rank	*Factor*	*Mean Rating*	*Evaluation*
1	*Quality*	3,51	*Extreme importance*
2	*Delivery*	3,42	
3	*Performance History*	3,00	
4	*Warranties and claim policies*	2,85	*Considerable importance*
5	*Production and claim policies*	2,78	
6	*Price*	2,76	
7	*Technical capability*	2,55	
8	*Financial position*	2,51	
9	*Prosedural compliance*	2,49	
10	*Communication system*	2,43	
11	*Reputation and position in industry*	2,41	
12	*Desire for business*	2,26	
13	*Management and organization*	2,22	
14	*Operating controls*	2,21	
15	*Repair service*	2,19	
16	*Attitudes*	2,12	
17	*Impression*	2,05	*Average importance*
18	*Packaging ability*	2,01	
19	*Labor relations records*	2,00	
20	*Geographical location*	1,88	
21	*Amount of past business*	1,60	
22	*Training aids*	1,54	*Average importance*
23	*Reciprocal arrangements*	0,61	*Slight importance*

Analytical Hierarchy Process

In solving problems with explicit logic analysis there are three principles: the principle of compiling hierarchy, the principle of setting priorities, and the principle of logical consistency. From the various considerations, synthesis is then carried out to determine the variables that have the highest priority and play a role in influencing the results of the system. Basically, this AHP method breaks down a complex, unstructured situation into its component parts, namely arranging parts or variables in a hierarchical arrangement giving numerical value to subjective considerations of the relative importance of each variable and synthesizing these various considerations to determine which variable has the highest priority and acts to influence the results of the situation. In solving problems with AHP there are several stages, namely: decomposition, pair comparisons (pair comparisons), priority synthesis (synthesis of priority), and logical consistency (logical consistency)[6].

***Technique for Order Preference by Similarity to Ideal Solutions* (TOPSIS)**

The Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) method is a method developed by Hwang and Yoong as an alternative to ELECTRE. The basic principle of this method is to choose an alternative with the shortest distance from a positive ideal solution and the solution farthest from a negative solution in a geometric sense. The TOPSIS method assumes that each attribute has a monotonous increase or reduced utility. This method makes it easy to find ideal positive solutions and negative ideal solutions. Thus, the preference sequence of alternatives is generated through a comparison of euclidean distances[7].

The distance between weighted values for each alternative value towards a positive ideal solution can be calculated as follows:

$$Dj^{+} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{ij}^{+})^2}$$

The preference value for each alternative can be calculated using the following formula

$$Cj^{*} = \frac{Dj^{-}}{Dj^{-} + Dj^{+}}$$

Method

The research was conducted at company that manufactures nail products from May 2018 to November 2018. The object of research observed were the three raw material suppliers.

The variables contained in this study are:

1. The dependent variable in this study is the best alternative supplier.
2. Independent variables in this study, namely supplier selection criteria, namely Quality, Delivery, Price, Guarantee and Complaint Service, and Previous Performance Achievement.

Data collection in this study was conducted using questionnaire instruments consisting of closed questionnaires about determining criteria, semi-open questionnaires about questionnaires about determining subcriteria and AHP about the relationship of influence between criteria. Questionnaire respondents were parties related to supplier selection namely factory manager, head of production, head of inventory, head of warehouse, delivery order.

The stages of conducting research are:

1. A preliminary study is carried out to identify problems found in the company, the production process and other information.
2. Study literatures and supporting theories to get solutions to problem solving.
3. Data collection for research with closed questionnaires to obtain criteria with dickson and semi-open theories to obtain subcriteria.
4. Data collection for research with AHP questionnaire to get the level of importance.
5. Processing data using AHP and TOPSIS methods.
6. Analyzed the results of data processing.
7. Draw conclusions and give suggestions for the research conducted.

Problem solving analysis starts with getting criteria and subcytia, then calculating the weight of subcriteria by using AHP and calculating and evaluating ranking with TOPSIS. the research thingking framework steps in the study can be seen in figure 1.

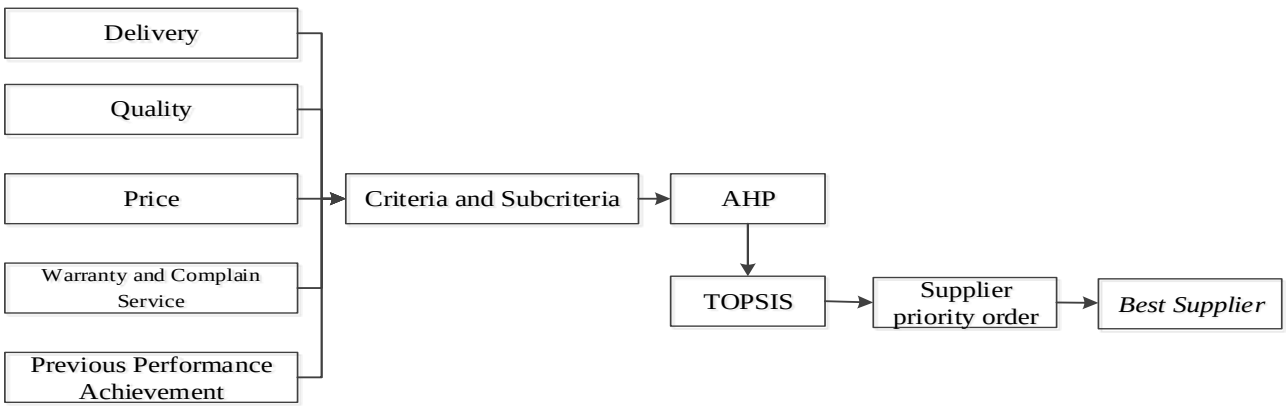

Figure.1. Research Thinking Framework

Conclusions

Criteria Results and supplier selection subcategories based on the results of the questionnaire include:

Table 2. Questionnaire Recapitulation

Dickson Criteria	Sub-criteria	Symbol
Quality (K1)	Quality of service provided	SK1
	Quality consistency	SK2
	Compliance with the desired specifications	SK3
Delivery (K2)	The accuracy of the amount sent	SK4
	Timeliness of delivery	SK5
	Continuity of delivery	SK6
Warranties and Claim Policies (K3)	Ease in claim process	SK7
	Goods guarantee on time	SK8
	Providing guarantee of raw materials	SK9
	Speed of responding to complaints	SK10
Price (K4)	Raw material prices	SK11
	Cost of shipping raw materials	SK12
	Shipping Cost Insurance	SK13
Performance History (K5)	Ability to fulfill the set schedule	SK14
	Ability to maintain contract agreements	SK15

Results of Relationship Between Criteria and Subcriteria After the criteria and subcriteria are determined, then the relationship between criteria and subcriteria is determined through the results of the AHP questionnaire. The results of the criteria and subcriteria relationship as shown in Figure 2.

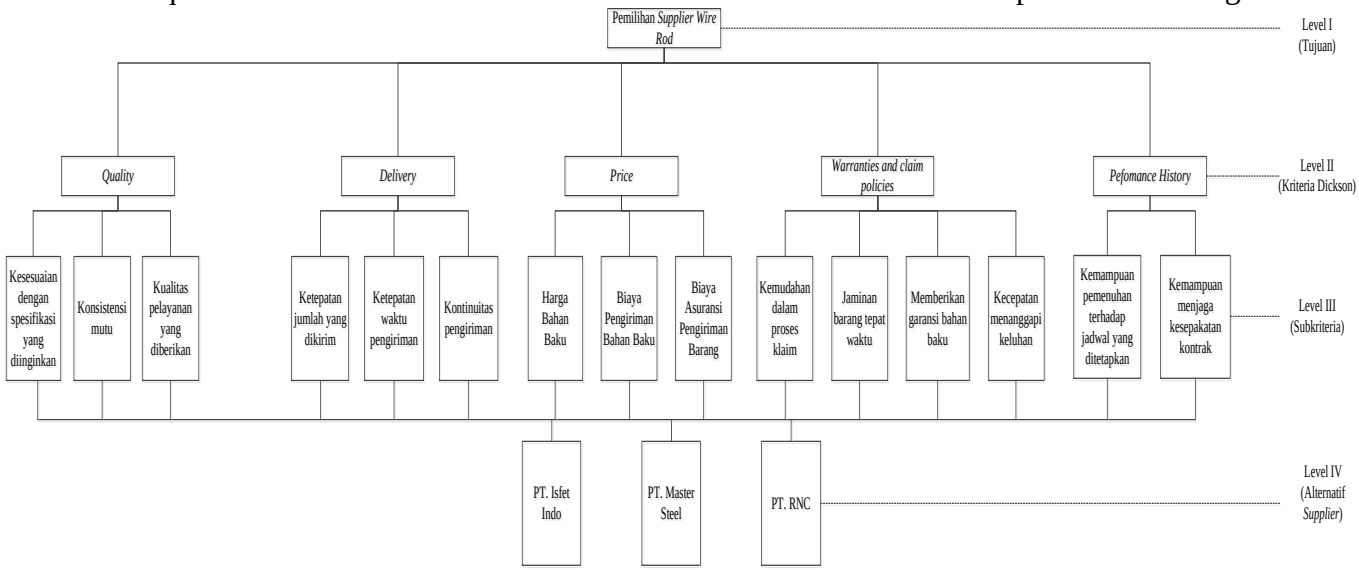

Figure 2. Hierarchy of Selection of Suppliers

Figure 2. shows that the hierarchical structure at Level 1 is the goal which is the choice of suppliers, at level 2 there are five criteria used to select suppliers, namely quality, delivery, price, warranty and complaint services, and previous performance achievements. This criterion was taken based on Dickson's theory with the distribution of closed questionnaires. At level 3 there are 15 sub-criteria of all criteria. These sub-criteria obtained from the distribution of semi-open questionnaires to experts in the company from the development of Dickson's theory

Subcriteria weighting

AHP method is used to get the weight of each supplier criteria The results of the criteria and subcriteria weights can be seen in Table 3.

Table 3. Criteria and Sub-criteria weights

Level 2		Level 3	
K1	0,5095	SK1	0,1396
		SK2	0,0748
		SK3	0,2951
K2	0,1272	SK4	0,0264
		SK5	0,0858
		SK6	0,0151
K3	0,0654	SK7	0,1480
		SK8	0,0574
		SK9	0,0263
		SK10	0,0260
K4	0,2317	SK11	0,0268
		SK12	0,0077
		SK13	0,0049
K5	0,0662	SK14	0,0464
		SK15	0,0198

Table 3 shows that the criteria that has the greatest weight is quality with a value of 0.5095. While at level 3, the subcriteria that has the greatest weight is conformity with the desired specifications with a value of 0.2951. The sub-criteria of conformity with the desired specifications are the main sub-criteria prioritized by the company because they are a determining factor whether the wire rod can be accepted by the company to be processed or not. If it is not suitable, then the raw material will be rejected and result in reduced supply of raw materials so that the company cannot run the production process to the maximum.

After all the weight values for each level are obtained, the selection of alternative suppliers is determined to have the highest weight or percentage. The total weight can be calculated by summing the priority level 4 weight for each alternative so that the total value obtained shows the weight. The results of the calculation of alternative weight of supplier selection can be seen in Table 4.

Table 4. Calculation of Total Weight of the Wire Rod Supplier

Supplier	Weight	Percentage	Rank
PT. Isfet Indo	0,3285	32,85%	II
PT. Master Steel	0,4589	45,89%	I
PT. RNC	0,2126	21,26%	III
Total	**1,0000**	**100%**	

Table 3 shows the results of the weight calculation for the order of nail suppliers, namely PT. Master Steel (45.89%), PT. Isfet Indo (32.85%), and PT. RNC (21.26%).

After calculating the weights using the AHP method, the TOPSIS calculation is then carried out by constructing a decision matrix. The processing steps of the TOPSIS method are as follows:

1. Arrange Normalization of Decision Matrix

Table 5. Normalization of Decision Matrices

Supplier	SK1	SK2	SK3	SK4	SK5	SK6	SK7	SK8	SK9	SK10	SK11	SK12	SK13	SK14	SK15
S1	0,3010	0,3854	0,3684	0,5364	0,2688	0,3748	0,2715	0,3591	0,3135	0,1763	0,2213	0,4128	0,3056	0,2870	0,4335
S2	0,5585	0,3916	0,4606	0,2926	0,5548	0,2964	0,4595	0,3905	0,3849	0,6607	0,4288	0,2494	0,4069	0,4283	0,1459
S3	0,1405	0,2230	0,1710	0,1710	0,1764	0,3288	0,2690	0,2504	0,3016	0,1630	0,3499	0,3377	0,2875	0,2848	0,4206

2. Normalization of the Weighted Decision Matrix

Table 6. Normalization of the Weighted Decision Matrix

Supplier	SK1	SK2	SK3	SK4	SK5	SK6	SK7	SK8	SK9	SK10	SK11	SK12	SK13	SK14	SK15
S1	0,0989	0,1266	0,1210	0,1762	0,0883	0,1231	0,0892	0,1180	0,1030	0,0579	0,0727	0,1356	0,1004	0,0943	0,1424
S2	0,2563	0,1797	0,2114	0,1343	0,2546	0,1360	0,2109	0,1792	0,1766	0,3032	0,1967	0,1145	0,1867	0,1965	0,0669
S3	0,0299	0,0474	0,0364	0,0364	0,0375	0,0699	0,0572	0,0532	0,0641	0,0347	0,0744	0,0718	0,0611	0,0606	0,0894

3. Positive and Negative Ideal Solution Matrix

Table 7. Recapitulation of Ideal Positive Solutions (A +) and Ideal Negative Solutions (A-)

Supplier	SK1	SK2	SK3	SK4	SK5	SK6	SK7	SK8	SK9	SK10	SK11	SK12	SK13	SK14	SK15
S1	0,0989	0,1266	0,1210	0,1762	0,0883	0,1231	0,0892	0,1180	0,1030	0,0579	0,0727	0,1356	0,1004	0,0943	0,1424
S2	0,2563	0,1797	0,2114	0,1343	0,2546	0,1360	0,2109	0,1792	0,1766	0,3032	0,1967	0,1145	0,1867	0,1965	0,0669
S3	0,0299	0,0474	0,0364	0,0364	0,0375	0,0699	0,0572	0,0532	0,0641	0,0347	0,0744	0,0718	0,0611	0,0606	0,0894
Max	0,2563	0,1797	0,2114	0,1762	0,2546	0,1360	0,2109	0,1792	0,1766	0,3032	0,1967	0,1356	0,1867	0,1965	0,1424
Min	0,0299	0,0474	0,0364	0,0364	0,0375	0,0699	0,0572	0,0532	0,0641	0,0347	0,0727	0,0718	0,0611	0,0606	0,0669

4. Distance Between Alternative Values and Positive and Negative Ideal Solution Matrix

Table 8. Distance between Alternative Values

	Dj^+	Dj^-
D1	0,4254	0,2508
D2	0,0889	0,5798
D3	0,5922	0,0226

5. Alternative Preference Value

Table 9. Recapitulation of Alternative Preference Values of TOPSIS Method

Supplier	Preference Value	Percentage	Ranking
S1	0,3709	37,09 %	II
S2	0,8670	86,70 %	I
S3	0,0367	3,67 %	III

Based on the results of the study, the most influential criteria for supplier selection are quality, while the most influential sub-criteria are conformity with the desired specifications. the priority principle of supplier of nail raw materials is PT. Master Steel (86.70%), PT. Isfet Indo (37.09%), and PT. RNC (3.67%).

Companies need to make a commitment in working with better suppliers such as establishing a system of fines, building a real time information system and creating high human resources so that this research can be realized.

The AHP method cannot consider the distance for each alternative but this method has the advantage of having a hierarchy that can make problems easier and take into account the inconsistencies of the assessment. While the TOPSIS method, does not do the decomposition of the problem, and there has been no determination of the priority weighting of the criteria, but the advantages of this method are because it can make decisions in a practical manner, the calculation is easier than other methods.

Based on the weaknesses and strengths of the two methods, a combination of AHP and TOPSIS methods was carried out, where the AHP method was applied for weighting criteria and subcriteria and TOPSIS for ranking based on input from the AHP criteria. Both methods are combined to produce maximum decisions.

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