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PROPOSED SELECTION OF PVC PIPE PRODUCT SUPPLIERS IN TOKO BESI LANCAR REJEKI USING THE ANALYTICAL NETWORK PROCESS METHOD

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Abstract: Toko Besi Lancar Rejeki is a shop that sells materials and equipment for building materials. This store was founded in 2003 and cooperates with several suppliers to supply some building materials. One of the items supplied is a pipe. Pipes are items that are quite often purchased. There is a main supplier that supplies PVC pipe product, namely Supplier A. However, there are some situations that make the store suffer losses, such as shipping errors made by the supplier and damage to the pipe which makes the store must return it to the supplier. Identification and decision-making processes are done using the Analytical Network Process (ANP) method which is based on the relationship between the criteria and sub-criteria. There are 6 criteria, 14 sub-criteria, and 10 relationships. The 6 criteria set are variety, price, quality, service, delivery, and flexibility. This assessment resulted in supplier selection priorities that can be carried out by Toko Besi Lancar Rejeki, namely Supplier C with a limiting value of 0.124982, for Supplier B it is 0.106648, and Supplier A it is 0.09128. Supplier selection is based on the priority sub-criteria obtained, namely the price of one pipe, pipe flexibility, and discounts.

Keywords: *Analytical Network Process (ANP), Criteria, PVC pipe, Sub criteria, Supplier*

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1. Introduction

The process of building a place requires materials and equipment that can be purchased at a shop. This shop sells materials and equipment, so collaboration with external parties is really important to do. External parties can also be called suppliers. Toko Besi Lancar Rejeki is a shop that sells materials and equipment for building materials which has been established since 2003 and is located in the Margacinta area, Bandung City. Sales are made to several types of consumers, such as paper factory consumers, furniture consumers or consumers who buy individually. All types of goods sold in this shop are finished goods that do not require a production process again. Toko Besi Lacar Rejeki collaborates with various different suppliers. Figure 1 shows the frequency of purchases of goods made by the shop from suppliers.

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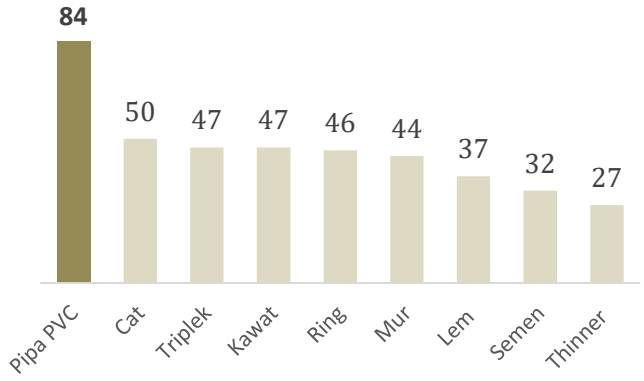

Figure 1. Frequency of purchasing goods from Toko Besi Lacar Rejeki in 2020

Based on this picture, it can be seen that PVC pipe products have the highest frequency level. The results of the interview show that the shop collaborates with 5 suppliers including Supplier A, Supplier B, Supplier C, Supplier D, and Supplier E. The system for purchasing goods from suppliers is carried out using purchase to stock, where the goods ordered will be stored by the shop in the warehouse. If there is demand, the products that have been stored will be given to consumers. The shop also operates a purchase to order system, this situation happen, if goods in the warehouse are not available or not enough to supply. Based on the five suppliers mentioned previously, there is a main supplier that collaborates with this shop, namely Supplier A. This collaboration with Supplier A has been formed 8 years ago. If there is demand for PVC pipe products, the shop will make purchases from Supplier A.

Determining Supplier, A as the main supplier for this shop is because supplier A has good quality goods. When placing an order with Supplier A, this iron shop orders according to the availability of goods in the warehouse. If the inventory of goods is running low, the shop will order goods from the supplier in accordance with existing regulations. The level of service in the form of response speed from Supplier A is quite fast compared to other suppliers. The cooperative relationship between Supplier A and Toko Besi Lancar Rejeki is quite good, however in 2020 there were several incidents that showed reduced performance from Supplier A. In the period from January to December 2020, there were several problems caused by Supplier A. Figure 2 shows Data on PVC pipe product returns for the Lacar Rejeki Iron Shop.

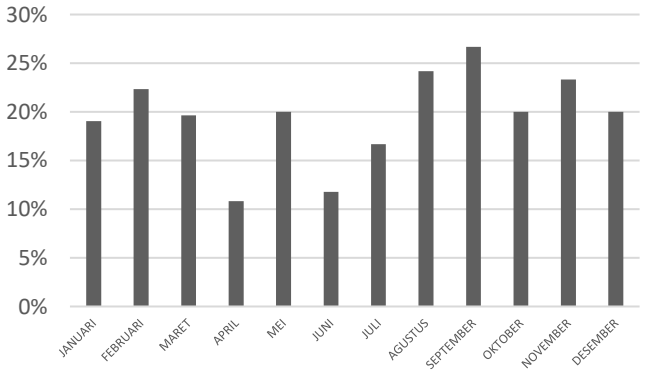

Figure 2. Toko Besi Lancar Rejeki Return Rate in 2020

This return rate does not show a decrease in each month and there is an increase in certain months. This is due to several problems caused by Supplier A, including incorrect specifications for the pipe products sent and defects found in the pipes. Defects are caused by forklift pressure on pipes in the distribution system and there was incorrect information conveyed by the supplier to the shop which caused the shop to experience losses due to a quite large difference, namely around 14.3%. In addition, several times in 2020, suppliers were unable to meet demand from stores. This makes the shop have to look for other suppliers to be able to meet existing demand. If we look at the problem of Toko Besi Lancar Rejeki, there are several relationships that can be seen from the relationship between the speed of response to the shop and the delivery time. If the speed of response to the store is faster, the delivery time will be faster. Then there is also a relationship between pipe variations and price, where gray pipes with the "AW" type will be more expensive than other variations.

This initial identification resulted in identifying the criteria and sub-criteria used in selecting suppliers at the Toko Besi Lancar Rejeki, including variety, price, quality, cooperation, delivery and ordering flexibility. Each alternative supplier has different performance for each existing criterion and sub-criteria. Each criterion that will be used has a different weight percentage or level of importance and really depends on the condition of the shop (Pujawan & Erawan, 2010).

In making decisions to select suppliers based on a number of criteria or Multi Criteria Decision Making (MCDM), one method that can be used is Analytical Network Process (ANP). The Analytical Process method applies a decision-making technique with the linkage between network structures and feedback from the decisions obtained (Saaty & Vargas, 2013). This is because the ANP method will consider various interrelated criteria and sub-criteria in selecting suppliers.

2. Literature Review

This research uses a method called Analytical Network Process. This method is a fairly accurate method for producing decisions (Saaty & Vargas, 2013). The Analytical Network Process (ANP) is a development of the Analytical Hierarchy Process (AHP). Both have the same similarity or goal, namely lowering the priority scale value by making pairwise comparisons of previously selected criteria. Figure 3 shows the differences in the representation of the ANP and AHP models for each selected criterion.

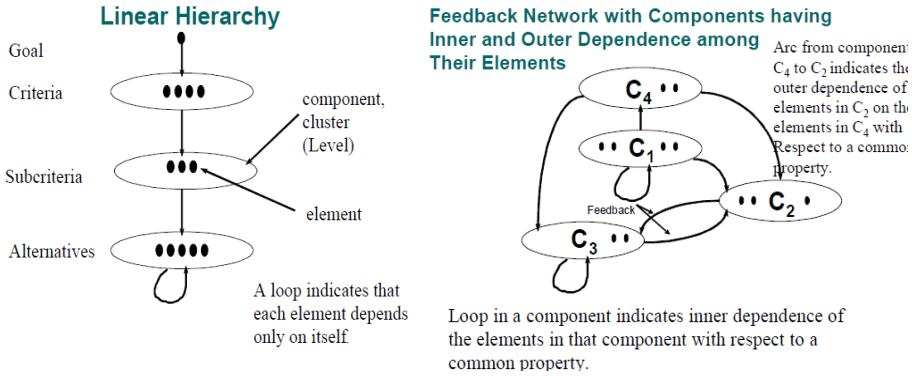

Figure 3. Differences in ANP and AHP Structures
(Sumber: Saaty & Vargas, 2013)

In Figure 3, it can be seen that AHP only focuses on hierarchical or sequential arrangements and is linear, whereas for the ANP method each criterion requires continuity or connected to one another. This feedback network model does not have a hierarchical form, but is looping or occurs continuously in the cluster (Saaty & Vargas, 2013). In the decision-making process using the ANP method, there are several stages. This stage is also in accordance with existing basic principles and axioms. According to Yuksel and Dagdeviren (2007), there are several stages in decision making using the ANP method.

1. Prepare the problem structure and develop the model.
   In identifying problems, it is necessary to determine the goals and objectives to be achieved. The aim is to determine the control criteria and existing alternative options.

2. Make a pairwise comparison matrix
   Decision makers will assess the modeling that has been formed using a fundamental scale. Table 1 shows the assessment references that decision makers can use.

Table 1. *Fundamental scale* ANP

Value	*Description*
1	*equal importance*
3	*moderate importance of one over another*
5	*strong or essential importance*
7	*very strong or demonstrated importance*
9	*extreme importance*
2,4,6,8	*intermediate values*
Use reciprocals for inverse comparisons	

(Source: Saaty & Vargas, 2013)

This comparison will be changed or transformed into a matrix form called matrix A. The notation for forming this matrix can be seen in the following equation.

$$a_{ij} = \frac{w_i}{w_j}$$ Equation 1

$$A = \begin{bmatrix} \frac{w_1}{w_2} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_2} \\ \frac{w_1}{w_2} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_2} \\ \vdots & \cdots & \cdots & \vdots \\ \frac{w_1}{w_2} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_2} \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \cdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}$$ Equation 2

3. Calculation of element weights (eigen vectors)
   After determining the pairwise comparison matrix, the weights are then calculated. The calculation begins by finding the c value for each part in matrix A by adding up each column in matrix A. Then normalization of matrix A will be carried out. The following equation is used to find the eigenvector value.

$$A_{norm} = \begin{bmatrix} \frac{1}{c_1} & \frac{a_{12}}{c_2} & \cdots & \frac{a_{1n}}{c_n} \\ \frac{a_{21}}{c_1} & \frac{1}{c_2} & \cdots & \frac{a_{2n}}{c_n} \\ \vdots & \cdots & \cdots & \vdots \\ \frac{a_{n1}}{c_1} & \frac{a_{n2}}{c_2} & \cdots & \frac{1}{c_n} \end{bmatrix} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \cdots & \cdots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nn} \end{bmatrix} \quad \text{Equation 3}$$

$$W_i = \frac{\sum_{j=1}^{j=n} X_j}{n_j} \quad \text{Equation 4}$$

4. Calculation of consistency ratio
   The next step is to calculate the consistency ratio. In the initial part, the Aw^T calculation is carried out, which is the multiplication of the A matrix with the eigenvector matrix. This calculation is carried out using the following equation.

   $$Aw^T = A \times Matriks\ Eigen\ Vector \quad \text{Equation 5}$$

   Then look for the value of λ_{max} to be input for the next calculation. λ_{max} is found by adding the Aw^T value which has been divided by the eigenvector. After that, calculations were carried out for the Consistency Index and Ratio values which can be seen in the Equation 6 and 7 below.

   $$CI = \frac{\lambda_{maks} - n}{n - 1} \quad \text{Equation 6}$$

   $$CR = \frac{CI}{RI} \quad \text{Equation 7}$$

   According to Saaty (1996), the random comparison to obtain the RI has been set at 500 samples. This RI value is a random value that is used according to the desired order number. Table 2 shows the random values used.

Table 2. *Random Index (RI)*

Order	**1**	**2**	**3**	**4**	**5**
RI	0	0	0,52	0,89	1,11
Order	**6**	**7**	**8**	**9**	**10**
RI	1,25	1,35	1,4	1,45	1,49

(Source: Saaty, 1996)

5. Supermatrix Creation
   According to Saaty (2013), the data processing process using the ANP method is followed by creating a supermatrix. In making a supermatrix, there are four parts, including cluster matrix, unweighted supermatrix, weighted supermatrix, and limiting supermatrix. Each of these will be discussed in the following sections.
   a. Cluster Matrix
      In forming this matrix, the eigenvector values of the relationships between existing clusters will be taken into account.

b. Unweighted Supermatrix
In this section, the value is obtained from the eigenvector value of pairwise comparisons between nodes, which still takes into account clusters, criteria and sub-criteria.
c. Weighted Supermatrix
This matrix shows the magnitude of the influence of one element on other elements. The weighted supermatrix value can be obtained by multiplying the unweighted supermatrix value by the cluster matrix.
d. Limiting Supermatrix
In the last part, a supermatrix is created by increasing the value of the weighted supermatrix. This is done by multiplying it several times with itself. This process is carried out for all existing nodes and until the weight of each column in one row is the same.

3. Research Method

In conducting this research to select suppliers for the Toko Besi Lancar Rejeki need a method that can make a final desicion. The plan for a research requires a methodology that shows theoretically systematic steps to apply the Analytical Network Process (ANP) method and can be seen in Figure 4.

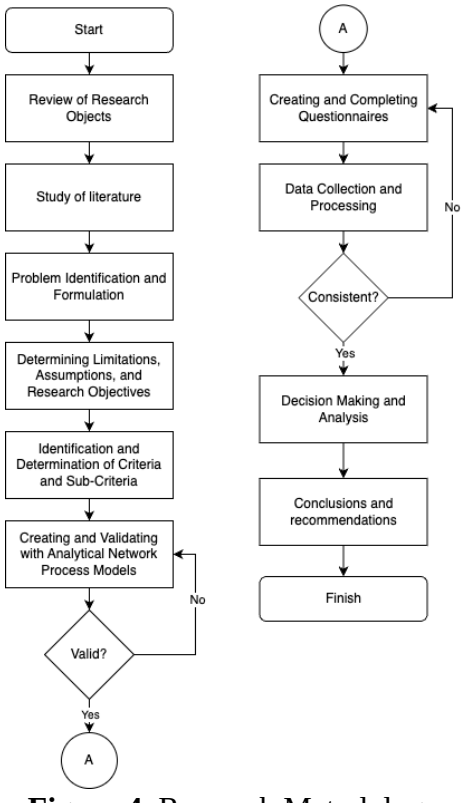

Figure 4. Research Metodology

ANP Modeling

In carrying out ANP modeling, several things need to be done so that the results obtained are in accordance with the conditions of the Smooth Rejeki Iron Shop. This modeling process is carried out by conducting follow-up interviews and literature studies to confirm whether the criteria and sub-criteria previously identified are appropriate or not. There are several journals

used in carrying out this identification and the results of the selection of criteria and sub-criteria based on the results of interviews and literature studies that have been carried out can be seen in Table 3.

Table 3. Criteria and Sub-Criteria

Criteria	Sub Criteria	Subcriteria Mark for New
Variation	Color	
	Type	
Price	Price Pipe	
	Payment Method	v
	Discount	v
Quality	Pipe flexibility	
Service	Accuracy of Information	
	Speed and Responsiveness of Service	v
	Return Deadline	
Delivery	Supplier distance from shop	
	Delivery time	
	Lead Time Delivery	
	Conformity of goods to established specifications	v
Ordering Flexibility	Ease of adding or reducing order quantities	v

In the model that has been created, there are relationships that are formed, namely for inner dependence and outer dependence. The relationships formed have been adjusted to the definitions that have been made previously. Making this model involves 6 different criteria with 14 sub-criteria related to these criteria. Figure 5 shows a depiction of the overall model.

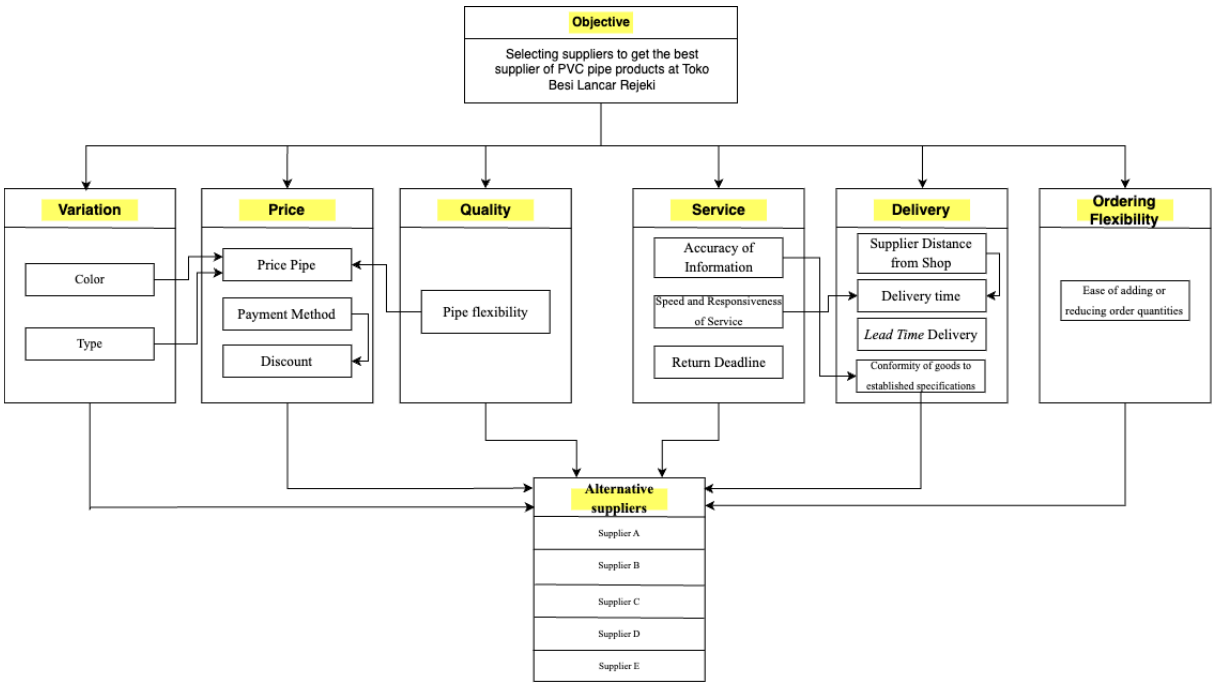

Figure 5. The overall ANP model at the Toko Besi Lancar Rejeki

4. Result and Discussion

Data processing is carried out using the results of questionnaires that have been filled in by decision makers. The results of this processing are carried out by looking for eigenvector values and then carrying out consistency testing to see whether the decision maker's assessment is consistent or not. There are 4 things that are assessed, including comparisons between criteria and between sub-criteria based on objectives, between criteria and between sub-criteria based on alternative suppliers, between alternative suppliers based on sub-criteria, and between criteria and alternative suppliers based on the relationship that is formed. The results of this data processing produce priority suppliers that can be used as replacements for the current main supplier. Table 4 shows a recapitulation of the limiting and normalized by cluster values obtained.

Table 4. Recapitulation of Limiting and Normalized Values by Cluster

Cluster	Node	Limiting	Normalized By Cluster
Alternative suppliers	Supplier A	0,09128	0,22099
	Supplier B	0,10665	0,2582
	Supplier C	0,12498	0,30259
	Supplier D	0,05731	0,13876
	Supplier E	0,03282	0,07946
Ordering Flexibility Criteria	Ease of adding or reducing order quantities	0,01116	1
Price Criteria	Payment Method	0,01134	0,03709
	Discount	0,06458	0,21118
	Price Pipe	0,22987	0,75173
Quality Criteria	Pipe flexibility	0,15536	1
Service Criteria	Return Deadline	0,00612	0,17047
	Speed and Responsiveness of Service	0,01419	0,39567
	Accuracy of Information	0,01556	0,43386
Delivery Criteria	Supplier Distance from Shop	0,00468	0,0838
	Conformity of goods to established specifications	0,03275	0,58587
	Lead Time Delivery	0,00286	0,05116
	Delivery time	0,01561	0,27917
Variation Criteria	Type	0,01817	0,7941
	Color	0,00471	0,2059
Objective	Supplier Selection	0	0

In Table 4, it can be seen that the supplier priority order obtained based on the results of data processing is that Supplier C can be used as the main supplier, then Supplier B and Supplier C. The priority of supplier selection is influenced by existing sub-criteria in accordance with the order of limiting values, including the sub-criteria price of one pipe, pipe flexibility, discounts/rebates, and conformity to specifications.

The sub-criteria price has Supplier C which has an absolute winning rating when compared to other suppliers. This is what makes Supplier C the supplier with the first priority. However,

if the pipe is not available from Supplier C, then Supplier B will be chosen. This decision was made because the pipe flexibility assessment between Supplier A and Supplier B is only slightly different, when compared to the eigenvector values. However, in the decision maker's assessment, the value between 2 suppliers is 1, which means that the suppliers have comparable levels. Therefore, the analysis will continue with the discount/rebate sub-criteria. If we look at the pairwise comparisons carried out, Supplier B has a very superior assessment when compared to Supplier A. Therefore, if the rating at Supplier C is not good, then it can be replaced with supplier B. In this selection there is also a relationship between sub-criteria for discounts/rebates on the price of one pipe. If the discount given is bigger, the price of one pipe will also be smaller and this will allow the supplier to be in second place in priority for selecting suppliers.

If you look at the third position, there is Supplier A which can be selected if the pipe is not found in Supplier C and Supplier B. This is because Supplier A is in second position for the sub-criteria price of one pipe, where this sub-criterion is the first thing seen in determining supplier selection. If we look at the sub-criteria for pipe flexibility, supplier A is in third position, so that the third order of determining supplier priorities is consistent.

5. Conclusion

The process of selecting suppliers for PVC pipe products results in conclusions being drawn based on previously established objectives. The conclusion is that the resulting network modeling consists of 6 criteria including variety, price, quality, service, delivery and flexibility. Then there are 14 sub-criteria including the price criteria consisting of the sub-criteria for the price of one pipe, payment method, and discounts/rebates. Quality criteria have 1 sub-criterion, namely pipe flexibility. The service criteria have 3 sub-criteria, namely accuracy of information, speed and responsiveness of service, and return time limit. Delivery criteria have 4 sub-criteria including supplier distance from the shop, delivery time, delivery lead time, and conformity of goods to specifications. The flexibility criterion has 1 sub-criterion, namely ease of adding and reducing the number of orders.

There are also several relationships that are formed, including inner and outer dependence, which includes the relationship between goals and each existing criterion, then the relationship between each criterion and alternative suppliers and vice versa. There is also a relationship between the criteria for variety and price and quality and price, then the criteria for delivery and service. The priority for selecting suppliers that can be carried out by the Toko Besi Lancar Rejeki is selecting Supplier C as the main supplier. Then in the next order there is Supplier B and in third place is Supplier A.

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