

A MULTI-CRITERIA DECISION-MAKING APPROACH USING AHP FOR PUDAK PACKAGING SUPPLIER SELECTION

PENDEKATAN PENGAMBILAN KEPUTUSAN MULTI KRITERIA MENGGUNAKAN AHP UNTUK SELEKSI PEMASOK KEMASAN PUDAK

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ABSTRAK

Pemilihan pemasok merupakan salah satu hal krusial dalam kegiatan rantai pasok. Pentingnya pemilihan pemasok sangat berpengaruh pada kualitas dan ketersediaan suatu produk. Pemasok kemasan pudak dalam memenuhi kebutuhan kemasan pudak belum optimal. Tujuan penelitian ini adalah menentukan pemilihan pemasok yang berbasis Multi-Criteria Decision Making (MCDM). MCDM yang digunakan pada penelitian ini adalah metode Analytical Hierarchy Process (AHP). Peran AHP pada penelitian ini yaitu menentukan pemasok terbaik yang ada di Industri Pudak Gresik. Penentuan pemasok terbaik berdasarkan pada kinerja tiap pemasok. Ada 4 pemasok yang bekerja sama dengan industri pudak. Penelitian ini menggunakan kriteria berdasarkan hasil wawancara dengan pemangku kepentingan di industri pudak Gresik. Kriteria terdiri dari harga, kualitas, pengiriman, dan pelayanan. Penyelesaian menggunakan metode AHP terhadap 4 pemasok telah mendapatkan nilai ranking pada masing-masing pemasok. Pemasok A merupakan prioritas pemasok terbaik dengan nilai tertinggi yaitu 0,379. Analisis sensitivitas menghasilkan nilai peringkat dari pemasok konsisten walaupun dilakukan perubahan bobot pada kriteria secara upward change maupun downward change. Penelitian ini mampu menentukan supplier terbaik dan meningkatkan kinerja pemasok di masa yang akan datang.

Kata kunci : analisis sensitivitas, analytical hierarchy process (AHP), Multi-Criteria Decision Making, pemilihan pemasok

ABSTRACT

Supplier selection is one of the crucial thing in supply chain acitivity. The importance of supplier selection greatly affects quality and availability a product. The problem in this study is fulfillment of pudak packaging needs that have not been optimal. supplier fulfill necessity have been not optimal. Such as price each supplier different, schedule exceed deadline. This study aims to determine packaging supplier based on Multi-Criteria Decision Making (MCDM). One of the MCDMs used is Analytical Hierarchy Process (AHP) method. Data analysis was obtained from supplier Pudak Industry at Gresik Regency. This study have been criteria such as: price, quality, service, and delivery. The result of ranking value is obtained from criteria value weighting. Identification of the supplier selection for Pudak packaging consists of quality, service, price, and delivery. Supplier A is the best supplier with the highest score, which is 0.379. The result of sensitivity analysis is supplier level remains the same even if the weight of the criteria is changed by an upward change or a downward change. This study was capable determined the best supplier and was increased the performance of the supplier.

Keywords: analytical hierarchy process (AHP), analysis sensitivity, multi-criteria decision making, supplier selection

INTRODUCTION

Pudak packaging known as Ope is a package derived from betel nut seeds and biodegradable (Kurniawan, 2014). Pudak packaging can be obtained from suppliers, namely betel nut farmers. Pudak packaging has tough competition as it has superior components. The five components of competitive advantage are Cost, Quality, Flexibility, Delivery, and Innovation (Russell and Millar, 2014). These five

components of excellence influence the success of the Pudak industry and Pudak packaging suppliers.

The important things in the purchasing and procurement activities of the company is supplier selections because it greatly affects the availability and quality of products. The main objective of the supplier selection process is to determine which supplier has the competency in meeting the needs of the company consistently and minimizing the risks associated with the acquisition of raw materials and components (Awasthi *et al.*, 2018).

So far, the supplier selection process is only based on the lowest price and method of payment until other factors are ignored. Neglect of other factors causes frequent problems, especially in the slave production process, and encounters obstacles to the production process due to not following the schedule. In addition, the quality of goods received from suppliers is inconsistency and there are often delays in the delivery process. So the company must bring the goods to the supplier. Therefore, the Puduk industry must choose suppliers carefully and accurately. Due to the many obstacles that occur due to the absence of clear criteria, multi-criteria decision-making models are needed to assist the supplier selection process.

Multi-Criteria Decision Making is a decision to determine an alternative from a number of alternatives based on certain criteria (Sahin *et al.*, 2020). Criteria are usually measures, rules, or standards used in decision making. MCDM has two categories, namely Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM) (Wątróbski *et al.*, 2020). One of the MCDMs used to reach the scale of various alternative sets to reasonably explain the perceptions of problem clearly related to the planned procedures is reached basically designed by The Analytical Hierarchy Process (AHP) (Pujawan and Mahendrawati, 2005). The working principle of AHP is a complex and unstructured problem that will be structured problem. Then a numerical value obtained from the level of interest in the variable and compared to other variables. Then synthesis analysis is carried out to determine the variables that have play a role and high priority in influencing system decisions (Pratiwi, 2015). This study related to selection of windows operating system that have been done by the AHP methods (Yulianti, 2012), for the entry of computer lab assistants.

This study aims to determine supplier selection of puduk packaging using MCDM (AHP). Choose the right puduk packaging supplier based on AHP formulation with quality, price, service, and delivery criteria. Assess the sensitivity of the Analytical Hierarchical Process model. Data was obtained through observations and interviews at Puduk Industry. The expected result is determining the best supplier from each performance.

RESEARCH AND METHODS

This study start collection data obtained from interviews in the Puduk Industry, Gresik Regency, observations, and interviews with 4 suppliers consisting of Hendrosari I (A), Margorejo (B), Suko (C), Hendrosari II (D). Supplier fulfillment data for January-June 2020. Data covering quality, price, service, and delivery criteria. This study is divided into 3 (three) stages, namely (1) Identification of supplier selection for packing puduk. (2) Perform

computational formulations using the Analytical Hierarchy Process (AHP) model. (3) Assess the sensitivity of the AHP model.

Methods

Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process is representation of a complex problem in a multi-level structure where the first level is the goal, followed by level factors, criteria, sub-criteria, and os on to the last level of alternatives (Saaty 1980). It supports decision making in the occurrence of many criteria discrete decision problem. The hierarchical order in this study consists of objectives, criteria, and alternatives. The criteria for making this decision are quality, service, price, and delivery. It was presented in Table 1.

Table 1. Comparative Assessment of Pairs (L. Saaty 1983)

Value	Description
1	Vertical factors and horizontal factors have the same interests
3	Vertical factors are more important than horizontal factors
5	Vertical factors are seriously more important than horizontal factors
7	Vertical factors are clearly more important than horizontal factors
9	The absolute vertical factor is more important than the horizontal factor
2,4,6,8	Vertical factor adjacent to horizontal factor

The steps to complete the AHP such as determining the criteria and sub-criteria for an interview with an expert (Muhammad Imadudin, 2017). The stage of method is classify criteria and construct a hierarchical structure of the inter-connections between the criteria. Then calculate the combined weight of each level element. Next is evaluate on each hierarchical level trough paired comparisons (Saaty, 1980). The values and definitions of qualitative opinions of the comparison scale can be seen in Table 1. Normalize the data by dividing the value of each element in the matrix by the total value for each column. Then, perform eigenvector calculations for each paired comparison. This step synthesizes the selection and priority of elements at the lowest hierarchical level until the goal is achieved. After finding the eigenvector, then calculate the eigenvalues (λ max) with the following formula:

$$x = \frac{\sum (\frac{w_{ij}}{\sum w_j})}{n} \dots \dots \dots (1)$$

Information:

- X : Vector Eigen
- Wij : Single line column cell value (i, j = 1, n)
- ΣW_j : Number of columns
- N : Number of matrices compared

After getting λ max then find (CI) as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \dots \dots \dots (2)$$

Information:

- CI : Consistency Index
- λ max : The largest eigenvalues
- n : Number of matrices to be compared

The consistency index compare with the value of the random index number (RI) to obtain a consistency ratio (CR) as follows:

$$CR = \frac{CI}{RI} \dots \dots \dots (3)$$

Information:

- CR : Consistency Ratio
- RI : Random Index a.

If the comparison matrix is paired with a value of $CR \leq 0,100$ then inconsistencies in the opinion of the decision-maker are still acceptable and if not, the assessment needs to be repeated. Hierarchical consistency test with $CR < 0.1$ provisions. If not qualified, re-evaluation is performed. The MCDM-AHP is proven investigate possible places of air pollution (Wątróbski *et al.*, 2020).

Sensitivity Analysis

Sensitivity analysis describes the severity of chage input value related to output value (Tunkiel *et al.*, 2020). The effectiveness of a supplier selection is evaluated by sensitivity analysis. It can predict the

situation in the value of significant changes. It was conducted to show the effect of changes in the weight of the criteria in supplier selection rankings. For example, there is a change in weight assessment of priorities due to changes in policy, which will lead to changes in the order of alternative priorities and change the actions to be taken (Cakra and Baihaqi, 2020). Sesityivity analysis is used to determine the criteria value supplier selection pudak packaging more significant.

RESULTS AND DISCUSSIONS

Pudak Packaging

Pudak packaging comes from betel leaf pelepah commonly called *OPE*. These leaves are made from natural material packaging. This is in accordance with the theory (Natadajaja and Yuwono, 2016) that ope leaves are used to wrap pudak and used as a container of jenang jubung, typical food of Gresik Regency. This ope has a layer resembling plastic, so it can wrap around food that is moist. Ope can give a distinctive aroma, taste, and shape to the pudak. Ope as a pudak wrapping material is ordered in the form of sheets measuring 15x15 cm, then folded, and sewn with thread on the sewing machine.

Supplier Selection

Pudak packaging have been supplied from suppliers is a packaging that has the best quality. The results of the selection of pudak packaging suppliers were obtained by suppliers from Hendrosari I Village. This study used 4 expert for determining the value of criteria. The result was presented in Figure 1.

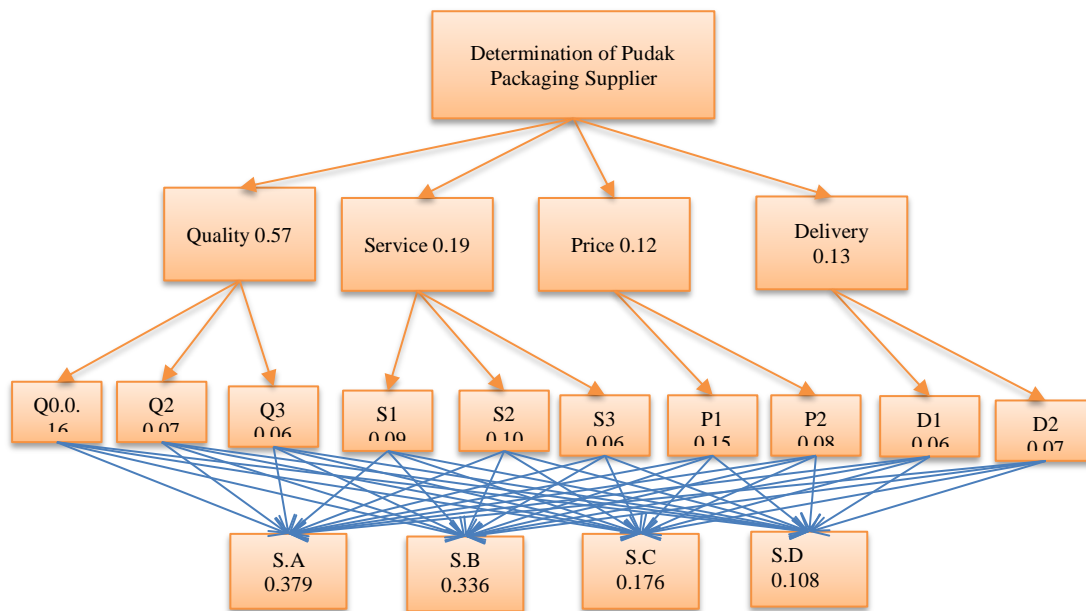


Figure 1. Selection of pudak packaging suppliers

Hierarchical arrangement begun with identifying elements related to selecting the best supplier. It consist of :

1. Level 0 is determination of pudak packaging supplier.
2. Level 1 is criteria used to achieve the goals of the hierarchy.
3. Level 2 is sub-criteria that determine the value of the alternative.
4. Level 3 is determination the highest criteria or priority weight.

The summary of the AHP model using the Super Decision Result Package show that Supplier A has the largest value of 0.379, Supplier B has a value of 0.336, Supplier C has a value of 0.176, and Supplier D has a value of 0.108. The selection of suppliers on this study that used to Analytical Hierarchy Process (AHP) has proved. The supplier has the best performance in accordance with the needs of the Pudak industry. This is determined by the weight of each alternative supplier.

Table 2. Description of hierarchical figures

No	Criteria Quality	Sub Criteria	Description	
1.	Q1	Complies with quality standard	Standard quality pudak packaging (%)	
	Q2	Delivery suitability	Match the order quantity to be ordered (%)	
	Q3	Matching delivery schedule	Matching delivery schedule without exceeding deadline (%)	
2	Service S1	Responsiveness	Cash to cash cycle time (day)	
		S2	Delivery time	Delivery time ratio (%)
		S3	Fleksible	Fleksible on give response
3	Price P1	Good price	Product price according to quality	
		P2	Discount	Discount with large purchase volume
4	Delivery D1	Delivery on time	Delivery on schedule (%)	
		D2	Time respon	Order fulfillment periods

Supplier A: Farmers in Hendrosari Village I
 Supplier B: Farmer in Margorejo Village
 Supplier C: Farmer in Suko Village
 Supplier D: Farmer in Hendrosari Village II

The selection of suppliers in the Pudak Industry based on the ability to fulfill the Pudak packaging needs, delivery time, order quantity, price

deductions, and high-quality service. One of the most frequently preferred methods is Analytical Hierarchy Process. AHP can be used independent or in combination with different methods in MCDM problems. Multi-Criteria Decision Making is the best solution of decision making tool that assists decision makers in selecting. AHP is one of the various methods of MCDM for resolving complex decision making. It was have been developed, being the most well known and widely used. The AHP offers flexibility in dealing bias decision making by incorporating a concistency ratio to validate the decision makers judgement (Hamidah *et al.*, 2022).

The AHP provides important convenience to users in terms of intelligibility and mathematical operations. In such case, weights generally obtained with AHP are used as input in different methods (Sahin *et al.*, 2020). The supply chain in the Pudak industry in this study consists of 4 suppliers working with the Pudak company. Quality criteria are used by the Pudak industry to see the quality or quality of products offered by suppliers. In addition, quality criteria are also used to see the supplier's great attention to the product to be offered. working with the right suppliers can reduce unnecessary costs, such as buying products of the same quality but at a higher price than they should (Govindan, 2015). Stakeholders in the slave industry consist of leaf midwife farmers and the slave industry.

Supplier companies that are included in the alternative in evaluation using the Analytical Hierarchy Process are Supplier A, Supplier B, Supplier C, Supplier D, each of these alternatives has a different evaluation from each of the criteria that have been determined. Supplier A originated from Hendrosari Village I. Supplier B originated from Margorejo Village. Supplier C originated from Suko Village. Supplier D originated from Hendrosari Village II. Supplier selection is the process by which firms identify, evaluate and contract with the supplier (Taherdoost and Brard, 2019).

Weight calculation is fixed by considering the criteria. The criteria considered in choosing a Pudak packaging supplier are quality, service, price, delivery. In accordance with the results of determining the preferences of suppliers using the AHP method, thus the company can establish cooperation (partnership) with suppliers in the order of best priority, namely Supplier A. Supplier A from Hendrosari I selected as an alternative supplier to meet the needs of the company. Multi-criteria decision-making has been applied in determining supplier selection (Paduloh *et at.*, 2020). The MCDM-AHP as decision making tool for prioritising and formulating criterion weight for Malaysian IPA (Hamidah *et al.*, 2022). Supplier selection helped company more succesfull. It was related to supplier selection based on environment (Cakra and Baihaqi, 2020).

The AHP is a time-tested method for pairwise comparison used in finding the weights of criteria (Sajid, 2021): The AHP has a subjective character of determining the weight of factors by expert scoring (Muller and Hiete, 2021). The AHP is able to determine the best supplier of pudak packaging. The supplier selection problem is diversified and contains the characteristics of multi-indicator standards, complexity, and non-structure. The effectively solve supplier selection issues is decision-making of AHP models. Beside of determining supplier selection, the AHP produces a strategy technique to build partner between of actor more transparency (Septarianes, 2020). The AHP allows decision makers to evaluate several alternative choices based on several existing criteria and to choose the optimal choice. The priority of the attributes or criteria can be modeled because the AHP have been formed a linier hierarchy. The

MCDM approach was helped determining the best refrigerant (Wątróbski *et al.*, 2020).

Sensitivity Analysis

Sensitivity analysis is performed based on the weight of priority decision criteria, which can occur due to changes in policy so that decision-makers change assessments. The results of the sensitivity analysis can be seen in Figure 2 and Figure 3.

Figure 2 shows that supplier evaluation remains the same even if weight changes are made according to quality criteria with upward or downward changes. The result of sensitivity analysis generate value consist of:

1. Supplier A 0.361
2. Supplier B 0.352
3. Supplier C 0.181
4. Supplier D 0.102

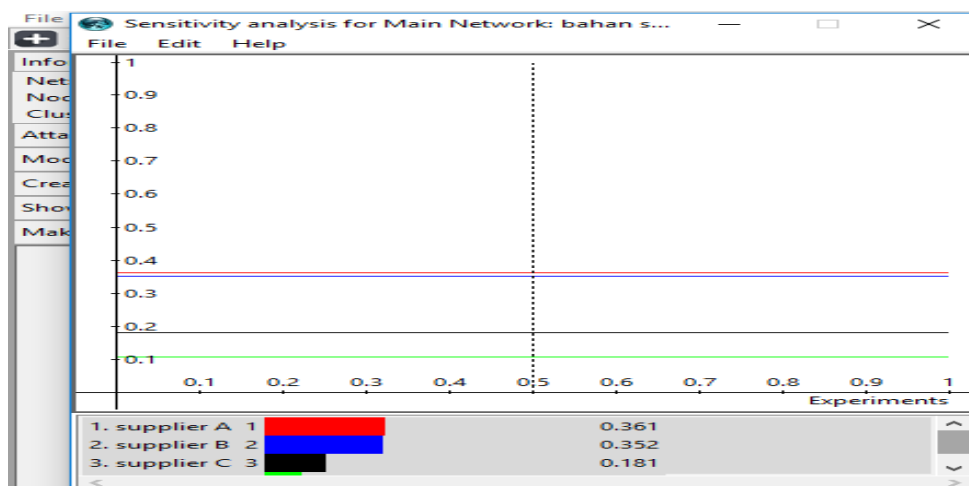


Figure 2. Sensitivity analysis to quality criteria

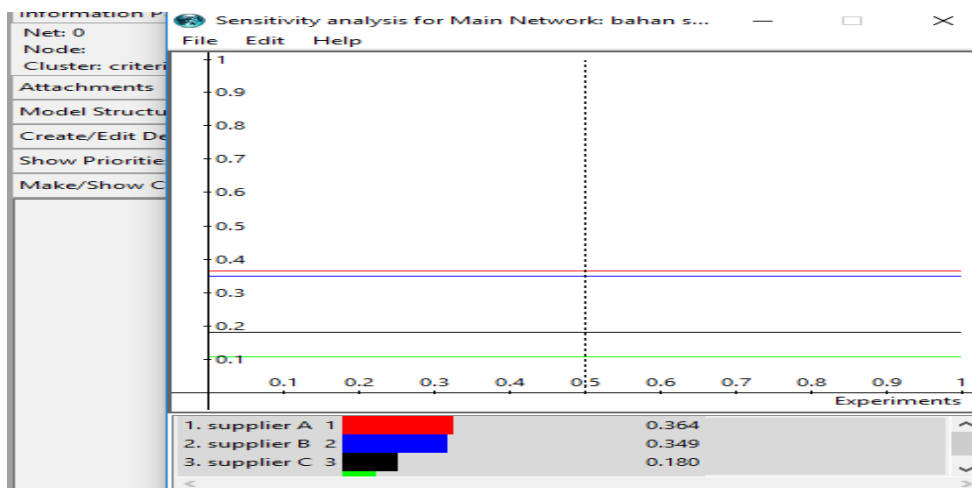


Figure 3. Sensitivity analysis to quality price

Figure 3 shows that supplier ratings remain the same even if weight changes are made according to price criteria with upward or downward changes. The result of sensitivity analysis generate value consist of:

5. Supplier A 0.364
6. Supplier B 0.349
7. Supplier C 0.180
8. Supplier D 0.100

Sensitivity analysis is very susceptible for supplier selection pudak packaging. It was related to accurate of complex machine learning model (Tunkiel et al., 2020). However, there was a change in the sensitivity value after changing the alternative weights. This study provided an overview of the research (Masudin and Saputro 2020). Changes in supplier selection criteria could be happened. These problem is solved by sensitivity analysis. Based on (Zira et al., 2021) theory was explained that criteria weight is the main factor to determine the best rank on supplier selections. The result of MCDM-AHP is Supplier A with highest value. Sensitivity analysis was proven that the value of supplier A consistent with highest value.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The performance of Pudak packaging suppliers based on quality, price, service, and delivery was successfully determined using AHP methods. This tool helps the industry in selecting the supplier with the greatest criterion value. Supplier A is the priority of the best supplier with the highest score, which is 0.379 out of the other three suppliers. The result of sensitivity analysis show that Supplier A (Hendrosari I) is consistent with the highest weight value. This solution helps companies knew the performance of each supplier and how to improve performance in the future.

Recommendations

This study should be continued using more crriteria. It can be integrated with new method for determining the value added.

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