Online Version:
http://journal.ubm.ac.id/index.php/jiems
Research

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

Analytical Hierarchy Process and TOPSIS Approach to Perform Supplier Selection in Construction Industry

Filscha Nurprihatin[1*], Riki Antonius[2], Glisina Dwinoor Rembulan[2], Rafie Djajasoepena[3], Eko Sulistyo[3]

[1]Department of Industrial Engineering, Sampoerna University, L'Avenue Building, Jl. Raya Pasar Minggu No. Kav. 16, Pancoran, South Jakarta 12780, Indonesia

[2]Department of Industrial Engineering, Universitas Bunda Mulia, Jl. Lodan Raya No. 2 Ancol, North Jakarta 14430, Indonesia

[3]Department of Information System, Sampoerna University, L'Avenue Building, Jl. Raya Pasar Minggu No. Kav. 16, Pancoran, South Jakarta 12780, Indonesia

Received: 22 June, 2022 / Accepted: 11 August, 2022

ABSTRACT

Suppliers play an important role as suppliers of production raw materials, making companies must choose suppliers correctly. This paper discusses the best supplier selection to avoid financial and non-financial losses This paper uses four criteria for determining the best supplier, such as price, lead time, payment terms, and quality & service. A reasonable price following initial planning is always expected by the customers. Lead time is an essential consideration to ensure on-time delivery. Failure to perform on-time delivery will direct in poor payment terms. Besides, any products that do not meet quality standards will always lead to waste. Analytical Hierarchy Process (AHP) and Technique Order Preference by Similarity to Ideal Solution (TOPSIS) are used to select and determine the best supplier for the company. Pairwise comparisons are performed by making comparisons between each criterion and the alternatives made at each level of the hierarchy in pairs to get the value of the importance of the elements in the form of a qualitative opinion. The weight values for price, lead time, payment terms, and quality and service criteria are 0.0709, 0.1409, 0.2682, and 0.5200, respectively. According to AHP, alternative weight values in each criterion are 0.3899, 0.3063, and 0.3038, namely supplier A (rank 1), supplier B (rank 2), and supplier C (rank 3), respectively. However, the results of supplier selection using the TOPSIS method are supplier B (rank 1), supplier C (rank 2), and supplier A (rank 3) with values of 518.4025, 469.2017, and 412.3928, respectively.

Keywords: *Supplier selection, Price, Lead time, Payment terms, Quality and service*

1. INTRODUCTION

This study focuses on a company engaged in the construction industry and it's quality products. Success in producing high-quality products is a top priority. The company focuses on and pays attention to the process from the beginning to the end of its production process. In the production process, one of the factors that must be considered is the raw material. Raw materials are goods obtained for the production process and are obtained from suppliers. In short, rapid demand growth requires higher working performance (Tannady, Erlyana and Nurprihatin, 2019).

Suppliers play an important role as suppliers of production raw materials, making companies must choose suppliers correctly. There are 4 (four) criteria for determining the best supplier, such as price, lead time, payment terms, and quality & service.

Product price is important to decide on the order quantity from the perspective of inventory management (Nurprihatin, Gotami and Rembulan, 2021). The price data always have been an important thing when it comes to the order fulfillment process (Andry, Tannady and Nurprihatin, 2020), and for designing the maintenance policy (Nurprihatin, Angely and Tannady, 2019). The price was also included to decide the truck scheduling through a cross-docking strategy (Nurprihatin *et al.*, 2021). However, the pricing strategy can also be the result of specific optimization models, such as network optimization (Filscha Nurprihatin *et al.*, 2019; Nurprihatin, Andry and Tannady, 2021). It was found that the shorter the supply

[*]email: filscha.nurprihatin@sampoernauniversity.ac.id

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

chain the lower the products' price (Nurprihatin, Regina and Rembulan, 2021). The specific model for the vehicle routing problem was discussed to minimize the traveled time (Nurprihatin and Lestari, 2020). In the end, a reasonable price following initial planning is always expected by the customers (Nurprihatin and Tannady, 2018; Tannady, Nurprihatin and Hartono, 2018).

Lead time is an essential consideration to decide the minimum inventory cost (Nurprihatin, Gotami and Rembulan, 2021). A focus on the delivery lead time was discussed to minimize travel times considering its stochastic properties (Nurprihatin and Montororing, 2021). In terms of lead time criteria, there is a lateness of 5 days which disrupts the production schedule and delivery of finished goods.

The effect of lateness leads to unfulfilled demand and impedes on-time delivery (Nurprihatin, Jayadi and Tannady, 2020). The lateness in the arrival of raw materials for 3 to 5 days causes losses such as paying losses due to lateness in delivery for 3 days. Payment of the loss is included in the agreement with the consumer or client by paying 0.1% per day of lateness through the value of the agreement for late delivery of goods, which is IDR 7 billion. It means the penalty should be IDR 7 million per day. Failure to perform good payment can endanger the organization's effectiveness (Tannady, Andry and Nurprihatin, 2020).

Maintaining consistency in the products' quality can result in the loyalty of the customer (Regent Montororing and Nurprihatin, 2021). A quality problem was solved by maintaining the standardized time from the operators (Nurprihatin, Jayadi and Tannady, 2020). An appropriate service should be provided in a cost-effective manner (F. Nurprihatin *et al.*, 2019). Any products that do not meet quality standards will always lead to waste (Tannady *et al.*, 2019).

There are several methods to assist the company in selecting and determining the best supplier for the company, including using the Analytical Hierarchy Process (AHP) and Technique Order Preference by Similarity to Ideal Solution (TOPSIS). The AHP method is generally used to set priorities from various alternatives or available options and these choices are complex or multi-criteria. In general, by using AHP and TOPSIS, the resulting priorities will be consistent with theory, logical, transparent, and participatory. This is the reason why the AHP and TOPSIS systems can help make the selection and determination of suppliers in the company.

Seeing the important role of suppliers in the company, this paper discusses the selection and determination of the best supplier to avoid financial and non-financial losses. This study tries to select and determine suppliers with the criteria that the company has set and utilizes the AHP and TOPSIS methods. There were studies conducted on AHP and TOPSIS as shown in Table 1.

Table 1. Related Works

No.	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Criteria			
				Price	Lead Time	Payment Terms	Quality and Service
1.	(Beskese *et al.*, 2020)	Wind Turbine Evaluation	Fuzzy AHP-TOPSIS	√	No	No	No
2.	(Çalık, Çizmecioğlu and Akpınar, 2019)	Foreign Direct Investment Selection	AHP-TOPSIS	No	No	No	No
3.	(James *et al.*, 2021)	Chassis Selection	AHP-TOPSIS	√	No	No	√
4.	(Wang *et al.*, 2019)	Plant Selection	AHP-TOPSIS	No	No	No	No
5.	(Sarkar and Biswas, 2021)	New Distance Measurement	Fuzzy AHP-TOPSIS	√	No	No	√
6.	(Zavadskas *et al.*, 2020)	Supplier Selection	Fuzzy AHP	√	√	√	√
7.	This Paper	Supplier Selection	AHP-TOPSIS	√	√	√	√

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

2. METHODS

In this study, the weight value of the criteria and its alternatives can provide suggestions by choosing the highest weight value. Pairwise comparisons are performed by making comparisons between each criterion and the alternatives made at each level of the hierarchy in pairs to get the value of the importance of the elements in the form of a qualitative opinion. The rating scale in Table 2 confirms the qualitative opinion. So that the value of opinion can be obtained in the form of numbers. The comparison values are then processed to obtain a ranking of criteria. Qualitative and quantitative criteria can be compared according to a predetermined assessment to generate priorities. Figure 1 exhibits the hierarchy of the criterion.

The purpose of the hierarchy is to determine the selection of the best or most satisfactory supplier among other suppliers. Based on the selected criteria and several alternative suppliers that already exist, then a matrix comparison is carried out between each element so that the weight values for the criteria and alternative suppliers are obtained.

The criteria for selecting this supplier are the criteria for the determination of the company. The company has 4 criteria for determining supplier selection, such as:

1. Price is the price offered by the supplier to the company.
2. Lead time is the period of ordering until the ordered goods reach the company.
3. Payment terms are the length of time the company makes payments to suppliers.
4. Quality and service is the quality of raw materials sent by suppliers and the services provided.

3. RESULTS AND DISCUSSION

3.1. Criteria Weights

Based on the criteria set by the company, a pairwise comparison is made between each criterion, then the weights for each criterion are obtained. The method used is a paired comparison scale. This principle makes judgments about the relative importance of 2 elements at a certain level with the level above or below it. In Table 2 there is an assessment of each criterion. After getting the criteria assessment, a matrix comparison is carried out, as shown in Table 3. After performing a matrix comparison, then doing calculations to get the weight value of each criterion. Table 4 points out the calculation of the weight of the criteria.

Table 2. Assessment of Each Criterion

No.	Criteria	Assessment
1.	Price	2
2.	Lead Time	3
3.	Payment Terms	4
4.	Quality and Service	5

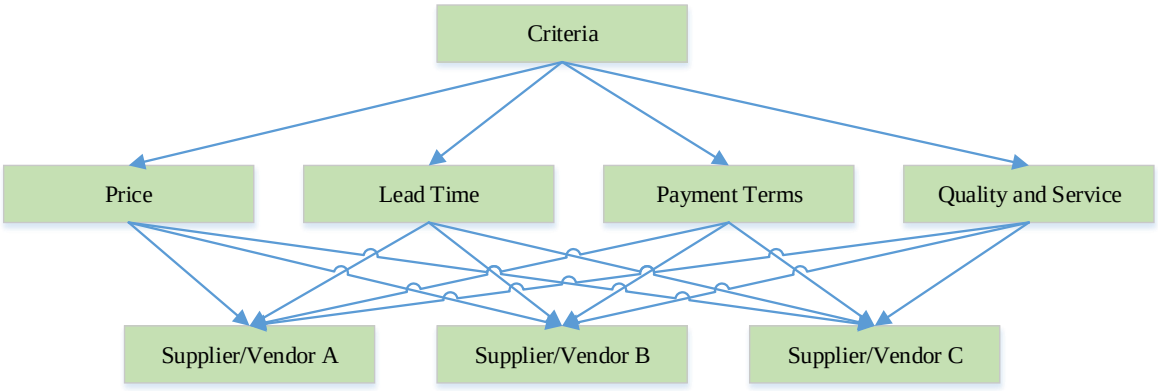

Figure 1. Hierarchy of the Criterion

Table 3. Criteria Matrix Comparison

Criteria	Price	Lead Time	Payment Terms	Quality and Service
Price	1	1/3	1/4	1/5
Lead Time	3	1	1/3	1/4
Payment Terms	4	3	1	1/3
Quality and Service	5	4	3	1

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

Total	**13**	**25/3**	**55/12**	**107/60**

Table 4. Criteria Weight

Criteria	Price	Lead Time	Payment Terms	Quality and Service	Criteria Weights
Price	1/13	1/25	3/55	12/107	0.0709
Lead Time	3/13	3/25	4/55	15/107	0.1409
Payment Terms	4/13	9/25	12/55	20/107	0.2682
Quality and Service	5/13	12/25	36/55	60/107	0.5200
Total	**1**	**1**	**1**	**1**	

Table 5. Consistency Ratio Value

Criteria	Weighted Sum Vector	Consistency Vector	Consistency Index	Consistency Ratio
Price	0.2889	4.0748	0.0612	0.0680
Lead Time	0.5730	4.0663		
Payment Terms	1.1479	4.2801		
Quality and Service	2.2428	4.3132		
$\boldsymbol{\lambda_{max}}$ **= 4.1836**				

The weight values for the price, lead time, payment terms, and quality & service criterion are 0.0709, 0.1409, 0.2682, and 0.5200, respectively. After obtaining the weight value for each criterion, data processing is then carried out to find the consistency ratio value to determine whether the data is consistent or not. Table 5 shows the calculation of the consistency ratio.

The Weighted Sum Vector (WSV) is obtained by performing a matrix multiplication between the weight values and their pairwise comparisons. After getting the WSV value, then do the calculations to find the Consistency Vector (CV) value by dividing each WSV value by the weight value of each criterion.

$$WSV_{price} = (1)(0.0709) + \left(\frac{1}{3}\right)(0.1409) + \left(\frac{1}{4}\right)(0.2682) + \left(\frac{1}{5}\right)(0.5200) = 0.2889$$

$$WSV_{lead\ time} = (3)(0.0709) + (1)(0.1409) + \left(\frac{1}{3}\right)(0.2682) + \left(\frac{1}{4}\right)(0.5200) = 0.5730$$

$$WSV_{payment\ terms} = (4)(0.0709) + (4)(0.1409) + (1)(0.2682) + \left(\frac{1}{3}\right)(0.5200) = 1.1479$$

$$WSV_{quality\ service} = (5)(0.0709) + (4)(0.1409) + (3)(0.2682) + (1)(0.5200) = 2.2428$$

$$CV_{price} = \frac{0.2889}{0.0709} = 4.0748$$

$$CV_{lead\ time} = \frac{0.5730}{0.1409} = 4.0663$$

$$CV_{payment\ terms} = \frac{1.1479}{0.2682} = 4.2801$$

$$CV_{quality\ and\ service} = \frac{2.2428}{0.5200} = 4.3132$$

After obtaining the CV value, then do the calculations to find the Consistency Index (CI) value using Equation (1) (Ekmekcioğlu, Koc and Özger, 2021). Lambda (λ_{max}) is the average of the consistency vectors and n is the number of criteria being compared.

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

$$CI = \frac{4{,}1836 - 4}{4 - 1} = 0.0612$$

After obtaining the CI value then look for the Consistency Ratio (CR) value using Equation (2) (Ekmekcioğlu, Koc and Özger, 2021). The Random Index (RI) value is obtained from Table 6, the value of *n* is 4 and the RI value is 0.9.

$$CR = \frac{CI}{RI} \quad (2)$$

Table 6. Random Index

n	Random Index
2	**0.00**
3	**0.58**
4	**0.90**
5	**1.12**
6	**1.24**

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

7	**1.32**
8	**1.41**
9	**1.45**
10	**1.49**
11	**1.51**
12	**1.48**
13	**1.56**
14	**1.57**
15	**1.59**

To get consistent results, the value of the CR must be less than 0.10. If the results of the CR are greater than 0.10, the decisions taken must be re-evaluated. The CR value obtained is 0.0680. Therefore, this data is consistent because the value of the CR obtained is <0.1.

$$CR = \frac{0.0612}{0.9} = 0.0680$$

3.2. Alternative Weights for Suppliers

Alternative weights are obtained in the same way by doing pairwise comparisons with fellow alternatives against the criteria used by the company. Table 7 shows the relevant data for suppliers.

After that, a pairwise or matrix comparison between alternatives and criteria should be performed. Table 8, Table 9, Table 10, and Table 11 show pairwise comparison matrices and their value weight for the price, lead time, payment terms, and quality and service, respectively.

Table 7. Data for Supplier

Criteria	Supplier A	Supplier B	Supplier C
Price (IDR/kg)	15,000	13,350	14,680
Lead time (days)	20	15	10
Payment Terms	Advance payment	45 days after delivery	30 days after delivery
Quality and Service	Best	Average	Good

Source: (Taylor, 2019)

Table 8. Matrix Comparison and Value Weight for Price

Matrix Comparison					Value Weight					
Score	**Supplier**	**A**	**B**	**C**	**Score**	**Supplier**	**A**	**B**	**C**	**Average**
2	A	1	1/6	1/4	**2**	A	1/11	2/17	1/21	0.0854
4	B	6	1	4	**4**	B	6/11	12/17	16/21	0.6711
6	C	4	1/4	1	**6**	C	4/11	3/17	4/21	0.2435
Total		**11**	**17/12**	**21/4**	**Total**		**1**	**1**	**1**	**1**

Table 9. Matrix Comparison and Value Weight for Lead Time

Matrix Comparison					Value Weight					
Score	**Supplier**	**A**	**B**	**C**	**Score**	**Supplier**	**A**	**B**	**C**	**Average**
2	A	1	1/4	1/6	**2**	A	1/11	1/21	2/17	0.0854
4	B	4	1	1/4	**4**	B	4/11	4/21	3/17	0.2435
6	C	6	4	1	**6**	C	6/11	16/21	12/17	0.6711
Total		**11**	**21/4**	**17/12**	**Total**		**1**	**1**	**1**	**1**

Table 10. Matrix Comparison and Value Weight for Payment Terms

Matrix Comparison					Value Weight					
Score	**Supplier**	**A**	**B**	**C**	**Score**	**Supplier**	**A**	**B**	**C**	**Average**
2	A	1	1/6	1/4	**2**	A	1/11	2/17	1/21	0.0854
6	B	6	1	4	**6**	B	6/11	12/17	16/21	0.6711
4	C	4	1/4	1	**4**	C	4/11	3/17	4/21	0.2435
Total		**11**	**17/12**	**21/4**	**Total**		**1**	**1**	**1**	**1**

Table 11.Matrix Comparison and Value Weight for Quality and Service

Matrix Comparison					Value Weight					
Score	**Supplier**	**A**	**B**	**C**	**Score**	**Supplier**	**A**	**B**	**C**	**Average**
6	A	1	6	4	**6**	A	12/17	6/11	16/21	0.6711
2	B	1/6	1	1/4	**2**	B	2/17	1/11	1/21	0.0854
4	C	1/4	4	1	**4**	C	3/17	4/11	4/21	0.2435

Total	**17/12**	**11**	**21/4**	**Total**	**1**	**1**	**1**	**1**

3.3. Supplier Selection Using AHP

Supplier selection using AHP is done by multiplying the alternative weight values for each criterion with the criterion weight values. Table 12 represents is a summary of the alternative weight values for each criterion. The further calculation is the multiplication of the criterion weight value for each supplier shown in Table 12. Eigenvalues for suppliers A, B, and C are 0.3899 (rank 1), 0.3063 (rank 2), and 0.3038 (rank 3), respectively. Calculation details for Eigenvalues are given as follows.

$$Eigen\ Value_A = (0.0709)(0.0854) + (0.1409)(0.0854) + (0.2682)(0.0854) + (0.5200)(0.6711) = 0.3899$$

$$Eigen\ Value_B = (0.0709)(0.6711) + (0.1409)(0.2345) + (0.2682)(0.6711) + (0.5200)(0.0854) = 0.3063$$

$$Eigen\ Value_C = (0.0709)(0.2345) + (0.1409)(0.6711) + (0.2682)(0.2345) + (0.5200)(0.2345) = 0.3038$$

3.4. Supplier Selection Using TOPSIS

Supplier selection using TOPSIS is done by multiplying the alternative weight values for each criterion with the criterion weight values. Table 13 exhibits the result of the weight between criteria. After carrying out the results of the weighting between the criteria, a multiplication of column 1 with each alternative should be performed. In short, this calculation is aimed to find the priority weights for each criterion at level 2. The similar assessment data that has been shown in Table 2 will be used again in this calculation. The next step is a calculation of the final score for the selection of raw material suppliers. Table 14 shows a summary of the calculation of the final score for the selection of raw material suppliers. The TOPSIS method shows that suppliers with the highest to lowest rank are suppliers B, C, and A, with scores of 518.4025, 469.2017, and 412.3928 respectively.

Table 12. Summary of Alternative Weight Values for each Criterion Using AHP

Supplier	Criteria				Eigenvalue	Rank
	Price	Lead Time	Payment Terms	Quality and Service		
A	0.0854	0.0854	0.0854	0.6711	0.3899	1
B	0.6711	0.2435	0.6711	0.0854	0.3063	2
C	0.2435	0.6711	0.2435	0.2435	0.3038	3

Table 13. Weight Between Criteria

Criteria	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Criteria Weights	Supplier A	Supplier B	Supplier C	Weighted Supplier A (1*2)	Weighted Supplier B (1*3)	Weighted Supplier B (1*4)
Price	0.0709	0.0854	0.6711	0.2435	0.0061	0.0476	0.0173
Lead time	0.1409	0.0854	0.2435	0.6711	0.0120	0.0343	0.0946
Payment Terms	0.2682	0.0854	0.6711	0.2435	0.0229	0.1800	0.0653
Quality and Service	0.5200	0.6711	0.0854	0.2435	0.3489	0.0444	0.1266

Table 14. Supplier Calculation Results Using TOPSIS

Criteria	Supplier A	Supplier B	Supplier C
Price	$\frac{0.0061}{0.0709}(2)(100) = 17.0783$	$\frac{0.0476}{0.0709}(2)(100) = 134.2161$	$\frac{0.0173}{0.0709}(2)(100) = 48.7055$
Lead time	$\frac{0.0120}{0.1409}(3)(100) = 25.6175$	$\frac{0.0343}{0.1409}(3)(100) = 73.0583$	$\frac{0.0946}{0.1409}(3)(100) = 201.3243$
Payment Terms	$\frac{0.0229}{0.2682}(4)(100) = 34.1567$	$\frac{0.1800}{0.2682}(4)(100) = 268.4322$	$\frac{0.0653}{0.2682}(4)(100) = 97.4111$

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

Quality and Service	$\frac{0.3489}{0.5200}(5)(100) = 335.5403$	$\frac{0.0444}{0.5200}(5)(100) = 42.6959$	$\frac{0.1266}{0.5200}(5)(100) = 121.7639$
Total	**412.3928**	**518.4025**	**469.2047**

4. CONCLUSION

The weight values for price, lead time, payment terms, and quality and service criteria are 0.0709, 0.1409, 0.2682, and 0.5200, respectively. The weight values of suppliers A, B, and C on price are 0.0854, 0.6711, and 0.2435, respectively. The weight values of suppliers A, B, and C on the lead time are 0.0854, 0.2435, and 0.6711, respectively. The weight values of suppliers A, B, and C on payment terms are 0.0854, 0.6711, and 0.2435, respectively. The weight values of suppliers A, B, and C on quality and service are 0.6711, 0.0854, and 0.2435, respectively.

According to AHP, alternative weight values in each criterion are 0.3899, 0.3063, and 0.3038, namely supplier A (rank 1), supplier B (rank 2), and supplier C (rank 3), respectively. However, the results of supplier selection using the TOPSIS method are supplier B (rank 1), supplier C (rank 2), and supplier A (rank 3) with values of 518.4025, 469.2017, and 412.3928, respectively.

Companies should be more concerned with Quality and Service, but companies must not ignore other criteria, such as Price, Lead Time, and Payment Terms. The selection of the best supplier based on AHP is supplier A. The company can use suppliers B and C if supplier A is in trouble so it cannot meet the company's needs. However, the selection of the best supplier using TOPSIS is supplier B. The company can use suppliers C and A if supplier B is in trouble so it cannot meet the company's needs.

REFERENCES

Andry, J.F., Tannady, H. and Nurprihatin, F. (2020) 'Eliciting Requirements of Order Fulfilment in a Company', in *IOP Conference Series: Materials Science and Engineering*, pp. 1–6. Available at: https://doi.org/10.1088/1757-899X/771/1/012023.

Beskese, A. *et al.* (2020) 'Wind Turbine Evaluation Using the Hesitant Fuzzy AHP-TOPSIS Method with A Case in Turkey', *Journal of Intelligent and Fuzzy Systems*, 38(1), pp. 997–1011. Available at: https://doi.org/10.3233/JIFS-179464.

Çalık, A., Çizmecioğlu, S. and Akpınar, A. (2019) 'An integrated AHP-TOPSIS Framework for Foreign Direct Investment in Turkey', *Journal of Multi-Criteria Decision Analysis*, 26(5–6), pp. 296–307. Available at: https://doi.org/10.1002/mcda.1692.

Ekmekcioğlu, Ö., Koc, K. and Özger, M. (2021) 'Stakeholder Perceptions in Flood Risk Assessment: A Hybrid Fuzzy AHP-TOPSIS Approach for Istanbul, Turkey', *International Journal of Disaster Risk Reduction*, 60, pp. 1–16. Available at: https://doi.org/10.1016/j.ijdrr.2021.102327.

James, A.T. *et al.* (2021) 'Selection of Bus Chassis for Large Fleet Operators in India: An AHP-TOPSIS Approach', *Expert Systems with Applications*, 186. Available at: https://doi.org/10.1016/j.eswa.2021.115760.

Nurprihatin, F. *et al.* (2019) 'A Distribution Strategy Using a Two-step Optimization to Maximize Blood Services Considering Stochastic Travel Times', in *IOP Conference Series: Materials Science and Engineering*. Available at: https://doi.org/10.1088/1757-899X/650/1/012043.

Nurprihatin, Filscha *et al.* (2019) 'The Extension Analysis of Natural Gas Network Location-routing Design Through the Feasibility Study', *Journal of Applied Research on Industrial Engineering*, 6(2), pp. 108–124. Available at: https://doi.org/10.22105/jarie.2019.174164.1082.

Nurprihatin, F. *et al.* (2021) 'Decision Support System for Truck Scheduling in Logistic Network Through Cross-docking Strategy', *Journal of Physics: Conference Series*, 1811(1). Available at: https://doi.org/10.1088/1742-6596/1811/1/012009.

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

Nurprihatin, F., Andry, J.F. and Tannady, H. (2021) 'Setting the Natural Gas Selling Price Through Pipeline Network Optimization and Project Feasibility Study', *Journal of Physics: Conference Series*, 1811(1). Available at: https://doi.org/10.1088/1742-6596/1811/1/012008.

Nurprihatin, F., Angely, M. and Tannady, H. (2019) 'Total Productive Maintenance Policy to Increase Effectiveness and Maintenance Performance Using Overall Equipment Effectiveness', *Journal of Applied Research on Industrial Engineering*, 6(3), pp. 184–199. Available at: https://doi.org/10.22105/jarie.2019.199037.1104.

Nurprihatin, F., Gotami, M. and Rembulan, G.D. (2021) 'Improving the Performance of Planning and Controlling Raw Material Inventory in Food Industry', *International Journal of Research in Industrial Engineering*, 10(4), pp. 332–345. Available at: https://doi.org/10.22105/riej.2021.306872.1250.

Nurprihatin, F., Jayadi, E.L. and Tannady, H. (2020) 'Comparing Heuristic Methods' Performance for Pure Flow Shop Scheduling Under Certain and Uncertain Demand', *Management and Production Engineering Review*, 11(2), pp. 50–61. Available at: https://doi.org/10.24425/mper.2020.133728.

Nurprihatin, F. and Lestari, A. (2020) 'Waste Collection Vehicle Routing Problem Model with Multiple Trips, Time Windows, Split Delivery, Heterogeneous Fleet and Intermediate Facility', *Engineering Journal*, 24(5). Available at: https://doi.org/10.4186/ej.2020.24.5.55.

Nurprihatin, F. and Montororing, Y.D.R. (2021) 'Improving Vehicle Routing Decision for Subsidized Rice Distribution Using Linear Programming Considering Stochastic Travel Times', *Journal of Physics: Conference Series*, 1811(1). Available at: https://doi.org/10.1088/1742-6596/1811/1/012007.

Nurprihatin, F., Regina, T. and Rembulan, G.D. (2021) 'Optimizing Rice Distribution Routes in Indonesia Using a Two-step Linear Programming Considering Logistics Costs', *Journal of Physics: Conference Series*, 1811(1). Available at: https://doi.org/10.1088/1742-6596/1811/1/012010.

Nurprihatin, F. and Tannady, H. (2018) 'An Integrated Transportation Models and Savings Algorithm to Minimize Distribution Costs', in *Proceeding of the 1st Asia Pacific Conference on Research in Industrial and Systems Engineering*. Depok: Department of Industrial Engineering Universitas Indonesia, pp. 216–221.

Regent Montororing, Y.D. and Nurprihatin, F. (2021) 'Model of Quality Control Station Allocation with Consider Work in Process, and Defect Probability of Final Product', *Journal of Physics: Conference Series*, 1811(1). Available at: https://doi.org/10.1088/1742-6596/1811/1/012013.

Sarkar, B. and Biswas, A. (2021) 'Pythagorean Fuzzy AHP-TOPSIS Integrated Approach for Transportation Management Through a New Distance Measure', *Soft Computing*, 25(5), pp. 4073–4089. Available at: https://doi.org/10.1007/s00500-020-05433-2.

Tannady, H. *et al.* (2019) 'Process Improvement to Reduce Waste in the Biggest Instant Noodle Manufacturing Company', *Journal of Applied Engineering Science*, 17(2), pp. 203–212. Available at: https://doi.org/10.5937/jaes17-18951.

Tannady, H., Andry, J.F. and Nurprihatin, F. (2020) 'Determinants Factors Toward the Performance of the Employee in the Crude Palm Oil Industry in West Sumatera, Indonesia.', in *IOP Conference Series: Materials Science and Engineering*, pp. 1–5. Available at: https://doi.org/10.1088/1757-899X/771/1/012066.

Tannady, H., Erlyana, Y. and Nurprihatin, F. (2019) 'Effects of Work Environment and Self-efficacy Toward Motivation of Workers in Creative Sector in Province

Journal of Industrial Engineering and Management Systems
Vol. 15, No. 2, 130-138, 2022
p-ISSN 1979-1720
e-ISSN 2579-8154

of Jakarta, Indonesia', *Quality - Access to Success*, 20(172), pp. 165–168.

Tannady, H., Nurprihatin, F. and Hartono, H. (2018) 'Service Quality Analysis of Two of the Largest Retail Chains with Minimart Concept in Indonesia', *Business: Theory and Practice*, 19, pp. 177–185. Available at: https://doi.org/10.3846/BTP.2018.18.

Taylor, B.W. (2019) *Introduction to Management Science*. 13th edn. New Jersey: Pearson Education.

Wang, B. *et al.* (2019) 'Application of AHP, TOPSIS, and TFNs to Plant Selection for Phytoremediation of Petroleum-Contaminated Soils in Shale Gas and Oil Fields', *Journal of Cleaner Production*, 233, pp. 13–22. Available at: https://doi.org/10.1016/j.jclepro.2019.05.301.

Zavadskas, E.K. *et al.* (2020) 'Modelling Procedure for the Selection of Steel Pipe Supplier by Applying the Fuzzy AHP Method', *Operational Research in Engineering Sciences: Theory and Applications*, 3(2), pp. 39–53. Available at: https://doi.org/10.31181/oresta2003034z.