Vendor Selection and Evaluation Strategy in Stevedoring Company Using Integration of ANP and TOPSIS Methods

Muhammad Novandiari Firmantara and I Nyoman Pujawan

Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
info@mmt.its.ac.idncs

Abstract. This research develops a vendor selection and evaluation strategy for a stevedoring company by integrating the Analytical Network Process (ANP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. Using a quantitative descriptive approach, the study identifies six main criteria and 14 sub-criteria. The ANP results highlight product quality (31.44%), delivery (18.07%), and human resource quality (17.48%) as the top priorities. From a cost and benefit perspective, product quality and technical capabilities are considered long-term investments that impact operational stability, while price and delivery are seen as short-term efficiency factors. TOPSIS is employed to rank vendors based on the combined ANP weights. In addition, a sensitivity analysis is conducted by varying the weights of four main criteria. The results show that vendor rankings remain stable despite moderate changes in the weights of product quality, delivery, human resource quality, and after-sales service, indicating that the model is robust and reliable for strategic decision-making. This model offers an objective and adaptive approach that can enhance the efficiency and sustainability of the stevedoring company's supply chain.

Keywords: Vendor evaluation, ANP, TOPSIS, Stevedoring Company, Sensitivity.

1 Introduction

In today's highly competitive logistics and maritime sectors, stevedoring companies play a vital role in ensuring efficient cargo handling at ports [1,2,3]. Their performance relies heavily on the seamless coordination of resources and services, particularly those involving external vendors [4,5,6]. Vendors provide critical equipment, maintenance, and support services necessary for daily operations. However, disruptions such as late deliveries, poor product quality, or inadequate technical support can severely impact the entire supply chain [7,8].

The vendor selection and evaluation process are inherently complex due to its multi-criteria nature [9,10,11]. It requires decision-makers to balance cost, quality, reliability, and service aspects simultaneously [12,13]. Moreover, in the stevedoring industry, certain criteria are deeply interconnected for instance, price often correlates with product

© The Author(s) 2026
R. Hurriyati et al. (eds.), *Proceedings of the 10th Global Conference on Business, Management, and Entrepreneurship (GCBME 2025)*, Advances in Economics, Business and Management Research 407,
https://doi.org/10.2991/978-94-6239-819-1_30

quality, and delivery performance is influenced by the vendor's operational capacity and resource availability. Traditional selection methods often fail to address these interdependencies, leading to suboptimal decisions [14,15,16].

To address these challenges, this study proposes an integrated approach using the Analytical Network Process (ANP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [17,18]. ANP allows for modeling interrelationships among criteria and sub-criteria, enabling a more realistic representation of the decision-making context [19,20]. TOPSIS complements this by offering a mathematical framework to rank vendors based on their relative closeness to an ideal solution [21,22]. This hybrid model enhances both the objectivity and adaptability of vendor evaluation [23,24]. The purpose of this research is to develop a robust, data driven model for vendor selection in stevedoring operations. The study identifies relevant evaluation criteria, assigns priority weights using ANP, and ranks vendors using TOPSIS [25,26]. Sensitivity analysis is also performed to assess the model's resilience under varying decision scenarios [27,28].

2 Research Methods

This study employs a descriptive quantitative approach that integrates expert judgment with structured analytical methods to ensure both objectivity and practical relevance [29]. The primary data for this research were obtained through structured questionnaires administered to procurement and operations experts within a stevedoring company [30]. The questionnaires were designed to collect information on the identification of evaluation criteria and sub-criteria, pairwise comparisons necessary for ANP modeling, and performance scores for each vendor used in the TOPSIS ranking process [31].

The Analytical Network Process (ANP) was implemented in four key steps. First, the decision model was constructed by identifying all relevant criteria and sub-criteria based on expert input and literature review [32]. Second, pairwise comparisons were carried out among criteria and sub-criteria to determine their relative importance, using Saaty's fundamental scale [33,34]. Third, the resulting judgments were used to develop unweighted, weighted, and limit super matrices [35]. Finally, from these matrices, global priority weights for each criterion and sub-criterion were extracted [36,37].

For the vendor ranking process, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was applied. The steps involved constructing a decision matrix using the vendor evaluation scores, normalizing this matrix, and then applying the ANP-derived weights to generate a weighted normalized matrix [38]. From this, the ideal and negative-ideal solutions were defined, and the Euclidean distances of each vendor from these solutions were calculated [39]. Vendors were then ranked based on their relative closeness to the ideal solution [40,41,42].

To evaluate the robustness of the integrated model, a sensitivity analysis was conducted. This involved systematically varying the weights of the top four criteria by up to ±10%, and analyzing the resulting changes in vendor rankings [43,44]. The aim was

to assess whether the model could maintain stable and reliable outcomes under different weighting scenarios [45].

3 Result and Discussion

The application of the ANP method produced final weights for the six main criteria:

Table 1. Final Priority Weight of Criteria and Sub-Criteria

Criteria	Criteria Weight	Sub-criteria	Sub-criteria Weight	Global Weight
Company Profile	7.54%	Completeness of Authorized Distributor Certification	45.7%	3.45%
		Similar Experience	54.3%	4.09%
Financial Aspect	9.21%	Product & Delivery Price	48.7%	4.48%
		Terms of Payment	24.7%	2.27%
		Compliance with Delay Penalties	26.6%	2.46%
Product Quality	31.44%	Certificate of Authenticity	49.9%	15.69%
		Product Durability	25.1%	7.89%
		Warranty	25.0%	7.86%
Delivery	18.07%	Delivery Efficiency	25.0%	4.52%
		Delivery Reliability	75.0%	13.55%
After Sales Service	16.26%	After-Sales Support	59.0%	9.59%
		Solution Provider	41.0%	6.67%
Human Resource Quality	17.48%	Personal Attitude	40.9%	7.15%
		Technical Capabilities	59.1%	10.33%

Cost criteria, which is a criterion where a lower value is considered better, consists of only two sub-criteria with a total weight of 8.00%. The first sub-criterion is Price of Goods & Delivery with a weight of 4.48%, the second sub-criterion is Delivery Efficiency with a weight of 4.52%, Benefit criteria, which is a criterion where a higher value is considered better, dominates with a total weight of 92.00% of the total criteria. The dominance of benefit criteria with a proportion of 92% shows the unique characteristics of the stevedoring industry which prioritizes aspects of quality, reliability, and service rather than price competition alone [46,47].

Based on ANP analysis, the following is a visualization of the relationship between criteria and sub-criteria:

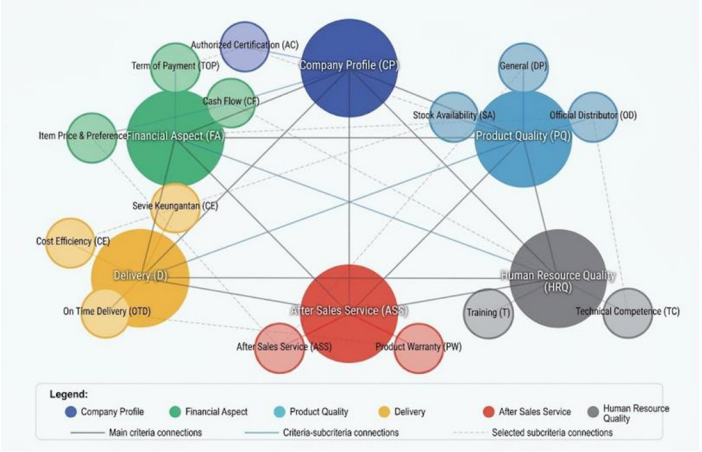

Fig. 1. Visualization of the Relationship Between Criteria and Sub-criteria

In order for the visualization to be more detailed, the following is a separate visualization of the relationship between criteria and the relationship between sub criteria, which can be seen in the image below:

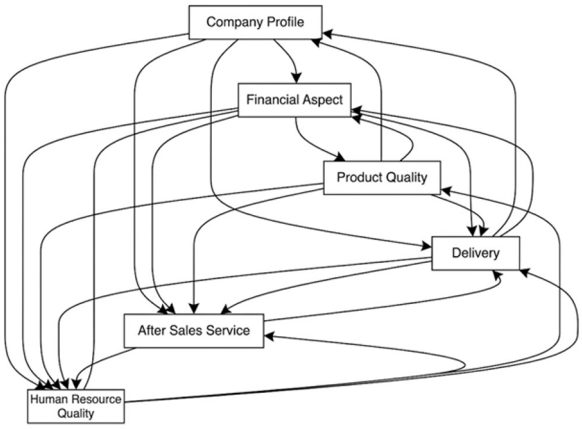

Fig. 2. Visualization of the Relationship Between Criteria

Based on the analysis results, it can be concluded that several criteria have the strongest influence on others, as indicated by the highest number of outgoing arrows. These criteria are Product Quality, Human Resources (HR) Quality, and Delivery, each with four outgoing arrows. Meanwhile, the criteria most influenced by others, shown by the highest number of incoming arrows, are Delivery, After-Sales Service, and HR Quality, each with five incoming arrows [48]. Strong reciprocal relationships were also identified between certain criteria, namely between Delivery and HR, Product Quality and HR, as well as Financial Aspects and HR. In addition, Company Profile tends to act as a criterion that influences others but is not significantly influenced by other criteria

[49]. To make the details clearer, here is a visualization of the relationship between sub criteria which can be seen in the image below:

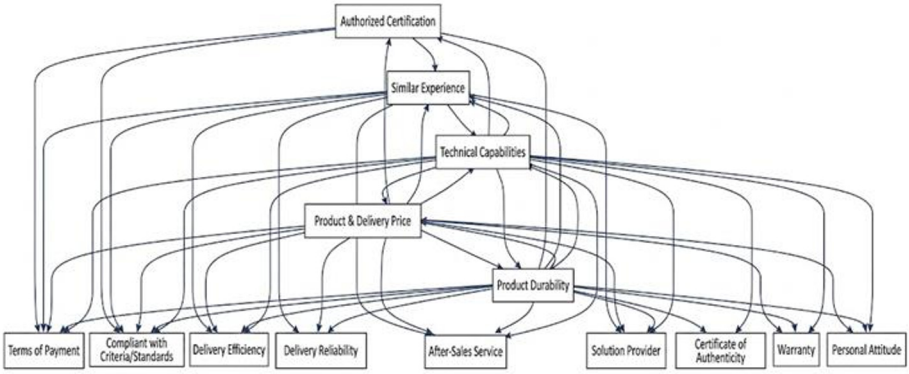

Fig. 3. Visualization of the Relationship Between Sub-criteria

Based on the visualization analysis above, it can be concluded that several sub-criteria exhibit the strongest influence on others, as indicated by the highest number of outgoing arrows. These sub-criteria are Product Durability (11), Product Price and Delivery (10), and Technical Capabilities (9) [50]. On the other hand, the sub-criteria that are most influenced by others, as reflected by the highest number of incoming arrows, are Terms of Payment and Compliance with Late Penalty Regulations, each with five incoming arrows.

After knowing the priority weight of the criteria and sub-criteria that have been determined using the ANP method, and determining the top 5 procurement of goods by repetition, a list of vendors involved in the 5 procurements can be found. The next step is the vendor assessment using the following TOPSIS method.

Table 2. Ci Values and Vendor Ranking on Top 5 Procurements

Procurement	Vendor	CI Value	Rank
Inner Tire, Outer Tire, Marset RTG	PT. RCA	1.0000	1
	PT. BSA	0.7655	2
	PT. SKS	0.5503	3
	PT. BIMA	0.0000	4
Twistlock	PT. DSP	1.0000	1
	PT. HB	0.6419	2
	PT. JSP	0.5424	3
	PT. BIMA	0.4421	4
	PT. GPE	0.3574	5
	CV. ESA	0.3529	6
Oil Engine	PT. LJT	1.0000	1
	PT. BIMA	0.9052	2
	CV. DSA	0.0000	3
Accu 12V	PT. SKS	0.5651	1
	CV. BT	0.5416	2
	PT. BSA	0.4242	3
	PT. BIMA	0.0000	4

Gloves & Cleaning Rags	CV. TAT	0.5000	-
	PT. PTUS	0.5000	-
	PT. BSA	0.5000	-
	CV. BT	0.5000	-

In this study, a moderate sensitivity analysis was conducted with moderate changes. Where the percentage change in the criteria weight was carried out on 4 criteria with the largest weight, namely product quality, delivery, after-sales service, and HR quality using a 10% increase in the percentage of criteria weight. The results of the ranking changes from the sensitivity analysis can be seen in the table below.

Table 3. Ci Values and Vendor Ranking After Sensitivity Analysis

Scenario	Procurement	Vendor	Ci	Rank	First Ci	First Rank
Product Quality +10%	Inner Tire, Outer Tire, Marset RTG	PT. RCA	1.0000	1	1.0000	1
		PT. SKS	0.6328	2	0.5503	3
		PT. BSA	0.4526	3	0.7655	2
		PT. BIMA	0.0000	4	0.0000	4
Delivery +10%	Inner Tire, Outer Tire, Marset RTG	PT. RCA	1.0000	1	1.0000	1
		PT. BSA	0.6645	2	0.7655	2
		PT. SKS	0.5758	3	0.5503	3
		PT. BIMA	0.0000	4	0.0000	4
After Sales Service +10%	Inner Tire, Outer Tire, Marset RTG	PT. RCA	1.0000	1	1.0000	1
		PT. SKS	0.5824	2	0.5503	3
		PT. BSA	0.4621	3	0.7655	2
		PT. BIMA	0.0000	4	0.0000	4
Human Resource Quality +10%	Inner Tire, Outer Tire, Marset RTG	PT. RCA	1.0000	1	1.0000	1
		PT. SKS	0.6328	2	0.5503	3
		PT. BSA	0.4625	3	0.7655	2
		PT. BIMA	0.0000	4	0.0000	4
Product Quality +10%	Twistlock	PT. DSP	1.0000	1	1.0000	1
		PT. HB	0.6680	2	0.6419	2
		PT. JSP	0.6672	3	0.5424	3
		PT. BIMA	0.4408	4	0.4421	4
		PT. GPE	0.3789	5	0.3574	5
		CV. ESA	0.3782	6	0.3529	6
Delivery +10%	Twistlock	PT. DSP	1.0000	1	1.0000	1

		PT. HB	0.7150	2	0.6419	2
		PT. JSP	0.7140	3	0.5424	3
		PT. BIMA	0.3882	4	0.4421	4
		PT. GPE	0.3842	5	0.3574	5
		CV. ESA	0.3830	6	0.3529	6
After Sales Service +10%	Twistlock	PT. DSP	1.0000	1	1.0000	1
		PT. HB	0.6902	2	0.6419	2
		PT. JSP	0.6892	3	0.5424	3
		PT. BIMA	0.5238	4	0.4420	4
		CV. ESA	0.4382	5	0.3529	6
		PT. GPE	0.3642	6	0.3574	5
Human Resource Quality +10%	Twistlock	PT. DSP	1.0000	1	1.0000	1
		PT. HB	0.6632	2	0.6418	2
		PT. JSP	0.6523	3	0.5423	3
		PT. BIMA	0.4612	4	0.4420	4
		CV. ESA	0.4378	5	0.3528	6
		PT. GPE	0.3612	6	0.3574	5
Product Quality +10%	Accu 12V	PT. SKS	0.5764	1	0.5651	1
		CV. BT	0.4663	2	0.5416	2
		PT. BSA	0.4289	3	0.4242	3
		PT. BIMA	0.0000	4	0.0000	4
Delivery +10%	Accu 12V	PT. BSA	0.8683	1	0.4242	3
		PT. SKS	0.7272	2	0.5651	1
		CV. BT	0.6542	3	0.5416	2
		PT. BIMA	0.0000	4	0.0000	4
After Sales Service +10%	Accu 12V	PT. SKS	0.5792	1	0.5651	1
		CV. BT	0.5138	2	0.5416	2
		PT. BSA	0.4293	3	0.4242	3
		PT. BIMA	0.0000	4	0.0000	4
Human Resource Quality +10%	Accu 12V	PT. SKS	0.5902	1	0.5651	1
		PT. BSA	0.5203	2	0.4242	3
		CV. BT	0.4412	3	0.5416	2
		PT. BIMA	0.0000	4	0.0000	4

Based on the sensitivity analysis conducted by adjusting the weight of each criterion by 10%, several key insights were identified. In the procurement of Tires and Marset RTG, ranking shifts occurred between PT. SKS and PT. BSA when the weights of product quality, after-sales service, and human resources quality were increased. This indicates

that these criteria have a significant influence on the final vendor ranking within this procurement.

In the Twistlock procurement, the rankings remained relatively stable, with PT. DSP consistently maintaining the first position. However, minor changes were observed between PT. GPE and CV. ESA in the 5th and 6th positions when the weights of after sales service and human resources quality were increased.

For the 12V Battery procurement, the sensitivity analysis revealed more dramatic changes. Specifically, PT. BSA rose from third to first place under the scenario where the delivery criterion's weight was increased. Additionally, a shift in ranking between PT. BSA and CV. BT was observed when the weight for human resources quality was raised.

In the case of the gloves and cleaning rags procurement, sensitivity analysis was not performed since all vendors had identical CI values (0.5000), making any ranking change impossible regardless of weight adjustments. Similarly, for the engine oil procurement, no sensitivity analysis was conducted because one vendor had a perfect CI score (1.0000), another had the lowest score (0.0000), and the remaining vendor's score, while subject to change, would not alter the overall ranking outcome. Therefore, adjustments to criterion weights were deemed irrelevant in this context.

Overall, the analysis shows that vendor selection decisions are somewhat sensitive to changes in criterion weights, particularly in the Tires and Marset RTG and 12V Battery procurements. However, these changes do not significantly affect the overall decision outcomes. This finding emphasizes the importance of proper and consistent validation of criteria weights in the implementation of procurement systems to ensure objectivity and accuracy in the selection of the best vendors.

4 Conclusion

This study developed a more robust and practical vendor evaluation framework for a stevedoring company by refining the selection criteria and integrating the DEMATEL-ANP-TOPSIS approach. The findings indicate that product quality, human resource quality, and delivery are the most influential criteria in vendor selection, with product quality receiving the highest priority weight. The interrelationship analysis further highlights the critical role of human resource quality in influencing other evaluation dimensions, emphasizing the need for a balanced assessment of operational capabilities. The application of the TOPSIS method objectively identified the most suitable vendors across the five major procurement categories, while the sensitivity analysis demonstrated that moderate changes in the weights of key criteria did not significantly affect vendor rankings. These results confirm that the proposed decision-making framework is stable, transparent, and reliable, providing practical support for strategic vendor selection and procurement management in the stevedoring industry.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Notteboom, T., Haralambides, H.: Port management and governance in a post-COVID-19 era: Quo vadis? Marit. Econ. Logist. 22(3), 329–352 (2020).
2. Notteboom, T., Rodrigue, J.P.: Port Economics, Management and Policy. Routledge, New York (2021).
3. Steenken, D., Voß, S., Stahlbock, R.: Container terminal operation and operations research: A classification and literature review. OR Spectr. 26(1), 3–49 (2004).
4. Lam, J.S.L., Dai, J.: Developing supply chain security design of logistics service providers: An analytical network process–quality function deployment approach. Int. J. Phys. Distrib. Logist. Manag. 45(7), 674–690 (2015).
5. Rezaei, J., van Roekel, W.S., Tavasszy, L.: Measuring the relative importance of port performance measures: An empirical analysis for maritime ports. Marit. Econ. Logist. 20(4), 555–577 (2018).
6. Roso, V., Woxenius, J., Lumsden, K.: The dry port concept: Connecting container seaports with the hinterland. J. Transp. Geogr. 17(5), 338–345 (2009).
7. Anwar, S.N.: Manajemen Rantai Pasokan (Supply Chain Management): Konsep dan Hakikat. Portal Garuda (2011).
8. Setiawan, A.I., Suhardi, B.: Integrasi supply chain dan dampaknya terhadap performa perusahaan: Survei pada perusahaan penyedia jasa makanan di Surakarta. Benefit 9(1) (2005).
9. De Boer, L., Labro, E., Morlacchi, P.: A review of methods supporting supplier selection. Eur. J. Purch. Supply Manag. 7(2), 75–89 (2001).
10. Ho, W., Xu, X., Dey, P.K.: Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. Eur. J. Oper. Res. 202(1), 16–24 (2010).
11. Wetzstein, A., Hartmann, E., Benton, W.C., Hohenstein, N.O.: A systematic assessment of supplier selection literature: State-of-the-art and future scope. Int. J. Prod. Econ. 182, 304–323 (2016).
12. Dickson, G.W.: An analysis of vendor selection systems and decisions. J. Purch. 2(1), 5–17 (1966).
13. Weber, C.A., Current, J.R., Benton, W.C.: Vendor selection criteria and methods. Eur. J. Oper. Res. 50(1), 2–18 (1991).
14. Cheng, E.W., Li, H.: Application of ANP in process models: An example of strategic partnering. Build. Environ. 42, 278–287 (2007).
15. Görener, A.: Comparing AHP and ANP: An application of strategic decision making in a manufacturing company (2012).
16. Belton, V., Gear, T.: On a short-coming of Saaty's method of analytic hierarchies. Omega 11(3), 228–230 (1983).
17. Rahma, A.U.: Pemilihan Supplier pada PT Pelopor Teknologi Implantindo dengan Integrasi Metode DEMATEL, ANP dan TOPSIS (2023).
18. Rahmanda, Y.E.: Pemilihan Vendor dan Evaluasi Kinerja Vendor pada Perusahaan Penyedia Jasa Logistik dengan Menggunakan Integrasi DEMATEL, ANP, dan TOPSIS (2019).
19. Saaty, T., Vargas, L.G.: Decision Making with the Analytic Network Process. Springer, New York (2013).
20. Sipahi, S., Timor, M.: The analytic hierarchy process and analytic network process: An overview of applications. Manag. Decis. 48(5), 775–808 (2010).
21. Behzadian, M., Otaghsara, S.K., Yazdani, M., Ignatius, J.: A state-of-the-art survey of TOPSIS applications. Expert Syst. Appl. 39(17), 13051–13069 (2012).

22. Zavadskas, E.K., Mardani, A., Turskis, Z., Jusoh, A., Nor, K.M.: Development of TOPSIS method to solve complicated decision-making problems: An overview on developments from 2000 to 2015. Int. J. Inf. Technol. Decis. Mak. 15(3), 645–682 (2016).
23. Chai, J., Liu, J.N., Ngai, E.W.T.: Application of decision-making techniques in supplier selection: A systematic review of literature. Expert Syst. Appl. 40(10), 3872–3885 (2013).
24. Velasquez, M., Hester, P.T.: An analysis of multi-criteria decision making methods. Int. J. Oper. Res. 10(2), 56–66 (2013).
25. Pambudi, A.S.: Pemilihan Engineering Contractor Proyek Dana Hibah Energi Terbarukan dengan Metode DEMATEL dan ANP (2017).
26. Septian, A.: Kajian Pemilihan Subkontraktor pada Perusahaan XYZ dengan Menggunakan Metode Analytic Network Process (ANP) (2020).
27. Junior, F.R.L., Osiro, L., Carpinetti, L.C.R.: A comparison between fuzzy AHP and fuzzy TOPSIS methods to supplier selection. Appl. Soft Comput. 21, 194–209 (2014).
28. Shih, H.S., Shyur, H.J., Lee, E.S.: An extension of TOPSIS for group decision making. Math. Comput. Model. 45(7–8), 801–813 (2007).
29. Rouyendegh, B.D., Erkan, T.E.: Selection of academic staff using the fuzzy analytic hierarchy process (FAHP): A pilot study. Teh. Vjesn. 19(4), 923–929 (2012).
30. Şahin, B., Yip, T.L.: Shipping technology selection for dynamic capability based on an improved Gaussian fuzzy AHP model. Ocean Eng. 136, 233–242 (2017).
31. Kahraman, C., Cebeci, U., Ulukan, Z.: Multi-criteria supplier selection using fuzzy AHP. Logist. Inf. Manag. 16(6), 382–394 (2003).
32. Govindan, K., Rajendran, S., Sarkis, J., Murugesan, P.: Multi-criteria decision making approaches for green supplier evaluation and selection: A literature review. J. Clean. Prod. 98, 66–83 (2015).
33. Saaty, T.L.: How to make a decision: The analytic hierarchy process. Eur. J. Oper. Res. 48, 9–26 (1990).
34. Saaty, T.L.: Decision making with the analytic hierarchy process. Int. J. Serv. Sci. 1(1), 83–98 (2008).
35. Dyer, J.S.: Remarks on the analytic hierarchy process. Manage. Sci. 36(3), 249–258 (1990).
36. Ishizaka, A., Labib, A.: Review of the main developments in the analytic hierarchy process. Expert Syst. Appl. 38(11), 14336–14345 (2011).
37. Vaidya, O.S., Kumar, S.: Analytic hierarchy process: An overview of applications. Eur. J. Oper. Res. 169(1), 1–29 (2006).
38. Amid, A., Ghodsypour, S.H., O'Brien, C.: A weighted max–min model for fuzzy multi objective supplier selection in a supply chain. Int. J. Prod. Econ. 131(1), 139–145 (2011).
39. Opricovic, S., Tzeng, G.-H.: A compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. Eur. J. Oper. Res. (2004).
40. Aleyhandro, D.J.: Sistem Penilaian Supplier di Industri Galangan Kapal Menggunakan Metode AHP dan TOPSIS (Studi Kasus: PT. Janata Marina Indah Semarang). Undergraduate thesis (2023).
41. Firdaus, A., Mulyati, E., Permadi, D.: Analisis Pemilihan Vendor Trucking Menggunakan Metode AHP dan TOPSIS pada PT. LK (2023).
42. Putra, A.R.W.: Perancangan Sistem Pemilihan Supplier Berbasis Spreadsheet Menggunakan Metode AHP dan TOPSIS (Studi Kasus: Klinik SM Saefudin) (2012).
43. Wang, X., Chan, H.K., Yee, R.W.Y., Diaz-Rainey, I.: A two-stage fuzzy AHP model for risk assessment of implementing green initiatives in the fashion supply chain. Int. J. Prod. Econ. 135(2), 595–606 (2011).

44. Boran, F.E., Genç, S., Kurt, M., Akay, D.: A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method. Expert Syst. Appl. 36(8), 11363–11368 (2009).
45. Kubler, S., Robert, J., Derigent, W., Voisin, A., Le Traon, Y.: A state-of-the-art survey and testbed of fuzzy AHP applications. Expert Syst. Appl. 65, 398–422 (2016).
46. Mangka, Z.M.: Pemilihan Pemasok Suku Cadang di Bawah Kontrak Vendor Managed Inventory Menggunakan Fuzzy Analytical Hierarchy Process di PT. XYZ (2023).
47. Siregar, M.L.: Pemilihan Supplier Terbaik di Procurement Section (Goods Spot Purchase) – Departement SCM dengan Metode Analytical Hierarchy Process (AHP) (2023).
48. Vural, C.A.: Sustainable demand chain management: An alternative perspective for sustainability in the supply chain. Procedia Soc. Behav. Sci. 207, 262–273 (2015).
49. Zimmer, K., Fröhling, M., Schultmann, F.: Sustainable supplier management: A review of models supporting sustainable supplier selection, monitoring and development. Int. J. Prod. Res. 54(5), 1412–1442 (2016).
50. Wang, Y.M., Luo, Y.: On rank reversal in decision analysis. Math. Comput. Model. 49(5–6), 1221–1229 (2009).

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

