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3PL Shipping Company Vendor Selection Model for Nickel Ore Processing Companies

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ABSTRACT

The nickel ore processing industry requires an efficient supply chain system to ensure production continuity and global competitiveness, especially in the distribution of raw materials to smelting facilities. One of the main problems faced by companies is the selection of Third-Party Logistics (3PL) vendors, which has not fully considered quality, performance, and safety aspects comprehensively. This study aims to analyze the selection of the most optimal 3PL vendor in supporting the effectiveness of the supply chain in nickel ore processing companies. The research method used is a quantitative approach based on Multi-Criteria Decision-Making (MCDM) with the integration of the Analytic Hierarchy Process (AHP) and VIKOR methods. AHP is used to determine the weight of six criteria and fifteen sub-criteria, while VIKOR is used to conduct the alternative ranking of 3PL vendors. The results showed that the quality and safety criteria carry a higher weight than price, which confirms the importance of the total cost of quality approach in logistics decision-making. *PT* A is recommended as the best vendor alternative based on the lowest VIKOR index value. This study concludes that the selection of the right 3PL vendor has a significant effect on the supply chain effectiveness of the nickel ore processing industry.

Keywords: *Third Party Logistics (3PL); Vendor Selection; supply chain; Nickel Industry; AHP; VIKOR*

INTRODUCTION

The development of the electric vehicle industry globally has driven an increase in demand for nickel as the primary raw material for lithium-ion batteries. This condition places Indonesia as one of the strategic players in the global nickel supply chain, in line with the downstream mineral policy that encourages increased added value through domestic processing and refining (Malik, 2024; Mubarok & Kartini, 2024). However, the increase in the production capacity of the nickel ore processing industry is also accompanied by complex challenges in supply chain management, especially in the logistics of distributing raw materials to smelting facilities. Inefficiencies in logistics systems can have a direct impact on production continuity, operational costs, and the competitiveness of companies in the global market (Chopra & Meindl, 2016; Tien et al., 2019). Therefore, the optimization of supply chain management, especially through the selection of the right logistics service provider, is a relevant strategic issue in the context of the current nickel processing industry.

Problems in the selection of Third-Party Logistics (3PL) vendors in the nickel ore processing industry are influenced by various interrelated factors. These factors include the complexity of vendor evaluation criteria, the limitation of objective information, the dominance of price considerations in decision-making, and the high level of subjectivity in assessment by decision-makers (Agarwal et al., 2011; Govindan et al., 2015). In practice, many companies still focus the selection of logistics vendors on the aspects of cost and delivery time, without thoroughly considering service quality, operational performance, flexibility, and freight safety (Beck & Hofmann, 2012). This condition is further exacerbated by the characteristics of the nickel processing industry, which carries high risk, large material value, and a strong dependence on the continuity of raw material supply (Wang et al., 2022).

These factors have significant implications for the company's operational performance. Improper selection of 3PL vendors can lead to delivery delays, increased cargo damage rates, disruptions to production schedules, and increased operational costs due to the emergence of hidden costs such as insurance claims and replacement of damaged materials. In the long run, logistics inefficiencies can also lower a company's productivity and weaken its competitive position in the global supply chain. Previous research has shown that failure to manage relationships with logistics service providers can negatively impact the overall performance of the supply chain, especially in industries with high supply risk characteristics such as mining and mineral processing (Rahmanda, 2019; Septian, 2020).

In this context, the selection of Third-Party Logistics (3PL) vendors is a strategic variable that plays an important role in supporting the effectiveness of the supply chain. 3PL providers not only function as transportation service providers, but also as strategic partners that contribute to cost efficiency, delivery reliability, service quality, and distribution safety. The effectiveness of the supply chain as a dependent variable reflects the company's ability to manage the flow of materials in a timely, safe, and efficient manner to ensure production continuity. Previous studies have confirmed that the success of supply chain management is strongly influenced by the quality of decision-making in the selection of logistics partners, which must consider various criteria in a structured and measurable manner (Awasthi et al., 2018; Siregar, 2023).

Although many studies have discussed the selection of logistics vendors using the Multi-Criteria Decision-Making (MCDM) approach, there are still significant research gaps. Most previous studies have focused on the general manufacturing, construction, or logistics services sector, with relatively different risk contexts than the nickel ore processing industry. In addition, research that specifically integrates the Analytic Hierarchy Process (AHP) and VIKOR methods in the context of selecting 3PL vendors for the nickel processing industry is still limited. In fact, the characteristics of this industry demand a decision-making approach that emphasizes not only cost efficiency, but also quality, performance, and safety aspects as part of the total cost of quality. Thus, this study offers novelty in the form of the AHP-VIKOR model adjusted to the risk characteristics and needs of the nickel ore processing industry.

The urgency of this research is further reinforced by the high economic value of nickel materials and the operational risks inherent in maritime distribution activities. Mistakes in the selection of a 3PL vendor not only impact a single delivery cycle, but can trigger systemic disruptions in a company's supply chain. In the long term, these conditions have the potential to hinder the achievement of production targets and weaken the contribution of the nickel processing industry to the national downstream agenda. Therefore, an objective, consistent, and data-driven 3PL vendor selection model is needed to support strategic management decision-making, while minimizing subjectivity and operational risk (Jovčić & Pruša, 2021).

Based on this background, the purpose of this study is to analyze and determine the best Third-Party Logistics (3PL) vendors in supporting supply chain effectiveness in nickel ore processing companies. In particular, this study aims to identify the most influential criteria and sub-criteria in the selection of 3PL vendors, determine the importance of each criterion using the AHP method, and conduct alternative vendor rankings using the VIKOR method. With this approach, it is hoped that the most optimal vendor recommendations will be obtained in accordance with the company's operational needs.

The benefits of this research are divided into academic and practical benefits. Academically, this research is expected to enrich the literature on supply chain management and multi-criteria decision-making, especially in the context of the nickel ore processing industry, which has been relatively underexplored. Practically, the results of this study are expected to serve as a reference for company management, especially the Purchasing and Logistics Department, in designing a more systematic, transparent, and data-driven 3PL vendor selection policy. In addition, the proposed model can also be adapted as a periodic vendor performance evaluation tool to support the sustainability and efficiency of the company's supply chain

METHODS

This study used a quantitative approach with a descriptive design that aims to analyze and map the selection process of Third-Party Logistics (3PL) vendors in supporting supply chain effectiveness in nickel ore processing companies. Research was conducted on nickel ore processing companies with a focus on raw material distribution activities to smelting facilities. The implementation of the research took place in the period from 2023 to 2024, with the object of the study in the form of 3PL vendors in collaboration with the company. This research highlights six main aspects that are the basis for decision-making, namely price, delivery, performance, quality, service, and safety, which are considered to affect the smooth and reliable supply chain of the company.

The research population includes all internal parties involved in the decision-making process of selecting 3PL vendors, especially in the Purchasing and Logistics Department. The research sample was determined purposively based on the competence and experience of respondents in evaluating the performance of logistics vendors. The data used consisted of primary data and secondary data, where primary data was obtained through the dissemination of a structured questionnaire to respondents to assess the level of importance of the vendor's alternative criteria and performance, while secondary data was obtained from the company's internal documents, such as procurement reports and vendor evaluations. This approach is used to ensure that the data collected is objective, measurable, and relevant to the research objectives.

The research instrument is in the form of a paired comparison questionnaire and a vendor performance assessment sheet which is prepared based on criteria and sub criteria that have been set by the company. The collected data is then processed and analyzed quantitatively to produce the importance weight of each criterion as well as the ranking of alternative 3PL vendors. The results of the analysis are presented in the form of numerical values and the order of priority vendors as the basis for decision-making recommendations. To ensure the validity of the data, this study applies a consistency test of respondents' assessments and checks the suitability of primary data with company documents, so that the results of the research can be scientifically accounted for.

RESULTS AND DISCUSSION

Results

This research was conducted on a company engaged in nickel ore processing, focusing on logistics activities for the distribution of raw materials to smelting facilities. In its operations, the company relies heavily on the performance of Third-Party Logistics (3PL) service providers to ensure a smooth supply chain, given the characteristics of high-value, risky, and sensitive nickel materials to delivery delays. Logistics activities are one of the crucial factors in supporting production continuity and achieving the company's operational targets (Chopra & Meindl, 2016).

The object of the research is specifically directed at the process of selecting 3PL shipping line vendors that collaborate with the company. This research involves three alternative vendors who have been the company's logistics partners, namely PT A, PT B, and PT C, each of which has different service characteristics, fleets, and performance levels. The evaluation was carried out based on the company's operational data for the 2023–2024 period, so that the results of the research reflect actual conditions and are relevant to current managerial needs.

The main variables studied in this study are the selection of Third Party Logistics (3PL) vendors as independent variables and supply chain effectiveness as dependent variables. The selection of 3PL vendors is measured through a number of criteria and sub-criteria compiled based on the results of literature studies and discussions with the company's internal parties, especially the Purchasing and Logistics Department. This approach is in line with previous research that emphasizes the importance of adjusting vendor selection criteria to industry characteristics (Beck & Hofmann, 2012).

Based on the identification results, six main criteria used in the selection of 3PL vendors were obtained, namely Price, Delivery, Performance, Quality, Service, and Safety, with a total of 15 sub criteria. The six criteria are considered to be able to represent aspects of cost, operational reliability, service quality, and safety risks inherent in marine distribution activities in the nickel processing industry.

The research data was obtained from the company's internal respondents who were directly involved in the evaluation and selection process of 3PL vendors. Respondents consisted of managers and key staff in the Purchasing and Logistics Department who had a deep understanding of vendor performance and the company's operational needs. The number of respondents was adjusted to the needs of decision-making and was considered representative to describe the company's managerial preferences and considerations.

Primary data was collected through a paired comparison questionnaire to determine the level of importance of each criterion and sub criterion, as well as an assessment of the vendor's alternative performance. Secondary data is obtained from internal company documents, such as vendor evaluation reports and logistics operational records, to strengthen the results of primary data processing.

The results of data processing showed that the six criteria had different weights of importance. The Quality criteria received the highest weight, followed by Performance, Safety, Delivery, Service, and Price. These findings show that companies do not solely focus decisions on the lowest prices, but rather consider the quality of service and vendor reliability in supporting a smooth supply chain.

Table 1. Total Value of Criteria and Sub criteria Based on Stage 1 Questionnaire Results

No Criteria	Criteria and Sub criteria	Rating			Average
		R1	R2	R3	
1.	Price	5	5	5	5,0
1.1.	Price of Service	5	4	5	4,7
1.2.	Cost Control of Added Values	5	4	5	4,7
2.	Delivery	5	3	5	4,3
2.1.	Delivery State	4	3	5	4,0
2.2.	Delivery Time	4	3	5	4,0
3.	Performance	4	4	5	4,3
3.1.	Effectiveness	4	4	5	4,3
3.2.	Responsiveness	5	5	5	5,0
3.3.	Document Accuracy	5	5	4	4,7
4.	Quality	5	5	4	4,7
4.1.	Vehicle Type	5	5	3	4,3
4.2.	Trust	5	5	4	4,7
5.	Service	4	4	4	4,0
5.1.	Customer Service	5	5	4	4,7
5.2.	Equipment	4	4	4	4,0
5.3.	Flexiblity	4	3	5	4,0
6.	Safety	5	5	4	4,7
6.1.	Accident Rate	5	5	3	4,3
6.2.	Average Vehicle Age	4	5	3	4,0
6.3.	Safety Tools	Addition from respondent 1			

Source: Data processing results from phase 1 questionnaire.

In the distribution of this phase 1 questionnaire, there was one respondent who provided an additional sub-criterion to the Safety criteria, namely Safety Tools. So the additional sub criteria were included in the new questionnaire phase 1 to be distributed again to the respondents. The total scores for each criterion and sub-criteria based on the new phase 1 questionnaire can be seen in Table 2.

Table 2. Total Value of Criteria and Sub criteria Based on the Results of the New Questionnaire Phase 1

No Criteria	Criteria and Sub criteria	Rating				
		R1	R2	R3	Average	Results
1.	Price	5	5	5	5,0	Accepted
1.1.	Price of Service	5	4	5	4,7	Accepted
1.2.	Cost Control of Added Values	5	4	5	4,7	Accepted
2.	Delivery	5	3	5	4,3	Accepted
2.1.	Delivery State	4	3	5	4,0	Accepted
2.2.	Delivery Time	4	3	5	4,0	Accepted
3.	Performance	4	4	5	4,3	Accepted
3.1.	E fectiveness	4	4	5	4,3	Accepted
3.2.	Responsiveness	5	5	5	5,0	Accepted
3.3.	Document Accuracy	5	5	4	4,7	Accepted
4.	Quality	5	5	4	4,7	Accepted
4.1.	Vehicle Type	5	5	3	4,3	Accepted
4.2.	Trust	5	5	4	4,7	Accepted
5.	Service	4	4	4	4,0	Accepted
5.1.	Customer Service	5	5	4	4,7	Accepted
5.2.	Equipment	4	4	4	4,0	Accepted
5.3.	Flexiblity	4	3	5	4,0	Accepted

No Criteria	Criteria and Sub criteria	Rating				
6.	Safety	5	5	4	4,7	Accepted
6.1.	Accident Rate	5	5	3	4,3	Accepted
6.2.	Average Vehicle Age	4	5	3	4,0	Accepted
6.3.	Safety Tools	5	4	4	4,3	Accepted

Source: Data processing results from phase 1 questionnaire.

The criteria and sub criteria selected according to the respondents can be included in the hierarchy of the assessment. The criteria and sub criteria that are included in the assessment hierarchy are criteria and sub criteria that have *an average* assessment greater than or equal to four (4). In this phase 1 questionnaire, the assessment scale is considered logical on a scale of 4 (Important) because a scale of 4 of a criterion and sub criteria shows that on average all respondents agree that the criteria and sub criteria are used in the selection of *third-party logistics shipping lines.*

In the form of a hierarchy, the structure of the assessment and selection of third-party logistic shipping line vendors can be seen in Figure 1 below:

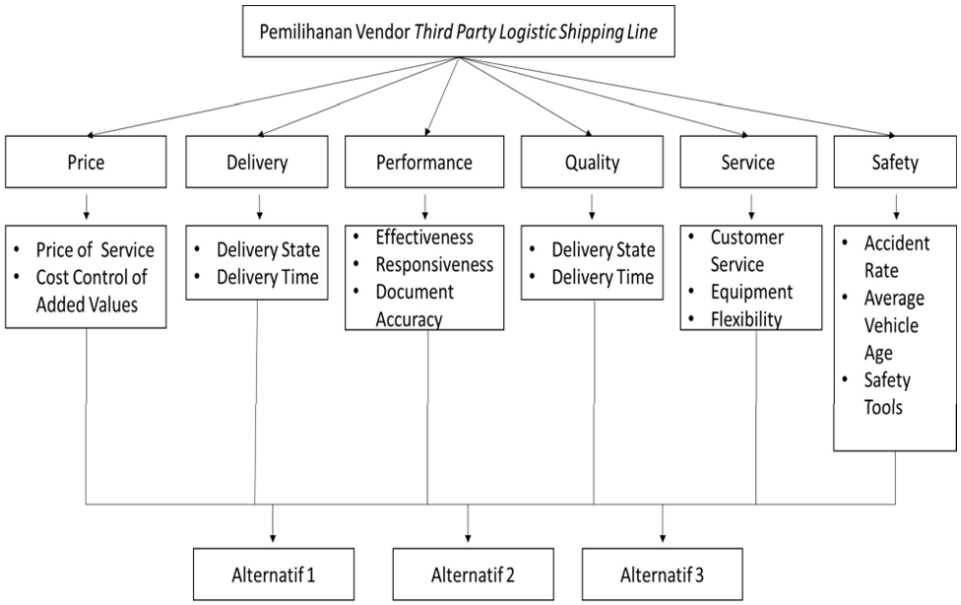

Figure 1. AHP Hierarchical Structure
Source: Data processing results from phase 1 questionnaire

A paired comparison between criteria formed on an AHP comparison matrix obtained from the second questionnaire about the level of importance of criteria in determining third party logistic shipping line.

The results of this study confirm that the selection of Third-Party Logistics (3PL) vendors in the nickel ore processing industry is a strategic decision that cannot be treated as a routine operational activity alone. The urgency of this research arises from the characteristics of the nickel industry which has a high level of risk, large material value, and direct dependence on the smooth distribution of raw materials to the smelting facility. The research findings show that failure to choose the right 3PL vendor has the potential to cause significant disruption to supply chain effectiveness, ultimately impacting the company's production continuity and

competitiveness. This condition is in line with the view of Chopra and Meindl (2016) who emphasize that logistics decisions have direct implications for the performance of the supply chain as a whole.

This urgency is further strengthened by the downstream mineral policy that encourages an increase in nickel processing capacity in Indonesia. Increasing production volume directly increases the intensity of logistics activities, so that errors in the management of raw material distribution will have a systemic impact on the company's overall business processes. Therefore, this research becomes relevant in response to the industry's need for an objective, structured, and data-driven 3PL vendor selection model.

Based on the results of the study, the main problem in choosing a 3PL vendor is not only caused by the limited number of service providers, but rather the complexity of the evaluation criteria that must be considered simultaneously. The findings suggest that price-only vendor selection practices are no longer adequate in the context of the nickel ore processing industry. Price is still a consideration, but it is not the dominant factor. This is reflected in the weight of the Price criterion which is at the lowest position compared to other criteria.

Another cause identified is the high subjectivity in the decision-making process if it is not supported by a systematic quantitative approach. Without a structured evaluation framework, assessments of vendors tend to be influenced by individual experiences, personal perceptions, or previous cooperation habits. This condition is in line with the findings of Beck and Hofmann (2012) who stated that logistics decision-making without a multi-criteria approach has the potential to produce biased and suboptimal decisions.

In addition, the characteristics of marine logistics in the nickel industry are also a factor causing the complexity of vendor selection. The risk of damage to goods, delivery delays, and potential work accidents make the safety and quality aspects of the fleet as crucial factors. The results of the study show that the Safety and Quality aspects gain a relatively high weight, indicating that the company is aware of the magnitude of operational risks that must be managed carefully.

The dominance of Quality and Safety criteria in the weighting results shows a paradigm shift in logistics decision-making in the nickel ore processing industry. These findings indicate that companies no longer view logistics solely as a function of cost, but rather as a strategic element that contributes to operational sustainability. Sub criteria such as Vehicle Type, Trust, Safety Tools, and Accident Rate are important indicators in ensuring that the distribution of raw materials is carried out safely and reliably.

These results support the concept of total quality cost, where logistics costs are measured not only from shipping rates, but also from potential losses due to damage to goods, production delays, and other hidden costs. The findings of this study are in line with the research of Siregar (2023) and Rahmanda (2019) who stated that the quality and reliability of logistics vendors often determine the success of the supply chain more than the lowest prices. In the context of the nickel industry, the difference in shipping costs is insignificant when compared to the potential losses due to disruptions in the supply of raw materials.

The results of the vendor ranking show that PT A occupies the top position as the best 3PL vendor. This position is not solely determined by one particular criterion, but by a relatively balanced combination of performance on all the main criteria. These findings show

that supply chain effectiveness cannot be achieved through partial advantages, but rather through holistic performance that includes aspects of cost, quality, delivery, service, and safety.

Vendors with superior performance in terms of safety and quality tend to have a positive impact on the company's operational stability. Safe and timely delivery contributes to the smooth smelting process, reduces the risk of production downtime, and increases the certainty of operational schedules. Thus, the results of this study strengthen the argument that the selection of the right 3PL vendor is an important prerequisite for the effectiveness of the nickel processing industry's supply chain.

This research offers a solution in the form of the application of a 3PL vendor selection model based on a structured quantitative approach. This model allows companies to systematically integrate various criteria and sub criteria , so that the resulting decisions are not purely partial or intuitive. The results of the consistency test showed that the respondents' assessments were reliable, so that the weight of the resulting criteria could be used as a basis for strategic decision-making.

These solutions are becoming relevant in the context of the industry's need for transparent and accountable decision-making. With a clear evaluation model, companies can minimize subjectivity, increase the accountability of the procurement process, and ensure that the vendor selected is truly a good fit for long-term operational needs. This approach is also in line with the recommendations of Jovčić and Pruša (2021) who emphasize the importance of using multi-criteria methods to reduce bias in the selection of logistics service providers.

If the company applies the results of this research consistently, several positive impacts can be obtained. First, increasing the effectiveness of the supply chain through reducing the risk of delays and damage to goods. Second, increased cost efficiency in the long run, although shipping rates are not always the lowest. Third, increasing operational reliability which has a direct impact on production stability and the fulfillment of the company's business targets.

In addition, the application of this model also allows companies to use the weight of criteria as the basis for the preparation of Key Performance Indicators (KPIs) and Service Level Agreements (SLAs) with 3PL vendors. Thus, the cooperative relationship is not only transactional, but also strategic and oriented towards long-term performance.

When compared to previous research, the results of this study show significant similarities and differences. Similarities can be seen in the findings that vendor quality and reliability are dominant factors in the selection of logistics service providers, as found by Siregar (2023) and Rahmanda (2019). However, the results of this study are different from the findings of Septian (2020) in the construction sector, where price is the most dominant criterion. This difference confirms that the preference of vendor selection criteria is greatly influenced by industry characteristics.

The novelty of this research lies in the application of the 3PL vendor selection model which is specifically tailored to the context of the nickel ore processing industry. The study not only adopts existing methods, but also adapts the structure of criteria and sub criteria to the level of risk, material value, and operational needs of the nickel industry. Thus, this study makes a new contribution to the supply chain management literature, particularly in the context of mineral resource-based industries that have high-risk characteristics.

Overall, this discussion shows that the problem of selecting 3PL vendors in the nickel ore processing industry stems from the complexity of the criteria and the high operational risks

that must be managed simultaneously. The results of the study prove that a structured and data-based vendor selection approach is able to provide a more comprehensive solution than the conventional price-based approach. By putting quality, performance, and safety as top priorities, companies can improve supply chain effectiveness while minimizing long-term risks.

CONCLUSION

This study aims to analyze and determine the most optimal Third-Party Logistics (3PL) vendors in supporting supply chain effectiveness in nickel ore processing companies. The main problem behind this study is the high complexity of decision-making in the selection of logistics vendors due to the many criteria that must be considered simultaneously and the high operational risks in the distribution of raw materials to smelting facilities. Based on these objectives, this study succeeded in developing a structured and data-based 3PL vendor selection evaluation framework. The results of the study show that the selection of a 3PL vendor cannot be based only on price considerations, but must pay attention to quality, performance, delivery, service, and safety aspects comprehensively. Key findings indicate that service quality and transportation safety have a dominant role in supporting the effectiveness of the nickel ore processing industry's supply chain. The vendor with the most optimal overall performance is recommended as the company's main logistics partner, as it is able to provide a higher level of reliability in maintaining the continuity of raw material supply and operational stability. The main contribution of this research lies in the provision of a 3PL vendor selection model that is specifically tailored to the characteristics of the nickel ore processing industry, which has high material value and large operational risks. This study enriches the supply chain management literature by showing that the preferences of vendor selection criteria are heavily influenced by the industry context, so price-based approaches are not always relevant for all sectors. Practically, this research provides a basis for decision-making that is more objective, transparent, and can be used as a reference in the formulation of procurement policies and evaluation of vendor performance. This research has limitations in the scope of the research object which focuses only on one company and a limited number of vendor alternatives. Therefore, further research is recommended to involve more companies or other industry sectors, as well as combine the approaches used with other multi-criteria decision-making methods or uncertainty-based approaches to obtain more comprehensive and generalizable results.

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