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Safety risk and operational efficiency on logistic service providers' sustainable coal supply chain management

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Safety risk and operational efficiency in sustainable coal supply was an issue in the coal distribution supply chain. An online survey evaluating safety hazards, operational effectiveness, logistic service providers, and sustainable supply chain management was completed by 89 consumers of coal logistic service providers. In contrast, this study aimed to evaluate the operational effectiveness and safety concerns of a sustainable coal supply chain managed by the logistic service providers on the Barito River. In addition to using path analysis, quantitative research methods were also applied to calculate and process the questionnaire data, producing a value that determined the weight of each vendor, criterion, and sub-criterion. It showed several positive and significant influences connected to the safety of sustainable supply chain management, the operational efficiency of logistic service providers, supply chain management, and security risks for the providers. Therefore, it was essential to unite the positive influences on the logistic flow to secure the coal supply chain activities on the Barito River. This research would have theoretical and practical applications, adding to the advancement of science through its applications. Such knowledge would affect the safety risk and operational efficiency of sustainable supply chain management through the logistic service providers on the Barito River, Central Kalimantan.

1. Introduction

Coal is the most exciting source of energy in the world. Indonesia is the biggest coal exporter in the world. Most of the export is to India and China (Endri et al., 2021). Although it is predicted that coal consumption will meet a smaller portion of the world's energy needs until 2040, the total energy consumption is anticipated to rise globally, and there will be a net increase in global coal consumption, requiring integrated cooperation to resolve the business issues and achieve inter-organizational cooperations through collaboration and partnership with network partners, who could be suppliers, network partners, service providers, or customers. It is predicted that 2040 coal production will increase from 171 billion to 208 billion GJ, with China and India as the two biggest consumers (Clark & Zhang, 2022). Consequently, coal production and distribution in Indonesia will be more critical in the context of global energy supply. Recently, an increasing number of customers need more attention to the condition in which the product is produced and whether the product must be treated sustainably. Based on the study by Lam and Dai (2015), the supply chain manager not only considers such standard criteria as cost, quality, and delivery for evaluating the components and materials but also the solutions to reduce the environmental and social impacts. According to Zhu and Sarkis (2004), a sustainable supply chain encourages handling eco-friendly returns, recycling, remaking, and adequate waste disposal. At the same time, Pagell and Shevchenko (2014) say that no relevant studies have contributed sufficiently to establishing a sustainable supply chain.

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Based on the background, the following issues can be identified: First, supply chain management has yet to become an integrated approach to solve business problems and achieve inter-organizational cooperation for the users of coal logistic service providers that cross the Barito River. Second, the users of coal logistic service providers who cross the Barito River need to optimally build collaboration and partnerships with network partners such as suppliers, third-party service providers, and customers. Third, there is an increasing number of concerns from the customers who use logistic service providers for coal crossing the Barito River about the conditions under which the product is produced and whether the product must be treated sustainably. Fourth, the supply chain managers who use logistic service providers for coal crossing the Barito River pay attention to the standard criteria for evaluating components and materials. At the same time, they cannot be seen only as solutions to reduce environmental and social impacts. The research conceptualizing sustainable logistics practices in logistics transportation still needs to be improved in developing a holistic business model that includes a social dimension (Kumar, 2022). The delivery of goods and services to customers or end users is the subject of channel strategy. This choice will influence whether the company will sell to specific market categories. Fourth-party logistics (4PL) is emerging in the market, seeking to coordinate complementary services and act as a single point of contact for shippers (Tezuka, 2011). The engineering and management fields promote efficiency by carrying out the relevant actions well or doing the right thing and effectiveness by performing the best action or doing the right thing (Abidin et al., 2021). Thus, to be effective, a company should identify the right strategic objectives, and to be efficient, it should achieve the objectives with minimum resources.

According to the study by Nam and Song (2011), many maritime service providers have tried to extend their business coverage and diversify to other sectors in the supply chain. Cooperation between two or more entities, individuals, organizations, or countries is established to achieve mutually beneficial results. This involves sharing resources, knowledge, and expertise to achieve common goals that are difficult to achieve independently. Sharing responsibilities and utilizing complementary skills to achieve results are better than separate individual efforts. In this Barito River supply chain activities, many processes still cannot be simplified and improved because Barito River customers of coal logistic service providers have not yet built cooperation and partnerships with network partners such as suppliers, intermediaries, third-party service providers, or customers that should be optimized in use.

Customers are increasingly concerned and expect the users of coal logistic service providers who cross the Barito River to care about the conditions in which the product is produced and whether it should be treated sustainably due to the safety factor of the goods being transported. It may need to meet the criteria expected by the customer during the trip. Meanwhile, it is also necessary to ensure that customer expectation is formed based on a variety of factors, including past experiences, marketing communication, and industry standards covering quality, the value of money, customer services, convenience and ease of use, transparency, and trust, timeliness, and innovation. Following Wu et al. (2017), the integrated strategy for resolving business issues and fostering inter-organizational collaboration is supply chain management.

Sustainable Supply Chain Management (SSCM) continues to develop with changes in substantive focus, methodology, and type of analysis. However, many future research opportunities on issues need to be studied, like diversity and human rights (Carter et al., 2020). Tay et al. (2015) find that various documented factors influence organizations in the decision-making of SSCM implementation. Research by Morali and Searcy (2013) reveals many challenges in integrating sustainability into SCM. It is proven by this comparative study that sustainable SCM facilitates the adoption and implementation of supply chain integration through the use of digital technologies, which leads to the operational competitiveness of suppliers (Lee, 2021). Various media report that the rising production costs in China push Chinese manufacturers to find cheaper manufacturing havens in Southeast Asia, a fast-growing emerging market. The coal companies go through three aspects of sustainability: economic, environmental, and social. This research is to find out the effects of price fairness and service convenience on customer satisfaction and the impact on customer loyalty related to supply chain management, collaboration, and partnership, increasing the number of customer concerns about the users of coal logistic service providers crossing the Barito River.

According to News (2013) and Chang et al. (2014), as the central element in the shipping business, container shipping plays an increasingly significant role in international trade. In the maritime business, which is so important, ensuring safety and security as well as minimizing risks and potential losses due to shipping operation incidents are undoubtedly important. Talley (1996) finds that ship operators who do not have licenses and smaller size of ships contribute to the increasing risk and the severity of cargo damage in the container shipment.

Fu et al. (2010) report that hijacking has significantly threatened container ships. Yang (2011) finds that the initiative for container safety, because the supply chain partner needs to send important information on time and process the document detained by the governmental department (for example, customs), significantly impacts Taiwan's shipping industry. Shipping companies usually have limited resources for investment in managing risks. It needs an inclusive empirical risk analysis of the shipment operation that may cause maritime safety and security damage. Three logistic flows in the shipment operation should be considered, namely information flow, physical flow, and financial flow.

In coal transportation, what is very important is the concept of door-to-door transportation. Such factors as cost, efficiency, accessibility, service, reliability concerning this concept, and inland distribution have become critical dimensions in the development of the global supply chain. In contrast, land accessibility and other logistical functions and characteristics

become prominent to achieve higher port performance and competitiveness. Research in maritime transport focuses on ports, including the relationship between ships and port operations and issues related to port services, pricing, efficiency, and performance. Sea transport is fundamentally concerned with port-to-port transportation and related operations, including the underlying market and corporate economics. Sea transport, accounting for more than 90% of global trade in volume, is an essential component of the supply chain (Huzaifi et al., 2020). Manufacturing companies are looking for integrated logistic packages that can add value to their cargo in their supply chain journeys instead of fragmented traditional transportation services.

2. Literature Review

2.1. Sustainable Supply Chain Management

Theoretically, Sustainable Supply Chain Management (SSCM) is a combination of Supply Chain Management (SCM) and sustainability theory (Ahi & Searcy, 2013; Hong et al., 2018; Signori et al., 2015; Nusraningrum et al., 2023). At the same time, SCCM and supply chain are parallelly related to the environmental condition and create the concept of dynamic capabilities in SSCM and are considered optimal (Beske, 2012; Hong et al., 2018). According to Putro et al. (2021), SCM is a tool for controlling the value-added processes until the final consumers. Critical parts, procedures, and testing make up the SCM. In order to maximize the benefits of the supply chain, preparations for five essential elements are required. Operations on production plans for products and services, strategic supply, complete supply chain, and investment chain management will all be impacted and shaped by this strategy. Outsourcing strategy: Analyzing the supplier chain's skills and knowledge is the first step in any outsourcing decision. Activities with minimal strategic interest should be outsourced if they can be done better, faster, or cheaper. SSCM has received increasing attention, while supply management is essential for increasing an organization's competitiveness (Panigrahi et al., 2018). Although the literature is still developing, most research on the sustainability dimension started to appear in 2002 (Seuring & Müller, 2008). In his study, Sarkis (2012) adds that SSCM includes nine overlapping boundaries and five main interrelated streams. By including the aspect of sustainability, SSCM, according to Carter and Rogers (2008), is also called an integration of social, environmental, and economic problems. Therefore, SSCM is not only a topic of academic research, but it has attracted the attention of various corporate interests.

2.2. Safety Risk

Risk is defined as the chance, in quantitative terms, of specific harm (Gurtu & Johny, 2021; Suryadi et al., 2021). In the existing literature, the risk assessment studies aimed at the analysis of maritime traffic safety usually consider the state of the system as two ultimate states—one is the normal state, and the other is the complete failure state (Wang et al., 2020; Ricardianto et al., 2023). Nikolashin and Khabirov (2022) say there are more complex differences between ship emergency and emergency evacuation processes from buildings and other vehicles.

2.3. Operational Efficiency

Operational efficiency is one of the primary factors of cost reduction. So, it is necessary to understand the balance between operational efficiency and cost (Wang et al., 2023; Ricardianto et al., 2022). Barros et al. (2013) and Endri et al. (2022) explain that a company's operational efficiency is affected by the size of the company, merger and acquisition, and time. Ramachandran and Janakiraman (2009) calculate operational efficiency comprehensively through the performance of indexes, efficiency index, and utilization index. Generally, in business financing, the lower the operational efficiency of a company, the bigger the financial exposure and the more sensitive the cost of debt to the company's performance (Krasker, 1986). In addition, Edmans et al. (2016) explain that reducing operational costs will undoubtedly reduce the efficiency of actual business and decrease the company's performance. The efficiency of operation is also studied by Beškovnik et al. (2020) and Ghufran et al. (20123). They focus on the price and timing of the transport service so that a higher level of awareness of cargo owners can be convinced to choose sustainable transport and logistic services (Beškovnik et al., 2020). Robinson (1998) gives an example of Asia, where the hub port system, as the main line and feeder net, reflects different levels of cost efficiency.

2.4. Logistics Service Providers

Suppliers and transportation service providers are the central elements in the supply chain construction, and they play roles when using logistic construction arrangements based on the third party's logistics (Ekeskär & Rudberg, 2022). Sea transportation today plays an integral role in the supply chain, which generates the concept of maritime logistics (Panayides, 2006). Sea transportation, accounting for over 90% of global trade volume, is a crucial supply chain component (UNCTAD, 2019). Theoretically, according to Panayides and So (2005), Logistics Service Providers perform logistic functions on their clients' behalf. Panayides (2006) adds that manufacturing companies look for integrated logistic packages to add value to their cargo through a supply chain journey instead of fragmented traditional transportation services. According to Drewry Shipping Consultants, for shipment, an average of 50% to 60% of the cargo delivery industry sends cargo on time (DSC, 2012). That is why maritime logistic providers should improve their performance.

Based on some theories above and previous research, this research is unique in using the variables of operational efficiency and logistic service providers, which are not found simultaneously with the other two variables being used. So, this research can be said to be a novelty, especially in maritime transportation and supply chain management research. The novelty of this research is necessary for logistic service providers, especially on Barito River, Kalimantan.

Based on the above description, a conceptual model and research hypotheses are formulated (Figure 1).

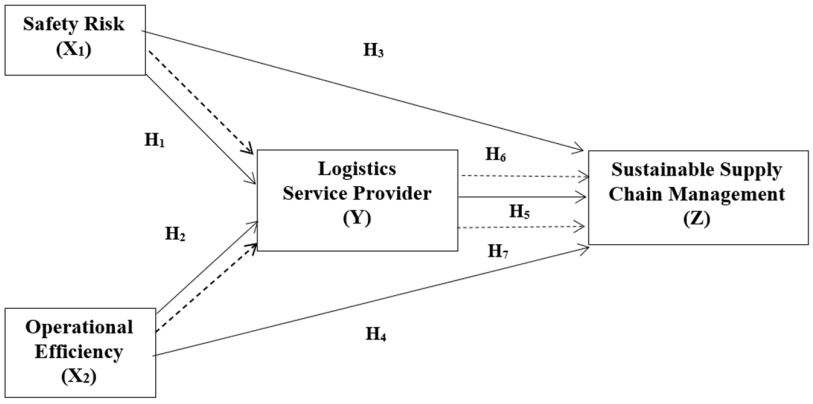

Fig. 1. Conceptual Model

2.5. Research Hypotheses

H1: *Safety risks directly affect sustainable supply chain management.*
H2: *Operational efficiency directly affects sustainable supply chain management.*
H3: *Logistic service providers directly affect sustainable supply chain management.*
H4: *Safety risks directly affect logistics service providers.*
H5: *Operational efficiency directly affects logistic service providers.*
H6: *Safety risks indirectly affect logistic service providers.*
H7: *Operational efficiency indirectly affects logistic service providers.*

Since all operations connected to such a chain begin with a safety risk, operational efficiency, and the provision of logistical services, it is concluded that all the processes impact one another. As a result, the sustainability of the supply chain will be impacted if some parts of the process are not supported smoothly and consistently. Given this, controlling the supply chain with sustainability in mind is always crucial to delivering excellent service at a low cost of operation and with minimal safety risk.

3. Research Methods

This research phase covered several steps, starting from planning, carrying out, processing field results, and giving explanations before concluding the research. The research was based on a quantitative study using simple random sampling as its sampling method. Since this is simple random sampling and drawn from the population at random due to any existing population strata, the Slovin formula with the sample size for the investigation was determined. The study was conducted from March 2022 to June 2022 in the Central Kalimantan Province's Barito River basin. According to statistics from 2022, the population of this research consists of 842 coal customers of Logistic Service Providers (LSP) that cross over the Barito River. Based on the calculation, the number of samples is determined by using the Slovin formula. So, as many as 89 coal logistic service providers are determined as respondents to be given questionnaires.

4. Result and Discussion

4.1. Validity and Reliability Test Results

Based on the validity and reliability test results, it is known that the $r_{\text{-statistics}}$ for all statement items is above 0.2083 ($r_{\text{-table}}$), with the $t_{\text{-statistics}}$ range between 0.296-0.755. Because $r_{\text{-statistics}} > r_{\text{-table}}$, all of the statement items are said to be valid so that they can be used to obtain further research data. The reliability test results were obtained based on research and calculations. The values of Cronbach's Alpha are obtained more significantly than the comparator (0.600), with the $t_{\text{-statistics}}$ range between 0.798-0.842. As a basis for decision-making in the reliability test above, it can be concluded that the questionnaire statement items are reliable or consistent.

4.2. Hypotheses Test

4.2.1. Results of T and F Test

Based on the research studies conducted, it can be explained that the $t_{-statistics}$ of the safety risk variable is 6.655, and the operational efficiency variable is 3.189. If it is confirmed in the t_{-table} that the provisions of $t_{-statistics}$ find the figure of 1.987> t_{-table}, then hypothesis 1 is accepted. Meanwhile, from the other research, it is proven that the variables of security risk and operational efficiency positively influence the logistics service provider variable. Hence, the $t_{-statistics}$ values of the safety variable 6.043 and the operational efficiency variable are 6.043 and 3.237, respectively. So, if it is concluded or confirmed in the t_{-table} that the provisions of $t_{-statistics}$ find the number of 1,987> t_{-table}, then the hypothesis is accepted. From the research, it is proven that the variables of security risk and operational efficiency positively influence the variable of sustainable supply chain management. Based on the ANOVA or F statistical test, the $F_{-statistics}$ is 41.227 > F_{-table} 3.95 with a probability level of 0.000 <0.05. The regression model can be used to predict logistic service providers or the variables of safety risk and operational efficiency simultaneously significantly affect the logistic service providers. Based on the ANOVA test or F statistical test, the $F_{-statistics}$ is 36.129, and the F_{-table} is 3.95 with a probability level of 0.000 <0.05. The regression model can be used to predict sustainable supply chain management, or the variables of safety risk and operational efficiency simultaneously significantly affect sustainable supply chain management.

4.2.2. Results of the Determination Coefficient Test

a. Effect of Safety Risk (X1), Operational Efficiency (X2) and Sustainable Supply Chain Management (Y)

Based on the test results for the coefficient of determination safety risk on operational efficiency, the magnitude of the influence of the two variables observed can be seen from the value of the coefficient of determination of R_{Square}, which is equal to 0.144 or 14.4%. This can be explained by the effect of the safety risk variable on the operational efficiency variable, which is 14.4%. Based on the test results for the coefficient of determination of safety risk on sustainable supply chain management, the magnitude of the influence of the two variables observed can be seen from the value of the coefficient of determination of R_{Square}, equal to 0.390 or 39%. This can be explained by the fact that the effect of the safety risk variable on the sustainable supply chain management variable is 39%. Based on the test results for the coefficient of determination of operational efficiency on sustainable supply chain management, the magnitude of the influence of the two variables observed can be seen from the value of the coefficient of determination of R_{Square}, equal to 0.226 or 22.6%. This can be explained by the effect of the operational efficiency variable on the sustainable supply chain management variable, which is 22.6%. Based on the test results for the coefficient of determination of safety risk and operational efficiency on sustainable supply chain management, the magnitude of the influence of the three observed variables can be seen from the value of the coefficient of determination of R_{Square}, which is equal to 0.457 or 45.7%.
This can be explained by the fact that the effect of the safety risk and operational efficiency variables on the sustainable supply chain management variable is 45.7%.

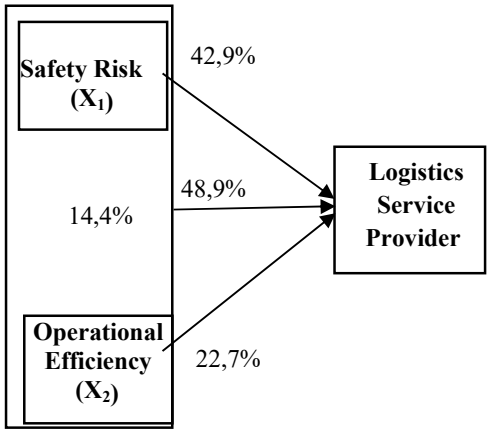

Fig. 2. Test Results of The Coefficient of Determination (R^2)

b. Effect of Safety Risk (X1) and Operational Efficiency (X2) on Sustainable Supply Chain Management (Z) through Logistics Service Provider (Y)

Based on the test results for the coefficient of determination of the safety risk variable on the logistics service provider variable, the magnitude of influence of the two variables observed can be seen from the value of the coefficient of determination of R_{Square}, which is 0.429 or 42.9%. It can be explained that the effect of the safety risk variable on the logistic service provider variable is 42.9%. Based on the test results for the coefficient of determination of operational efficiency variable on sustainable

supply chain management variable, the magnitude of influence of the two variables observed can be seen from the value of determination coefficient R_{Square}, which is equal to 0.227 or 22.7%. It can be explained that the effect of the operational efficiency variable on the sustainable supply chain management variable is 22.7%. Based on the test results for the coefficient of determination of the operational efficiency variable on the logistic service provider variable, the magnitude of influence of the two variables observed can be seen from the value of determination coefficient R_{Square}, which is equal to 0.489 or 48.9%. It can be explained that the effect of the operational efficiency variable on the logistics service provider variable is 48.9%. Based on the test results for the coefficient of determination of the logistic service provider variable on the sustainable supply chain management variable, the magnitude of influence of the two observed variables can be seen from the value of determination coefficient R_{Square}, which is equal to 0.926 or 92.6%. It can be explained that the effect of the logistic service provider variable on the sustainable supply chain management variable is 92.6%.

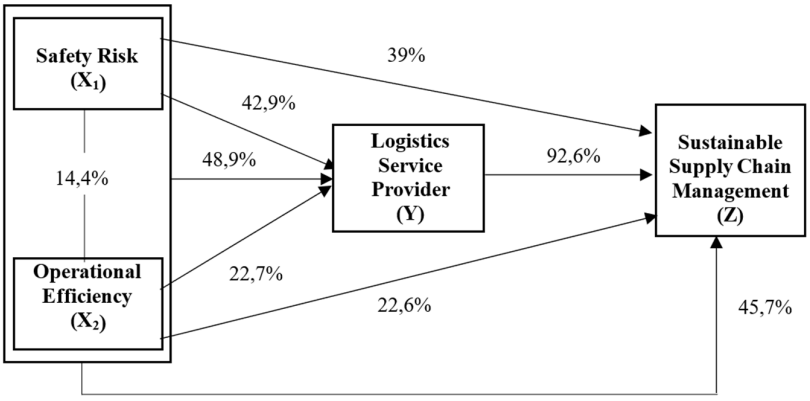

Fig. 3. Results of Coefficient of Determination Test (R^2) Research Model

4.3. Discussion of Research Results

4.3.1. Direct Effect of Safety Risk and Operational Efficiency on Logistic Service Providers

Then, based on the t-test results, it can be presented that the $t_{-statistics}$ of the safety risk variable is 6.655, and the operational efficiency variable is 3.189 if it is confirmed in the t_{-table} that the figure of 1.987 is found by the provisions that if $t_{-statistics} > t_{-table}$, then the hypothesis is accepted. This study proves that the variables of safety risk and operational efficiency positively influence the logistic service provider variable. Furthermore, the ANOVA or F statistical test obtains an $F_{-statistics}$ of 41.227 > F_{-table} 3.95. Thus, the regression model can be used to predict logistics service providers, or it can be said that the variables of safety risk and operational efficiency simultaneously significantly affect logistics service providers. Based on the R_{Square} determination coefficient test, the magnitude of the influence of the three variables observed can be seen from the value of the R_{Square} determination coefficient, which is equal to 0.457 or 45.7%. It can be explained that the effect of safety risk and operational efficiency variables on the logistic service provider variable is 45.7%.

This research supports the study by Kudla and Klaas-Wissing (2012) that logistic service providers are very responsive by performing sustainable activities. This research is still in line with the opinion of Gultekin et al. (2022) that uncertainty and risk are very influential in creating vulnerability in the logistic service operation. This research is reinforced by Gupta and Singh (2020), concluding that logistic service providers utilize green practices to conserve resources for long-term sustainability. They are also concerned about the safety of goods and contribute to the environment and society. Logistic service providers (Full-Service Providers) position themselves as “service leaders” by leveraging their service capabilities to create superior service performance.

4.3.2. Direct Effect of Safety Risk and Operational Efficiency on Sustainable Supply Chain Management

Then, based on the t-test results, it can be explained that the $t_{-statistics}$ values of the safety risk variable and the operational efficiency variable are 3.237 and 3.189, respectively. If confirmed in the t_{-table}, a figure of 1.987 is found by the provisions that if $t_{-statistics} > t_{-table}$, then the hypothesis is accepted. From this study, it is proven that the variables of safety risk and operational efficiency positively influence sustainable supply chain management variables. Furthermore, the ANOVA or F statistical test obtains an $F_{-statistics}$ of 36.129 > F_{-table} 3.95. Thus, the regression model can be used to predict sustainable supply chain management. Safety risk and operational efficiency variables significantly affect sustainable supply chain management. Based on the R_{Square} determination coefficient test, the magnitude of influence of the three observed variables can be seen from the value of the R_{Square} determination coefficient, which is equal to 0.489 or 48.9%. It can be explained that the effect of the safety risk and operational efficiency variables on the sustainable supply chain management variable is 48.9%. This research supports the study by Carter and Rogers (2008), Wu et al. (2017), and Mani et al. (2017), concluding that Sustainable Supply Chain Management (SCCM) must include the concept of security and explain the direction of future research in

SSCM. The result of this research aligns with the study by Kusi-Sarpong et al. (2021), who gives a better understanding and control of the nature of risk inherent in the supply chain. This research is reinforced by Reinerth et al. (2019), Mukhsin and Suryanto (2022), and Ozkan-Ozen et al. (2023), concluding that sustainable supply chain management must include the concept of security. This research also aligns with Goerlandt and Pulsifer (2022) and Thanu et al. (2022), concluding that applying safety risk will improve environmental performance by placing standards on environmental issues. ISO 14001 certification provides a safety standard for the industry.

5. Conclusion

This research reveals how to source coal supply chain processes related to safety risk, operational effectiveness, operational efficiency, logistic service providers, and sustainable supply chain management. The positive impact will be delivered through sustainable supply chain management and logistic service providers that may influence high categories to manage safety risk and overall operational efficiency. By implementing sustainable supply chain management practices and working with reliable logistic providers, the coal supply chain may achieve positive outcomes in safety, operational effectiveness, efficiency, and sustainability. These improvements can enhance the supply chain of coal in Barito River in the long-term viability.

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