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The Role of Big Data Analysis Capabilities in Mediating the Relationship between Sustainable Supply Chain Management Practices and Company Performance in Manufacturing Companies

Syafa Alya Camila¹, Wahyuningsih Santosa², Ratna Darasih³, Dorina Widowati⁴

^{1,2,3,4} Department of Management, Faculty of Economics and Business, Universitas Trisakti, Jakarta. Indonesia.

Email: syafaalya07@gmail.com¹, wahyuningsih@trisakti.ac.id², ratna.darasih@trisakti.ac.id³, dorina.widowati@trisakti.ac.id⁴

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ABSTRACT

This study aims to analyze the influence of sustainable supply chain management practices (SSCMP) on operational and environmental performance, with the mediation of big data analysis capabilities (BDAC) as a mediating variable. The research was conducted using a quantitative approach with a hypothesis testing method through Structural Equation Modeling based on Partial Least Squares (PLS-SEM), using primary data from 200 respondents in manufacturing companies. The results of the study show that PBRPB has a significant effect on the increase in BDAC, which then has a positive impact on operational performance. However, sustainability practices do not directly impact operational performance without the support of data technology. On the other hand, sustainable practices can directly improve environmental performance, even though BDAC does not significantly influence environmental aspects or act as a mediator. Other findings suggest that good operational performance significantly contributes to improving environmental performance. These results emphasize the importance of integrating sustainability strategies and analytics technology to drive operational efficiency while fulfilling environmental responsibility. As such, manufacturing companies need to build sustainable, data-driven supply chain systems to increase competitiveness amid market demands and regulations that increasingly emphasize sustainability.

Keywords: Sustainable Supply Chain Management Practices, Big Data Analytics Capabilities, Operational Performance, Environmental Performance, Smartpls, Manufacturing Companies.

I. Introduction

Today, companies are required to achieve financial profits and to run socially and environmentally responsible businesses. Consumer encouragement and government regulations force companies to apply sustainability principles in all their business processes (Ilyas et al., 2020). The Sustainable Development Goals (SDGs) are also a guideline in balancing economic growth, environmental protection, and social welfare. In

addition, big data analysis capabilities are now being used by companies to increase accuracy and speed in decision-making. This utilization is mainly applied in waste management, energy consumption monitoring, and logistics optimization. The data generated from the implementation of sustainable supply chain management is leveraged through advanced analytics systems to support the efficiency of the production and distribution processes (Santosa, 2024).

The manufacturing sector, including Indonesia, is focused on contributing to carbon and waste emissions (Álvarez Jaramillo et al., 2019). Therefore, implementing sustainable supply chain management practices is effective because it integrates economic, social, and environmental aspects in every production process (Ahmad et al., 2019; Zhu et al., 2022). Along with digital developments, companies utilize Big Data analytics capabilities to improve efficiency and decision-making. This technology enables data collection from various supply chain points, which is then processed to support efficiency and sustainability (Mikalef et al., 2019; Zhu et al., 2022). Technology support, such as IoT, also helps with early detection of breakdowns and real-time tracking of products. However, few studies have comprehensively examined the mediating role of big data analytics capabilities in the relationship between sustainability practices and environmental and operational performance in Indonesia's manufacturing sector. Applying big data and sustainability practices still faces challenges, such as high investment needs and human resource readiness (Iheukwumere et al., 2024). Therefore, a mature strategy is needed for technology and sustainable practices to improve company performance (Lee et al., 2022). This study aims to analyze the influence of sustainable supply chain management practices on the company's operational performance and environment and evaluate the mediating role of Big Data analysis capabilities. It is hoped that the results of this research can be a reference in encouraging sustainable transformation in Indonesia's manufacturing sector (Zhu et al., 2022).

II. Literature Review and Hypothesis Development

Supply chain management efficiently integrates suppliers, managers, warehouses, and logistics to produce and distribute products at the correct quantity, location, and time to lower costs and meet customer needs. The planning and management of all processes necessary to provide products to customers is included in supply chain management, according to Heizer et al. (2020). In addition, Sustainable Supply Chain Management is a strategic approach that integrates economic, environmental, and social considerations in managing the flow of materials, information, and capital throughout the supply chain. The goal is to ensure that the procurement, production, and distribution of goods or services are carried out efficiently and effectively, while meeting the needs of stakeholders and increasing profitability, competitiveness, and organizational resilience in the short and long term (Suwanda, 2023). Furthermore, according to Mulyono et al. (2023), Big Data analytics capabilities play an important role in business sustainability by helping to manage and leverage data to achieve sustainability goals. For example, big data analytics can help businesses identify emerging patterns in consumer behavior and changes in product demand, thereby reducing operational inefficiencies and supporting better environmental initiatives.

Operational performance is also significant for businesses because it allows them to produce high-quality products and improve the efficiency of the production process, which in turn results in increased revenue and profits (Jawaad & Zafar, 2020). It shows how companies have improved efficiency and reduced costs across the supply chain. Meanwhile, good environmental performance shows the company's commitment to fulfilling social responsibility and preserving the environment. It can improve the company's image and operational efficiency through better management of resources. Consumers and investors who care about environmental issues are likelier to choose businesses with good environmental performance (Istiningrum, 2023). This research is expected to make a theoretical contribution by explaining how the ability of big data analysis strengthens the impact of sustainable supply chain management practices on performance. Practically, these findings can be a reference for manufacturing industry players in designing data-driven sustainability strategies. Based on the literature review above, it can be seen that sustainable supply chain management practices have the potential to drive improvements in the company's operational

and environmental performance, mainly when supported by big data analytics capabilities. However, there is still a research gap regarding the role of big data analysis ability mediation in the context of the Indonesian manufacturing industry. Therefore, this study formulates several hypotheses to test the direct and indirect influence of sustainable supply chain management practices on company performance.

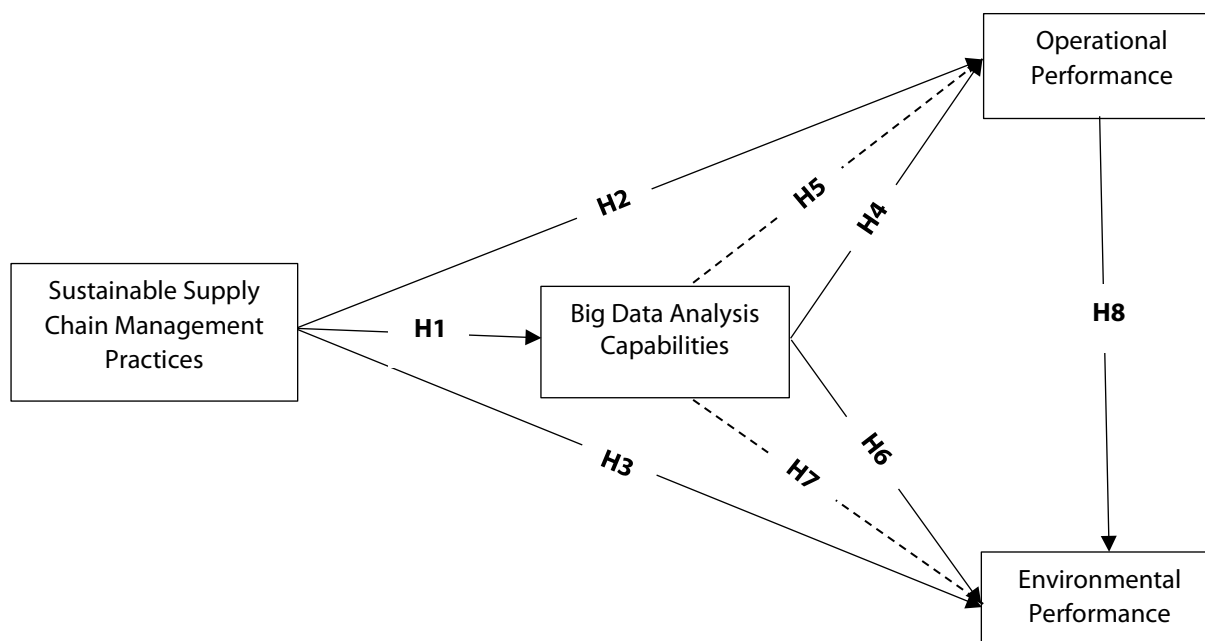


Figure 1. Conceptual Framework

Companies that implement sustainability practices in their supply chains tend to have an integrated data management system, thus supporting the development of comprehensive big data analysis capabilities. Focusing on sustainability, Companies improve the quality of the data they collect and drive better data integration between various stakeholders in the supply chain (Zhu et al., 2022). Research conducted by Scott (2021) also shows that applying big data analytics and sustainable supply chain management significantly impacts supply chain sustainability, especially in the manufacturing industry. Big data analytics increases transparency in sustainable supply chain management by allowing companies to collect, process, and analyze real-time supply chain data. This transparency helps with accurate data-driven decision-making. Research conducted by Mohammed et al. (2017) indicates that applying Big Data analytics significantly improves supply chain management efficiency. The study results revealed that big data analysis allows the Company to analyze historical data and market trends in real-time, which improves demand planning accuracy.

H1: Sustainable Supply Chain Management Practices Have a Positive Effect on Big Data Analysis Capabilities

Companies that implement Sustainable Supply Chain Management are more likely to experience increased efficiency, reduced costs, and improvements in supply chain management. In addition, implementing Sustainable Supply Chain Management improves the company's operational performance by improving the quality of products and services, accelerating delivery times, and increasing flexibility in responding to market demands (Zhu et al., 2022). In line with this, Sustainable supply chain initiatives can significantly improve operational efficiency. Organizations can reduce costs and improve their overall performance by adopting practices such as green procurement and optimizing logistics (Ezekwu, 2025). In

addition, Research Results Amentae et al. (2025) show that sustainable supply chain management practices have a statistically significant positive influence on various aspects of business sustainability performance, including economic, environmental, and social dimensions.

H2 : Sustainable Supply Chain Management Practices Have a Positive Effect on Operational Performance

Sustainable supply chain management practices improve operational performance and significantly improve environmental performance. Focusing on sustainable resource management helps companies reduce pollution and overuse of resources. This suggests that sustainability can be integral to a successful business strategy (Zhu et al., 2022). Peileen Nick O'Neill (2023) reinforces this by showing that companies that apply sustainability principles in supply chain management tend to experience a decrease in carbon emissions and natural resource consumption. The research results of Adegoke et al. (2021) also support the positive influence of Sustainable Supply Chain Management practices on environmental performance, showing that implementing sustainable supply chain management significantly improves the company's environmental performance.

H3 : Sustainable Supply Chain Management Practices Have a Positive Effect on Environmental Performance

Research by Zhu et al. (2022) shows that Big Data analysis capabilities positively affect the company's operational performance. Companies that have good Big Data analytics capabilities can optimize supply chain management, improve operational efficiency, and accelerate decision-making. This is also proven by the results of research from Paula et al. (2024) showing an apparent positive effect on the operational performance of digital startups. By improving their capabilities in big data analytics, these startups can improve their decision-making processes, operational efficiency, and ultimately their competitive performance in the market. A significant and positive relationship between adopting big data analytics capabilities and operational performance shows that big data analytics capabilities improve organizational capabilities and performance, especially in dynamic environments, thereby contributing to competitive advantage and operational improvement (Cherla & Sharma, 2024).

H4 : Big Data Analysis Ability Has a Positive Effect on Operational Performance

Research results Zhu et al. (2022) show that Big Data analytics capabilities mediate the relationship between Sustainable Supply Chain Management practices and organizational performance. Big data analytics capabilities help optimize business processes, reduce waste, and increase the speed of response to market dynamics. Research results Adie Setyawan et al. (2024) indicate that applying big data analytics capabilities in sustainable supply chain management practices helps companies collect, process, and analyze supply chain data more effectively, ultimately improving operational efficiency and organizational performance. This is also reinforced by the Hypothesis Testing Bag et al. (2020). With big data analytics capabilities, companies can manage their supply chains more efficiently, improve data integration, and make more accurate analytics-based decisions. Therefore, companies implementing sustainable supply chain management with big data analytics capabilities can achieve superior and sustainable operational performance.

H5 : Big Data Analysis Capabilities Mediate the Positive Influence of Supply Chain Management Practices on Operational Performance

Hypothesis test results Zhu et al. (2022) regarding the positive influence of Big Data on environmental performance show that Big Data analysis capabilities have a significant role in improving environmental performance through sustainable supply chain management practices. The study found that big data

analytics capabilities mediate the relationship between sustainable supply chain management and environmental performance, meaning that companies that implement sustainable supply chain management well tend to have stronger big data analytics capabilities, which ultimately contribute to improved environmental performance. Research by Nilashi et al. (2023) demonstrated that adopting big data analytics positively affects environmental performance, which is critical for organizations that aim to implement environmentally friendly practices. In addition, economic performance is also improved, leading to better financial outcomes for the organization. From the health sector, the ability to analyze big data positively impacts the integration of environmental processes in healthcare settings. This means that using big data analytics capabilities helps hospitals improve collaboration and coordination among different departments, essential for making informed environmental decisions (Benzidia et al., 2024).

H6 : Big Data Analysis Ability Has a Positive Effect on Environmental Performance

Research results Zhu et al. (2022) suggest that Big Data analyst capabilities are a mediator that strengthens the relationship between sustainable supply chain management practices and environmental performance. With big data analytics capabilities, companies can collect and analyze environmental data more effectively, enabling optimization of pattern identification, waste reduction, and resource utilization. In this case, the ability to analyze big data serves as a bridge that connects sustainable practices with better environmental performance outcomes. According to previous research, the capacity of big data analysis plays an important role in regulating the relationship between sustainable practices and environmental performance outcomes. The results of this study show that analytical skills can help regulate this relationship (Shahbaz et al., 2020). In addition, by improving sustainable supply chain management practices, businesses can collect more relevant and high-quality data, which improves their ability to analyze the environmental impact of processes. This shows a positive relationship between sustainable supply chain management practices and big data analytics capabilities, contributing to improved environmental performance (Mikalef et al., 2019).

H7 : Big Data Analysis Capabilities Mediate the Positive Influence of Supply Chain Management Practices on Environmental Performance

Research results Zhu et al. (2022) show that improved operational performance significantly contributes to improved environmental performance. Efficiency in operational processes, such as optimizing the use of resources, applying environmentally friendly technology, and reducing waste, has been proven to reduce negative environmental impacts. P. Eileen Amarasuriya et al. (2024) also show that higher operational productivity improves the relationship between environmental performance and financial performance, suggesting that companies with competitively high operational productivity experience greater profitability associated with lower carbon emissions, highlighting the importance of operational efficiency. Research by Soesilo (2024) also shows that improving operational performance through green manufacturing practices benefits the company economically and significantly improves environmental performance.

H8 : Operational Performance has a positive effect on Environmental Performance

III. Research Method

The research approach is quantitative, and the research design uses the hypothesis testing method. This study tests four variables for their relationship and influence: Sustainable Supply Chain Management Practices as independent variables, Big Data Analysis Ability as a mediating variable, and Operational Performance and Environmental Performance as dependent variables. The data obtained from this study were disseminated through an online questionnaire using the purposive sampling method, which is based on

specific criteria, including employees, supervisors, managers, and directors who have work experience in fields related to the supply chain for more than one year. In determining the number of respondent samples in this study, the researcher refers to the approach put forward by Hair et al. (2019), that is, by multiplying the number of indicators used by multiples of 5 to 10. This study has 36 indicators, so the minimum number of respondents is 180. After the questionnaire was distributed, 200 respondents were obtained. This research is limited to the manufacturing sector in Bogor, so the results may not be generalized to other sectors or regions. Further research is suggested to broaden the sector's scope and combine quantitative and qualitative approaches to gain a deeper understanding.

The data analysis method is a procedure used to process, understand, and interpret the data obtained in research. This study uses the Structural Equation Model (SEM) analysis method based on Partial Least Squares (PLS). According to Hair et al. (2019), SEM-PLS is a multivariate statistical method that combines factor analysis and tests the structural relationships between constructs and variables in a research model. The SEM-PLS method was chosen because it is suitable for exploratory research with complex models and small to medium sample sizes. In addition, SEM-PLS does not require normal data distribution. However, preliminary data analysis is still carried out to determine the characteristics of the distribution through skewness and kurtosis analysis, as well as the Kolmogorov-Smirnov test. It can test the mediation relationship efficiently. The analysis was performed using SmartPLS 4 software. Model evaluation included testing the reliability and validity of the construct through Cronbach's alpha, Composite Reliability, and AVE values. The structural model was evaluated using R^2 , Q^2 , f^2 , and SRMR values to measure the overall suitability of the model. The SEM-PLS method was used to test and prove the hypothesis by comparing the p-value to the significance level of 5% ($\alpha = 0.05$), with the following conditions: if the p-value ≤ 0.05 , then the hypothesis is supported, and if the p-value > 0.05 , then the hypothesis is not supported.

IV. Results and Discussion

4.1. Respondent Characteristics

The following table presents the characteristics of the respondents, including age, last education level, job position, and length of work experience.

Table 1. Respondent Characteristics

Measurement	Category	Frequency	Percentage
Gender	Male	175	62.5%
	Female	105	37.5%
Age	20–30 years	67	33.5%
	31–40 years	77	38.5%
	41–50 years	29	14.5%
	>50 years	27	13.5%
Education	High School/Equivalent	28	14.0%
	Diploma (D1/D2/D3/D4)	30	15.0%
	Bachelor's Degree (S1)	127	63.5%
	Master's Degree (S2)	15	7.5%
Position	Director	1	0.5%
	Manager	49	24.5%
	Staff	110	55.0%
	Supervisor	40	20.0%
Length of Work	1–5 years	54	27.0%
	6–10 years	35	17.5%
	11–15 years	67	33.5%

Measurement	Category	Frequency	Percentage
	>15 years	44	22.0%

4.2. Prerequisites Test

According to Sekaran and Bougie (2016), a variable can be defined as a component that exhibits different or varying values. These values may represent variations over time for the same object or differences among objects simultaneously. The following table presents the results of the validity test:

Table 2. Validity Test

No	Question Items	Factor Loadings	Decision
Environmental Management Practices			
1	Our organization implements environmental management systems to meet ISO standards.	0.689	Valid
2	We provide suppliers with design specifications that include environmental compliance for purchased goods.	0.681	
3	We help suppliers set up environmental management systems.	0.613	
4	We pay attention to our customers' environmental concerns regarding environmentally friendly product design/distribution.	0.651	
5	We solve the environmental problems faced by our customers by adopting cleaner production.	0.639	
6	We have successfully designed our products to use fewer raw materials/energy.	0.725	
Operational Practices			
1	We facilitate our suppliers and implement TQM/Six Sigma to build quality into products.	0.626	Valid
2	We help our suppliers carry out value engineering to reduce component costs.	0.556	
3	We consistently follow timely/scientific inventory control techniques to keep inventory under control during production.	0.569	
4	We have implemented lean production and followed it consistently to minimize waste.	0.709	
5	We strive for economies of scale in inbound and/or outbound transportation.	0.580	
Supply Chain Integrity			
1	We update our production plans according to customers' needs and share them with suppliers.	0.630	Valid
2	Our organization responds to customer needs fairly quickly by providing adequate inventory.	0.612	
3	We estimate the future needs of customers based on realistic assessments.	0.575	
4	We communicate customers' future needs to suppliers quickly.	0.669	
Big Data Analysis Capabilities			
1	We have exceptional expertise in processing structural data.	0.911	Valid

No	Question Items	Factor Loadings	Decision
2	Our analytics personnel actively gain insights from unstructured data.	0.899	
3	We effectively process complex data and information for organizational performance.	0.551	
4	Our personnel programming skills help us regularly gain analytical insights from large data sets generated from our smart devices.	0.662	
5	Our personnel effectively gain insights from web-based data.	0.624	
6	We effectively use real-time information for day-to-day operations.	0.898	
7	Our IT infrastructure is very focused on information integration using advanced technology.	0.630	
8	We often disseminate useful information throughout our departments.	0.904	
Operational Performance			
1	The effectiveness of our organization in meeting the requirements.	0.984	Valid
2	The effectiveness of our organization in responding to changing market demands.	0.992	
3	The effectiveness of our organization in timely delivery.	0.979	
4	Reduced waiting time for orders.	0.990	
5	The effectiveness of our organization in providing reliable, quality products.	0.986	
6	Reduced costs to reach customers.	0.984	
7	Reduction of overhead costs.	0.706	
8	Reduction of inventory costs.	0.941	
Environmental Performance			
1	Environmental performance is improved in terms of material reuse.	0.983	Valid
2	Environmental performance is improved in terms of environmental compliance.	0.987	
3	Environmental performance is improved in terms of environmental preservation.	0.984	
4	Environmental performance is improved in terms of reduction.	0.575	
5	Environmental performance is improved in terms of reduced resource consumption (e.g., energy, water, electricity, gas, and gasoline)	0.943	

Based on Table 2, the validity results obtained in this study indicate that the loading factor value of each indicator is greater than 0.40. Therefore, the indicators used to measure the variables in this study are considered to have passed the convergent validity test. The following table presents the results of the Average Variance Extracted (AVE) test:

Table 3. AVE Values

Variable	Average Variance Extracted (AVE)
Big Data Analysis Capabilities	0.599
Environmental Performance	0.825
Operational Performance	0.902
Sustainable Supply Chain Management Practices	0.406

Based on the results in Table 3, it can be seen that most constructs have AVE values above 0.5, such as Big Data Analysis Capabilities (0.599), Environmental Performance (0.825), and Operational Performance (0.902), indicating that they meet the criteria for convergent validity. However, the Sustainable Supply Chain Management Practices construct has an AVE value of 0.406, below the required threshold. This indicates that the construct does not fully meet the criteria for optimal convergent validity. Although this value is still considered acceptable, further attention is required to the measurement items used in this variable, including re-evaluating the indicators and considering instrument revisions in future research. The following table presents the results of the discriminant validity test:

Table 4. Discriminant Validity Test

Variable	Big Data Analysis Capabilities	Environmental Performance	Operational Performance	Sustainable Supply Chain Management Practices
Big Data Analysis Capabilities	0.774			
Environmental Performance	0.712	0.909		
Operational Performance	0.754	0.907	0.950	
Sustainable Supply Chain Management Practices	0.727	0.610	0.598	0.637

Based on these results, the discriminant validity test is satisfied because each construct has a higher square root of AVE than the correlation between constructs. This indicates that each variable is sufficiently distinct from the others and, therefore, can be considered discriminantly valid within this research model. The following table presents the results of the reliability test:

Table 5. Reliability Test

Variable	Cronbach's Alpha	Composite Reliability (ρ^*)
Big Data Analysis Capabilities	0.897	0.920
Environmental Performance	0.940	0.958
Operational Performance	0.983	0.986
Sustainable Supply Chain Management Practices	0.897	0.911

The results of the reliability test show that the Cronbach's Alpha values for Sustainable Supply Chain Management Practices, Big Data Analysis Capabilities, Operational Performance, and Environmental Performance are all around 0.7 or higher, indicating moderate to high reliability. In addition, the Composite Reliability values for all constructs are greater than 0.7. Therefore, it can be concluded that all indicators in this study have passed the reliability test.

4.3. Goodness of Fit Test

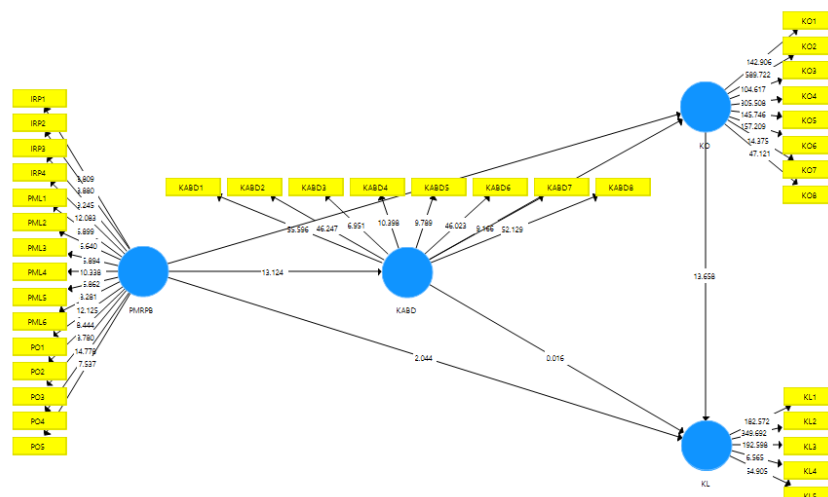
Based on the goodness of fit analysis results, the research model was evaluated using six Goodness of Fit (GoF) indicators: SRMR, d_ULS, d_G, NFI, Chi-square, and RMS Theta. The results showed that only two indicators, namely d_ULS (7.009) and d_G (3.173), met the good fit criteria, while the other four indicators—SRMR (0.103), NFI (0.771), Chi-square (2,494.634), and RMS Theta (0.179)—indicated a poor fit. A high d_ULS value demonstrates the strength of the model's structure in representing the data, whereas d_G reflects the

geodetic proximity between the model and the empirical data. Although several indicators suggest a lack of fit, referring to Hair et al. (2019), a model can still be considered acceptable if at least one fit indicator meets the required threshold. Therefore, the model in this study is deemed suitable for further hypothesis testing. The following table presents the results of the R-square test:

Table 6. R-Square Test Results

Variable	R-Square Adjusted
Big Data Analysis Capabilities	0.529
Environmental Performance	0.830
Operational Performance	0.573

Based on the results in Table 6, it can be seen that Big Data Analysis Capabilities in companies are influenced by approximately 52.9% by Sustainable Supply Chain Management Practices. This indicates a significant effect, although other contributing factors still exist. Meanwhile, Environmental Performance is strongly influenced by the model, with an R-square value of 83%, meaning that most of the variation in environmental performance can be explained by applying sustainable practices and data analytics capabilities. As for Operational Performance, the model explains 57.3% of the variation, showing that companies can improve operational efficiency through sustainability strategies and data-driven technologies. Overall, the model is sufficient to describe the relationship among the variables studied.

**Figure 2. Smartpls Output Results**

4.4. Hypothesis Testing

The following table presents the results of the hypothesis testing:

Table 7. Hypothesis Test Results

Hypothesis	Original Sample (O)	T-Statistics (O/STDEV)	P-Values	Information
Sustainable Supply Chain Management Practices have a positive effect on Big Data Analysis Capabilities	0.727	13.254	0.000	Supported
Sustainable Supply Chain Management Practices have a positive effect on Operational Performance	0.106	1.516	0.133	Not Supported

Hypothesis	Original Sample (O)	T-Statistics (O/STDEV)	P-Values	Information
Sustainable Supply Chain Management Practices have a positive effect on Environmental Performance	0.106	2.104	0.035	Supported
Big Data Analysis Capabilities have a positive effect on Operational Performance	0.677	9.636	0.000	Supported
Big Data Analysis Capabilities mediate the positive influence of Sustainable Supply Chain Management Practices on Operational Performance	0.492	7.301	0.000	Supported
Big Data Analysis Capabilities have a positive effect on Environmental Performance	-0.001	0.017	0.987	Not Supported
Big Data Analysis Capabilities mediate the positive influence of Sustainable Supply Chain Management Practices on Environmental Performance	-0.001	0.017	0.987	Not Supported
Operational Performance has a positive effect on Environmental Performance	0.845	14.610	0.000	Supported

H1: Sustainable Supply Chain Management Practices Have a Positive Effect on Big Data Analysis Capabilities

Hypothesis 1 in this study aims to determine whether sustainable supply chain management practices influence big data analysis capabilities. The analysis results show a positive and significant relationship, with an original sample value of 0.727, a t-value of 13.254, and a p-value of 0.000. These findings provide strong evidence that sustainability practices in the supply chain support the development and utilization of big data within companies. These results are consistent with the findings of Zhu et al. (2022), Scott (2021), and Mohammed et al. (2017), which also indicate a positive relationship. In response to pressures to implement social and environmental responsibility, companies increasingly select suppliers based on environmental and social criteria, collaborate with environmentally conscious partners, and integrate sustainability goals into their supply chain strategies. This encourages companies to enhance their data acquisition capabilities, integrate data from multiple sources, and apply predictive analytics to support decision-making. Therefore, Hypothesis 1 is supported.

H2: Sustainable Supply Chain Management Practices Have a Positive Effect on Operational Performance

Hypothesis 2 tests whether sustainable supply chain management practices positively impact operational performance. However, the test results indicate that the effect is not statistically significant, with an original sample value of 0.106, a t-statistic of 1.516, and a p-value of 0.133. Although the relationship is positive, its strength is very weak. This may indicate that companies have not fully integrated sustainability practices into their operational processes. One possible reason is the suboptimal alignment between sustainability initiatives and core systems, such as cost-reduction strategies that have not been maximized. Therefore, this hypothesis is not supported. These findings differ from the studies by Ezekwu (2025), Zhu et al. (2022), and Amentae et al. (2025), but are in line with the results of Mahabir and Pun (2022), which found that sustainable supply chain management practices do not significantly affect operational performance. Although some companies have adopted environmental standards such as ISO 14001, lean production systems, and partnerships with green suppliers, the integration of sustainability into key production systems remains insufficient. This suggests that sustainability can only have a meaningful impact on operations when

supported by robust quality management systems (e.g., TQM or Six Sigma) and effective cross-functional collaboration.

H3: Sustainable Supply Chain Management Practices Have a Positive Effect on Environmental Performance

Hypothesis 3 investigates the influence of sustainable supply chain management practices on environmental performance. Based on the test results, a significant effect was found, with an original sample value of 0.106, a t-statistic of 2.106, and a p-value of 0.035. This indicates that applying sustainability principles—such as waste management and energy efficiency—positively impacts a company's environmental performance. These results are in line with the findings of Zhu et al. (2022), Nick O'Neill (2023), and Adegoke et al. (2021). Companies implement various strategies such as assisting suppliers to comply with environmental regulations, designing eco-friendly products, and optimizing energy-efficient logistics. Moreover, strict resource usage monitoring through digital technologies reduces emissions and waste. These efforts are carried out throughout the supply chain, not only to comply with regulations but also to reduce long-term environmental costs. Therefore, Hypothesis 3 is supported.

H4: Big Data Analysis Capabilities Have a Positive Effect on Operational Performance

Hypothesis 4 tests the direct relationship between big data analysis capabilities and operational performance. The relationship is highly significant with an original sample value of 0.677, a t-statistic of 9.351, and a p-value of 0.000. The findings of this study support those of Zhu et al. (2022), Nilashi et al. (2023), and Benzidia et al. (2024). Companies are strategically developing big data capabilities to address the challenges of increasing data complexity in the digital era. Proficiency in big data analytics enables companies to process large volumes of structured and unstructured data in real time. This allows for faster and more accurate operational decision-making, including production scheduling, raw material ordering, and workforce management. Additionally, a strong IT infrastructure and the availability of dashboard-based analytics accelerate responses to production issues. Operational information is no longer siloed across departments but shared in real-time to enhance coordination. These factors contribute to increased productivity, reduced costs, and improved consistency in order fulfillment. Thus, Hypothesis 4 is supported.

H5: Big Data Analysis Capabilities Mediate the Positive Influence of Sustainable Supply Chain Management Practices on Operational Performance

Hypothesis 5 examines whether big data analytics capabilities mediate the relationship between sustainable supply chain management practices and operational performance. The results are compelling, with an original sample value of 0.492, a t-statistic of 2.490, and a p-value of 0.014. The findings confirm that big data analytics capabilities mediate the positive effect of sustainable supply chain management practices on operational performance. This result aligns with studies by Zhu et al. (2022), Adie Setyawan et al. (2024), and Bag et al. (2020), which demonstrate that companies effectively implementing sustainability practices to enhance operational efficiency heavily rely on their ability to manage and analyze data. Through data collection on carbon footprints, environmental audits, and waste management, companies can integrate and analyze data in real time. This enables faster, better-informed decision-making regarding production scheduling, inventory control, and labor efficiency—ultimately improving productivity and reducing operational costs. Therefore, big data analytics capabilities serve as a strategic bridge between sustainability initiatives and operational performance outcomes. Hence, Hypothesis 5 is supported.

H6 : Big Data Analysis Capabilities Have a Positive Effect on Environmental Performance

Hypothesis 6 examines the relationship between big data analysis capabilities and environmental performance. The results showed an original sample value close to zero (-0.001), a t-statistic of 0.017, and a p-value of 0.986. Statistically, this relationship is not significant. These findings do not align with the research conducted by Paula et al. (2024), Cherla & Sharma (2024), and Zhu et al. (2022). However, they are consistent with the findings of Rahman et al. (2024), which suggest that big data analysis capabilities do not directly enhance a company's environmental performance. Although IoT sensors and predictive maintenance have been used to monitor energy consumption and prevent pollution, their implementation has not been fully integrated into environmental strategies. The data generated does contribute to operational efficiency and raises internal awareness, but its impact on environmental performance remains limited. Therefore, while applying big data supports regulatory compliance and long-term efficiency goals, it has not significantly affected environmental outcomes. Thus, this hypothesis is not supported.

H7 : Big Data Analysis Capabilities Mediate the Positive Influence of Sustainable Supply Chain Management Practices on Environmental Performance

Hypothesis 7 investigates whether big data analysis capabilities mediate the relationship between sustainable supply chain management practices and environmental performance. The results showed an original sample value of -0.001, a t-statistic of 0.017, and a p-value of 0.987. These values indicate an insignificant relationship, with an inconsistent direction of effect. This suggests that big data analysis capabilities are insufficient to mediate the influence of supply chain sustainability on environmental performance. While big data analytics can be used to manage environmental information in a structured way, this study shows that these capabilities do not mediate the relationship. These findings are not consistent with the studies by Shahbaz et al. (2020), Mikalef et al. (2019), and Zhu et al. (2022), but align with Sahoo et al. (2023), who emphasize that the effectiveness of big data in supporting environmental sustainability depends heavily on cross-functional integration and strong strategic commitment. Although companies can detect energy waste and emissions through data analysis, without concrete sustainability policies and organizational commitment, the data alone does not lead to meaningful environmental improvements. Therefore, this hypothesis is not supported.

H8 : Operational Performance Has a Positive Effect on Environmental Performance

Hypothesis 8 tests whether strong operational performance positively affects environmental performance. The analysis results indicate a strong relationship, with an original sample value of 0.845, a t-statistic of 14.799, and a p-value of 0.000. This indicates that improved operational efficiency reduces energy consumption and waste generation, positively contributing to environmental outcomes. These findings are consistent with the studies by Zhu et al. (2022), Amarasuriya et al. (2024), and Soesilo (2024), which highlight that production optimization, reduced waiting times, and efficient logistics promote energy and raw material savings. This study further shows that efficient operational performance directly contributes to enhanced environmental performance. Operational achievements such as higher productivity and reduced operating costs positively correlate with lower waste, increased resource efficiency, and reduced emissions. This means operational excellence provides competitive business advantages and measurable environmental benefits. Based on these results, this hypothesis is supported.

V. Conclusion

This study concludes that sustainable supply chain management practices (SSCMP) improve manufacturing companies' big data analysis (BDAC) capabilities. The increase in BDAC also benefits the

company's operational performance. The results show that integrating sustainability practices with analytics technology is a key strategy to improve operational efficiency. However, without the role of BDAC as a mediator, SSCMP has no direct influence on operational performance. On the contrary, SSCMP directly influences the company's environmental performance. However, BDAC has not been shown to influence environmental performance directly or as a mediating variable significantly. On the contrary, it has been proven that operational efficiency is a key factor driving improvements in environmental performance. This reinforces that operational success can be the basis for achieving environmental goals. Thus, the results of this study enrich the literature linking sustainability, analytical capabilities, and company performance, and underscore the need for an integrated approach to managing complexity in modern supply chains.

This research helps decision-makers in industry, especially in manufacturing. These results first show how important it is to combine sustainability strategies with improving big data-driven analytics capabilities. To optimize the utilization of BDAC, companies must invest in information technology infrastructure and HR training. Big data technology improves operational efficiency and enables continuous sustainability evaluation based on real-time data. Second, companies that have implemented SSCMP must not only do environmentally friendly things, but they must also learn how to maximize the impact of sustainability strategies on business performance through internal analytics capacity. It also includes building a data-driven sustainability reporting system to improve companies' transparency, accountability, and competitiveness. Third, these findings also provide government stakeholders and policymakers with practical direction. To accelerate the achievement of the Sustainable Development Goals (SDGs), policies that support the adoption of analytics technologies and support digital transformation in the manufacturing industry will be critical. This is especially true for resource management and environmental efficiency. This research shows that digitalization and sustainability cooperation are essential to drive flexible, efficient, and long-term-oriented industry growth. As with any quantitative research, this study has several limitations that must be noted. First, the data used in this study were obtained through the self-reported survey method, which can cause a perception bias from respondents, especially in assessing company performance and implementing sustainability practices. Second, the methodological approach using PLS-SEM is more oriented towards predicting and exploring relationships between variables, so it has limitations regarding confirmatory theoretical model testing as is possible in CB-SEM. Therefore, interpreting the results must be done carefully, and the findings must be retested using other methods to improve external validity. Third, this study's scope only covers Bogor's manufacturing sector, so the results cannot be generalized directly to other sectors or regional contexts. Variations in organizational culture, technological readiness, and local regulations can influence the dynamics between SSCMP, BDAC, and company performance. Fourth, limitations in the number and distribution of respondents are also a concern. Although the sample count has met the minimum requirements for PLS-SEM analysis, the uneven distribution of respondents between industry subsectors can affect the accuracy of data representation. Fifth, some literature used to develop the hypothesis has not been fully integrated into the discussion. For further studies, it is recommended that the relevance of quotations to hypothetical arguments be clarified to strengthen the theoretical contribution. For further research, it is recommended to use a mixed-method approach with qualitative data to deepen understanding of the company's internal processes in integrating sustainability and analytics technology. It is also necessary to conduct longitudinal studies to see the progress of the implementation of SSCMP and BDAC over a longer period.

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