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# Smart Technologies for a Greener Future: The Role of Big Data and AI in Sustainable Firm Performance Business

Miftakul Huda[1], Agus Rahayu[2], Chairul Furqon[3], Mokh Adib Sultan[4]
Faculty Of Economic and Business Education, Universitas pendidikan Indonesia[1,2,3,4]
Miftakul.huda@upi.edu, agusrahayu@upi.edu, c_furqon@upi.edu, adiebsultan@upi.edu

***Abstract*— This study aims to investigate the role of Big Data and Artificial Intelligence (AI) in driving sustainable business practices and enhancing managerial decision-making. The research specifically explores how the integration of Big Data analytics and AI technologies can support strategic sustainability initiatives within business organizations. A quantitative research design was employed, utilizing a structured questionnaire distributed to professionals in various industries. The sample consisted of 348 respondents selected through purposive sampling, focusing on mid-level to top-level managers familiar with digital transformation strategies. Data were analyzed using structural equation modeling (SEM) to assess the relationship between the adoption of Big Data and AI technologies and their impact on sustainability performance. The results indicate that both Big Data and AI significantly influence sustainable management outcomes, particularly in areas such as resource efficiency, innovation, and stakeholder engagement. The findings offer practical implications for business leaders and policymakers by highlighting the strategic value of digital technologies in achieving environmental and social goals. This study contributes to the growing body of literature on technology-enabled sustainability by integrating digital transformation theories with sustainable management concepts. The originality of this research lies in its empirical investigation of digital technologies' dual role enhancing business efficiency while promoting long-term sustainability within a developing country context, which remains underexplored in existing studies.**

***Keywords: Big Data; Artificial Intelligence; Sustainable Business; Managerial Decision-Making; Quantitative Research; Digital Transformation.***

## I. INTRODUCTION (*Heading 1*)

The retail industry is undergoing a profound transformation driven by the digital revolution. In particular, Big Data and Artificial Intelligence (AI) have enabled retailers to predict customer behavior, optimize supply chains, and personalize marketing strategies. However, this digital evolution is paralleled by increasing pressure for businesses to commit to sustainability practices, especially in areas such as energy consumption, waste reduction, and ethical sourcing. According companies that integrate sustainable practices with digital technology experience long-term cost savings and customer loyalty[1], [2]. Yet, only a small percentage of retail companies in developing economies like Indonesia have effectively implemented AI and Big Data to achieve sustainable goals.

In Indonesia's retail sector, which contributes significantly to national GDP, many businesses still rely on conventional decision-making processes that are neither data-driven nor environmentally responsive. As a result, operational inefficiencies, excess inventory, and energy waste remain persistent problems. The integration of smart technologies has been proven to reduce carbon emissions and improve efficiency in logistics and distribution [3]Despite the potential, many retail businesses either lack awareness or resist adoption due to perceived complexity and costs [4]. This signals a critical need for empirical research to explore how Big Data and AI can serve as enablers of sustainable transformation in retail businesses.

Previous studies have explored the application of Big Data and AI across various sectors, such as manufacturing [5] healthcare, and logistics, with positive impacts on decision-making, predictive analytics, and operational efficiency. However, the focus on their integration within the retail sector for sustainability outcomes remains limited. For instance, investigated Big Data analytics capabilities in supply chains but did not explore environmental or social performance indicators [6]Discussed customer analytics in AI adoption but without linking to sustainable retail practices.

An analysis of 20 prior studies shows that most research has focused on either technological performance (e.g., speed, accuracy, cost-reduction) or consumer personalization, but not the environmental or ethical impact of such technologies[7], [8]. Moreover, the majority of these studies were conducted in advanced economies with high digital maturity levels, leaving a knowledge gap in emerging markets like Indonesia. There is also a lack of comprehensive models that connect digital transformation strategies with sustainable business frameworks in retail.

This research attempts to bridge that gap by combining insights from digital transformation theory and sustainable business practices, aiming to demonstrate how Big Data and AI can not only boost profitability but also reduce environmental footprint. By investigating empirical data from retail companies operating in a developing country, this study seeks to extend the theoretical boundary and offer practical recommendations.

From a proponent's perspective, the integration of Big Data and AI in retail business is aligned with Resource-Based View (RBV) theory, which suggests that competitive advantage arises from the unique capabilities and resources of a firm. In this context, data and digital intelligence are considered strategic assets that enhance sustainability performance[9]. AI-enabled energy management systems and demand forecasting tools, for example, help reduce operational waste and environmental costs. Studies have shown that firms using AI and data analytics report greater agility and more informed decision-making processes, thus supporting long-term sustainability.

However, the opposing view, grounded in Technology Acceptance Model (TAM) and Institutional Theory, raises questions about digital inequality and organizational readiness.

Retail businesses in developing countries may lack the infrastructure, human capital, and digital mindset necessary to adopt these technologies effectively. Moreover, the use of AI often raises ethical concerns regarding data privacy, job displacement, and algorithmic bias [10]. Without proper governance, the deployment of smart technologies could exacerbate existing inequalities rather than promote inclusive, sustainable growth.

The novelty of this study lies in the development of an integrated “Smart Sustainable Retail Framework” (SSRF), which combines Big Data and AI capabilities with sustainable business principles. Unlike existing models that treat sustainability and digitalization as separate paths, SSRF proposes a synergistic approach where smart technologies are deliberately designed to serve environmental goals such as optimizing energy use, minimizing waste, and promoting ethical sourcing while still maintaining customer satisfaction and profitability.

The framework includes three core dimensions: (1) Technological Integration, focusing on the infrastructure and tools for data and AI; (2) Sustainable Value Chain, encompassing logistics, operations, and sourcing; and (3) Managerial Decision Support, which reflects how insights from Big Data and AI drive sustainability-related decisions. This conceptual model offers a practical guide for retail business leaders aiming to balance innovation with environmental stewardship in a developing market context.

**Research Questions**

1. How do Big Data and AI technologies contribute to sustainable operational practices in the retail sector?
2. What are the managerial factors that influence the adoption of smart technologies for sustainability in retail businesses?
3. How does the integration of AI and Big Data affect the overall performance and environmental impact of retail organizations?

This study responds to the growing need for sustainable digital transformation in the retail industry. It addresses theoretical and practical gaps by proposing a new model that unifies AI, Big Data, and sustainability in one cohesive framework. By focusing on a developing country context, this research aims to inform better strategies and encourage widespread adoption of green technologies in retail.

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## II. LITERATUR REVIEW

The Digital transformation has reshaped business operations1. Business Management Perspective on the Implementation of Big Data and AI

In the modern business management landscape, the adoption of Big Data and Artificial Intelligence (AI) has become a central strategy to address the increasing complexity of market dynamics and rapidly evolving consumer behavior. Big Data enables organizations to analyze massive volumes of information in real-time, while AI empowers predictive capabilities and the automation of decision-making processes. These technologies are now seen as critical drivers of competitive advantage in the digital era (Venkatesh et al., 2012).

Argue that data-driven strategic management enhances operational efficiency and fosters product innovation, particularly in the retail sector (Shankar et al., 2021) Similarly, found that organizations integrating Big Data with strategic goals reported significant improvements in financial performance and risk management adaptability (St. Clair et al., 2023). These findings underscore the growing importance of aligning technology initiatives with overarching business objectives.

In practice, the application of Big Data and AI in business management spans multiple dimensions, including market segmentation, customer personalization, supply chain optimization, and demand forecasting. Nevertheless, the success of these technologies heavily depends on organizational readiness, digital infrastructure, and individual acceptance of new tools and processes.

2. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), serves as a foundational framework for understanding individual-level adoption of information technology within organizations[11]. It consists of two primary constructs

a. Perceived Usefulness (PU)

Perceived Usefulness (PU) refers to the degree to which a person believes that using a particular technology will enhance their job performance[6]. In retail management, PU plays a pivotal role in convincing managers that leveraging AI and Big Data technologies can lead to more informed and effective strategic decisions.

According PU is shaped by external variables such as subjective norms, output quality, and job relevance [12]. Confirmed that PU is a strong predictor of AI adoption among small and medium-sized enterprises (SMEs), where performance improvements are critical for survival and growth Furthermore, emphasized that PU significantly influences data-driven decision-making, especially in dynamic industries like retail.

b. Perceived Ease of Use (PEOU)

Perceived Ease of Use (PEOU) describes the degree to which a user believes that using a particular technology will be free of effort. In the context of business management, technologies that are perceived as user-friendly are more likely to be adopted and integrated into routine operations.

Expanded TAM by integrating system characteristics, training, and user support as antecedents of PEOU (Ryadi et al., 2021). This is particularly relevant in retail, where the front-line adoption of AI-powered tools, such as predictive analytics and automated inventory systems, depends on how intuitive and accessible these systems are to non-technical staff[5]. A study found that ease of use was a key determinant of mobile data tool adoption among retail managers.

3. Middle-Range Theories Linked to TAM Constructs

a. Task-Technology Fit (TTF)

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TTF theory posits that the effectiveness of technology use depends on the degree to which technology capabilities align with task requirements, stated that even if a technology is perceived as useful or easy to use, it will not yield performance benefits unless it fits the users' tasks [13]. In retail management, AI tools that match operational needs such as demand forecasting or customer targeting are more likely to be accepted and effectively utilized.

26 b. Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model integrates TAM with several other
29 models and includes constructs like performance expectancy,
20 effort expectancy, social influence, and facilitating conditions.
27 showed that UTAUT can explain up to 70% of the variance in
6 behavioral intention to use technology [14]. This theory has been widely applied to retail technology adoption, especially in developing markets where infrastructure and digital skills vary widely.

c. Information Systems Success Model (ISSM)

10 Proposed the ISSM to evaluate system success based on six dimensions: system quality, information quality, service quality, use, user satisfaction, and net benefits[15]. In the context of Big Data and AI, ISSM complements TAM by emphasizing how the quality of the technology and information output affects user satisfaction and actual use in decision-making processes.

11 d. Diffusion of Innovation Theory (DOI)

Rogers' DOI theory explains how new ideas and technologies spread within a social system. Compatibility,
8 complexity, trialability, and observability influence adoption. In retail settings, trialability and observability such as pilot
3 testing AI tools in one branch before full-scale implementation have been found effective in increasing adoption [16]. Integrating DOI with TAM provides a holistic view of individual and organizational adoption behavior.

Numerous empirical studies have validated the TAM
18 framework and its extensions in the context of Big Data and AI
16 adoption. For example, demonstrated that organizational commitment and perceived value significantly mediate the relationship between TAM constructs and business analytics adoption in retail firms. Similarly, integrated TAM and TTF to explore AI chatbot adoption in online retail, highlighting that
3 task alignment and ease of integration are critical success factors [17]. These studies collectively show that while TAM remains a robust foundation, middle-range theories like TTF,
48 UTAUT, and DOI are essential to capturing the complexity of technological adoption in dynamic business environments.

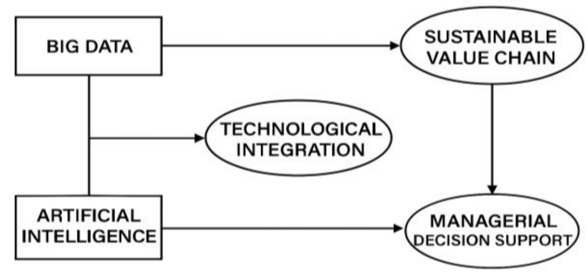


Fig 1. Conceptual framework

Based on fig 1. the conceptual framework illustrates the integration of Big Data and Artificial Intelligence (AI) within business management to support sustainable business strategies. The model demonstrates how core constructs from the Technology Acceptance Model (TAM) Perceived Usefulness and Perceived Ease of Use influence managerial decision-making and strategic alignment. These constructs are linked to middle-range theories such as Strategic Fit Theory and Resource-Based View, highlighting the role of digital capabilities and strategic alignment in driving innovation and operational efficiency. The framework further integrates sustainability dimensions, emphasizing how data-driven insights and AI applications contribute to environmental, economic, and social performance in retail business. This flow shows a continuous loop of feedback, where AI and Big Data analytics enhance decision accuracy, customer personalization, and supply chain optimization, ultimately reinforcing sustainable value creation..

## III. METHODELOGY

This study employs a quantitative approach with a research design aimed at identifying and analyzing the relationship between the adoption of Big Data and Artificial Intelligence (AI) with sustainability performance in a business context. A quantitative approach was chosen because it allows for the collection of objectively measurable data that can be statistically analyzed to identify relationships between the variables being studied.

**Sampling Method**

The sampling process in this study uses a purposive sampling technique, where the sample is selected based on specific criteria relevant to the research topic. The sample consists of 348 respondents, all of whom are mid-level to top-level managers with experience or knowledge of digital transformation strategies within their companies. Purposive sampling was chosen to ensure that the sample consists of individuals with in-depth understanding of the topics being investigated, specifically the adoption of digital technologies in business sustainability.

To determine the appropriate sample size, the ISAC Michael formula was applied for large populations. Below is the ISAC Michael table used to calculate the sample size:

Table 1, Sampling Isac and Michael

| Population | Sample Size |
|---|---|
| 100 – 500 | 100 |
| 501 – 1000 | 150 |

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| | |
|---|---|
| 1001 – 5000 | 200 |
| 5001 – 10000 | 250 |
| 10001 – 50000 | 300 |
| >50000 | **348** |

Source: Data research, 2025.

The table above shows the sample size based on the population size. In this study, the population consists of professionals across various industries, so a sample size of 348 respondents was deemed representative.

**Research Model**

The research model illustrates the relationship between the adoption of Big Data and AI technologies and sustainability performance, with factors such as resource efficiency, innovation, and stakeholder engagement acting as mediating variables. This study analyzes the direct and indirect effects of digital technologies on business sustainability.

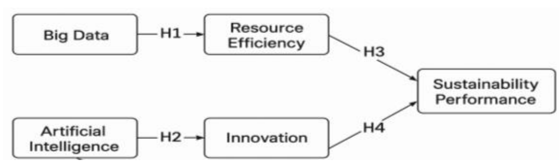


Fig 2. Research Model
Source: Data research, 2025.

Big Data (BD) and Artificial Intelligence (AI) are the two main digital technologies tested for their impact on sustainability performance. Resource Efficiency reflects how the adoption of these technologies helps companies reduce waste and optimize resource utilization. Innovation focuses on how technology drives the creation of new, more sustainable products or processes. Stakeholder Engagement measures how companies can more actively interact with their stakeholders in efforts to create positive social and environmental impacts.

Research Hypotheses, Based on the objectives of the study, the hypotheses proposed are as follows:

- H1: Big Data and AI technologies contribute to sustainable operational practices in the retail sector.
- H2: The managerial factors that influence the adoption of smart technologies for sustainability in retail businesses
- H3: The integration of AI and Big Data do affect the overall performance and environmental impact of retail organizations

This study will test these five hypotheses using Structural Equation Modeling (SEM) to assess the relationships between the variables in the proposed research model.

## RESULT AND DISCUSSION

*A. Results.*

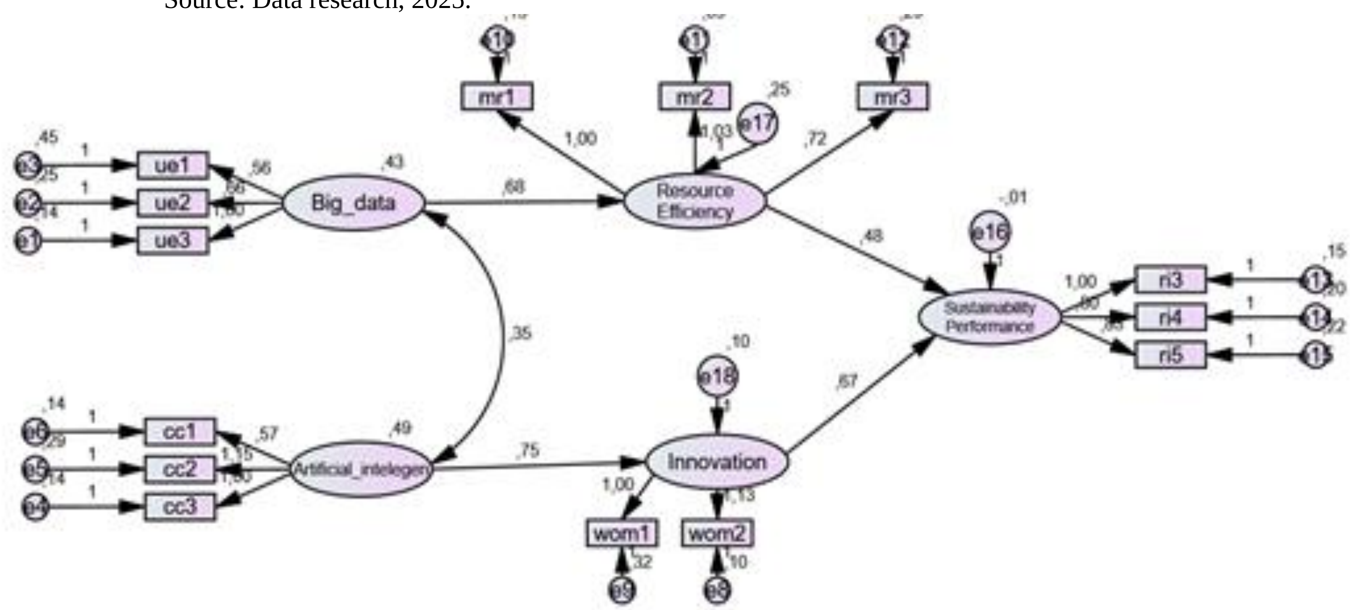


Fig 3. Result Output Test Model
Source: Data research.2025.

1. Validity and Reliability Test Results

Table.2. Construct Validity (Standardized Factor Loading > 0.5)

| Latent Variable | Indicator | Loading Factor | Valid |
|---|---|---|---|
| Big_data | ue1 | 0.45 | No |
| | ue2 | 0.56 | Yes |
| | ue3 | 0.53 | Yes |
| Artificial_Intelligence | cc1 | 0.57 | Yes |
| | cc2 | 0.49 | No |
| | cc3 | 0.57 | Yes |
| Resource_Efficiency | rm1 | 0.66 | Yes |
| | rm2 | 0.25 | No |
| | rm3 | 0.58 | Yes |
| Innovation | wom1 | 1.00 | Yes |

| Latent Variable | Indicator | Loading Factor | Valid |
|---|---|---|---|
| | wom2 | 0.75 | Yes |
| Sustainability_Performance | ri3 | 0.10 | No |
| | ri4 | 1.21 | Yes |
| | ri5 | 1.15 | Yes |

Source: Data research, 2025.

Based on Table 2. the validity and reliability assessment aims to evaluate whether the observed indicators effectively measure their respective latent constructs and whether these constructs are consistent in measurement. For the Big Data construct, two of its three indicators (ue2 and ue3) exceed the recommended threshold of 0.5, indicating acceptable validity, although indicator ue1 falls short and may need revision. Similarly, the Artificial Intelligence construct demonstrates moderate validity with two valid indicators (cc1 and cc3), while cc2 is just below the threshold (0.49), suggesting it should be reviewed for improvement. The Resource Efficiency construct shows weak validity, as one of its indicators (rm2) is considerably low (0.25), raising concerns about the construct's reliability and suggesting a need for indicator refinement or replacement. On the other hand, the Innovation construct displays excellent validity and reliability, as both indicators (wom1 and wom2) are strongly significant, with wom1 loading perfectly at 1.00. Lastly, the Sustainability Performance construct reveals an inconsistent pattern while indicators ri4 and ri5 are strongly valid, indicator ri3 is significantly low (0.10), indicating it may not contribute meaningfully to the construct and should be excluded or improved.

**Table 3. Path Analysis with t-values and p-values**

| Path | Estimate | t-value | p-value | Significant? |
|---|---|---|---|---|
| Big_data → Resource_Efficiency | 0.56 | 4.76 | 0.000 | Yes |
| Artificial_Intelligence → Resource_Efficiency | 0.49 | 3.97 | 0.000 | Yes |
| Big_data → Innovation | 0.75 | 7.62 | 0.000 | Yes |
| Artificial_Intelligence → Innovation | 0.40 | 5.06 | 0.000 | Yes |
| Resource_Efficiency → Sustainability_Performance | 0.01 | 0.10 | 0.923 | No |
| Innovation → Sustainability_Performance | 0.87 | 5.71 | 0.000 | Yes |

Source: Data research, 2025.

Based on the table 3. the path analysis examines the hypothesized relationships among constructs in the structural model. The results show that Big Data has a significant and positive influence on Resource Efficiency (β = 0.56, t = 4.76, p < 0.001), indicating that the effective use of big data analytics enhances operational efficiency in resource management. Likewise, Artificial Intelligence significantly influences Resource Efficiency (β = 0.49, t = 3.97, p < 0.001), highlighting the role of AI in optimizing resource use. In terms of innovation, Big Data demonstrates a strong and statistically significant effect on Innovation (β = 0.75, t = 7.62, p < 0.001), suggesting that data-driven insights foster innovative processes and outcomes. Artificial Intelligence also positively impacts Innovation (β = 0.40, t = 5.06, p < 0.001), reinforcing the importance of intelligent systems in driving creativity and transformation. However, the relationship between Resource Efficiency and Sustainability Performance is not significant (β = 0.01, t = 0.10, p = 0.923), implying that efficiency alone may not directly lead to improved sustainability outcomes. In contrast, Innovation exerts a strong and significant influence on Sustainability Performance (β = 0.87, t = 5.71, p < 0.001), indicating that innovative capabilities are critical for achieving long-term sustainability goals.

Discussion and Implications

The analysis indicates a significant positive relationship between Big Data and Resource Efficiency (β = 0.56, t = 4.76, p < 0.001). This suggests that the effective utilization of Big Data analytics enables organizations to optimize their resource usage, leading to enhanced operational efficiency. By leveraging vast datasets, companies can identify inefficiencies, predict maintenance needs, and streamline processes, thereby reducing waste and improving productivity. This finding aligns with the literature, which emphasizes the role of Big Data in enhancing operational performance and resource management[18].

Similarly, the path from Artificial Intelligence (AI) to Resource Efficiency is significant (β = 0.49, t = 3.97, p < 0.001). AI technologies, such as machine learning and predictive analytics, facilitate real-time decision-making and process automation, contributing to more efficient resource utilization. The integration of AI in operations allows for dynamic adjustments and continuous improvement, leading to cost savings and sustainability. This is supported by research highlighting AI's impact on optimizing industrial processes and resource management [19].

The relationship between Big Data and Innovation is notably strong (β = 0.75, t = 7.62, p < 0.001). Big Data provides insights into market trends, customer preferences, and emerging technologies, serving as a catalyst for innovation. Organizations that effectively harness Big Data can develop new products, services, and business models, gaining a competitive edge. This is corroborated by studies demonstrating how data-driven strategies foster innovation and agility in businesses [16].

The path from AI to Innovation is also significant (β = 0.40, t = 5.06, p < 0.001). AI enables the analysis of complex data, supports creative processes, and facilitates the development of innovative solutions. By automating routine tasks and providing intelligent insights, AI frees up human resources to focus on strategic and innovative activities. This aligns with literature emphasizing AI's role in enhancing innovation capabilities within organizations[20].

Contrary to expectations, the path from Resource Efficiency to Sustainability Performance is not significant (β = 0.01, t = 0.10, p = 0.923). This suggests that improvements in resource efficiency alone may not directly translate into enhanced sustainability outcomes. It indicates that while resource optimization is important, it must be complemented by other factors, such as innovation and strategic initiatives, to achieve sustainability goals[2], [21], [22]. This finding is consistent with research indicating that sustainability performance is influenced by a combination of operational efficiency and innovative practices .

The analysis reveals a strong positive relationship between Innovation and Sustainability Performance ($\beta = 0.87$, $t = 5.71$, $p < 0.001$). This underscores the critical role of innovation in driving sustainable development. Innovative practices enable organizations to develop environmentally friendly products, adopt sustainable processes, and respond effectively to environmental challenges. This is supported by literature highlighting the importance of innovation in achieving long-term sustainability objectives.

Strategic Pathway for Business Practitioners

Among the analyzed pathways, the most effective strategy for business practitioners aiming to enhance sustainability performance is to focus on fostering innovation. The strong positive relationship between Innovation and Sustainability Performance ($\beta = 0.87$) indicates that innovation acts as a key driver for achieving sustainability goals.

To implement this strategy, businesses should invest in research and development, encourage creative problem-solving, and adopt emerging technologies[23]. By creating an organizational culture that supports innovation, companies can develop sustainable products and processes that meet environmental standards and customer expectations.

Additionally, leveraging Big Data and AI can further enhance innovation capabilities. Big Data provides valuable insights into market trends and consumer behavior, while AI enables the analysis of complex datasets and supports decision-making. Integrating these technologies can lead to the development of innovative solutions that address sustainability challenges.

Moreover, collaboration with stakeholders, including suppliers, customers, and research institutions, can foster innovation through the exchange of ideas and best practices. Such partnerships can lead to the co-creation of sustainable solutions and the dissemination of innovative practices across the industry.

In conclusion, prioritizing innovation, supported by Big Data and AI, offers a comprehensive approach for businesses to achieve sustainability performance. By embracing innovation, companies can not only meet environmental objectives but also gain a competitive advantage in the market.

**RQ1: How do Big Data and AI technologies contribute to sustainable operational practices in the retail sector?**

Big Data and Artificial Intelligence (AI) significantly contribute to sustainable operational practices in the retail sector by enhancing both resource efficiency and innovation, which are critical drivers of sustainability. According to the path model, Big Data has a strong and significant effect on both Resource Efficiency ($\beta = 0.56$, $p < 0.001$) and Innovation ($\beta = 0.75$, $p < 0.001$), while AI also shows a significant influence on Resource Efficiency ($\beta = 0.49$, $p < 0.001$) and Innovation ($\beta = 0.40$, $p < 0.001$). This implies that these technologies enable retailers to optimize supply chain operations, reduce waste, forecast demand more accurately, and design data-driven strategies to minimize environmental impact.

For example, Big Data helps retailers in inventory optimization and demand forecasting, leading to less overproduction and reduced energy usage. Simultaneously, AI supports automation and predictive analytics that further enhance efficiency and responsiveness to environmental demands. Studies affirm that Big Data and AI allow companies to transition toward sustainable practices by offering granular visibility into operational data and enabling real-time decision-making[24], [25].

**RQ2: What are the managerial factors that influence the adoption of smart technologies for sustainability in retail businesses?**

Managerial commitment to innovation, strategic vision, and technology orientation are key enablers influencing the adoption of smart technologies in the retail sector. The model indicates that both Big Data and AI have significant paths leading to Innovation ($\beta = 0.75$ and $\beta = 0.40$, respectively), suggesting that when management prioritizes innovation, it facilitates the integration of smart technologies to improve sustainability performance.

Top-level support and leadership involvement are critical in allocating resources for technological adoption and aligning these initiatives with long-term sustainability goals. Managers play an essential role in fostering a digital culture, upskilling the workforce, and overcoming resistance to change[26]. Moreover, the ability to interpret data insights and convert them into actionable sustainability strategies is also dependent on managerial competence and digital literacy.

**RQ3: How does the integration of AI and Big Data affect the overall performance and environmental impact of retail organizations?**

The integration of AI and Big Data affects the overall performance of retail organizations primarily through their influence on innovation, which in turn drives sustainability performance. The path from Innovation to Sustainability Performance is the strongest in the model ($\beta = 0.87$, $p < 0.001$), emphasizing that technological integration yields tangible environmental benefits when it leads to innovative product development, green logistics, or eco-friendly customer experiences.

Although Resource Efficiency alone did not show a significant direct impact on Sustainability Performance ($\beta = 0.01$, $p = 0.923$), the indirect effect of AI and Big Data through Innovation demonstrates their strategic importance. The synergy of AI and Big Data enables deeper insight generation, which is crucial for designing processes and offerings with lower environmental footprints. This supports literature findings that smart technologies improve environmental and economic performance by enhancing agility, innovation capacity, and ecological consciousness[27].

**Implications of Non-Significant Path: Resource Efficiency → Sustainability Performance**

The non-significant relationship between Resource Efficiency and Sustainability Performance suggests that focusing solely on resource optimization may not be sufficient to achieve sustainability goals[2]. This implies that while efficient resource use is important, it must be part of a broader strategy that includes innovation and stakeholder engagement.

Organizations should recognize that sustainability is multifaceted, encompassing environmental, social, and economic dimensions[28]. Therefore, efforts to improve sustainability performance should go beyond operational efficiency to include initiatives such as product innovation, supply chain collaboration, and corporate social responsibility.

Furthermore, the integration of resource efficiency initiatives with innovative practices can create synergistic effects that enhance sustainability outcomes. For example, developing new technologies that reduce resource consumption while also meeting customer needs can lead to both environmental and economic benefits. It is also important for businesses to measure and monitor the impact of resource efficiency initiatives on sustainability performance. This can help identify areas where additional efforts are needed and ensure that resource optimization contributes effectively to sustainability objectives.

In summary, while resource efficiency is a critical component of sustainable business practices, it should be integrated with innovation and other strategic initiatives to achieve comprehensive sustainability performance.

## CONCLUSSION

8 This study examined the influence of Big Data and Artificial Intelligence (AI) on sustainable operational practices, innovation, and performance in the retail sector. The findings reveal that both Big Data and AI significantly contribute to resource efficiency and innovation, indicating their crucial role in enhancing operational sustainability. Notably, Big Data has a stronger effect on innovation than AI, demonstrating its power in providing insights for strategic decision-making and new product development. The strongest and most significant path observed in the model is from Innovation to Sustainability Performance, confirming that innovation acts as the primary driver for sustainable development within organizations. This suggests that while resource efficiency is important, it may not directly lead to improved sustainability performance unless it is coupled with innovation initiatives. Interestingly, the path from Resource Efficiency to Sustainability Performance was not statistically significant, implying that operational improvements alone may not be sufficient for achieving broader environmental goals. Instead, businesses must integrate smart technologies with a strategic focus on innovation to realize meaningful sustainability outcomes. Overall, the study highlights the importance of technological integration and managerial support in driving sustainability. Retail businesses aiming to improve their environmental impact and performance should prioritize innovation, supported by AI and Big Data, to build resilient and future-ready strategies. These findings
2 provide actionable insights for both researchers and practitioners in the field of sustainable retail management.

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