A STUDY ON AI IN GREEN SUPPLY CHAIN MANAGEMENT

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Abstract: Artificial intelligence (AI) has been considered an important enabler of supply chains (SC), as it helps to monitor SC competitiveness and management. Thus, AI has been gaining notability in management. However, no academic manuscript offers a detailed study of specific artificial intelligence techniques. Indeed, several existing reviews in this field provide considerable insight, but are often too general. The integration of artificial intelligence (AI) into green supply chain management has gained considerable attention as a promising approach to achieving sustainability goals while increasing operational efficiency. This article presents a comprehensive overview of the application of artificial intelligence techniques in the context of green supply chain management. Drawing on a wide range of scholarly literature, the abstract highlight's key themes and findings regarding the implementation of AI technologies in optimizing various aspects of the green supply chain, including sourcing, manufacturing, transportation and distribution. The abstract also explores the potential benefits and challenges associated with the implementation of artificial intelligence in green supply chain practice, highlighting its role in reducing carbon emissions, minimizing waste and supporting green manufacturing processes. Additionally, the abstract discusses emerging trends, future research directions, and practical implications for organizations seeking to use AI for sustainable supply chain management. Overall, this paper contributes to the understanding of the transformative impact of AI on green supply chain practices and offers valuable insights for researchers, practitioners, and policy makers.

I. INTRODUCTION

In recent years, the intersection of artificial intelligence (AI) and sustainable supply chain
management has become a focal point of academic research and industrial innovation. As global concerns about environmental degradation and resource depletion intensify, organizations are under increasing pressure to adopt environmentally friendly practices while maintaining operational efficiency. In response to these challenges, the integration of artificial intelligence
technologies into green supply chain management have come to the fore as a promising solution to enhance sustainability performance and gain competitive advantage. This introduction sets the stage for exploring the role of artificial intelligence in the context of green supply chain management. It begins by providing an overview of the growing importance of sustainability in supply chain operations and the need for organizations to adopt environmentally responsible practices. Subsequently, the introduction describes the transformative potential of artificial intelligence in solving key sustainability challenges within the supply chain, such as reducing carbon emissions, minimizing waste, and optimizing resource use. The introduction further outlines the objectives of the research paper, which include exploring the current state of AI adoption in green supply chain practice, exploring the benefits and challenges associated with AI implementation, identifying emerging trends, and proposing recommendations for future research and practical applications. Overall, this introduction serves as a basic framework for understanding the importance of artificial intelligence in green supply chain management and sets the context for the subsequent discussions and analysis presented in the research paper. Through an in-depth exploration of AI solutions, this paper seeks to illuminate the transformative potential of AI in advancing sustainability goals in the supply chain domain. The concept of sustainability has become an increasingly important global discourse, reflecting growing concerns about environmental degradation, resource depletion and climate change. In this context, supply chain management has emerged as a critical area for organizations to address sustainability issues and mitigate their environmental footprint. Green supply chain, characterized by practices aimed at reducing environmental impact throughout the supply chain lifecycle, has emerged as a strategic approach to promote sustainability while ensuring operational efficiency. The advent of artificial intelligence (AI) technologies has revolutionized various aspects of supply chain management, offering unprecedented opportunities for optimization, automation, and decision-making. Artificial intelligence encompasses a wide range of technologies, including machine learning, natural language processing, robotics, and predictive analytics. These technologies have the potential to transform traditional supply chain processes and enable organizations to achieve their sustainability goals more effectively.

Integrating artificial intelligence into green supply chain management holds significant promise for improving sustainability performance, improving resource efficiency, and fostering innovation across supply chain operations. AI-driven solutions offer capabilities for real-time data analysis, predictive modelling, and intelligent automation, enabling organizations to optimize transport routes, reduce energy consumption, minimize waste generation, and improve overall environmental stewardship. Despite the potential benefits, the adoption of artificial intelligence in green supply chain practices is not without challenges. Organizations must navigate privacy, cybersecurity, ethical

considerations, and workforce impacts when implementing AI technologies. In addition, there may be barriers to AI adoption, including cost constraints, technical complexity, and organizational resistance to change.

In this context, this research paper aims to provide a comprehensive exploration of the role of artificial intelligence in green supply chain management. Through a review of existing literature, case studies, and empirical research, the paper seeks to explore the current state of AI implementation in green supply chain practice, analyze the potential benefits and challenges associated with AI implementation, identify emerging trends, and best practices, and offer recommendations for future research and practical application.

By illuminating the transformative potential of AI in advancing sustainability goals in the supply chain domain, this research paper aims to contribute to the growing body of knowledge on AI solutions for sustainable supply chain management. Finally, this paper seeks to provide organizations with insights and strategies for harnessing the power of AI to support environmental sustainability and value creation within a green supply chain.

Since the disruptions caused by the Covid-19 pandemic, boards and CEOs have been putting pressure on corporate procurement leaders to de-risk supply chains. Our recent research at Walmart, Tyson Foods, Koch Industries, Maersk, Siemens and Unilever revealed how these global companies are using advanced artificial intelligence technologies to plan and adapt to supply chain disruptions. These tools have various applications. They can improve large companies' visibility into what's happening in their supply chains, enable them to respond more quickly to disruptions, deepen their ties with current suppliers by expanding purchases to include new items, enable them to discover and qualify new suppliers ahead of potential crises, and even automate negotiations. Companies that quickly adopt these AI tools will gain an advantage. "When there is a supply chain crisis, the key to being competitive is to be faster than everyone else in finding alternative suppliers because everyone wants to do the same thing," Maggie Brommer, head of purchasing for Unilever's Prestige Products, told us.

Here are details on how the global companies we studied are using AI in procurement.

Search for alternative suppliers.

Unilever uses an AI app and service provided by German startup Scout bee to quickly find alternative sources of supply. The software generates a list of potential new suppliers by searching websites for supplier financial data, customer ratings, sustainability scorecards, diversity scores, intellectual property information such as patents and design awards, customs documents from US Customs to verify experience with international trade and real-time alerts from social media and news channels that the user can set to include things like financial news and major hires or terminations. After the software generates a list of potential suppliers, the process becomes manual. Corporate buyers then instruct Scout bee staff to request additional information from specific buyers on the list.

Unilever, which has pledged to buy 2 billion euros a year from businesses around the world by 2025, is also using the technology to find such suppliers in the United States. Lullit Jezequel, Unilever's purchasing manager for sustainability and partnerships, says many of the diverse suppliers identified by the AI tool are small or medium-sized enterprises (SMEs). "Sometimes what we're looking for can't be defined with a keyword," she told us. "This tool does a thorough search to find pitch decks and the types of clients they serve to better understand their capabilities. Improving supplier diversity supports the diversification of the supplier base and introduces suppliers who can fill gaps and step-up during outages".

Siemens also uses Scoutbee to quickly find alternative sources of supply — such as when it faced a shortage of Surlyn, a highly specialized ionomer resin created by DuPont that is used in the packaging of medical diagnostic products. As Surlyn is a proprietary product, there were no alternative manufacturing suppliers. Scoutbee searched the import and shipping documents and created a list of 150 Surlyn distributors within days. Siemens' corporate buyers quickly narrowed down the choices, and Scoutbee staff then found several distributors on a short list with inventory available for Siemens to purchase. "Technology won't give you the insight to reliably prevent supply disruptions before they happen, but they can give you the information to help you respond to supply chain disruptions much faster than human buyers can," Michael Klinger, the company's senior director of supply chain Siemens perfection, he told us. Discovering what else existing suppliers can do. Onboarding new suppliers can be time-consuming in specialized operations and manufacturing. Rolls-Royce can take a year or more to qualify, test, certify and onboard a new supplier. An alternative approach is to use artificial intelligence to assess whether existing suppliers can provide additional materials. Subsidiaries of Koch Industries, one of America's largest private conglomerates, are using an AI tool designed by Arkestro to optimize their supply base. Unlike traditional procurement methods that rely on supplier management based on high-level purchasing categories and aggregate spend, this AI tool dives into granular data down to the stock-holding unit (SKU). It creates supply options, often between existing suppliers, reducing the need for lengthy RFPs.

The tool achieves this level of detail by ingesting complex data sets, including information on existing suppliers, purchase orders, invoices and even failed bids from previous purchase cycles. This offers a differentiated view of qualified suppliers, allowing companies to identify backup suppliers across different categories.

An AI algorithm uses this historical data to automatically populate new Requests for Quotations (RFQs) with basic parameters such as lead times, geographic locations, quantities, service level agreements, and material costs. It then e-mails the RFQ to the appropriate supplier for review. If the supplier agrees with the AI-generated quote, it's just one click to submit. If the supplier decides to adjust the offer, the algorithm learns from these changes and continuously improves its predictive capabilities. This win-win approach saves suppliers 60 to 90% of the time they would normally spend filing an inquiry. For Koch, the primary goal of the AI tool is to identify additional sourcing opportunities within the existing supplier network. However, the technology also benefits suppliers by creating new opportunities to expand their business with Koch.

Automation of negotiation Both Maersk and Walmart use a software product called Pactum AI to automate negotiations. Maersk uses its chatbot to more quickly search for shipping rates within existing agreements, or for the bot to automatically secure a quote if none is available. Walmart, which has more than 100,000 suppliers, uses it to negotiate with people at "end" suppliers — those who make up roughly 20% of Walmart's spending on low-value items. Michael DeWitt, Vice President of Strategic Sourcing at Walmart International shared with us, "This technology allows us to reach suppliers that we simply wouldn't have the bandwidth for without AI."Deciding how to proceed When deciding whether or where to implement AI, it would be wise to follow these guidelines: Try the technologies. While solutions from Pactum, Scoutbee, and Arkestro delivered on their promises to the customers we studied, a few other AI-based tools fell short. Lesson: Companies should use

pilot programs to test technologies. Tyson Foods encountered a significant snag while testing one AI application: The software mistakenly labeled one of Tyson's most trusted suppliers, a publicly traded cloud services provider, as "high risk" based solely on its involvement in cybersecurity.

1.1   OBJECTIVE OF THE STUDY

1.   To identify existing AI technologies and approaches in supply chain management.
2.   To Identify and analyses key challenges and opportunities associated with integrating AI in green supply chain management.
3.   To study how you can use efficiencies in supply chain management to reduce waste, energy use and the environmental Sustainability.

1.2   RESEARCH METHODOLOGY

Research design: The research will use a mixed methods approach to comprehensively examine the role of artificial intelligence (AI) in green supply chain management. This approach will integrate qualitative and quantitative methods to capture the depth and breadth of insights into AI adoption and its impact on sustainability within the supply chain.

Data Collection:

A. Qualitative data: Qualitative data will be collected through in-depth interviews with key stakeholders involved in green supply chain management, including supply chain managers, sustainability experts and AI technology providers. These talks will explore the perceptions, experiences and challenges related to integrating AI technologies into sustainable supply chain practices.

b. Quantitative data: Quantitative data will be collected through online surveys distributed to organizations in various industries and geographic regions. The survey will assess the extent of adoption of AI in green supply chain management, the perceived benefits and barriers to implementation, and the impact of AI on sustainability performance metrics.

1.3   SAMPLE SIZE

In our study will take a sample size of 5 to 6 company employees.

1.4   SAMPLING METHOD

Purposive sampling will be employed for qualitative interviews to ensure representation from diverse stakeholder groups with relevant expertise in AI and green supply chain management. For the quantitative survey, a stratified random sampling technique will be utilized to ensure a representative sample across different industries, company sizes, and geographical locations.

1.5   NEED FOR THE STUDY

•Increasing awareness for the AI in Green Supply Chain

•How AI inclusion made changes in supply chain management

1.6   LIMITATIONS OF THE STUDY

Relying on secondary data: The study had to rely on secondary data sources, news articles and other published sources which may not be accurate or complete.

1.7   RESEARCH GAP

The integration of artificial intelligence (AI) into supply chain management and sustainable practices is gaining attention, but there is a significant gap in literature regarding the intersection of AI and green supply chain management. Existing research mainly focuses on AI applications in traditional supply chain optimization or sustainable practices without considering the synergistic relationship between AI and environmental sustainability. Studies often lack empirical evidence or practical insights for organizations implementing AI-based green supply chain initiatives. While some research explores potential environmental benefits of AI, there is limited understanding of its broader implications on sustainability metrics beyond operational levels.

The literature often focuses on AI applications in developed countries, overlooking the unique challenges and opportunities for AI adoption in green supply chains in emerging markets. Addressing this gap requires empirical research that examines AI's role in enabling green supply chain practices, its impact on sustainability outcomes, and best practices for organizations operating in diverse geographic and industry contexts.

2. REVIEW OF LITERATURE

(2020) Reza Toorajipour, Vahid Sohrabpour, Ali Narzarpour, Pejvak Oghazi, Maria Fischl, et.al. This journal provides a comprehensive overview of a systematic literature review of systematic analysis and synthesis. Also, specifics set of inclusion and exclusion criteria are used to identify and examine papers from four SCM fields: logistics, marketing, supply chain and production. By conducting detailed research about Artificial intelligence in supply chain management. This paper seeks to identify the contributions of artificial intelligence (AI) to supply chain management.

(SCM) through a systematic review of the existing literature. Specifically, the following four aspects were covered: (1) the most prevalent AI techniques in SCM; (2) the potential AI techniques for employment in SCM; (3) the current AI-improved SCM subfields; and (4) the subfields that have high potential to be enhanced by AI. A specific set of inclusion and exclusion criteria are used to identify and examine papers from four SCM fields: logistics, marketing, supply chain and production. This paper provides insights through systematic analysis and synthesis.

(2022) Sameh M Saad, Mohamed Khamkham, et.al. This is a literature review about The Applications of AI in GSCM. This review emphasizes AI's role in enhancing GSCM and achieving sustainability. It identifies five main AI technologies contributing to GSCM: Machine learning, fuzzy logic, genetic algorithms, natural language processing, and knowledge-based systems. The review highlights applications like optimized resource allocation, green product design, and sustainable transportation management. This review aims to explore and identify the main contribution of Artificial intelligence to GSCM growth and implementation through a systematic literature review. Five systematic processes are employed to evaluate and derive the latest published literature, using a set of inclusion and exclusion criteria to identify the papers in the GSCM field.

(2023) Bárbara Ferreira, João Reis, et.al. This study offers a broader perspective on AI in supply chain management, including GSCM. It analyzes various AI techniques like neural networks, fuzzy logic, and genetic algorithms. While not solely focused on GSCM, it provides valuable insights into AI's potential for optimizing resource utilization, reducing waste, and improving energy efficiency. They conducted a systematic literature review that aims to provide solid and relevant foundation, targeting the artificial intelligence techniques that are most prevalent in supply chain management. This research identified the main artificial intelligence technics in the field of supply chain management, namely, artificial neural networks, fuzzy logic, and genetic algorithm, although other topics have emerged as well, such as sustainability, environment, big data, and automatization. They recognize that AI plays a vital role in SCM and how beneficial it is to use it while being considered risky at the same time.

(2023) Jianqi Qiao, Suicheng Li, Su Xiong, Na Li, et.al. This journal is about the review on the Use of Digital Technology to Achieve Green Supply Chain Management. That green supply chain innovation has gained significant attention from academics and practitioners due to its ability to mitigate chain liability risks, meet consumer environmental demands, and create sustainable.

competitive advantages. Digital technology, a valuable tool for enhancing organizational information processing capabilities, plays a crucial role in promoting successful green supply chain innovation. this study aims to explore the impact of digital capability advantage on green supply chain innovation and examine the mediating role of green supply chain learning (green supplier learning and green customer learning). The survey results from 221 Chinese manufacturing firms indicate that digital capability advantages contribute directly and positively to green supply chain innovation and indirectly enhance it through green supplier learning and green customer learning.

(2023) Yi Wang, Yafei Yang, Zhaoxiang Qin, Yefei Yang, Jun Li, et.al. The article is a literature review on the Application of Digital Technology in Achieving Green Supply Chain Management. This review specifically focuses on the use of digital technology, including AI, in achieving GSCM goals. It emphasizes the importance of real-time data and predictive analytics for optimizing green practices. The review also highlights challenges like data security and privacy, ethical considerations, and the need for organizational change management to effectively implement AI solutions. They systematically reviewed 144 relevant papers published in the last 14 years. They used qualitative analysis to classify, summarize and analyze the literature in two dimensions (i.e., digital technologies and green supply chain practices). The study also discusses how technologies can reduce the input of resources and energy and the emission of pollutants, finally improving the operating efficiency of the green supply chain, and achieving economic, social, and environmental benefits.

(2021) Smail Benzidia, Naouel Makaoui, Omar Bentahar, et.al. In this journal is about the impact of bigdata analytics and artificial intelligence on green supply chain process integration and hospital environmental performance. This journal gives a brief about Green digital learning as a moderating role in the process of green supply chain collaboration. This article provides valuable insight for logistics/supply chain managers, helping them in mobilizing BDA-AI technologies for supporting green supply processes and enhancing environmental performance. This study also underlined that both environmental process integration and green supply chain collaboration have a significant impact on environmental performance.

(2021) Surajit Bag, Shivam Gupta, Sameer Kumar, and Uthayasankar Sivarajah, et.al. The aim of this journal is to understand the special properties of the GSCM system under the moderating effects of product complexity and purchasing structure. This is a literature review led to the building of the conceptual framework. Six constructs were identified using systems theory. These constructs include green supply chain technological dimensions (particularly, Artificial Intelligence (AI) based), green supply chain strategy, green supply chain process, product complexity, purchasing structure, and firm performance. The research study aims to investigate green supply chain management (GSCM) elements as part of a complete system. It aims to understand the special properties of the GSCM system under the moderating effects of product complexity and purchasing structure.

(2024) Riya Barthwal, Deepika Kathuria, Saloni Joshi, R.S.S. Kaler, Narpinder Singh, et.al. This is a literature review about latest trends in the development and application of artificial intelligence in food processing. This is about Artificial intelligence (AI) supports food processing operations, AI inspect defect in food products, ensure quality and reduce wastage, optimize supply chain logistics by predicting demand and AI acclaims personalized diet based on dietary preferences, allergens, health goals. This review aims to offer valuable insights into the latest AI technologies helping agricultural farmers and food processing endeavours. The countless scenarios and use cases pertaining to AI, with the lenses of product development, sorting and grading, enhancing quality and safety, supply chain management, and waste management, are explored herein. Finally, discussion about the pivotal role of AI in fostering sustainable food production is also involved in this review.

(2021) Smail Benzidia, et al. The study described delves into the impact of big data analytics and artificial intelligence (BDA-AI) on supply chain integration and environmental performance. It extends organizational information processing theory by incorporating BDA-AI and positions digital learning as a moderator of the green supply chain process. Through empirical analysis of 168 French hospitals, the study found that BDA-AI technologies significantly influence environmental process integration and green supply chain collaboration, which in turn impact environmental performance.

(2022) Vipin Kumar, et.al. study that emphasis on environmental impact and sustainability has become increasingly vital for businesses, particularly small and medium-sized enterprises (SMEs). Green Supply Chain Management (GSCM) integrates environmental considerations into procurement, production, distribution, consumption, and resource recycling, aiming to minimize the environmental footprint. Concurrently, data analytics, particularly machine learning, has gained traction in operations management. This review paper will delve into the role of machine learning in GSCM and operations management, highlighting how these technologies can influence and improve organizational performance in environmental sustainability and operations efficiency.

(2022) Yunting Feng, et.al. This study addresses a research gap by defining and exploring Green Supply Chain Innovation (GSCI) in the context of Industry 4.0. GSCI refers to innovation practices in manufacturing that leverage digital technologies to integrate environmental concerns into supply chain management activities. It encompasses five key dimensions: internal environmental management, green purchasing, customer cooperation, inventory recovery, and eco-design. The study notes a growing interest in GSCI, especially in conjunction with digital technologies such as artificial intelligence, blockchain, cloud computing, and big data analytics. However, there is a lack of comprehensive studies on GSCI, including its examination, adoption motivations, and challenges. The paper aims to fill this gap by explaining GSCI, discussing its practices, emphasizing digital technology applications, and identifying challenges and opportunities for adoption and diffusion, thereby extending knowledge in the emerging field of GSCM.

(2021) Jun Zhang, et.al. study of this article highlights China's focus on promoting ecological civilization and green, circular, and low-carbon development due to the near-limit environmental carrying capacity. It emphasizes enterprise green operation to integrate environmental protection into the entire business process. The study aims to address the balance between corporate GDP growth and environmental protection and analyze the impact of green business development policies on China's corporate GDP. Investigating economic and environmental aspects of green transformation enterprises nationwide, the research shows that China's green enterprise development has made significant strides. The average growth rate of China's green development GDP has surpassed the overall green GDP growth rate, indicating remarkable achievements.

(2020) Surajit Bag, et.al. study investigates green supply chain management (GSCM) elements within a comprehensive system, aiming to comprehend the unique properties of the GSCM system under the moderating effects of product complexity and purchasing structure. Using systems theory, six constructs were identified: green supply chain technological dimensions (particularly AI-based), green supply chain strategy, green supply chain process, product complexity, purchasing structure, and firm performance. Survey data collected from 250 automotive components and allied manufacturers in South Africa led to the finding that GSCM technological dimensions positively influence GSCM strategy, which in turn affects the GSCM process, subsequently impacting environmental, social, and financial performance. Notably, product complexity moderates the paths of GSCM strategy and GSCM process.

(2020) Jia Liu, et.al. studies conduct a systematic literature review of 36 relevant papers published in the past decade to explore the intersection of big data analytics (BDA) and green supply chain management (GSCM). It identifies four types of BDA techniques—statistics, machine learning, data mining, and optimization—applied across four GSCM areas: internal environment management, green purchasing, customer green cooperation, and general GSCM. By summarizing the types of BDA techniques and their applications within GSCM, the study contributes to the literature on BDA-enabled GSCM. Additionally, it offers insights into the specific GSCM areas influenced by BDA techniques. The implications of the literature review are discussed, and directions for future research are provided, further advancing understanding in this domain.

3. DATA INTERPRETATION

1.   AI and analytics solutions provide data-driven insights to inform everything from setting environmental policies to rerouting supply lines. Scale your opinion.

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagrees.

Opinion	Count	Percentage
Strongly Agree	4	7.02%
Agree	43	75.44%
Neutral	16	28.07%
Disagree	16	28.07%
Strongly disagree	1	1.75%

Interpretation:

The frequency table illustrates the distribution of opinions regarding the statement "AI and analyticssolutions provide data-driven insights to inform everything from setting environmental policies to rerouting supply lines." Among the respondents, the majority (75.44%) agreed with the statement, with 43 individuals expressing agreement. Additionally, 7.02% of respondents strongly agreed, while 28.07% were neutral and 28.07% disagreed, with 16 individuals expressing both disagreementand neutrality. Only a small fraction (1.75%) strongly disagreed with the statement, representing a minority opinion. Overall, the data suggests a relatively positive perception of the role of AI and analytics solutions in informing decision-making processes related to environmental policies and supply chain management.

2.   Scale your opinion on AI can power platforms used for identifying opportunities and rating riskin ESG ratings.

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

Opinion	Count	Percentage
Strongly Agree	3	9.25%
Agree	0	4.78%
Neutral		.48%
Disagree	4	0.90%
Strongly disagree		.49%

Interpretation: The frequency table displays the distribution of opinions regarding the statement "AIcan power platforms used for identifying opportunities and rating risk in ESG ratings." Nearly halfof the respondents (49.25%) strongly agreed with the statement, while 44.78% agreed. Only a smallpercentage (4.48%) were neutral, indicating a lack of strong opinion. Conversely, 20.90% disagreed with the statement, with 14 individuals expressing disagreement, and a negligible portion (1.49%) strongly disagreed.

The data suggests a generally positive perception of the potential for AI to enhance platforms for ESG (Environmental, Social, and Governance) ratings, with a majority either strongly agreeing or agreeing with the statement. However, it's noteworthy that a notable minority expressed disagreement, indicating some skepticism or concerns regarding the efficacy of AI in this context.

3.   What is your opinion on the statement "AI can optimize product design for circularity, creatingsuggestions for reuse, refurbishment, or recycling opportunities within the business' supplychain"?

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

Opinion	Count	Percentage
Strongly Agree	7	6.84%
Agree	9	6.71%
Neutral	1	3.92%
Disagree		.06%

Interpretation: The frequency table represents the distribution of opinions regarding the statement "AI can optimize product design for circularity, creating suggestions for reuse, refurbishment, or recycling opportunities within the business' supply chain."

A significant portion of respondents (46.84%) strongly agreed with the statement, indicating a beliefin AI's capacity to optimize product design for circularity. Additionally, 36.71% agreed with the statement, further supporting the idea. However, a smaller proportion (13.92%) remained neutral, suggesting uncertainty or a lack of strong opinion on the matter.

Furthermore, only a minority (5.06%) disagreed with the statement, implying that some respondentsdo not believe AI can effectively optimize product design for circularity or provide suggestions forreuse, refurbishment, or recycling opportunities within the supply chain.

Overall, the data suggests a predominantly positive perception of AI's potential to enhance productdesign for circularity, with a notable minority expressing uncertainty or disagreement.

4.　　　Do you agree with the statement "Public-cloud Enterprise Resource Planning (ERP) Tools is usein GSCM after AI adoption"?

a.　　　Strongly Agree

b.　　　Agree

c.　　　Neutral

d.　　　Disagree

e.　　　Strongly disagree

Opinion	Count	Percentage
Strongly Agree	9	5.37%
Agree	6	1.71%
Neutral	3	5.85%
Disagree	2	4.63%
Strongly disagree		.22%

Interpretation: The frequency table illustrates the distribution of opinions regarding the statement "Public-cloud Enterprise Resource Planning (ERP) Tools are used in Global Supply Chain Management (GSCM) after AI adoption."

A notable portion of respondents (35.37%) strongly agreed with the statement, indicating a strong belief that public-cloud ERP tools are indeed utilized in GSCM following AI adoption. Additionally,31.71% agreed with the statement, further supporting the notion.
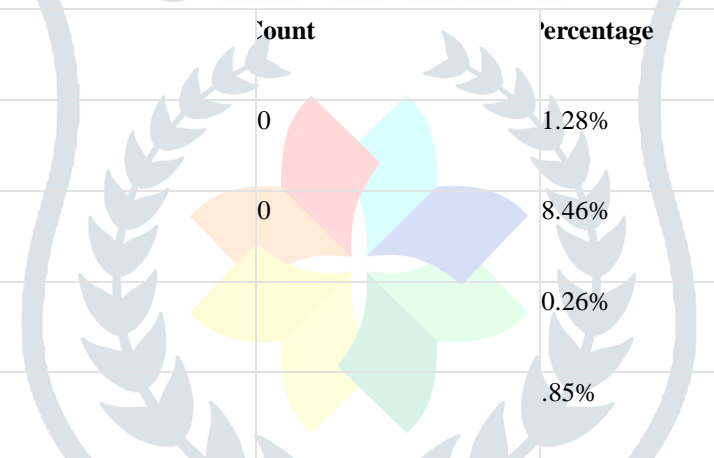
On the other hand, a smaller proportion of respondents (15.85%) remained neutral, suggesting uncertainty or a lack of strong opinion regarding the statement. Furthermore, 14.63% disagreed with

the statement, implying skepticism or disagreement with the idea that public-cloud ERP tools are used in GSCM post-AI adoption. Only a negligible fraction (1.22%) strongly disagreed with the statement.

Overall, the data suggests a mixed perception of the extent to which public-cloud ERP tools are integrated into GSCM after AI adoption, with a significant portion agreeing but also a notable portion expressing neutrality or disagreement.

5.   Businesses can create digital twins, which are AI-driven virtual depictions of supply chain components, including warehouses, suppliers, and inventory. What is your opinion about this.

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

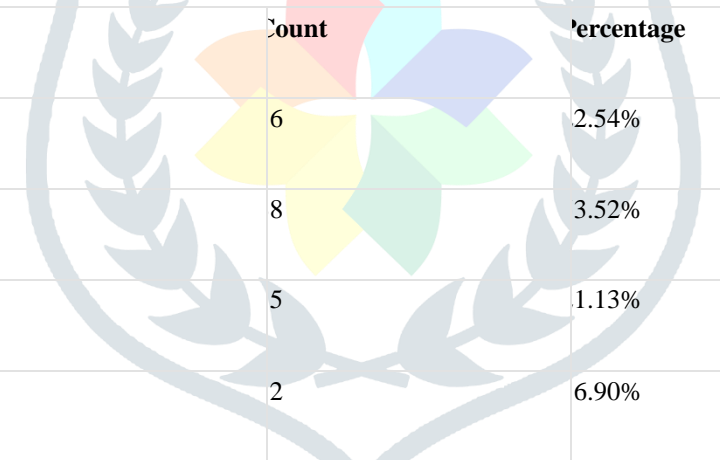| Opinion	Count	Percentage
Strongly Agree	0	1.28%
Agree	0	8.46%
Neutral		0.26%
Disagree		.85%

Interpretation: The frequency table presents the distribution of opinions regarding the statement "Businesses can create digital twins, which are AI-driven virtual depictions of supply chain components, including warehouses, suppliers, and inventory."

A majority of respondents (51.28%) strongly agreed with the statement, indicating a strong belief inthe feasibility and potential benefits of creating digital twins for supply chain components using AItechnology. Additionally, 38.46% agreed with the statement, further supporting the idea.

A smaller proportion of respondents (10.26%) remained neutral, suggesting a lack of strong opinionor uncertainty regarding the statement. Furthermore, only a minor percentage (3.85%) disagreed with the statement, implying scepticism or disagreement with the concept of using AI-driven digitaltwins for supply chain components.

Overall, the data suggests a predominantly positive perception of the ability of businesses to leverageAI to create digital twins for supply chain components, with a minority expressing neutrality or disagreement.

6.   Do you agree that AI in Green Supply Chain Management providing jobs?

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

Opinion	Count	Percentage
Strongly Agree	6	2.54%
Agree	8	3.52%
Neutral	5	1.13%
Disagree	2	6.90%

Interpretation: The frequency table displays the distribution of opinions regarding the statement"Do you agree that AI in Green Supply Chain Management provides jobs?"
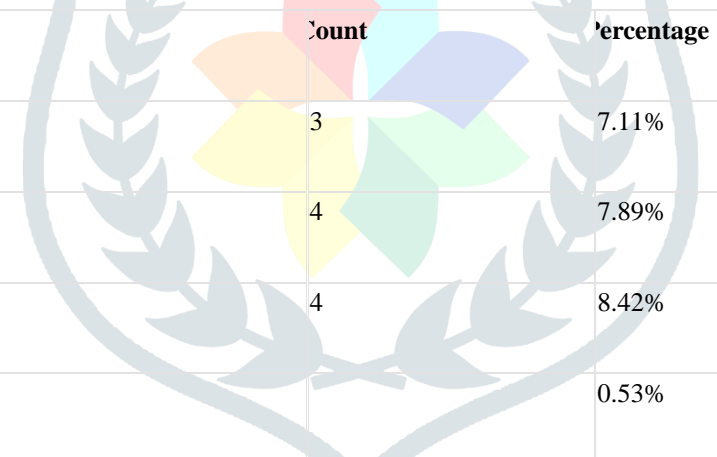
A significant portion of respondents (53.52%) agreed with the statement, indicating a belief that AI in Green Supply Chain Management indeed provides job opportunities. Additionally, 22.54% of respondents strongly agreed with the statement, further supporting the idea.

A considerable percentage (21.13%) remained neutral, suggesting a lack of strong opinion or uncertainty regarding the statement. Furthermore, 16.90% of respondents disagreed with the statement, indicating skepticism or disagreement with the notion that AI in Green Supply Chain Management creates job opportunities.

Overall, the data suggests a generally positive perception of the potential for AI in Green Supply Chain Management to provide employment opportunities, with a notable portion expressing agreement. However, there is also a significant portion that remains neutral or disagrees with thisnotion.

7.   Do you agree that AI in Green Supply Chain Management replaces the human?

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

Opinion	Count	Percentage
Strongly Agree	3	7.11%
Agree	4	7.89%
Neutral	4	8.42%
Disagree		0.53%

Opinion	Count	Percentage
Strongly disagree		2.63%

Interpretation: The frequency table represents the distribution of opinions regarding the statement"Do you agree that AI in Green Supply Chain Management replaces humans?"

The majority of respondents (57.89%) agreed with the statement, suggesting a belief that AI implementation in Green Supply Chain Management could lead to the replacement of human workers to some extent. Additionally, 17.11% of respondents strongly agreed with this idea, providing further support for the notion.

A significant percentage (18.42%) remained neutral, indicating a lack of strong opinion oruncertainty regarding the statement. On the other hand, 10.53% disagreed with the statement, implying skepticism or disagreement with the idea that AI would replace human workers in GreenSupply Chain Management. Only a small fraction (2.63%) strongly disagreed with the statement.

Overall, the data suggests a mixed perception of the impact of AI on human employment in GreenSupply Chain Management, with a majority expressing agreement with the possibility of AI replacing humans, but with a notable portion expressing neutrality or disagreement with this notion.

8.　　Is AI in Green Supply Chain Management good for the environment?

a.　　Yes

b.　　No

Opinion	Count	Percentage
Yes	3	7.78%
No	8	2.22%

Interpretation: The frequency table illustrates the distribution of opinions regarding the statement"Is AI in Green Supply Chain Management good for the environment?"

A significant majority of respondents (77.78%) answered affirmatively, indicating that they believe AI in Green Supply Chain Management is beneficial for the environment. This suggests a strong positive perception of the potential environmental benefits of integrating AI into green supply chain practices.

Conversely, a smaller proportion of respondents (22.22%) answered negatively, indicating skepticism or disagreement with the idea that AI in Green Supply Chain Management is good forthe environment.

Overall, the data suggests a predominantly positive perception of the environmental impact of AIimplementation in Green Supply Chain Management, with a minority expressing a contrary opinion.

9.   What do you think that can AI offer in terms of waste reduction in the supply chain management?

a.   Yes

b.   No

Opinion	Count	Percentage
Yes	5	2.59%
No		.41%

Interpretation: The frequency table displays the distribution of opinions regarding the question "What do you think AI can offer in terms of waste reduction in supply chain management?"

A vast majority of respondents (92.59%) answered affirmatively, indicating their belief that AI canindeed offer solutions for waste reduction in supply chain management. This overwhelming agreement suggests a strong positive perception of AI's potential to address waste reduction challenges within supply chains.

Conversely, a small proportion of respondents (7.41%) answered negatively, suggesting skepticismor disagreement with the idea that AI can contribute to waste reduction efforts in supply chain management.

Overall, the data indicates a widely held belief among respondents in the efficacy of AI in addressing waste reduction challenges within supply chain management, with only a minority expressing a contrary opinion.

10.   AI help optimize energy usage in a Green Supply Chain. What is your opinion on this statement?

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

Opinion	Count	Percentage
Strongly Agree	0	3.51%
Agree	2	0.27%
Neutral	7	2.97%
Disagree		.70%

Interpretation: The frequency table represents the distribution of opinions regarding the statement "AI helps optimize energy usage in a Green Supply Chain."

The majority of respondents (70.27%) agreed with the statement, indicating a belief in the capability of AI to optimize energy usage within a Green Supply Chain. Additionally, 13.51% of respondents strongly agreed with the statement, providing further support for this idea.
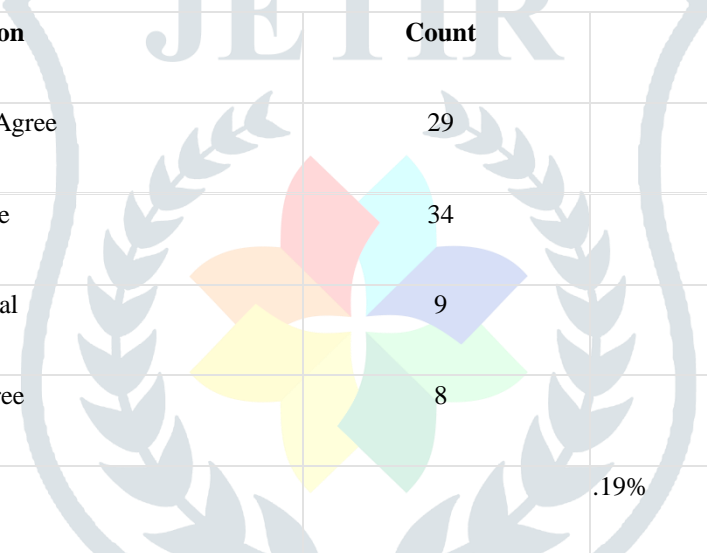
A notable percentage of respondents (22.97%) remained neutral, suggesting a lack of strong opinion or uncertainty regarding the statement. On the other hand, only a small fraction (2.70%) disagreed

with the statement, implying skepticism or disagreement with the notion that AI can effectively optimize energy usage in a Green Supply Chain.

Overall, the data suggests a predominantly positive perception of AI's role in optimizing energy usage within Green Supply Chains, with a minority expressing neutrality or disagreement with thisconcept.

11.   Al play in enhancing transparency in the Green Supply Chain. Scale your opinion.

a.   Strongly Agree

b.   Agree

c.   Neutral

d.   Disagree

e.   Strongly disagree

Opinion	Count	Percentage
Strongly Agree	29	34.52%
Agree	34	40.48%
Neutral	9	10.71%
Disagree	8	9.52%
Strongly disagree		.19%

Interpretation: The frequency table illustrates the distribution of opinions regarding the statement"AI plays a role in enhancing transparency in the Green Supply Chain."

A notable portion of respondents (34.52%) strongly agreed with the statement, indicating a strongbelief in the role of AI in enhancing transparency within the Green Supply Chain. Additionally, 40.48% of respondents agreed with the statement, further supporting the idea.

A smaller percentage of respondents (10.71%) remained neutral, suggesting a lack of strong opinion or uncertainty regarding the statement. Furthermore, 9.52% of respondents disagreed withthe statement, indicating skepticism or disagreement with the notion that AI enhances transparencyin the Green Supply Chain. Only a very small fraction (1.19%) strongly disagreed with the statement.

Overall, the data suggests a generally positive perception of AI's role in enhancing transparency within the Green Supply Chain, with a significant portion expressing agreement. However, there is also a portion that remains neutral or disagrees with this notion.

CONCLUSION

The data reveals a clear consensus among respondents regarding the potential benefits of AI in revolutionizing supply chain management towards sustainability and efficiency. Most respondents'express agreement that AI can significantly contribute to reducing carbon footprint, promoting sustainable practices, and optimizing resource usage. This acknowledgment underscores a growingawareness within the industry of the role AI can play in addressing pressing environmental concerns and improving operational performance.

Moreover, respondents also highlight the importance of AI in enhancing decision-making processes, particularly in real-time scenarios. The belief that AI can help businesses adapt quicklyto changing information and make key decisions reflects a recognition of AI's ability to analyze vast amounts of data efficiently and provide actionable insights in dynamic supply chain environments.

However, amidst the optimism surrounding AI adoption, there are notable concerns regarding the need to address AI algorithms carefully to ensure trust and regulatory compliance. This apprehension suggests a recognition of the potential risks associated with AI implementation, including issues related to bias, transparency, and ethical considerations. It underscores the importance of developing robust governance frameworks and ethical guidelines to mitigate these risks and build trust in AI-driven decision-making processes.

In conclusion, while there is widespread optimism about the transformative potential of AI in supply chain management, there is also a recognition of the need for responsible and ethical AI deployment. By addressing concerns related to algorithmic transparency, fairness, and regulatory compliance, businesses can harness the full potential of AI to drive sustainability, efficiency, and innovation in supply chain operations.

Overall, the data reflects a widespread recognition of the potential benefits of AI in various aspects of supply chain management, particularly in enhancing sustainability, decision-making, and efficiency. Most respondents' express agreement with statements suggesting that AI can contribute positively to reducing carbon footprint, promoting sustainable practices, optimizing resource usage, and improving real-time decision-making. However, there are also concerns expressed regarding the need to carefully address AI algorithms to ensure trust and regulatory compliance. Despite some scepticism and neutral responses, the overwhelming agreement on the potential of AI indicates a strong inclination towards adopting AI technologies in supply chain management for achieving sustainability goals and operational efficiency. Therefore, it can be concluded that there is a significant consensus on the transformative role of AI in shaping the future of sustainable supply chain management.However, amidst the optimism surrounding AI adoption, there are notable concerns regarding the need to address AI algorithms carefully to ensure trust and regulatory compliance. This apprehension suggests a recognition of the potential risks associated with AI implementation, including issues related to bias, transparency, and ethical considerations. It underscores the importance of developing robust governance frameworks and ethical guidelines to mitigate these risks and build trust in AI-driven decision-making processes.

In conclusion, while there is widespread optimism about the transformative potential of AI in supply chain management, there is also a recognition of the need for responsible and ethical AI deployment. By addressing concerns related to algorithmic transparency, fairness, and regulatorycompliance, businesses can harness the full potential of AI to drive sustainability, efficiency, andinnovation in supply chain operations.

Overall, the data reflects a widespread recognition of the potential benefits of AI in various aspectsof supply chain management, particularly in enhancing sustainability, decision-making, andefficiency. Most respondents' express agreement with statements suggesting that AI can contributepositively to reducing carbon footprint, promoting sustainable practices, optimizing resource usage, and improving real-time decision-making. However, there are also concerns expressed regarding the need to carefully address AI algorithms to ensure trust and regulatory compliance. Despite some scepticism and neutral responses, the overwhelming agreement on the potential of AI indicates a strong inclination towards adopting AI technologies in supply chain management for achieving sustainability goals and operational efficiency. Therefore, it can be concluded that there is a significant consensus on the transformative role of AI in shaping the future of sustainablesupply chain management.

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