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The role of information technology in shaping sustainable supply chain practices: Moderating role of artificial intelligence

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ABSTRACT

The current study aimed to shed light on the moderating role of artificial intelligence (AI) on the relationship between technology specifically big data analysis, resource optimization, process automation, collaboration and communication, lifecycle, and impact assessments and supply chain management (SCM). The study adopted a correlational and moderation (interaction) design, which seeks to examine the connections among variables and determine whether AI moderates (modifies the strength or direction of) the relationship between technology and supply chain management outcomes. A quantitative methodology was employed, with a total of 288 operational managers from 2,800 food manufacturing organizations in Jordan completing an online questionnaire. SPSS was used to screen and analyze the collected data. The analysis results indicated that artificial intelligence functions as a key linking mechanism to strengthen the relationship between information technology and sustainable supply chain management in Jordanian food manufacturing organizations. The research provides practical support for organizations aiming to utilize AI to develop resilient, efficient, and environmentally friendly supply chains in resource-limited areas.

Contribution/Originality: The novelty of the presented research is that it is devoted to the particular moderating effect of artificial intelligence (AI) within the framework of sustainable supply chain management (SCM) in the food manufacturing sector in Jordan, which remains understudied in the literature. Although past studies have already discussed technological adoption or sustainability individually, this work is the first to explore how AI improves key technological aspects, big data analysis, resource optimization, and automation to foster sustainability.

1. INTRODUCTION

Supply chain management (SCM) operations now operate significantly differently because of technological advancements in this field. The typical supply chain operation depended extensively on manual work and paper documentation, along with segregated information technologies that resulted in time-consuming operations and unclear monitoring. Current digital technology enables companies to implement multiple systems, including enterprise resource planning (ERP) systems and cloud computing, together with real-time tracking solutions to enhance their supply network visibility, coordination, and responsiveness. Lele, Kumari, and White (2023) argued that organizations use advanced technology for better inventory management, streamlined procurement operations, and enhanced market response, which lead to increased efficiency and improved customer satisfaction. Data-driven SCM systems emerge from evolving technological capabilities to provide superior capabilities for demand forecasting, planning, and risk management.

According to Redzeb (2024), AI operates as a distinct element of emerging technologies to enhance supply chain management by accelerating its transformative processes. The analysis of large data quantities through AI algorithms reveals crucial patterns and future forecast outcomes to generate autonomous decisions, which boost operational flexibility. AI predictive analytics systems help organizations predict market trends systematically through data analysis for better route planning and inventory management. Mohan, Patle, and Pawar (2024) noted that artificial intelligence enables supply chain automation through its implementation of robotics and intelligent systems, which support several operational procedures from purchasing to warehouse logistics. The implementation of artificial intelligence offers both minimized operational expenses and fewer human errors while providing companies with proactive approaches to sustainability and risk reduction, along with innovation potential. AI will further develop in supply chain management to create smarter supply chains that possess both resilience and sustainability worldwide (Riad, Naimi, & Okar, 2024).

Modern research on technological integration and sustainable supply chains has failed to explain how artificial intelligence affects the relationship between these two elements in food manufacturing companies throughout Jordan. The existing literature only presents separate viewpoints concerning technological adoption or sustainability, while lacking analysis of AI's precise effects on these dynamics and its specific impact on operational management approaches. The relationship between technology and sustainability remains insufficiently studied in both developing nations and resource-limited environments because local factors influence implementation and sustainability outcomes. The proposed research examines how artificial intelligence influences different technological elements, including big data analysis, resource optimization, and automation, to affect sustainable supply chain management in an underexplored geographical and industrial context.

From the argument above, this research aims to uncover the moderating role of AI on the relationship between technology and sustainable supply chain practices within food manufacturing organizations in Jordan during the fiscal years 2024-2025. Researchers have considered aspects of technology in supply chain management, including big data analysis, resource optimization, process automation, collaboration and communication, and lifecycle and impact assessments. The perspective of operations managers within the selected organizations has been taken into account.

It is expected that the current study will contribute to the existing literature by analyzing the moderating effect of artificial intelligence (AI) on the relationship between technology and sustainable supply chain management (SCM) in Jordan's food manufacturing industry. While most studies examine what technology or AI can do in general, this study investigates how AI enhances big data analysis, resource optimization, and automation for more sustainable outcomes. By focusing on an area and industry that are less extensively studied, the research addresses a significant gap and provides detailed insights into how AI influences supply chain operations.

2. LITERATURE REVIEW

2.1. Sustainability in Supply Chain Management (SCM)

Ngo, Quang, Hoang, and Binh (2024) stated that supply chain management (SCM) has emerged as a fundamental business operation that enables organizations to optimize product and information flows, as well as financial flows, from suppliers to customers. A system of strategic planning, sourcing, production, logistics, and distribution functions exists to deliver products according to customer needs at reduced costs while creating maximum value. Alzghoul, Khaddam, and Al-Kasasbeh (2024) confirmed that the implementation of effective SCM systems results in superior product quality, faster deliveries, and reduced inventory costs, coupled with enhanced market adaptability. These elements help companies maintain their market leadership roles in today's fast-moving global markets.

According to Awad et al. (2023), SCM stands for an integrated method that controls and implements supply chain operations to generate net value, build a competitive infrastructure, and utilize worldwide logistics systems while matching supply to demand and measuring performance on a global scale. SCM administrators manage all stages, from raw material sourcing through manufacturing, transportation, storage, and distribution, to deliver products and services with maximum effectiveness. SCM establishes partner collaboration to maximize resource efficiency, minimize costs, and improve customer satisfaction through continuous coordination of supply chain stages (Hashem, 2020; Wreikat & Awamleh, 2025).

Carissimi, Creazza, and Colicchia (2023) argued that modern organizations emphasize sustainability in supply chain operations because they aim to achieve financial goals while protecting environmental ecosystems and communities. Organizations now require essential supply chain integration of sustainable practices because they face increasing pressure from various groups, including regulators, consumers, and stakeholders, to reduce their environmental impact. Sustainability in supply chain management requires companies to implement green sourcing processes, waste reduction methods, and fair labor standards at every level of the supply chain. Organizations that prioritize sustainability tend to enhance their brand reputation and customer retention, especially in markets where consumer awareness of social equity and environmental preservation is growing (Esan, Ajayi, & Olawale, 2024).

Daghighi and Shoushtari (2023) argued that the practice of sustainability in supply chain management (SCM) requires implementing strategies that ensure universal environmental health, social well-being, and economic sustainability for the entire supply chain structure. The practice includes sourcing raw materials from renewable resources, optimizing supply chain logistics to minimize environmental impact, and maintaining continuous ethical treatment of workers (Yontar, 2023). The main objective of sustainable SCM is to establish supply chains that demonstrate resilience through environmental adaptation and the maintenance of social responsibility and operational profitability. Sustainable supply chain management practices enable businesses to reduce operational risks while respecting environmental regulations and creating new sustainable solutions, thereby making their global contributions more sustainable (Mohsen, 2023).

2.2. Technology for Better SCM

From the perspective of Abou Kamar, Albadry, Sheikhelsouk, Ali Al-Abyadh, and Alsetoohy (2023), business operations have undergone revolutionary changes due to the implementation of technological solutions for improved supply chain management, which enhances observation capabilities, operational speed, and responsiveness. Companies utilize advanced digital tools such as enterprise resource planning (ERP) systems, real-time tracking, and data analytics to improve their inventory monitoring and shipment tracking capabilities, as well as to make better demand predictions (Amini & Jahanbakhsh Javid, 2023). The combined deployment of technology results in better supply chain decisions while shortening delays, decreasing mistakes, and maximizing resource use throughout the entire supply chain. Organizations gain a superior marketplace position through their enhanced market responsiveness because they achieve faster deliveries and decreased operational expenses (Hashem, 2025; Mohsen, 2023).

Zelbst, Yang, Green, and Sower (2024) noted that the adoption of modern technological solutions in supply chain management fosters better collaboration opportunities among supply chain partners. Blockchain technology serves as a tool for supply chain monitoring because it provides full product authentication alongside ethical acquisition documentation. Through Internet of Things (IoT) devices, companies obtain live data regarding product status and position to execute preventive maintenance and risk mitigation (Garcia-Buendia, Moyano-Fuentes, Maqueira, & Avella, 2023). The analysis of large datasets by artificial intelligence (AI) and machine learning algorithms enables predictive disruption analysis, route optimization, and inventory level optimization. Companies can establish intelligent and durable supply chains that handle customer needs while reducing expenses thanks to these modern innovations (AL-Shboul, 2023).

Many aspects of technology have contributed to increasing the efficiency and operational effectiveness of SCM. Among these aspects are:

- Big Data Analysis

Li (2024) noted that big data analysis systems require organizations to gather, process, and analyze enormous datasets produced from supply chain operations. The data analysis tools in SCM provide organizations with important insights into customer demand patterns, supplier operations, transportation efficiency, and inventory data. Advancements in analytics, together with machine learning, enable businesses to predict demand more accurately while identifying supply chain disruptions, allowing them to base decisions on data for optimizing supply chain execution. Such practices result in quicker response times, cost savings, and enhanced market leadership in rapidly changing market conditions.

- Optimizing resource use

According to Ojadi, Odionu, Onukwulu, and Owulade (2024), technology adoption enables the efficient management of materials, labor, and transportation elements in supply chain operations. Modern technology, including advanced planning systems, allows organizations to track resources in real-time with the help of IoT devices and achieve continuous monitoring of resource utilization. The system reduces waste by preventing stockout situations, avoiding overstocking, and optimizing asset usage. Optimization software for delivery routes helps companies reduce transportation costs and air pollution, while inventory control programs adjust stock levels to meet precise requirements, thereby improving supply chain efficiency.

- Process Automation

Chinnathai and Alkan (2023) confirmed that business processes in supply chain management are automated through the implementation of robotics in combination with AI and ERP systems technology. The automation of procurement, order processing, inventory management, and logistics activities leads to faster operations while reducing human errors. Automated order fulfillment systems decrease processing times to improve inventory levels and customer satisfaction. By automating routine procedures, businesses save resources for strategic work, make their operations faster, and reduce costs.

- Collaboration and communication

De Feo and Ferrara (2024) stated that supply chain management effectiveness depends significantly on complete collaboration and communication between suppliers, partners, and internal teams. Real-time information sharing, transparency, and coordination, along with technological tools such as cloud-based platforms and shared dashboards with instant messaging capabilities, become possible. The supply chain network achieves better relationships through efficient communication, which helps prevent delays and miscommunications. When stakeholders collaborate effectively, they maintain alignment of their objectives and schedules, leading to supply chain operations that are both resilient and responsive.

- Lifecycle and impact assessments

According to El Haouat, Essalih, Bennouna, Ramadany, and Amegouz (2024), technology organizations have full access to conduct lifecycle assessments (LCAs), which provide detailed evaluations of environmental and social impacts throughout their supply chain operations. The analysis of data points from raw materials sourcing through manufacturing and transportation, alongside disposal, helps businesses identify all areas that impact environmental sustainability. These assessments offer companies valuable information for selecting suppliers, designing products, and developing packaging, thereby promoting responsible supply chain management and long-term sustainability.

2.3. Artificial Intelligence in SCM

Patrício, Varela, and Silveira (2025) stated that supply chains have fundamentally changed through the application of artificial intelligence technology because it delivers enhanced decision-making tools that improve operational efficiency and reaction time. AI technologies, including machine learning, natural language processing, and computer vision, emerged because of data expansion and growing computing power to help supply chains perform demanding dataset analysis and improve both demand prediction and inventory management activities. Through AI-based analytics, companies have become able to discover patterns that help them make proactive responses instead of relying solely on reactive measures. The implementation of AI as a tool for supply chain management has increased operational speed and decreased expenses, making it a vital component of contemporary supply chain systems (Beyaria, Hashemb, & Alrusainic, 2024; Tariq, 2023).

Yadav, Garg, and Sachdeva (2024) noted that organizations rapidly adopt AI for supply chains since they understand its competitive benefits. AI implementations that automate demand forecasting, predictive maintenance, and intelligent routing strengthen operational effectiveness. AI robots, along with autonomous vehicles, continue to gain ground in warehouses and logistics facilities because they increase speed through operations while reducing human errors. Suppliers and customers can receive real-time assistance from chatbots and virtual assistants, which help with their communication needs. Artificial intelligence solutions are now accessible to small and medium-sized enterprises due to decreasing costs and increased availability, enabling these organizations to compete effectively in modern markets (Qi, Shen, & Xu, 2023).

Rathor (2023) confirmed that the future promises expanded supply chain operation innovation combined with improved resilience through the adoption of AI technology. The combination of AI with supply chains now enables organizations to track entire operations from beginning to end and establish risk oversight alongside sustainability-based projects. AI systems will evolve to handle more autonomous decision-making processes, thus eliminating human involvement to assist supply chains in fast adaptation to changing conditions. The rising adoption of AI in supply chain management generates new privacy issues and ethical problems and demands workers with specific AI knowledge (Rane, Choudhary, & Rane, 2024).

From the literary argument and previous studies above, researchers have developed a conceptual framework that can formulate hypotheses of study, as shown in Figure 1.

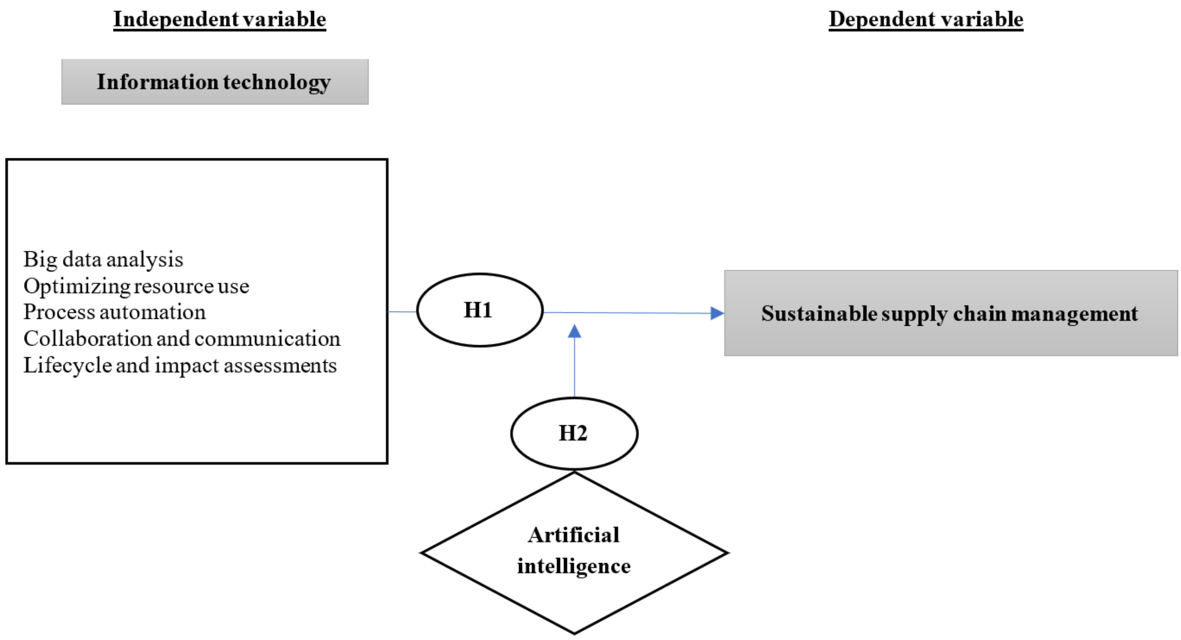

Figure 1. Conceptual framework.

Note: Li (2024); Ojadi et al. (2024) and El Haouat et al. (2024).

From the model above, the following set of hypotheses was reached:

H_1: Information technology is capable of shaping sustainable supply chain management within food manufacturing organizations in Jordan.

H_2: Artificial intelligence moderates the relationship between information technology and sustainable supply chain management within food manufacturing organizations in Jordan.

It is worth mentioning here that the current study was based on the premises of the Technology-Organization-Environment (TOE) Framework. Organizations adopt technological innovations because of three fundamental elements, which include technology itself, as well as organizational and environmental aspects. In this study, the technological component encompasses big data analysis, automation, and AI. Organizational elements such as operational managers' perceptions and readiness, together with environmental elements such as regulatory requirements and market competition, influence the integration process of AI systems with sustainability practices. AI functions as a tool for understanding its effects on how technology affects sustainability outcomes.

It was expected from the current study to have both practical and theoretical implications. From a theoretical perspective, the research contributes to the understanding of artificial intelligence as a moderation variable, demonstrating its ability to enhance sustainable supply chain practices. The study shows that AI acts as a strategic tool beyond being merely a technological feature, as it improves existing IT resources to advance theoretical frameworks regarding technology-sustainability connections in supply chain management. From a practical perspective, food manufacturing organizations in Jordan should allocate their strategic funds to develop advanced data analytics and impact assessment capabilities, as these technologies are most effective for promoting sustainability. Companies implementing this approach will have better capabilities to make environmentally conscious decisions and optimize resources and supply chain sustainability.

3. METHODS AND MATERIALS

3.1. Methodological Approach

Researchers have resorted to quantitative methodology in the current study in order to collect primary data for analysis. Quantitative methodology was found to be more suitable for collecting data from a larger sample size. This has helped to guarantee generalized results.

3.2. Tool of Study

A questionnaire was developed to collect essential primary data. The questionnaire included items related to study variables, such as Big Data Analysis, resource optimization, process automation, collaboration and communication, lifecycle and impact assessments, as sub-variables of the independent variable. Additionally, SCM sustainability was considered the dependent variable, with AI serving as the moderating variable.

The questionnaire required a validity test, which was conducted through arbitration. A group of specialized scholars and academics in the field arbitrated the questionnaire; items that received 80% approval were retained. Regarding reliability and consistency, Cronbach's Alpha test was employed, as shown in Table 1. The results indicated that all alpha values were higher than 0.70, demonstrating that the study tool was reliable and consistent.

The Cronbach's alpha results in Table 1 demonstrate high reliability across all constructs, with values ranging from 0.848 to 0.935. The reliability measurement for "Process Automation" reached its highest value (α = 0.927), indicating consistent measurement of this variable through its items. The internal consistency of "Sustainable Supply Chain Management" variables reached an excellent level according to Cronbach's alpha (α = 0.935). The measurement variables "Optimizing Resource Use" (α = 0.905) and "Collaboration and Communication" (α = 0.901) proved to have strong reliability levels in their ability to measure their intended concepts effectively. Internal consistency analysis through alpha values showed that "Big Data Analysis" and "Lifecycle and Impact Assessments" both reached 0.859, indicating good stability within these variables. The results from this study establish the reliability of measurement scales, allowing researchers to have confidence in the stable data they will use for further analysis.

3.3. Population and Sampling

The population of the study consisted of 2,132 operation managers within 2,800 food manufacturing organizations operating in Jordan during the fiscal year 2024-2025. A convenience sample was chosen to represent the population, with a total of 326 operation managers. After the data collection process, researchers were able to gather primary data from 288 operation managers, indicating a response rate of 88.3%, which is statistically acceptable.

Table 1. Alpha value.

Variable	α
Big data analysis	0.859
Optimizing resource use	0.905
Process automation	0.927
Collaboration and communication	0.901
Lifecycle and impact assessments	0.859
Sustainable supply chain management	0.935
Artificial intelligence	0.848

A number of careful techniques were used in the study to avoid bias. Using data from a large number of operation managers (288) through quantitative research makes it possible to generalize the findings more widely and overcome potential selection bias. The items in the questionnaire were approved after expert arbitration, as long as they reached 80% agreement, ensuring the questionnaire was valid and did not have any construct bias. Cronbach's Alpha confirmed that every construct in the study was reliable since its internal consistency was greater than 0.70. Since a convenience sample was taken, the high response rate of 88.3% indicates that non-response bias did not seriously influence the results.

All respondents were asked to give their informed and voluntary consent before participating in this study. Participants were informed about the research's purpose, their involvement, and their right to withdraw at any time without consequences. The survey was designed to ensure confidentiality and anonymity, encouraging honest responses. The material was reviewed by specialists and experts to obtain ethical approval and to prevent discomfort or harm. With a response rate of 88.3%, it indicates a willingness to participate and affirms our commitment to respecting their involvement. Throughout the research process, the researchers adhered to ethical guidelines to ensure responsible participation, thereby enhancing the study's integrity and reliability.

3.4. Screening and Analysis

Statistical Package for Social Sciences (SPSS) was used to screen and analyze the collected primary data. Frequencies and percentages of sample demographics were calculated. Additionally, means (μ) and standard deviations (σ) were determined for questionnaire items. Regarding hypotheses, multiple regression analysis and Variance Inflation Factor (VIF) were employed to test the hypotheses, as detailed later in the analysis section. The standard statistical techniques applied in SPSS included multiple regression and VIF checks to address multicollinearity and control for confounders. Using these approaches together ensured an unbiased and reliable study with valid results.

4. ANALYSIS AND RESULTS

4.1. Demographics

Results of individuals' responses to demographics are presented in Table 2. It was observed that the majority of participants were males, constituting 72.2% of the sample, and held an MA degree as their educational qualification, accounting for 51.7% of the sample. Additionally, demographic analysis indicated that 44.4% of the participants had more than 12 years of experience.

Table 2. Demographic results.

Demographic variable	f	%
Gender		
Male	208	72.2
Female	80	27.8
Educational level		
BA	53	18.4
MA	149	51.7
PhD	86	29.9
Experience		
Less than 5 years	14	11.8
6-11	126	43.8
More than 12 years	128	44.4
Total	**288**	**100.0**

Table 3. Questionnaire analysis.

Item	μ	σ
Big data analytics facilitates enhanced visibility of the supply chain.	3.903	0.990
It can provide insights into resource usage.	4.000	0.981
It can effectively monitor the performance of the supply chain.	3.781	1.004
It can help in presenting insights based on accurate forecasting.	4.049	0.954
The accurate forecast supports all possible risks and crises.	3.861	0.992
Big data analysis	**3.919**	**0.787**
IT-based supply chain optimization improves routes and logistics.	4.267	0.848
Through technology, fuel consumption can be better controlled.	3.990	1.067
IT tools can locate the best delivery routes and minimize distances.	4.229	0.794
Through minimizing distance, it helps reduce the carbon footprint.	4.174	0.961
It can analyze supplier data and highlight sourcing options.	4.094	0.802
Optimizing resource use	**4.151**	**0.767**
IT integration automates smart contracts within sustainability criteria.	4.201	0.819
Operations are ensured that they comply with sustainability standards.	4.240	0.827
Inventory management is much simpler and more effective with sustainability policies.	4.111	0.771
There is a more efficient use of resources through IT.	4.267	0.884
Smart SC can help minimize environmental impact by automating repetitive tasks.	3.965	0.962
Process automation	**4.157**	**0.753**
Stakeholders in SC are better communicated.	4.337	0.793
Collaboration is facilitated through automatically connecting businesses with sustainable suppliers.	4.062	0.935
Constant collaboration guarantees the sharing of sustainable practices.	4.000	0.984
Collective goals can be analyzed to improve efforts toward sustainability.	4.003	0.820
Recommendations and progress tracking are communicated on the clock.	4.267	0.831
Collaboration and Communication	**4.134**	**0.741**
Environmental impact of products can be assessed easily.	3.865	0.782
IT can automate products from production to disposal.	4.052	0.903
Insights on redesigning products help increase sustainability.	4.208	0.875
IT suggests new sustainability strategies for SC.	4.208	0.786
Informed decisions are easy to obtain for better sustainability efforts.	3.927	0.980
Lifecycle and Impact Assessments	**4.052**	**0.694**
Sustainable supply chain management can be achieved through accurate monitoring of operations.	4.035	1.078
The accurate monitoring can lead to informed decisions.	3.944	1.087
Informed decisions can be made in accordance with sustainability efforts.	4.090	1.042
Developing a sustainable supply chain management enhances organizational performance.	3.969	1.090
Reaching a sustainable supply chain management can lead to a decrease in the carbon footprint.	4.222	1.025
Sustainable supply chain management	**4.052**	**0.948**
Technology can enhance sustainable supply chain management.	3.854	0.851
IT can leverage data and decisions to optimize resources.	4.045	0.960
IT can be part of transparent sustainability efforts.	4.194	0.950
Businesses can develop their sustainability initiatives based on AI operations.	4.229	0.811
AI tools facilitate better management of the supply chain in a timely manner.	3.990	0.954
Artificial intelligence	**4.062**	**0.715**

4.2. Questionnaire Results

Mean (μ) and standard deviation (σ) were calculated based on individuals' responses to the questionnaire. It was observed that all statements and variables scored a mean higher than the scale's midpoint of 3.00. This indicates that the questionnaire content was positively received by participants. The highest-scoring variable, 'process automation,' had a mean of 4.15/5.00, while the lowest, 'big data analysis,' also received a positive score with a mean of 3.91/5.00. See Table 3.

4.3. Multicollinearity Test

VIF and tolerance computations were performed on the independent variables to identify potential multicollinearity. These computations led to findings in Table 4. All VIF values in the table are below 10, and all tolerance values are above 0.10, indicating no evidence of multicollinearity in the data.

Table 4. VIF.

Variable	Tolerance	VIF
Big data analysis	0.486	2.058
Optimizing resource use	0.400	2.502
Process automation	0.259	3.854
Collaboration and communication	0.279	3.583
Lifecycle and impact assessments	0.429	2.333

4.4. Hypotheses Testing

Multiple regression was used to test H1, which stated that *information technology is able to shape sustainable supply chain management within food manufacturing organizations in Jordan*, as shown in Table 5. The results indicated a correlation coefficient of r = 0.579, suggesting a strong and positive relationship between the independent and dependent variables. Additionally, 33.5% of the variation in the dependent variable was attributed to the independent variables. The F value was also significant at the 0.05 level, indicating that information technology can influence sustainable supply chain management within food manufacturing organizations in Jordan.

Table 5. H1 Testing.

H1: Information technology is capable of shaping sustainable supply chain management within food manufacturing organizations in Jordan.								
		Unstandardized coefficients					**R**	**R^2**
Model		**B**	**Std. error**	**β**	**t**	**Sig.**		
1	(Constant)	0.660	0.303		2.181	0.030	0.579	0.335
	Big data analysis	0.425	0.084	0.353	5.061	0.000		
	Optimizing resource use	0.023	0.095	0.018	0.239	0.811		
	Process automation	-0.045	0.120	-0.036	-0.374	0.709		
	Collaboration and communication	0.192	0.118	0.150	1.635	0.103		
	Lifecycle and impact assessments	0.253	0.101	0.185	2.498	0.013		

Note: B (Unstandardized Coefficients)/ Std. error (Standard Error)/ β (Standardized Coefficients)/ t (t-value)/ Sig. (p-value or Significance Level)/ R (Correlation coefficient)/ R^2 (Coefficient of Determination).

Table 6 shows that there is a statistically significant influence of information technology and sustainable supply chain management, with a value of ($R^2 = 0.303$, $p \leq 0.05$). In the second phase, the artificial intelligence variable is introduced, and it is discovered that it contributes $\Delta R^2 = 1.5\%$ to the overall explanatory power, which is a substantial increase.

In the third phase, the interaction between artificial intelligence and the information technology variable is introduced, and it is found that it contributes $\Delta R^2 = 1\%$ to the overall explanatory power, which is also significant. This indicates that artificial intelligence moderates the relationship between information technology and sustainable supply chain management within food manufacturing organizations in Jordan.

Table 6. Testing H2.

H2: Artificial Intelligence Moderates the Relationship Between Information Technology and Sustainable Supply Chain Management Within Food Manufacturing Organizations in Jordan									
				Std. error	Change statistics				
Model	R	R square	Adjusted R square	of the estimate	R square change	F change	df1	df2	Sig. F change
1	0.551[a]	0.303	0.301	0.79274	0.303	124.381	1	286	0.000
2	0.564[b]	0.318	0.313	0.78574	0.015	6.122	1	285	0.014
3	0.572[c]	0.328	0.320	0.78145	0.010	4.137	1	284	0.043

ANOVA						
Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	78.166	1	78.166	124.381	0.000[b]
	Residual	179.733	286	0.628		
	Total	257.899	287			
2	Regression	81.945	2	40.973	66.365	0.000[c]
	Residual	175.954	285	0.617		
	Total	257.899	287			
3	Regression	84.472	3	28.157	46.110	0.000[d]
	Residual	173.427	284	0.611		
	Total	257.899	287			

Note: a. Predictors: (Constant), ind.
b. Predictors: (Constant), ind, Artificial intelligence.
c. Predictors: (Constant), ind, Artificial intelligence, mod.

4.5. Discussion

In the current study, researchers aimed to shed light on the moderating role of artificial intelligence (AI) in the relationship between technology specifically big data analysis, resource optimization, process automation, collaboration and communication, lifecycle, and impact assessments and supply chain management (SCM). A total of 288 operation managers from 2,800 food manufacturing organizations in Jordan completed an online questionnaire. SPSS was used to screen and analyze the collected primary data. The analysis results indicated acceptance of the hypotheses, demonstrating that artificial intelligence moderates the relationship between information technology and sustainable supply chain management within food manufacturing organizations in Jordan.

In addition to that, it was observed that H2 was accepted, and it appeared that artificial intelligence moderates the relationship between information technology and sustainable supply chain management within food manufacturing organizations in Jordan. Artificial intelligence functions as an essential linking mechanism to strengthen the relationship between information technology and sustainable supply chain management in Jordanian food manufacturing organizations. Organizations achieve operational optimization through the integration of existing IT systems with artificial intelligence to improve decision-making and proactive societal and environmental responses. AI enhances the capabilities of big data analysis, lifecycle assessments, and collaboration platforms, providing organizations with better tools to identify operational inefficiencies, make accurate predictions, and implement eco-friendly practices professionally. These findings are consistent with Tariq (2023), Qi et al. (2023), and Rathor (2023), who argued that the AI-enabled relationship between IT and supply chain management fosters sustainable practice implementation and reduces waste generation through supply chain transparency. The combination of IT and sustainable supply chain management improves sustainability performance levels through the enabling power of AI within the food manufacturing sector in Jordan.

Among the adopted variables, it was noted that big data analysis scored the highest influence with B= .425. Through big data analysis, supply chains obtain better operational performance since it provides complete data about market developments along with environmental impact information. Through this technology, businesses gain the ability to detect operational deficiencies, make accurate demand predictions, and reduce inventory needs and waste amounts, thereby constructing data-centric decisions that minimize environmental effects. This was agreed upon by Li (2024), who noted that an inspection of supply chain data helps businesses identify social responsibility and environmental compliance risk areas, leading to more sustainable operational practices.

In the second rank, lifecycle and impact assessments scored B= .253. The complete lifecycle and impact assessment analyze environmental, social, and economic effects on products and processes, starting from extraction to end disposal. Organizations gain valuable insights into essential improvement areas through such assessments, which lead them to develop sustainable products while decreasing their negative footprints. El Haouat et al. (2024) agreed with these results, adding that a thorough understanding through this approach enables wise choices as well as eco-friendly design practices to incorporate sustainability considerations into supply chain strategies.

The third rank was for the benefit of collaboration and communication with B= 0.192. Modern collaboration methods among members of supply chain networks enable partners to achieve transparency and efficiency through mutual sustainability goal pursuit. The efficient use of advanced communication systems enables immediate information exchange, which supports team coordination for environmental improvements, better social welfare, and strengthened ethical strategies. The combination of strong collaboration supports innovation development for sustainability while preserving social and environmental standards across the entire supply chain, as agreed upon by De Feo and Ferrara (2024).

As for the fourth rank, optimizing resource use scored B= .023. Companies maximize resource utilization by establishing advanced technologies and deployment strategies that help decrease material usage, as well as energy and water consumption during supply chain operations. The reduction of resources becomes more efficient because this practice minimizes both environmental effects, such as pollution and resource exhaustion, and operational expenses. Ojadi et al. (2024) agreed on the same idea, confirming that sustainable production and consumption practices emerge from this approach, which aids responsible resource utilization and reserves natural resources for future generations.

In the final rank with the least influence, it was observed that process automation scored negatively, with B= -0.045. Business improvement through robotics, digital systems, and artificial intelligence eliminates repetition in supply chain operations. Operational efficiency increases while human errors decrease, and energy consumption is reduced through workflow optimization. Sustainability outcomes from automation depend on how energy sources and implementation methods are utilized because renewable energy-based automation reduces carbon emissions, whereas non-renewable power usage could lead to higher energy requirements and electronic waste. Chinnathai and Alkan (2023) also noted that effective control of automation technologies enables maximum sustainability benefits to be achieved.

5. CONCLUSION AND RECOMMENDATIONS

This research demonstrated that artificial intelligence functions as a vital regulator that enhances the relationship between different technological tools and sustainable supply chain management practices within food manufacturing establishments in Jordan. The research shows how big data analysis, together with lifecycle impact assessments, remains the leading technological factors in sustainability development by supporting data-based decisions, environmental safety, and environmentally friendly product creation. Supply chain transparency and innovation are formed through mutual collaboration and comprehensive communication efforts. The positive impact of resource optimization remains small compared to the more intricate effects of process automation on sustainability outcomes unless proper management measures are taken. The implementation of AI supplements technological dimensions with significant sustainability potential but requires strategic planning, mainly regarding automation systems, to achieve maximum gains.

Launching from the results and conclusion of the study, the following recommendations are suggested:

1. Organizations should use resources to build sophisticated data analytic capabilities as well as exhaustive impact evaluation processes because these elements demonstrate the maximum potential for sustainability benefits.
2. Companies should develop or enhance digital communication systems that enable stakeholders to share real-time information because collaboration and communication remain essential factors for success.

3. Sustainability objectives throughout the supply chain become more aligned by implementing transparent initiatives and coordinated actions, which produce more effective and cohesive sustainability initiatives.
4. Organizations should thoroughly examine all automation procedures to determine which processes support sustainability, as automation initially produced negative results in this situation.
5. Energy-efficient automation innovation should be prioritized alongside sustainable automation approaches that align with all sustainability objectives to prevent negative effects such as higher energy usage or expenses.

5.1. Limitations of Study

The study's use of self-report online surveys with operation managers results in response bias, which reduces the reliability and universal applicability of the results for Jordanian food manufacturing organizations. Cross-sectional research collects only a single point of data, which hinders researchers' ability to establish cause-and-effect relationships or monitor temporal changes in AI moderation within supply chain systems over time.

5.2. Future Research

Research should adopt long-term observational methods in the future to study AI's time-based effects on sustainable supply chain practices, thereby better revealing temporal influences on these practices. The evaluation scope needs expansion to conduct comprehensive examinations of AI's sustainability impact on food manufacturing supply chains by including suppliers, customers, and regulatory bodies in different operational settings.

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