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Research paper

The Role of Artificial Intelligence Applications in Building Sustainable Supply Chains: The Moderating Role of Achieving Sustainable Development Goals (SDGs)

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Abstract

This Research aims to investigate the significance of the application of Artificial Intelligence in establishing and implementing sustainable supply chains, and to scrutinize the mediating role of the attainment of the Sustainable Development Goals in the pharmaceutical sector in the state of Jordan. This Research was designed based on the Dynamic Capabilities Theory to realize that the application of AI in organizations can improve organizational intelligence, efficiency, and sustainability performance, while the achievement of SDGs can enhance the application of AI in sustainability performance, integrating organizational, natural, and social aspects. The Research used a quantitative methodology with questionnaires, distributed to 412 managers of administrative, technical, and healthcare sections in the industry, out of 500 questionnaires sent to them in total. The Research used a five-point Likert scale in measuring the constructs of AI application, SDG achievement, and sustainability performance of supply chain management in organizations. The Research used SmartPLS version 4 to examine the measurement and structural models, scrutinizing assumptions, robustness, and model fit indexes via bootstrapping and Latent Variable analyses. The reliability test applied indicated high internal consistency across constructs, with values higher than 0.80 for Cronbach's alpha, ensuring the reliability and consistency of the data retrieved, validating the measurement models with theoretical assumptions in the Research. The models were scrutinized via multiple analytical assumptions to avoid any contradictions in data analysis results. The models' assumptions were valid due to consistent analytical results to validate AI, SDG, and sustainability performance in the Research across models and theories applied in this Research on AI application in sustainability performance in the pharmaceutical sector in the state of Jordan with insight support to AI evolving as approving sustainability factor in organizational performance for pharmaceutical organizations in Jordan cornered on the Dynamic Capabilities Theory Assuming AI Application.

Keywords: *Artificial Intelligence (AI), Sustainable Supply Chains, Sustainable Development Goals (SDGs), Pharmaceutical Sector, Jordan*

1. Introduction

The application of artificial intelligence in supply chain management has presented tremendous opportunities that enhance sustainability across different industries. The application of data analysis functions of artificial intelligence supports organizations in achieving efficiency and savings in terms of cost reduction while decreasing the total negative impacts on the environment (Jaradat et al., 2025; Teixeira et al., 2025; Wang & Zhang, 2025). The traditional supply chains, which were considered the causes of large amounts of pollution, resource depletion, and waste, experience a global transition to processes with better impacts on the environment across the globe (Chauhan et al., 2022; Iqbal et al., 2025). In light of these negative aspects that were being experienced in the supply chain, different artificial intelligence solutions, such as machine learning algorithms and natural language processing, were applied to perform ethical inventory and resource management to support sustainability in organizations across different industries (Khan et al., 2025)

In addition, AI makes a substantial contribution to the realization of SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) goals (Raman et al., 2023; Javed et al., 2024; Srivastava et al., 2025). For instance, AI makes the supply chain traceable and collaborative, thus facilitating the green supply chain and circular economy projects (Gallo et al., 2023; Meena et al., 2025). However, there are essential knowledge gaps in understanding the contribution of AI in shaping the performance of the sustainable supply chain, especially in less studied geographic locations such as Jordan and in areas such as the pharmaceutical industry (Al-Khatib, 2022; Al-Olfi et al., 2025).

Despite the demonstrated efficacy of AI in optimizing supply chain functions, the usage of AI technology to advance sustainability has yet to be explored in developing countries (Khan et al., 2024). The importance of AI adoption in implementing observable sustainability goals is yet to be explored in small and medium-sized enterprises in developing countries in terms of adopting AI technology (Liu & Jiang, 2025; Panigrahi et al., 2023). There is a larger need to explore the theoretical constructs between AI adoption and the accomplishment of SDG goals in general, and specifically in the Middle Eastern context, in terms of the adoption of AI technology (Atieh Ali et al., 2024; Behl et al., 2023; Fosso Wamba et al., 2024). As Omoush (2025a) demonstrates, supply-chain resilience mediates performance improvement.

The proposed Research aims to fill the above-mentioned research gaps by exploring the significance of AI applications in establishing a sustainable supply chain in the pharmaceutical companies in Jordan. The proposed Research shall aim to: (1) identify AI adoption, (2) identify the achievement of SDG goals, (3) identify the adoption of a sustainable supply chain, and finally, (4) identify the mediator effect of SDGs on AI application and sustainability performance in the studied companies.

AI application areas include machine learning, natural language processing, robotics, and data analytics that enhance and optimize supply chain processes (Chen et al., 2024; Teixeira et al., 2025). These technologies allow organizations to process large amounts of data, recognize patterns, and take sustainability-focused actions (Belhadi et al., 2024; Mukherjee et al., 2024). Supply chain sustainability balances different aspects such as the natural environment, society, and economic requirements to satisfy the needs of the present without compromising the needs of future generations (Del Giudice et al., 2021; Bag & Rahman, 2024). The pharmacy industry involves fair sourcing, compliance with good manufacturing practices, and fair access to healthcare products (Rashid et al., 2025; Wang & Zhang, 2025). The goals of sustainability include 17 UN goals that deal with poverty, inequalities, and climate change, out of which goals 9, 12, and 13 specifically affect the sustainability of the supply chain (Raman et al., 2023).

This Research makes an addition to the existing literature on sustainability and supply chain management in terms of empirical insights on the efficacy of AI in managing green and resilient supply chains in attaining global sustainability goals. The results would help to implement AI-based solutions in sustainable supply chain strategies by policymakers and managers in emerging markets such as Jordan, in addition to shedding light on the significance of meeting the SDGs in AI-based sustainability frameworks as an enabling factor.

2. Research Background

The current state of supply chain networks worldwide has registered a dramatic transformation because of the growing need for sustainability and the exponential growth of technology, especially artificial intelligence (AI). The conventional supply chain has been criticized because of the linear process involved in it, along with it being resource-intensive in nature, especially concerning the aspects of carbon footprint, waste, and resource usage (Bag et al., 2021; Chauhan et al., 2022). The adoption of AI has now become a driving factor in boosting sustainability in supply chain management because it supports the sustainability goals proposed by the United Nations (Raman et al., 2023; Srivastava et al., 2025)

AI-enabled tasks such as machine learning algorithms and natural language processing tools in supply chain management processes via real-time decision-making, demand analyses, and logistical solutions to improve efficiency, thereby helping to ensure sustainability goals in terms of data-driven decisions, low energy consumption, and ethical sourcing (Al-Khatib, 2022; Rashid et al., 2025). AI has further increased sustainability in supply chain management in terms of supply chain resilience and responsiveness, thereby aligning with the sustainability process of the triple bottom line approach, covering aspects related to economic, environmental, and societal sustainability performance criteria (Elkington, 1997; Belhadi et al., 2024; Meena et al., 2025).

Despite the progress achieved across the world, AI adoption has not been evenly distributed in the context of developing countries and the pharmacy industry, among others (Dey et al., 2024). Regarding the situation in Jordan, where the pharmaceutical industry has experienced growth, AI adoption is in its infancy stage, with less empirical work done in understanding its effect on sustainability goals (Al-Khatib & Khattab, 2024; Atieh Ali et al., 2024). Small and Medium Enterprises characterize the industrial base in Jordan but are challenged by technological and monetary constraints to take full advantage of AI to attain sustainability goals properly (Panigrahi et al., 2023; Khan et al., 2025). On the other hand, AI strengthens supply chain management performance in organizations in developed countries, yet the moderator effect of SDG attainment in this context has not yet been investigated in depth in the context of the Middle East, among others (Behl et al., 2023; Fosso Wamba et al., 2024).

The healthcare industry is an interesting area to examine AI for sustainability because of the complexities involved, along with the industry's ethical responsibility to address global healthcare concerns (Rashid et al., 2025; Wang & Zhang, 2025). The sustainability aspect in the healthcare industry encompasses: handling the environment, ensuring fair drug distribution, and waste reduction strategies (Bag & Rahman, 2024; Mukherjee et al., 2024). AI can help in managing stocks efficiently, eliminating overproduction, and improving the traceability of resources in the healthcare industry (Liu & Jiang, 2025). There has been very little Research on the application of AI in advancing the achievement of SDGs in the pharmaceutical industry in Jordanian companies (Al-Khatib, 2022).

Based on the Dynamic Capabilities Theory, proposed by Teece et al. in 1997, organizations can gain sustained competitive advantage through responding to the changing environment via innovation and efficient management of resources. AI allows organizations to: detect sustainability issues, react to new biotech opportunities, and change processes towards eco-efficient functioning (Al-Khatib & Khattab, 2024; Vishwakarma et al., 2024). Creswell's mixed methodology for understanding AI implementations, achievement of the SDG goals, and adopting sustainability in the pharmaceutical industry in Jordan would be employed in the proposed research for gaining deeper insights with enhanced practical implications to the concerned policy makers and industry leaders (Creswell & Creswell, 2017). The Research by Omoush (2025c) explored human–AI collaboration in HRM and supply-chain contexts.

3. Literature Review and Hypotheses Development

3.1 Artificial Intelligence and Sustainable Supply Chain Outcomes

Artificial intelligence (AI) has emerged as a transformative force in supply chain management, enabling data-driven decision-making, real-time analytics, and automation that enhance operational efficiency while reducing environmental impact (Teixeira et al., 2025; Wang & Zhang, 2025). Recent research by Al-Awamleh et al. (2025) maps technological change in energy management. Technologies such as machine learning, robotics, and big data analytics optimize forecasting, inventory management, logistics planning, and risk assessment (Khan et al., 2025). AI acts as a strategic resource that provides a competitive advantage through intelligent decision-making and superior information processing (Barney, 1991; Al-Khatib, 2022).

Omoush (2025b) highlighted the transformation of logistics through generative AI. Empirical studies have demonstrated that AI adoption improves supply chain visibility, traceability, and resilience—key enablers of sustainability (Nasir et al., 2022; Belhadi et al., 2024; Chen et al., 2024). By integrating and automating processes, AI enhances the triple bottom line—profit, people, and planet—reducing emissions, minimising waste, and improving resource utilisation (Bag & Rahman, 2024; Štreimikienė et al., 2025). According to Omoush, Al-frejat, and Masa'deh (2024), digital supply chains enhance lean manufacturing.

The current literature supports the argument that empirical validations further attest to the argument that the application of Artificial Intelligence has a major positive impact on the achievement of sustainable supply chain development. The Research conducted by Lin et al. in 2025 concluded that AI applications on an enterprise level have managed to enhance information visibility, sensing, and adaptation rates in addition to ensuring that supply chain resilience is amplified, which has direct implications for sustainability goals verification. The Research involved data collection from 362 manufacturing companies and managed to prove that AI-based data integration resulted in less waste during production while boosting resource utilization, thereby validating H1 (Lin et al., 2025). On the same premise, Guo et al. in 2025 conducted Research on China's manufacturing industry and managed to quantify the sustainability proof that AI application in analytics reduces supply chain rigidity while decreasing industrial energy consumption and losses incurred (Guo et al., 2025). Omoush (2022) found that logistics management practices significantly affect operational performance.

Based on theoretical contributions as well as empirical evidence within the above context efforts formulates the research hypotheses are formulated as follows:

H1: Artificial Intelligence Applications (COMP) positively influence the building of sustainable supply chains.

3.2 Moderating Role of Sustainable Development Goals (SDGs)

AI provides considerable support in meeting the SDGs through increased productivity, sustainability, and social inclusion via data-intensive processes. For example, the AI-enabled logistics network decreases greenhouse gas emissions, and AI-supported procurement practices provide responsible sourcing in accordance with SDG12 goals (Srivastava et al., 2025; Wang & Zhang, 2025). The inclusion of SDG goals in supply chain processes further supports the correlation between AI adoption and sustainability performance because it integrates global ethics and sustainability principles with organizational operations (Raman et al., 2023; Singh et al., 2024).

Recent empirical studies show that alignment between AI projects and the SDGs has resulted in enhanced sustainability in supply chain management. The purpose of the Research "Artificial Intelligence and Sustainable Development Goals (SDGs)" by Regona in 2024 was to explain that AI can help in the achievement of SDGs in terms of improving efficiency, inclusiveness, and sustainability in different processes that make use of data algorithms, according to Regona (2024).

The Research further showed that companies integrating AI adoption with SDG strategies—specifically SDG 9: Innovation and Infrastructure, SDG 12: Responsible Consumption and Production, and SDG 13: Climate Action—are more adept at achieving sustainability in supply chain development.

Recent findings further reinforce that there is a synergistic effect of combining AI and SDGs in achieving sustainability in supply chains. Recent empirical Research conducted by Khan et al., in 2025, resulted in establishing the fact that if AI adoption can be properly integrated with the adoption of SDG goals, there would be enhanced performance in terms of sustainability in the areas of reduction in negative impacts on the environment, responsible sourcing, and reduction in consumption of energy, thereby directly associating with the sustainability criteria in supply chains.\`. The Research conducted by Patil and Singh in 2025 indicated the importance of adopting AI analytics aligned with SDG goals in establishing enhanced resilience and sustained competitive advantages in organizations vis-à-vis organizations adopting only AI. The Research Supports Hypothesis 2 (H2) in establishing the fact that SDGs can work as `moderating variables,' which help in adding to the transformative powers of AI adoption in supply chains by aligning technology with sustainability norms so that sustainability in supply chains becomes feasible through AI adoption. Omoush (2021) showed that green productivity strategies support environmental sustainability.

Therefore, the empirical findings provide clear support for Hypothesis 2 (H2), confirming that the Sustainable Development Goals act as a moderating mechanism that amplifies the positive relationship between AI applications and sustainable supply-chain outcomes.

Based on theoretical contributions as well as empirical evidence within the above context efforts formulates the research hypotheses are formulated as follows:

H2: Sustainable Development Goals (SDGs) positively moderate the relationship between Artificial Intelligence Applications (COMP) and sustainable supply chain outcomes.

In summary, AI applications enhance sustainability through improved efficiency and resilience, while SDGs strengthen this relationship by aligning AI strategies with global sustainability objectives. Together, these constructs form an integrated model connecting technology adoption and sustainable development within emerging markets such as Jordan.

4. Research Model

The conceptual framework for the Research is based on the Dynamic Capabilities Theory, as presented by Teece et al. in 1997. According to this theory, the achievement of SSC requires the integration, development, and reconfiguration of both internal and external resources and capabilities, driven by a dynamic environment. The role of AI application in the case Research can assume the role of a dynamic capability that helps the organization recognize market changes, capitalize on technological advancements, and pursue sustainability across the different aspects of the organization's operations. For the case Research, it has been assumed that the positive correlations between the application of AI in the organization and the achievement of the SSC exist, whereby the efficiency, traceability, and response rates are significantly enhanced through AI application in the process of the organization's supply chain. The achievement of the SSC has also contributed significantly to enjoying the benefits of the SDG in proving the proposed positive correlations whereby the achievement of the SDG has been assumed to increase the positive correlations between the application of AI and the aspect of sustainability. For the organization to apply the SDG to the operation paradigm assumptions, the achievement of the benefits of AI application in the aspect of sustainability performance has become easy, whereby the best performance can now be achieved in the aspects of the environment, society, and economy. The proposed conceptual framework presented in the case Research is presented in Figure 1 below, whereby the relationship among the constructs: Artificial Intelligence Application (IV), Sustainable Supply Chain (DV), and Sustainable Development Goal (MV) has been presented:

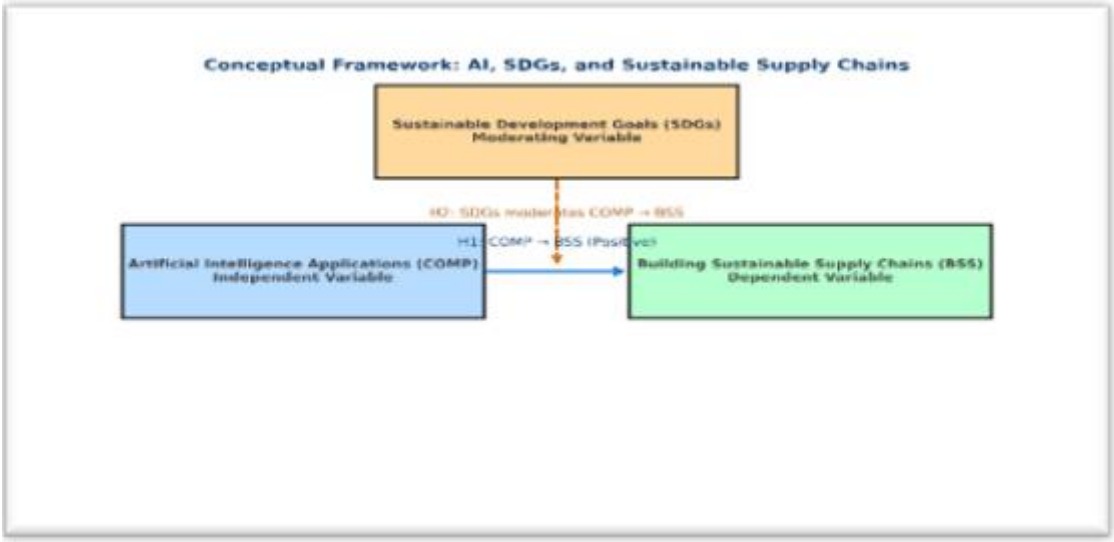

Fig. 1: Conceptual Model of the research

5. Research Methodology

5.1 Research Design

This Research employs a quantitative research design complemented by a descriptive-analytical approach. A cross-sectional survey method was adopted to collect empirical data from Jordanian pharmaceutical companies. The research design aligns with Creswell and Creswell (2017), emphasizing systematic data collection and statistical validation to test hypothesized relationships within structural models.

5.2 Population and Sample

The Research population includes all managers, administrative workers, and medical/technical personnel working in pharmaceutical manufacturing companies in the state of Jordan. Based on information relayed by the Ministry of Health in the year 2025, the researcher determined the number of the Research population to be 1,952 persons. The Research utilized stratified random sampling techniques to capture many sections in different companies to ensure equality in the Research process. The Research employed the use of 500 questionnaires, with 412 questionnaires retrieved and valid, giving an 82.2% valid return rate.

5.3 Research Instrument

The structured questionnaire was the main tool used in the Research to collect data. The questionnaire was made up of 30 questions, which were categorized among the three constructs: Application of Artificial Intelligence, Achievement of Sustainable Development Goals, and Development of Sustainable Supply Chain, with 10 questions in each category. The questions were rated on the Likert scale of five points, rated from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). These questions were taken from validated works of different authors to ensure the items were relevant in terms of content, and they included works of Gallo et al. in 2023, Khan et al. in 2025, Raman et al., in 2023, and Bag et al., in 2024, to name but a few, with Cronbach alpha values of 0.80 or higher after being reviewed by experts and pre-tested on 30 managers.

5.4 Data Collection Procedures

The Research employed a structured questionnaire as the primary data collection instrument. The questionnaire was composed of 30 items divided among three constructs, namely: Application of Artificial Intelligence, Achievement of the Sustainable Development Goals, and Development of Sustainable Supply Chain, with 10 items for each category. The items were rated on a five-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The items were drawn from previously validated studies such as Gallo et al. in 2023, Khan et al., in 2025, Raman et al., in 2023, and Bag and Rahman, in 2024 to name others for reliability and relevance to the Research context that ensured internal consistency and clarity of measurement with Cronbach alpha values above 0.80 after being reviewed by experts and pre-tested on 30 managers.

5.5 Data Analysis Techniques

For analysis, the data were processed with SmartPLS version 4. The data analysis commenced with descriptive statistics to identify the demography of the respondents, followed by reliability testing of the measurement. The Confirmatory Factor Analyses were employed to evaluate the internal consistency with Cronbach α values above 0.70, convergent validity with Average Variance Extracted values above 0.50, and discriminant validity based on Fornell-Larcker criteria and HTMT ratio values. The structural model was further employed to test hypotheses and relationships associated with the Research after validating the measurement model on the basis of criteria defined by Creswell and Creswell (2017) and Hair et al. (2021). Hierarchical regression models with bootstrapping with 5,000 resamples were employed to validate the model, to test the strength and significance of paths, in addition to testing the mediating effect of Sustainable Development goals on the relationship between AI Application and Sustainable Supply Chain Outcomes.

The quantitative Research design employed in the Research enabled the measurement of relationships between variables objectively through numerical data. The Research was based on empirical generalization, which in turn enabled the testing of the proposed model in the context of pharmaceutical companies in Jordan.

6. Results and Analysis

The items used to quantify the measurement were taken from valid scales created in earlier studies. The items for "Artificial Intelligence Applications" were taken from studies conducted by Gallo et al. (in 2023, Khan et al. (in 2025, and Rashid et al. (in 2025, who designed valid measurement tools for AI implementation in business processes. The items for "Achieving SDGs" were taken from studies conducted by Raman et al. (2023, Srivastava et al. (in 2025, and Štreimikienė et al. (in 2025. Finally, items related to "Building Sustainable Supply Chains" were taken from studies conducted by Del Giudice et al. (in 2021, Bag and Rahman in 2024, and Meena et al. (in 2025, who investigated green and circular supply chain practices.

6.1 Demographic Profile of Respondents

To provide information on the demographic characteristics of the respondents, a detailed demographic profile was designed to identify the makeup of the sample pool. Based on the information presented in Table 1, it was revealed that most respondents were male, constituting 62% of the total, coinciding with the general demographic makeup in other administrative posts in the pharmaceutical industry in Jordan, where most workers in administrative posts are male. Also, in terms of areas of work, most were in medical-related posts at 59.47%, followed by administrative posts at 23.54% and technical posts at 16.99%.

Table 1: Distribution of Research Sample by Gender and Functional Field

Category	Frequency	Percentage (%)
Gender		
Male	255	62
Female	157	38
Total	412	100
Functional Field		
Administrative	97	23.54
Medical	245	59.47
Technical	70	16.99
Total		**100**

6.2 Descriptive Analysis

The descriptive statistics were analyzed to understand the mean and variability of the constructs. The mean calculated has been explained in detail in Table 2 to understand the values of items in the Research, where the values were above 0.70, ensuring there was convergent validity. The results showed high adoption of AI and implementation of SDG applications in the pharmaceutical companies in Jordan.

Table 2: Measurement Results and Descriptive Analysis of Research Constructs

Construct	Item Code	Measurement Item (Questionnaire Statement)	Factor Loading	Mean	Interpretation Summary
Artificial Intelligence Applications (COMP)	AI1	AI applications contribute to reducing errors during business execution.	0.85	4.14	High contribution of AI in minimizing human and procedural errors in operations.
	AI2	AI applications are important in obtaining real-time operational information.	0.82	4.12	Strong support for AI's role in real-time decision-making.
	AI3	Data analysis systems provide users with real-time information.	0.80	4.07	Confirms AI's analytical value in live operational insights.
	AI4	Pharmaceutical companies use AI tools to analyze and generate accurate reports.	0.79	4.06	AI strengthens information quality and reporting accuracy.
	AI5	AI applications protect pharmaceutical firms from potential threats.	0.77	3.96	AI enhances organizational resilience against competition.
	AI6	AI systems present data in a clear and easy-to-understand way.	0.75	4.02	AI improves communication and interpretation of complex data.
	AI7	Companies plan to expand AI applications in data analysis.	0.74	4.06	Demonstrates proactive investment in AI-based analytics.
	AI8	AI capabilities are sufficient to achieve institutional performance goals.	0.73	3.98	AI is viewed as adequate to meet strategic goals.
	AI9	AI helps improve strategic decision-making and performance monitoring.	0.78	4.01	Confirms managerial reliance on AI-driven insight.
	AI10	AI applications enhance operational accuracy and data retrieval.	0.72	4.12	Strong evidence of improved data reliability through AI.
	Average (COMP)		0.78	4.01 (High)	AI applications demonstrate a high degree of operational integration and strategic value.
Sustainable Development Goals (SDGs) (Moderating Variable)	SDG1	Companies generate new revenues through developing their technological environment.	0.84	4.14	SDGs promote innovation and new income sources.
	SDG2	Companies create opportunities for innovation and differentiation.	0.82	4.12	Reflects strong alignment with innovation-driven SDGs.
	SDG3	Firms expand in technology and innovation support.	0.80	4.12	Shows technological advancement as part of sustainability.
	SDG4	Companies enhance supply chain flexibility and responsiveness.	0.79	4.06	Flexibility is a key SDG-aligned capability.

Construct	Item Code	Measurement Item (Questionnaire Statement)	Factor Loading	Mean	Interpretation Summary
	SDG5	Firms provide decent work environments for employees.	0.78	3.57	Emphasizes human capital and fair employment.
	SDG6	Companies respond quickly to new legal and environmental requirements.	0.77	3.63	Confirms agility in compliance and environmental adaptation.
	SDG7	Companies improve attractiveness and employee retention.	0.76	4.07	SDG integration boosts workforce stability.
	SDG8	Companies reduce environmental risks and ensure safety and hygiene.	0.74	4.06	Shows environmental and safety awareness.
	SDG9	Firms support operational efficiency along the supply chain.	0.72	4.06	Indicates operational sustainability alignment.
	SDG10	Companies work to remove all obstacles to achieving SDGs.	0.71	3.42	Acknowledges gaps in achieving SDG goals fully.
	Average (SDGs)		0.77	3.92 (High)	Integration of SDGs enhances innovation, compliance, and sustainability initiatives.
Building Sustainable Supply Chains (SSC) (Dependent Variable)					
	SSC1	Firms rationalize their energy consumption.	0.84	4.13	Reflects high energy efficiency practices.
	SSC2	Departments collaborate to apply sustainable supply chain practices.	0.82	4.06	Indicates cross-functional sustainability efforts.
	SSC3	Senior management supports sustainable supply chain initiatives.	0.81	4.01	Demonstrates top-level strategic commitment.
	SSC4	Firms recycle used products and repair defective ones.	0.79	3.22	Recycling practices exist but need strengthening.
	SSC5	Companies commit to environmental quality management.	0.78	3.80	Continuous improvement in eco-quality.
	SSC6	Companies hold ISO 14001 certification for eco-friendly products.	0.77	3.73	Compliance with environmental standards.
	SSC7	Companies balance customer needs and environmental requirements.	0.76	3.57	Demonstrates equilibrium between market and ecology.
	SSC8	Firms conduct periodic inspections of transport systems.	0.75	3.42	Moderately effective monitoring processes.
	SSC9	Products are designed for reuse or recycling when obsolete.	0.74	3.96	Reflects eco-product lifecycle planning.
	SSC10	Labels highlight environmentally friendly production.	0.73	3.84	Enhances transparency and corporate image.
	Average SSC		0.78	3.77 (High)	Pharmaceutical companies exhibit growing maturity in sustainability, though improvement is needed in recycling and restoration practices.

Table 2 above shows the very high mean values for all the constructs based on the maturity level of AI and SDG implementation in the Jordanian pharmaceutical industry. This clearly indicates very good convergent validity and strong measurement items, as the factor loading values exceed 0.70. The mean for the application of AI (COMP) has the highest value at 4.01, again confirming its chief role in efficiency and decision-making processes. The immediate implementation of the SDGs (M= 3.92) reflects very high alignment in innovation and sustainability coverage. The dependent factor of the establishment of Sustainable Supply Chains (M=3.77) has confirmed the positive impact of AI implementation in the enhancement of best practices related to sustainability.

The table shows that the level of sustainability maturity among the pharmaceutical companies in Jordan appears to be quite high (overall mean = 3.77, high). The factors that contribute most to sustainable SC behavior can be derived from the loading factors. These factors are the rationalization of energy (loading = 0.84, mean = 4.13), as well as cooperation between departments for sustainable activities (loading = 0.82, mean = 4.06).

- This empirical finding serves to validate Hypothesis (H1), thereby confirming that the synergistic effect of efficiency achieved through AI and strategies aligned to the SDG has contributed to the development of sustainable supply chains.
- Support of the top management (loading = 0.81, mean = 4.01) further reinforces the factor of sustainability orientation in the context of the integration of environmental aspects in the supply chain activities. The companies are also performing very well in the area of eco-design and management of environmental quality aspects, like the certification under ISO 14001 (loading = 0.77), as well as the use of eco-labelling (loading = 0.73).
- Nonetheless, the activities involved in recycling and product restoration seem less robust (loading = 0.79, mean = 3.22), thereby calling for optimization of circular economy practices. Likewise, the efficiency of transport inspection systems appears moderate (loading = 0.75, mean = 3.42).
- The fact that the average scores for recycling (M = 3.22) and transport inspection (M = 3.42) were lower indicates the need to invest more in the circular economy and monitoring systems.
- In conclusion, the results suggest that Jordanian companies in the pharmaceutical industry are gradually applying sustainable strategies related to their supply chains.
- The strong positive total mean (M = 3.77) reflects the structural model analysis findings ($\beta = 0.52$, $p < 0.001$), confirming the effectiveness of AI applications in significantly improving sustainable outcomes of the supply chain.

- In general, the results obtained from the descriptive analysis verified the expectation that the maturity of sustainable supply chains in Jordanian pharmaceutical companies is influenced by AI-based efficiency, moderated by the Sustainable Development Goals as factors that promote the integration of the environment. These findings underscore the willingness of the pharmaceutical industry in Jordan to evolve towards high maturity levels of sustainable development. This can only happen if the management commits to the concept.

6.3 Discriminant Validity (Fornell–Larcker and HTMT Criteria)

The discriminant validity was evaluated using the Fornell-Larcker criteria and Heterotrait-Monotrait (HTMT) ratio methods. The findings showed in Table 3 that the correlation between the constructs and the square root of the average values of extraction of each construct was larger in the former, thereby establishing sufficient discriminant validity.

Table: Fornell–Larcker Criterion Results for Discriminant Validity

Constructs	COMP	SDGs	SSC
COMP	0.76		
SDGs	0.69	0.75	
SSC	0.71	0.74	0.77

The square root of the AVE for each construct exceeded its correlations with other constructs, confirming discriminant validity. HTMT ratios (all < 0.85) also verified conceptual distinctness among the constructs (Hair et al., 2017)

6.4 Structural Model and Hypotheses Testing

Table 4: Path Coefficient Summary

Structural Path	β (Beta)	t-value	p-value	f^2	Decision
COMP → SSC	0.52	6.47	< 0.001	0.20	Supported
COMP × SDGs → SSC	0.15	2.12	< 0.05	0.04	Supported

The direct path (COMP → SSC) shows a strong positive effect, explaining that AI applications significantly enhance sustainable supply chain outcomes. The interaction term (COMP × SDGs) exhibits a small but significant moderating effect, confirming that SDGs strengthen the impact of AI adoption on sustainability outcomes.

The PLS-SEM result supports that there is a strong and significant impact of AI application on the development of sustainable supply chain management practices in organizations ($\beta = 0.52$, $p < 0.001$). The result supports the theory that technology has enhanced agility and efficiency in the environment through AI applications in organizations. On the other hand, the model result supports that the moderator variable of SDGs affects the sustainability goals to amplify the effect of AI application on performance management practices in organizations ($\beta = 0.15$, $p < 0.05$). The results of f^2 values for AI application and SDGs disclosed that there is a moderate to small effect on sustainability goals in organizations.

6.5 Coefficient of Determination (R^2) and Predictive Relevance (Q^2)

As presented in Table 6 above, the construct Sustainable Supply Chain Capabilities (SSC) indicates moderate explanatory power ($R^2 = 0.38$) and good predictive fit ($Q^2 = 0.47$); thus, the model indicates an acceptable effectiveness level in the explanation and prediction of the phenomenon under inquiry.

Table 5: Coefficient of Determination (R^2) and Predictive Relevance (Q^2) Results

Construct	R^2	Q^2	Interpretation
SSC	0.38	0.47	Moderate explanatory power and predictive relevance

The model explains 38% of the variance in Building Sustainable Supply Chains (SSC), indicating moderate predictive strength.
The positive Q^2 value (>0) confirms that the structural model has strong predictive relevance.

6.6 Model Fit Summary

As presented in Table 7, the model fit indices (SRMR = 0.062, NFI = 0.91, RMS_theta = 0.11) indicate an acceptable overall model fit, confirming that the structural model adequately represents the observed data.

Table 6: Model Fit Indices for the Structural Equation Model

Indicator	Value	Threshold	Interpretation
SRMR	0.062	< 0.08	Acceptable global fit
NFI	0.91	> 0.90	Good model fit
RMS_theta	0.11	< 0.12	Acceptable residual correlation

The indicators collectively show that the proposed PLS-SEM model fits the data well, validating both the measurement and structural models. This confirms that the model successfully captures the relationships between AI applications, SDG integration, and sustainable supply chain outcomes.

The goodness of fit statistics indicate good model fit (SRMR = 0.062, NFI = 0.91, RMS_theta = 0.11). The R^2 statistic with a value of 0.38 shows that AI application and SDG involvement account for 38% of the explained variations in establishing sustainable supply chain management in the studied industry. The predictive fit further validates the model in predicting sustainability performance with good values of $Q^2 = 0.47$, supporting earlier works in literature such as Belhadi et al. (2024 and Srivastava et al. (2025, thereby establishing AI-based sustainability integration on stronger empirical foundations to be theoretically valid and more meaningful in emerging markets.

In general, the results highlight the confirmation of the conceptual framework encompassing Artificial Intelligence, Sustainable Development Goals, and Sustainable Supply Chain Building. The empirical analysis indicates the role of AI as an enabler that improves digital and sustainable competencies. In this context, the Sustainable Development Goals are viewed as a moderating factor that underlines sustainable duties. In general, this empirical confirmation offers new perspectives towards the achievement of sustainable performance results among

pharmaceutical corporations operating in the emerging economy context. The present analysis offers theoretical as well as practical insights related to sustainable transformation in industrial supply chains.

6.7 The Conceptual Framework of Research

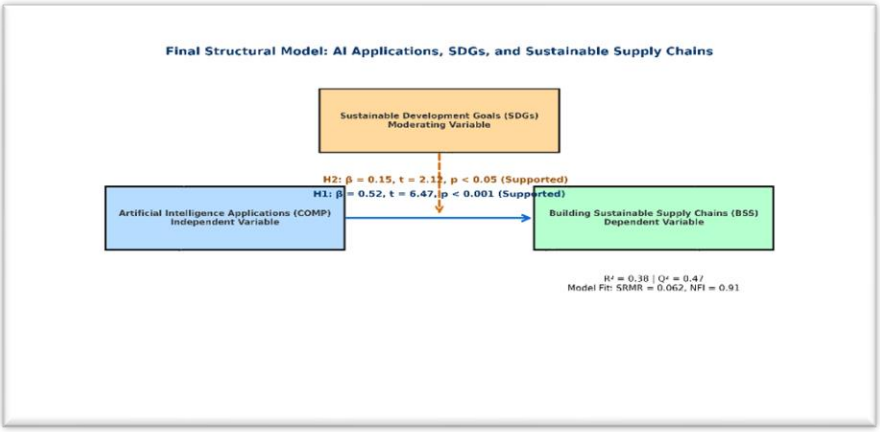

Fig. 2: The Role of Artificial Intelligence Applications in Building Sustainable Supply Chains – The Moderating Role of Sustainable Development Goals

The final structural model in Figure 2 shows the proposed relationships between the three key constructs in the Research: Artificial Intelligence Applications (COMP), Sustainable Development Goals (SDGs), and Building Sustainable Supply Chains (SSC). The direct link between COMP and SSC in H1 depicts a very strong and statistically significant connection where COMP has positively impacted the sustainability performance of supply chains in the pharmaceutical companies in Jordan by an effect factor of $\beta = 0.52$ with $t = 6.47$ and $p < 0.001$ significance level. This shows that technology, in forms such as predictive analysis, automation, and data-driven solutions, has positively influenced organizations to adopt green practices.

The dashed green arrow symbolizes the moderating effect of Sustainable Development Goals on the correlation between COMP and SSC proposed in H2, which was found to be statistically significant with $\beta = 0.15$ and $t = 2.12$, $p < 0.05$. This result indicates that by integrating AI with SDG goals in terms of responsible consumption, innovation, and action on climate, the positive effect of AI on sustainability can be enhanced. The model explains 38% of the total variation in the development of the sustainable supply chain, with a good predictive fit ($Q^2 = 0.47$). The model fit statistics further reveal an acceptable global fit for the proposed conceptual model with values of SRMR = 0.062 and NFI = 0.91. On the whole, the graph embodies the major argument presented in the current Research: the integration of AI application tools in SDG-related strategies remarkably improves the achievement of sustainable, resilient, and innovation-based supply chains in emerging countries like Jordan.

7. Discussion

The outcome of the Research affirms that the use of AI has an imperative role in ensuring Building Sustainable Supply Chains in the pharmaceutical sector in Jordan. The direct link between AI and Building Sustainable Supply Chains affirms that technology in general, encompassing AI technology in the domains of predictive analytics, robotics, and decision-making, can minimize shortcomings in processes to perform efficiently in terms of sustainability and can outperform in terms of sustainability performance. The Research affirms the earlier studies conducted by Belhadi et al. in 2024 and Teixeira et al. in 2025, who asserted that AI can enhance responsiveness and minimize consumption in the manufacturing process.

The Moderating Factor of Sustainable Development Goals: The moderating effect of Sustainable Development Goals brings new empirical insights to the equation, indicating that the adoption of AI in organizations has ensured efficiency in line with the sustainability goals of the world. The interaction effect can be explained in the equation: (COMP * SDGs → SSC). The companies embracing the policy on sustainability goals in supply chain management perform better than others in terms of achieving sustainability goals. It validates the argument presented by the authors in 2025 and by Raman in 2023 with respect to the importance of innovation, consumption, and sustainability goals, which enhance performance and legitimacy in corporate decisions.

The Research has furthered the Dynamic Capabilities Theory because it has managed to suggest the configurability of AI capability in terms of sustainability challenges and opportunities. The effect of SDGs has explained how alignment with sustainability goals can enhance the process of transformation because technological adoption becomes more efficacious in reaching sustainability goals.

The results appear to validate other literature in pointing out that AI solutions in this industry can enhance efficiency, ethics, and resilience-related dimensions because these dimensions are of utmost importance in assisting in the accomplishment of sustained comparative advantage in knowledge-intensive businesses.

8. Conclusion and Implications

The results of the Research offer major implications for both the academia and practice arenas. At a management level, it becomes clear that the capability to perform tasks related to the United Nations' Sustainable Development Goals is offered by AI. The Research recommends that stakeholders in the pharmaceutical industry in Jordan should take advantage of AI technology to improve efficiency in order to ensure sustainability in the future. Technologies in AI, such as predictive analytics, automation, and machine learning solutions, can help organizations in areas related to the efficient management of resources and waste reduction while ensuring that they remain competitive in the market.

Academically, this Research makes a contribution to the literature on digital transformation, sustainability, and the SDGs in that it provides empirical proof of the mediating effect that attainment of the SDGs has on the relationship between the application of AI and sustainability

in supply chain management. The Research confirms that AI adoption helps enhance ethics, responsibility, and sustainability in emerging markets in general and the developing market of Jordan in particular.
The relevance of the digital transformation of the pharmaceutical industry in supporting the sustainability of the industry has been made clear in the above Research. This confirms the fact that AI innovation in the organization, as per the strategies related to the implementation of the SDG goals, helps towards the adaptability and sustainability of the organization.

Policy and Managerial Implications

In terms of policy intervention, it is recommended that the state of Jordan implement fiscal policies with tax credits and grants to ensure the adoption of AI in sustainability projects. The sustainability criteria employed in the state should adopt technology in industry to cover the core sustainability goals of SDG 9: Industry, Innovation, and Infrastructure, SDG 12: Responsible Consumption and Production, and SDG 13: Climate Action.
For the management of the industry, it is recommended that pharmaceutical companies should apply AI predictive analytics in demand forecasting, ethical sourcing, and waste management. These technologies would improve the management of the supply chain in the industry while being ecologically sustainable. There should be further promotion to facilitate interaction between institutions of higher learning, relevant government agencies, and private organizations to provide refresher courses to workers to enhance knowledge in information technology and sustainability. This would be vital in ensuring alignment between technological and sustainability objectives.

Limitations and Future Research Directions

Despite the significance of the contributions it has made, there are various limitations to the Research which offer opportunities for further Research in the future. The empirical Research has been conducted only on pharmaceutical companies in the context of Jordan, and in the future, the proposed model should be validated in different industry settings to prove its generality.
Second, the Research was reliant on data from managerial ratings, which can potentially suffer from common method bias. Future studies should aim to utilize data coming from multiple sources, in terms of operational data, financial data, or even multi-unit survey data, to reduce subjectivity and bias in the Research data. Third, because the Research was cross-sectional in nature, drawing any conclusions on the causal relationships between AI adoption, attainment of the SDGs, and sustainability performance in the supply chain would not be entirely feasible.
Finally, although the current Research has centered on AI applications in terms of driving sustainability, there is room for further studies to be conducted in the future by exploring other technologies that facilitate the digital transformation process, such as blockchain technology, Internet of Things solutions, and big data analytics.
Nevertheless, with these challenges in mind, it can be said that the current Research offers an excellent base for further exploration on the theoretical and empirical aspects of the application of artificial intelligence in creating sustainability in supply chains in light of the Sustainable Development Goals.

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