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ROLE OF ADVANCED TECHNOLOGIES IN SUPPLY CHAIN COLLABORATION

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Abstract

The current business environment is highly competitive with supply chains that are more complex, uncertain and interconnected with each other than it was before, because of the globalization concept. The supply chain collaboration is thus needed to facilitate improvements in coordination, visibility and performance among supply chain networks in organizations. The recent fast-growing trend of digital technologies has turned the conventional supply chains into integrated and data-driven networks to support real-time information sharing and collaborative decision-making. Artificial Intelligence (AI), Internet of Things (IoT), blockchain, automation, and sophisticated analytics are technologies that are essential in facilitating transparency, trust, efficacy, and robustness in modern supply chains. The main aim of this research is to discuss the purpose of advanced technologies in improving the collaboration of the supply chain and supply chain performance. The paper also explores the effects of blockchain technology on partner trust within the supply chain and explores how the cost of implementation, cybersecurity, and availability of skilled labor can affect the adoption of technology. The study method adopted a quantitative research design and employed the structured questionnaire comprising of 21 close-ended questions that were measured on a 5-point Likert scale. The sample size used was 74 supply chain professionals such as logistics, operations managers and procurement managers. The SPSS was used to perform statistical analysis including descriptive statistics, reliability analysis, correlation, and regression analysis. The results show that hi-tech technologies positively and largely influence the supply chain partnering and performance. The implementation of blockchain technology was identified to increase greatly the trust of the supply chain partners through the advancement of transparency and data reliability. The barriers to technology implementation that were found to be significant to adoption were cost, cybersecurity and the availability of skills. The findings underscore strategic digital investment, employee training and strong data security provisions. This research adds to the body of empirical evidence research on the topic of digital supply chains and has practical implications on supply chain managers, who want to utilize advanced technologies to enhance collaboration and competitive advantage.

1. Introduction

1.1 Background of the Study

The global supply chains have experienced significant change in the last few decades due to the forces of globalization, technology development and shifting market forces. Historically supply networks were linear and locally concentrated, with little communication

among suppliers, manufacturers, distributors, and customers (Baldwin & Freeman, 2022). The growth in international trade, outsourcing and global sourcing has dramatically changed the form of supply chains to be more widely geographically distributed and operationally sophisticated. In the current business landscape, organizations rely on a variety of partners operating in various regions, cultures, and regulatory directions to provide products and services smoothly (Christopher, 2022). This increased globalization has brought in new levels of uncertainty and risk into the supply chains. Supplies chain management has never been more difficult than it is currently due to such factors as changing demand, geopolitical tensions, natural disasters, pandemics, and economic instability. Companies have been exposition to shocks, which can have a devastating impact on the continuity of operations, client satisfaction, and profit margins (Ivanov & Dolgui, 2020). Traditional and isolated supply chain management methods are no longer applicable in such an environment.

Cooperation between supply chain partners has become an important strategy to cope with this complexity and uncertainty. Good coordination makes organizations to communicate and manage activities, goals, as well as being able to collectively respond to risks and market dynamics. Close collaboration among suppliers, logistics providers, manufactures and customers increase visibility, responsiveness and aids in improved decisions made throughout the chain of supply. The concept of supply chain collaboration has become one of the most important factors of competitive advantage and future organizational success (Hayakawa & Mukunoki, 2021; Jia et al., 2025). The blistering development of digital technologies has become the key to transforming how modern supply chains work and cooperate. Companies are ceasing the use of the traditional, paper-based, and manually handled supply chains and switching to digitally integrated networks based on real-time data and automated applications (Zhao et al., 2022). This digital transformation into digital supply chains has helped companies to conquer most of the restrictions that come with the fragmentation and siloed operations.

The existing inventory management systems enable organizations to accurately track stock levels, cut waste inventory, and facilitate sound business decision-making (Gaur, 2020). Digital tracking technologies, commonly relying on the Internet of Things (IoT), create a real-time insight on how goods are moving throughout the supply chain which allows firms to recognize bottlenecks and enhance operations. The technology of blockchain has received attention due to its capacity to improve transparency, traceability, and trust among supply chain partners by means of providing secure and immutable records of transactions. The enhanced cooperation with the supply chain is achieved through the application of Artificial Intelligence (AI) and augmented analytics that allow companies to predict demand, assess risks, and make decisions based on data. Those technologies assist organizations to partly foresee demand shifts, optimize the provision of resources, and react in advance to disturbances (Dewulf et al., 2019). Digital transformation efforts and automation efforts also enhance the speed, precision and resilience of operations within the supply chain. The advanced technologies are essential in facilitating closer collaboration, improving performance, and are more flexible to the contemporary supply chains.

1.2 Problem Statement

Even though sophisticated technologies can be used, several organizations still experience severe difficulties in establishing effective supply chain harmonization. Among the main problems, there is the absence of a smooth flow of information because of data silos and incompatible systems among the supply chain partners. The inability to share information in a timely and accurate fashion results in fragmented decision-making, inefficiencies, delays, and more expensive operations (Delen, 2020; Bogdan & Borza, 2019). The other outstanding issue with supply chain relationships is trust. The absence of transparency, risks of manipulating data and doubts regarding the reliability of partners usually prevent cooperation. These concerns of trust are further increased at moments of disruption, e.g., global crises or unexpected swings in demand, where co-

ordination plays a key role. This means that the supply chains would not be able to sustain service and continuity of operations. There exist a number of obstacles to the use of new technologies in supply chains. Digital solutions are not appealing to organizations, especially the small and medium-sized enterprises, due to high implementation and maintenance costs (Chopra & Meindl, 2019). The issue of cybersecurity and data privacy induces the dread of data hacks and unpermitted access to sensitive data. The access to the advanced technologies is not exercised due to a shortage of skilled labor and the lack of training programs. These issues indicate the necessity to understand a better how advanced technologies can impact supply chain collaboration and what prevents them to be adopted effectively (Ben-Daya et al., 2019).

1.3 Research Gap

Though available literature emphasizes the role of advanced technologies in supply chain management, there is observable gap in empirical studies that directly correlate such technologies with supply chain collaboration results (Benton Jr, 2020; Bai and Sarkis, 2020). Most existing literature concentrates on the technological capabilities or performance improvement individually, and does not investigate how the technologies help in enabling partnering supply chains to collaborate in detail (Baldwin & Freeman, 2022). The available evidence concerning the practical role of digital transformation in collaboration, trust, resilience, and decision-making is scarce with a viewpoint of practitioners. Most of the research is either theoretical or case-oriented, limiting the extrapolation of the results (Al Mashalah et al., 2022). It is evident that empirical studies are necessary involving structured data to evaluate the connection between progressive technologies and supply chain partnership, and the obstructions to the adoption of new technologies.

1.4 Research Objectives

- To examine how developed technologies such as inventory management systems, digital tracking, blockchain, automation, and analytics are applicable to supply chain collaboration by improving coordination, transparency, and information exchange among supply chain partners.
- To explore how digital transformation affects the global performance of the supply chain, specifically in terms of efficiency, cost-saving, timely delivery, and resilience to interferences.
- To determine the major obstacles to the implementation of advanced technologies in supply chains, including too expensive implementation, cybersecurity and data privacy issues, and unskilled labor and training.

1.5 Research Questions

- How do advanced technologies improve collaboration within supply chains?
- Do digital tools enhance trust, visibility, and decision-making among supply chain partners?
- What challenges and barriers limit the adoption of advanced technologies in supply chain management?

1.6 Significance of the Study

This research contributes a number of aspects. Academically, it provides empirical data to the current body of knowledge because it quantitatively investigates the association of advanced technologies and supply chain cooperation (Charles et al., 2023). The results can assist in sealing the space between theory and practice and a basis of further study in digital supply chain management. As a manager, the study presents effective insights that could prove useful to supply chain managers and decision-makers by clarifying the advantages of technology-enhanced collaboration and critical adoption issues. The insights can be used to make more informed investment choices and strategic planning (Bhatia & Gangwani, 2021). Policy and strategic-wise, the paper highlights the role of digital infrastructure development, workforces training and cybersecurity measures to incorporate sustainable and resilient supply chains in an ever-globalized economy.

2. Literature Review

2.1 Supply Chain Collaboration

Supply chain collaboration is the extent of strategic coherence and joint communication among autonomous bodies in the flow of products, services, information, and money between suppliers and final consumers. It implies exchange of information, resources, risks, and rewards to realize a mutual benefit (Elofsson and Paulsson, 2020). The cooperation is generally considered one of the key success factors in supply chain management today as no single entity could work efficiently independently in highly complex and globalized markets (Christopher, 2022). Increased customer demands, reduced product life cycles, and market volatility have been increasing the importance of supply chain collaboration. Collaborative supply chains allow organizations to be quicker in reacting to changes in demand, decrease uncertainty, and enhance performance (Emon et al., 2024; Ghadge et al., 2020). Incorporating proper collaboration, firms are able to increase visibility of supply chain, lead time reduction, minimization of inventory, and service quality. Research repeatedly notes that collaborative relationships contribute to trust, enhance communication, and facilitate joint problem solving that are all key to sustainable competitive advantage (Hayakawa & Mukunoki, 2021).

Supply chain collaboration can be broadly divided into two categories, namely vertical and horizontal collaboration. Vertical collaboration is the interaction between organizations at various levels of the supply chain, including suppliers, manufactures, distributors, logistics service providers, and retailers (Hofmann et al., 2019). This type of collaboration is concerned with the exchange of information, coordinated planning and activities coordination to enhance efficiency and responsiveness. Horizontal collaboration, in its turn, occurs between organizations of the same tier of the supply chain, including competitors or companies in similar markets (Ivanov, 2021). Horizontal collaboration enables organizations to share assets, cut on transportation expenses, and attain economies of scale. The two types of collaboration are crucial in enhancing supply chain performance and resilience, especially with the help of advanced technologies.

2.2 Advanced Technologies in Supply Chain Management

The rate at which digital technologies have advanced has greatly changed the supply chain management practices. High technology technologies allow organizations to combine processes, make them more visible, make better decisions and build stronger relationships between supply chain partners. These technologies are enablers and overcome most of the traditional problems encountered like information asymmetry, absence of transparency and operational inefficiencies. Inventory management systems are critical in facilitating effective business decisions and cost management in the chain of supply (Queiroz et al., 2020). These systems deliver precise and prompt data regarding the amount of stock, reordering level and turnover of inventory to enable organizations to manage both supply and demand. Inventory management systems can help organizations reduce holding costs by decreasing the number of stocks and preventing stock-outs, without impacting the level of service (Maheshwari et al., 2021).

In collaborative approach, with integrated inventory systems, it is easier to coordinate suppliers and buyers through sharing information on demand forecast, replenishment schedules and availability of inventory. This transparency will facilitate the combined planning and lessen the doubts throughout the supply chain. According to previous studies, the adoption of modern inventory management systems by organizations results in better decision-making, operational efficiency, and costs which in turn makes the use of technology in the collaborative supply chain setting particularly salient. The Internet of Things (IoT) provides technology to track supply chains and operational analysis using digital tracking technologies. The IoT also supports sensors, RFID tags, and GPS trackers, which allow monitoring of the goods in real time during their transit through the supply chain (Kamble & Gunasekaran, 2020). This real-time visibility enables companies to know the status of its shipments, environmental

conditions, and possible disruptions before they become large scale issues. The fact that real time data is available improves collaboration as everyone in the supply chain partners could have access to the same precise and current data. Such common visibility enhances coordination and minimizes delays as well as facilitate better informed decisions. It has been shown that digital tracking solutions enhance the responsiveness and reliability of the supply chain, especially in the context of complex and global supply chains, enabling proactive problem-solving and constant performance enhancement (Ka et al., 2019). real-time data enhances collaborative relationships between the partners.

The use of blockchain technology has become a potential really promising answer to the problem of trust, transparency, and traceability in supply chains. It is an immutable and decentralized ledger that documents the transactions securely and transparently. All transaction data relate to several nodes, which minimizes the possibility of data manipulation and fraud (Min, 2019). Blockchain can improve trust in supply chain collaboration because it offers partners a single, shared point of truth (Mofokeng and Chinomona, 2019). It facilitates the end-to-end tracing of products enabling the stakeholders to authenticate the origin, flow, and authenticity of the goods. This transparency is especially useful in food, pharmaceutical, luxury goods, and other industries, in which traceability and compliance are essential (Kosacka-Olejnik et al., 2019). Empirical research indicates that adoption of blockchain raises the supply chain performance through minimizing disputes, boosting accountability and building cooperative relations between vendors and buyers. The use of Artificial Intelligence (AI) and predictive analytics is essential to changing supply chain decision-making procedures (Joshi et al., 2023). These technologies process high amounts of both structured and unstructured data to determine trends, forecast future trends and aid strategic planning. AI-based analytics will make it possible to predict the demand accurately, manage the inventory effectively, and evaluate the risk in order to predict changes and react appropriately (Ivanov and Dolgui, 2020). In collaborative supply chains, AI helps to align the partners better as it offers common information and predictions. Predictive analytics assist in supporting the joint planning efforts and minimizing uncertainties related to demand fluctuation and supply interference (Jia et al., 2025). It indicates that AI-enabled solutions are used to be more efficient and agile throughout the supply chain, more accurate in forecasting, and help plan the decision-making into real time. These technologies are becoming more available and therefore are being considered as standard tools of management in modern supply chains.

Automation has also had a major impact on the operations of the supply chain as it has minimized human interference and enhanced efficiency. Robotic process automation, automated warehousing systems, and autonomous transportation are among the technologies that enhance speed, accuracy, and consistency in the activities of a supply chain (Kamble et al., 2019). Automation also helps to create resilient supply chains that could handle unforeseen disruption. Dynamically accommodating changes in demand and supply conditions, autonomous supply chains are characterized by high levels of advance automation and AI. These systems can strengthen cooperation because they maintain a unified execution of procedures and lessen the dependence on human actions in case of a crisis (Longo et al., 2019). According to literature, automated supply chains can handle disruptions in the world better, and can ensure continuity of services and recover quicker in response to shocks, which makes automation a key element of the modern supply chain cooperation.

2.3 Impact of Technology on Supply Chain Performance

The operation of the whole supply chain is also influenced to a great extent by advanced technologies. Cost reduction is one of the most commonly cited gains (Manhart et al., 2020). The initiatives of digital transformation facilitate processes, eradicate redundancy, and enhance resource use, leading to a reduction in the cost of operations. Technology (automation and advanced analytics) assists the organization to

optimize production, transportation, and inventory management, leading to financial efficiency (Masood & Sonntag, 2020). Another important area that is affected by technology adoptions is the on-time delivery performance. Tracking in real time, predictive analytics and automated scheduling helps organizations to deal with delays and respond to them in advance. The following effects increase customer satisfaction and maintain the trust of the supply chain partners: more reliable delivery (Ning & Yao, 2023). These efficiency and visibility improvements created through technology help increase customer experience through improved response time, quality services, and transparency.

2.4 Barriers to Technology Adoption

Although there are many advantages linked with advanced technologies, there are various obstacles impeding their usability in the supply chains. The implementation cost is still high and this is a major challenge especially to small and medium-sized enterprises. The expenses required to acquire, integrate, and keep up with the more sophisticated technologies can deter organizations when it comes to initiating digital transformation efforts (Park and Li, 2021; Russell and Taylor, 2019). Privacy and security of the data also represents significant challenges. With the growing digitalization of supply chains, the threat of cyberattacks and data breaches is growing. Organizations might be unwilling to disclose sensitive information to partners because of the risk of unauthorized access and misuse. This is due to untrained labor and insufficient training programs that restrain effective application and use of new technologies (Onunka et al., 2023). Organizations without the required technical skills might not fully enjoy the fruits of the digital transformation.

2.5 Global Trends in Digital Supply Chains

The business of global supply chains is changing very fast with more organizations adopting new and modern technologies in their operations. Digital transformation is no longer perceived as a rather exotic project but a strategic imperative to remain competitive in dynamic markets. The use of analytics based on AI, sophisticated monitoring mechanisms, and automated warehousing is becoming customary across industries (Sartal et al., 2020). The digital supply chain future looks more integrated, collaborative and resilient. It is anticipated that advanced technologies will be at the heart of streamlining the production and warehousing processes, improving the sustainability, and aiding the made decisions based on data (Schwab, 2020). With the ever-changing nature of supply chains, companies capable of adeptly utilizing emerging technologies will be in a better position to realize high-level performance, greater cooperation, and sustained success.

3. Conceptual Framework and Hypotheses Development

3.1 Conceptual Framework

This research is founded on conceptual framework which explores association between advanced technology and main supply chain results. The framework describes the impact of the adoption of digital technologies on collaboration, performance, trust, and resilience in the supply chains with regard to some moderating factors.

Independent Variables:

- Artificial Intelligence (AI)
- Blockchain Technology
- Internet of Things (IoT)
- Automation and Digital Technologies

These technologies create real-time information exchange, predictive analytics, transparency, and automation of processes among supply chain partners.

Dependent Variables:

- **Supply Chain Collaboration:**
  - Improved coordination among suppliers, logistics partners, and customers
  - Enhanced information sharing and joint decision-making
- **Supply Chain Performance:**
  - Operational efficiency
  - Cost reduction
  - On-time delivery
  - Improved customer satisfaction
- **Trust:**

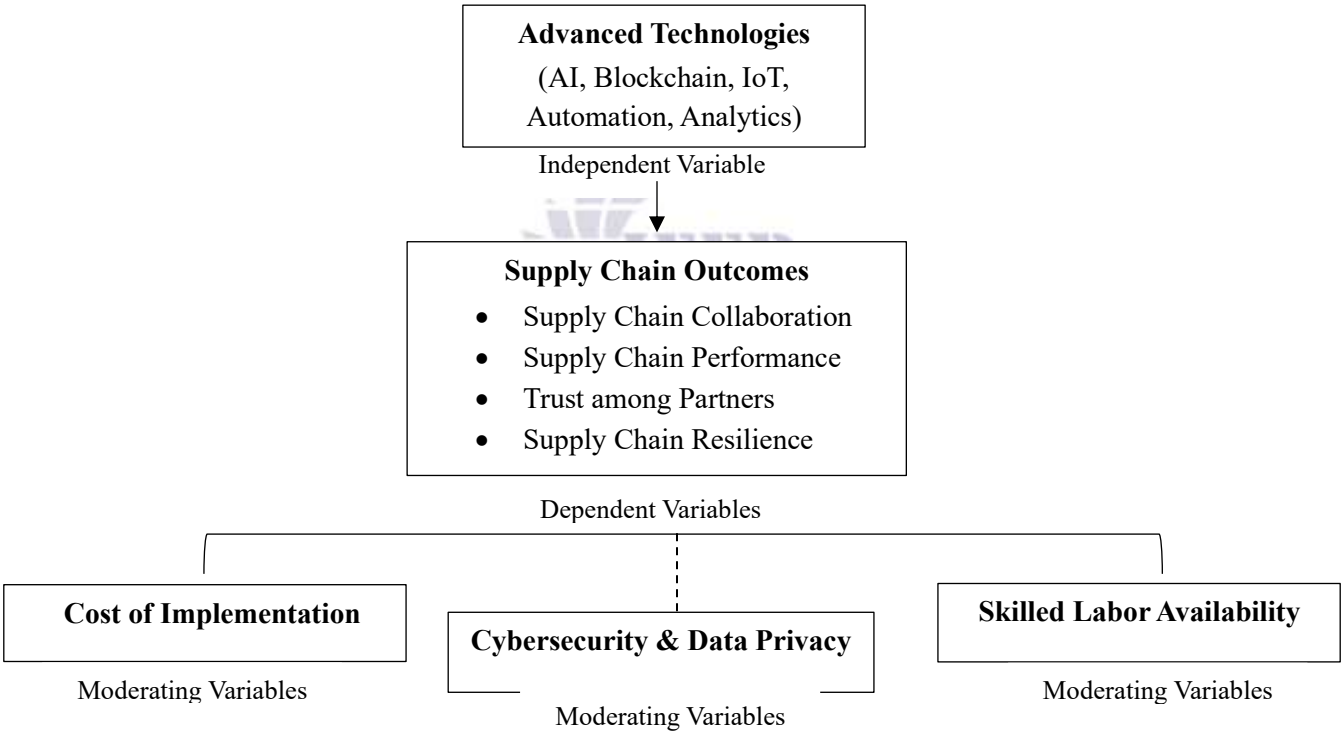
- Transparency in transactions
- Data accuracy and reliability
- Strengthened relationships with vendors and partners

- **Resilience:**
  - Ability to respond to disruptions
  - Faster recovery from unexpected events
  - Continuity of operations during global crises

Moderating Variables:

- **Implementation Cost:** High initial investment and maintenance costs may reduce technology adoption
- **Cybersecurity and Data Privacy:** Risk of cyber threats may limit information sharing and collaboration
- **Skilled Labor Availability:** Availability of trained employees enhances effective technology utilization

The framework indicates that high-tech solutions also have a positive impact on the cooperation and efficiency of supply chain, and the robustness of these links is conditional upon the cost, security issues, and expertise of the labor force.



The theoretical model shows how the advanced technologies and the outcomes of the supply chains are interrelated. The independent variable is advanced technologies, artificial intelligence, blockchain, IoT, automation, and analytics, which impact the following key outcomes in the supply chain, collaboration, performance, trust among partners, supply chain resilience. The framework postulates that adopting the mentioned technologies fosters information sharing, transparency, and operational efficiency in supply chains, and the updated studies align with the preceding studies in pointing at the strategic value of digital transformation in supply chain management (Al Mashalah et al., 2022). Moreover, the framework also includes cost of

implementation, cybersecurity and data privacy, and the presence of skilled labor as moderating variables that can reinforce or undermine this relationship. According to previous research, these factors are the key determinants of effective adoption and efficient use of advanced technologies (Kamble et al., 2019; Gaur, 2020).

3.2 Hypotheses Development

H1: The positive effect of advanced technologies (AI, Blockchain, IoT, Automation, and Analytics) on the collaboration in the supply chain and the performance have a substantial impact.

H2: The impact of blockchain technology on trust among supply chain partners is quite positive.

H3: The cost of implementation, training of employees and availability of skilled labor all play a major role on the adoption and proper utilization of advanced technologies in supply chains.

4. Research Methodology

4.1 Research Design

The proposed study adheres to the quantitative research design because it seeks to quantify and examine the links between superior technologies and supply chain cooperation by employing numerical data. The research design is a descriptive method that explains the present state of technology adoption and its effect on supply chain performance. The research is also cross-sectional since it involves respondents being collected at one point in time. The design would be applicable to knowledge on perceptions, attitudes, and practices of the professionals of supply chain towards advanced technologies (Yadav & Singh, 2020).

4.2 Data Collection Method

The structured questionnaire is used to gather primary data required in this study. The use of questionnaire technique is due to its ability to ensure the researcher obtains standardised responses of a large number of respondents in a cost-effective manner. The survey will be conducted as an online survey and this will be easy to access the respondents in various organizations and at varying locations. Online surveys are inexpensive, time-conserving, and can be used by professionals in the domain of supply chain, logistics, and operations.

4.3 Questionnaire Design

The questionnaire will include 21 close-ended questions, crafted to gauge perceptions of the respondents as to how they feel that advanced technologies are used in collaborating with suppliers. All items are rated on a 5-point Likert scale, which is 1 = *Strongly Disagree* to 5 = *Strongly Agree*. The scale gives the respondents an opportunity to point out the level of their agreement to each statement, and it facilitates quantitative analysis. The questions are formulated after a thorough examination of available literature and in line with the objectives and hypotheses of the study.

4.4 Population, Sample, and Sampling Technique

The study population would comprise of professionals engaged in supply chain related activities; supply chain professionals, logistics managers, operations managers and procurement personnel engaged in supply chain activities in different organizations. The reason why these individuals are selected is due to their acquired relevant knowledge and experience in the areas of technology use, decision-making, and teamwork in the supply chain operation. The sample will be based on respondents directly or indirectly involved in supply chain management operations. The research will use a mix of convenience and purposive sampling. The convenience sampling would allow reaching out to the respondents that are easily accessible, whereas purposive sampling would make sure that they possess the right background in supply chain management and the adoption of improved technology (Schmidt & Wagner, 2019). This method is appropriate in descriptive research where a complete sampling frame is not available and promotes the realization of the research objectives of the study.

4.5 Data Analysis Tools

The analysis of data is performed with Statistical Package of Social Sciences (SPSS) because it is reliable and effective in the analysis of quantitative research data. Descriptive statistics (frequency, mean, and standard deviation) are used to elaborate the demographic attributes and general patterns of responses used by the respondents. Correlation analysis will be implemented to identify the linkage between advanced technologies and the variables of supply chain collaboration and performance. The proposed hypotheses are tested with the help of regression analysis to measure the impact of advanced technologies on supply chain collaboration and supply chain performance in general. Cronbach's Alpha is used to determine the reliability of the measurement instrument to determine the internal consistency of the questionnaire items. Content validity is used to guarantee validity, since the questionnaire items have been formulated using existing literature and in accordance with the objectives of the study.

4.6 Ethical Considerations

The research process follows ethical principles to the latter. The respondent is assured the confidentiality of their answers, as no individual answers are disclosed. There is anonymity because no personal identifying details will be gathered. The participation in the study is completely voluntary, and the respondents are presented the fact that at any stage of the survey, they can quit the study and it will have no impacts of any nature. The information obtained is exclusively academic and research-related (Sawyerr & Harrison, 2020).

5. Data Analysis & Results

5.1 Demographic Analysis

Table 1 shows the demographic description of the research respondents who took part in the study. There were 74 valid responses observed and they became part of the analysis.

Table 1: Demographic Profile of Respondents (n = 74)

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	53	71.6
	Female	21	28.4
	Total	74	100.0
Job Experience (Years)	1–3	17	23.0
	3–5	14	18.9
	5–8	20	27.0
	8–12	13	17.6
	12–15	10	13.5
	Total	74	100.0

The demographic data indicates that males formed the larger proportion (71.6) and females were comprised of 28.4 of the sample which indicates the masculine character of supply chain and logistics positions. In terms of job experience, the majority of the respondents had 5-8 years' experience (27.0%), 1-3 years' experience (23.0%), and 3-5 years' experience (18.9%). Generally, the respondents were relatively successful in terms of professional experience; they had either moderate or considerable experience in supply chain operations and technology adoption.

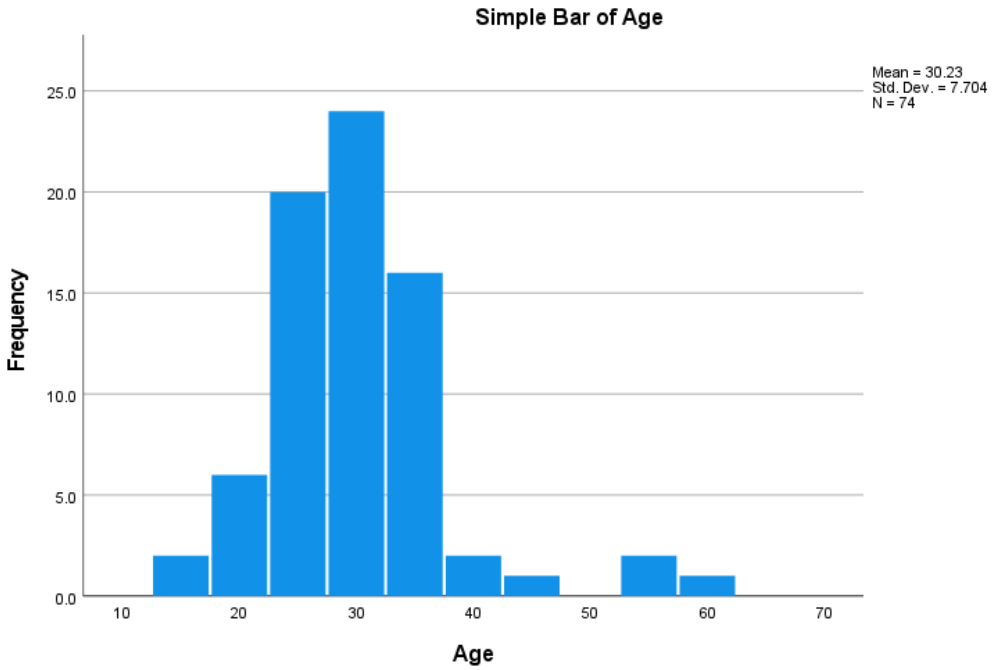


Figure 1: Age Distribution

Figure 1 illustrates the age distribution of the respondents, the mean of the age is 30.23 with a standard deviation of 7.704, which is the middle of the age variation. The age group of the majority of respondents falls between 20 and 35 years which emanates a youthful and an energetic working population. This age distribution helps to justify the timeliness of the study because these professionals are usually much more oriented to advanced digital technologies adopted in current supply chains.

5.2 Descriptive Statistics

Table 2 shows the descriptive statistics of the study variables using 74 valid responses. The average mean of each questionnaire question is between 3.51 and 4.16 and demonstrates the overall positive evaluation of advanced technologies and their contribution to the supply chains collaboration. Q1 (inventory software that supports business decisions, Mean = 4.16) and Q2 and Q4 (digital tracking and predictive analysis, Mean = 4.15) report the highest mean values, which points to a high level of consensus among participants about the use of digital tools in supply chains.

Table 2: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Q1	74	1	5	4.16	1.060
Q2	74	1	5	4.15	.946
Q3	74	1	5	3.86	.984
Q4	74	1	5	4.15	.975
Q5	74	1	5	3.76	.948
Q6	74	1	5	3.95	.874
Q7	74	1	5	3.77	.930
Q8	74	1	5	3.88	.950

Q9	74	1	5	3.76	1.145
Q10	74	1	5	3.85	1.056
Q11	74	1	5	3.51	1.208
Q12	74	1	5	3.58	1.085
Q13	74	1	5	3.93	.956
Q14	74	1	5	3.68	1.136
Q15	74	1	5	4.03	.965
Q16	74	1	5	3.89	.987
Q17	74	1	5	3.85	1.081
Q18	74	1	5	3.77	.987
Q19	74	1	5	4.04	.913
Q20	74	1	5	4.01	.852
Q21	74	1	5	4.11	.900
Valid N (listwise)	74				

Items related to digital transformation benefits and real-time information sharing also showed high mean scores, such as Q19 (Mean = 4.04), Q20 (Mean = 4.01), and Q21 (Mean = 4.11), indicating that respondents perceive advanced technologies as key drivers of efficiency, collaboration, and performance improvement. Questions related to barriers and organizational readiness, including training and skill availability, recorded moderate mean values, suggesting that while technology adoption is viewed positively, challenges still exist. The standard deviation values range from 0.852 to 1.208, reflecting a reasonable level of variability in respondents' opinions. The descriptive results suggest that respondents largely agree that advanced technologies positively influence supply chain management and collaboration (Trushkina et al., 2020).

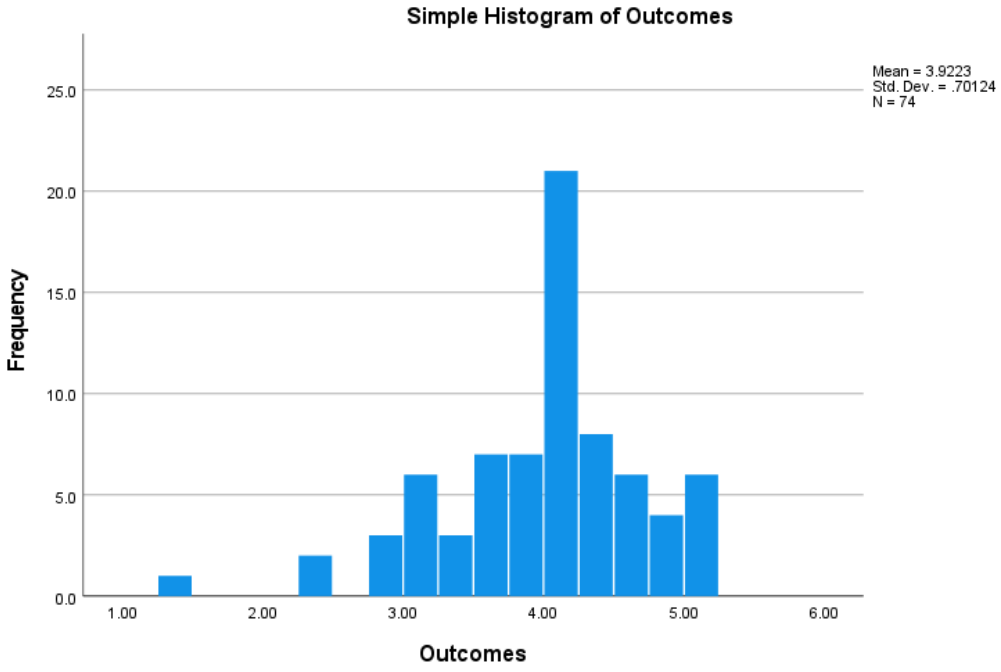


Figure 2: Histogram Showing the Distribution of Supply Chain Outcomes

The following figure, Figure 2, shows the histogram using which one can see the distribution of the supply chain outcomes among the respondents. The outcome results are 3.92 with a standard deviation of 0.70, which reveals that most of the responses are more concentrated on the bigger side of the scale. This implies that the majority of participants concur that innovative technologies positively influence supply chain performance, such as teamwork, effectiveness, and productivity. The distribution is moderately normal with few extreme values displaying consistency in how the respondents perceive. The histogram validates that most of the participants tend to have a positive perception of supply chain outcomes, a fact that justifies the descriptive and regression findings of the study.

5.3 Reliability Analysis

Table 3 shows the reliability analysis of the questionnaire applied in this study. These findings show that the Cronbach's alpha value is 0.926 with a total of 21 measurement items and this shows an excellent internal consistency. This is a value that is way above the generally accepted lower limit of 0.70, which attests to the high validity of the measurement scale. The large Cronbach's Alpha value indicates that the items of the questionnaire are strongly correlated and repeatedly measure the constructs of the advanced technologies and the collaboration in supply chains.

Table 3: Cronbach's Alpha

Cronbach's Alpha	N of Items
.926	21

The instrument is considered appropriate and dependable for further statistical analysis. The strong reliability of the scale enhances the credibility of the research findings and supports the validity of subsequent analyses, including correlation and regression tests conducted in this study.

5.4 Correlation Analysis

Table 4 shows a Pearson correlation between advanced technologies, supply chain outcomes, barriers, technology adoption, and trust. The findings indicate that advanced technologies are positively and strongly linked with supply chain outcomes ($r = 0.809$, $p < 0.01$), which indicates that the greater the adoption of advanced technologies the better the supply chain collaboration and performance. The individual relationship between advanced technologies and trust is also positive and significant ($r = 0.809$, $p < 0.01$), which emphasizes the importance of digital tools in improving transparency and confidence in the supply chain partners.

Table 4: Correlations

		Advanced_Tech	Outcomes	Barriers	Tech_Adoption	Trust
Advanced_Tech	Pearson Correlation	1	.809**	.766**	.594**	.809**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	74	74	74	74	74
Outcomes	Pearson Correlation	.809**	1	.764**	.634**	.713**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	74	74	74	74	74
Barriers	Pearson Correlation	.766**	.764**	1	.573**	.667**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	74	74	74	74	74
Tech_Adoption	Pearson Correlation	.594**	.634**	.573**	1	.576**
	Sig. (2-tailed)	.000	.000	.000		.000

	N	74	74	74	74	74
Trust	Pearson Correlation	.809**	.713**	.667**	.576**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	74	74	74	74	74
**. Correlation is significant at the 0.01 level (2-tailed).						

The barriers and technology adoption have a significant positive correlation ($r = 0.573$, $p < 0.01$), which indicates that the level of adoption is affected by implementation challenges. They are also positively associated with supply chain outcomes ($r = 0.634$, $p < 0.01$). All variables are highly correlated at the 0.01 level, which proves that meaningful relationships exist between the constructs and justifies further regression analysis to test the hypothesis.

5.5 Regression Analysis

The regression analysis was carried out to investigate the influence of advanced technologies on supply chain results, trust and technology acceptance. Three distinct regression models were run to test the hypotheses. Model 1 focused on the impact of advanced technologies on overall supply chain the outcomes and Model 2 focused on the impact of blockchain technology on trust between supply chain partners and Model 3 focused on the impact of barriers to adoption on the adoption of technologies. The findings of the regression results are reported using model summary, ANOVA and coefficients tables.

Table 5: Model Summary of Regression Analysis

Model	Dependent Variable	Predictor(s)	R	R^2	Adjusted R^2	Std. Error
Model 1	Supply Chain Outcomes	Advanced_Tech	0.809	0.654	0.649	0.415
Model 2	Trust	Blockchain (Q3)	0.795	0.632	0.627	0.457
Model 3	Technology Adoption	Barriers	0.573	0.328	0.319	0.709

Table 5 shows the model summary results of the three regression models applied in this study. Model 1 investigates how sophisticated technologies influence the results of the supply chain and demonstrates a rather predictable relationship with the R value of 0.809. The value of R^2 is 0.654 which means that advanced technologies explain 65.4 percent of the variation in supply chain outcomes and the explanatory power is therefore high. Model 2 evaluates the impact of blockchain technology on trust and produces an R value of 0.795 and an R^2 of 0.632, implying that blockchain technology alone can explain 63.2% of the variance in trust among supply chain partners. Model 3 considers the effect of barriers on technology adoption and has R value of 0.573 and R^2 of 0.328, which is moderate in its strength of explanation. The regression model result of the model summary elucidates that the regression models have a statistical strength and can be used in hypothesis testing.

Table 6: ANOVA Results of Regression Models

Model	Dependent Variable	F-value	Sig.
Model 1	Supply Chain Outcomes	136.057	0.000
Model 2	Trust	123.665	0.000
Model 3	Technology Adoption	35.149	0.000

Table 6 shows the ANOVA output of the three regression models as they determine the overall significance of each model. In the case of Model 1, the F-value is 136.057 with a significance level of

p = 0.000 which means that the model that assesses the effect of advanced technologies on the outcomes of supply chains is statistically significant. Model 2 also reveals high level of statistical significance, showing F-value =123.665 and value of p= 0.000, affirming that blockchain technology substantially accounts into the differences in trust amid supply chain associates. In the same way, the F-value of Model 3 is 35.149 (p = 0.000) which shows that such barriers as the cost, cybersecurity issues, and availability of skills have a considerable impact on technology adoption (Shrivastava, 2023). The ANOVA results reveal that all the models have a significance value less than 0.05 hence demonstrating that the regression models are legitimate and that the independent variables are significant predictors of their dependent counterparts.

Table 7: Coefficients of Regression Analysis

Model	Predictor	B	Std. Error	Beta	t-value	Sig.
Model 1	Advanced_Tech	0.853	0.073	0.809	11.664	0.000
Model 2	Blockchain (Q3)	0.604	0.054	0.795	11.120	0.000
Model 3	Barriers	0.689	0.116	0.573	5.929	0.000

Table 7 shows the values of regression coefficients of all three models which represent the strength and direction of the relationships between predictors and dependent variables. Model 1, advanced technologies exhibit a high positive impact on supply chain results, the standardized beta is 0.809, and the high t-value 11.664 (p = 0.000) represents a significant one. This shows that the more the advanced technologies are adopted, the better the supply chain collaboration and performance. Model 2 shows a positive result of the blockchain technology with a t-value of 11.120 and beta of 0.795 indicating that the technology has a positive influence on the trust of supply chain parties. Model 3 demonstrates that barriers form a substantial part of technology adoption with a beta value of 0.573 and a t-value of 5.929 indicating that implementation problems contribute to the adoption decisions. All of the predictors are found to be statistically significant to accept all hypotheses.

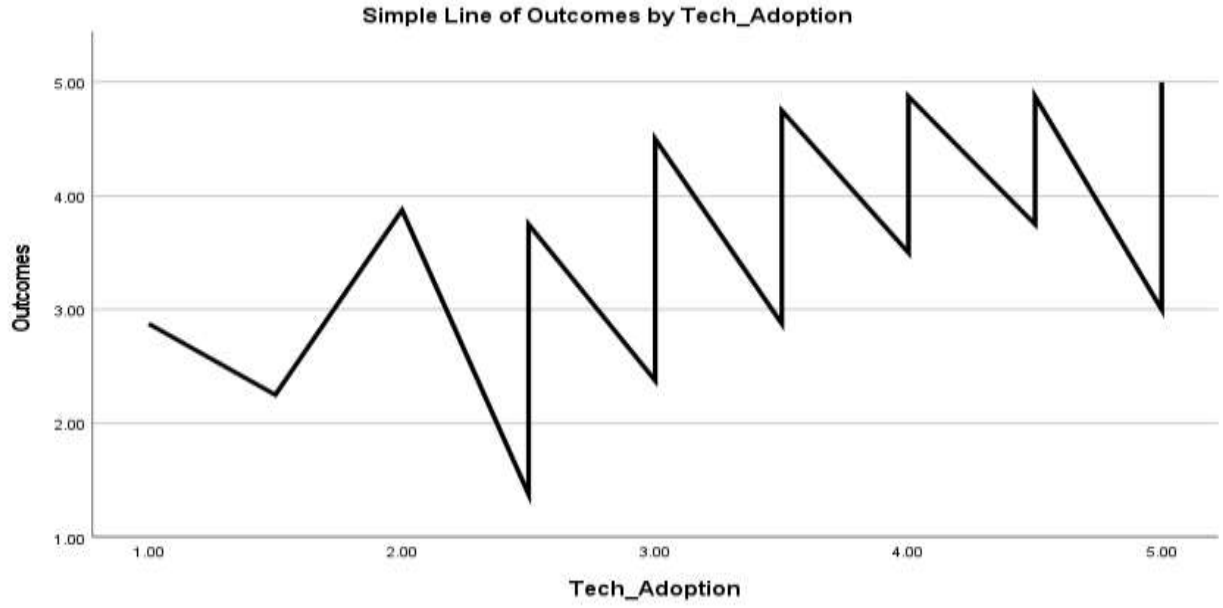


Figure 3: Line Graph Showing the Relationship between Technology Adoption and Supply Chain Outcomes

Figure 3 demonstrates using a simple line graph that technology adoption goes hand in hand with supply chain outcomes. Through the graph, it is evident that the general trend is an upward trend, meaning that increased adoption of technology is accompanied by favorable results of the supply chain. With the growing usage of better technologies by organizations, including automation and use of electronic systems, collaboration, efficiency, and performance across the supply chain can be improved. In spite of minor fluctuations that are seen in the graph, the overall trend is positive indicating a stable relationship between the two variables. The regression findings of the study are supported by this visual trend, which indicates that technology adoption is a notable factor in the overall improvements of supply chain results.

6. Discussion

The purpose of the study was to analyze how advanced technologies promoted supply chain collaboration, trust, performance, and technology adoption. The final results of the descriptive, correlation, and regression analyses have a solid empirical basis, as well as some rich information regarding the influence of digital transformation on contemporary supply chains (Sartal et al., 2020; Onunka et al., 2023). The descriptive statistics show that the respondents generally have pleasant perceptions towards the use of advanced technologies in supply chain management. The mean values of above-mentioned inventories software, digital tracking, predictive analytics, and real-time information sharing are high, indicating that organizations are increasingly moving towards using digital tools to maximize decision-making within organizations and operational efficiency (Shetty, 2019). Such results are not unprecedented since previously stated research indicates that digitalization enhances visibility, coordination, and responsiveness in supply chain networks. There are moderate mean scores about barriers, including those cost barriers, training, and the availability of skills, which implies that despite the optimistic attitude towards technology adoption, the practical implementation of the technology adoption is encompassed with the organizational obstacles. This reliability analysis also contributes to the findings as the Cronbach's Alpha of 0.926 represents a high level of internal consistency. This proves that measurement items are consistently effective at assessing constructs of advanced technologies and supply chain cooperation and thus results are reliable enough to be interpreted and compared to available literature (Shukor et al., 2021; Min, 2019).

The correlation results show that there are strong and statistically significant relationships between all the important variables. The correlation between sophisticated technologies and a successful supply chain is very positive, which proves the importance of digital tools to enhance collaboration, efficiency, and performance (Sinha & Wuest, 2021). This tight relationship between high-technologies and trust implies that transparency, real time information exchange, and safe systems increase trust among supply chain participants. These findings conform to the current literature that postulates that digital integration leads to less information asymmetry and enhances inter-organizational relationships. The positive correlation between the barriers and technology adoption suggests that the adoption behavior is heavily influenced by the implementation issues making it important to address the organizational and infrastructural limitation (Tseng et al., 2019). The results of the regression analysis give more support to the hypotheses of the study. This initial regression equation demonstrates that digital technologies constitute a significant part of the variation in supply chain performance, which has validated the assertion that digital transformation has a substantial effect on collaboration and performance (Wong et al., 2020; Manhart et al., 2020). The result aligns with previous studies that have classified the advanced technology as the major provider of supply chain integration and competitiveness. The second model proves that blockchain technology is powerful and influential on trust within the supply chain partners. This contributes to the developing literature emphasizing that blockchain can be used to increase transparency, traceability, and data integrity in supply chains (Zhao et al., 2022). The

third regression model shows that the cost of implementation, cybersecurity concern, and skills availability serve as important barriers to technology adoption. These barriers do not stop adoption; however, they significantly affect the speed and efficiency of digital transformation (Russell & Taylor, 2019).

The statistical results are also supported by the graphical analysis. The histogram reveals that the supply chain performance is more concentrated on the upper part of the scale which confirms the positive perceptions of the respondents (Onunka et al., 2023). The line graph reveals an increasing trend between supply chain results and technology adoption that visually supports the regression findings and highlights the performance advantages of advanced technologies. The discussion affirms that, new technologies are vital suppliers of supply chain partnership, faith, and efficiency. The implementation of technology is not only viable with the availability of the technology but also organizational preparedness, workforce skills, and the capacity to handle the cost and security risk. The results of the studies indicate that organizations should be prepared in terms of a balanced approach that integrates investments in technology and training, change management, and supportive policies to get the full potential of the digital supply chains benefits.

7. Conclusion

This paper examined how developed technologies can make the supply chain more collaborative, trusting, performative, and technologically adoptive. Supply chains are growing increasingly complex in a modern highly competitive and uncertain business environment, which makes collaboration and digital integration inevitable. The results of this study are highly empirical that advanced technologies artificial intelligence, blockchain, IoT, automation, and advanced analytics are important factors to enhance the overall effectiveness of the supply chain. The findings reveal that firms that implement the technologies enjoy better coordination, information sharing, increased visibility and more informed decision making in supply chain networks. The research confirms that high-tech solutions influence, positively and significantly, supply chain results, such as teamwork, productivity, and performance. Inventory management systems, digital tracking, real-time data sharing and other technologies allow organizations to react more efficiently to market changes and operational issues. The findings also underscore the role of blockchain technology in creating confidence between supply chain partners. Blockchain increases confidence and minimizes uncertainty in inter-organizational relationships by raising the level of transparency, traceability, and data integrity. These results relate to the literature available, which underlines the increasing role of digital transformation as a source of competitive advantage in supply chains. The paper outlines critical obstacles that shape the implementation and successful utilization of superior technologies. The cost of implementation, cybersecurity issues, and access to skilled labor were identified to highly influence decisions regarding the adoption of technology. Although organizations are aware of the value of digital transformation, these difficulties may slow the process of its adoption or restrict the successful use of advanced technologies. It means that effective digital transformation is achieved not only by investing in technology but also organizational preparedness, staff development, and effective data protection policies.

The implications of this study to managers are significant. The supply chain managers ought to take a long and strategic perspective on the investment of technology, as the digital ventures ought to align with the organizational goals and supply chain needs. The technologies to be given priority by managers include those that support real-time visibility, teamwork and resilience. To make the most of the advanced technologies, organizations are advised to invest in the process of employee training and skill development programs. Cybersecurity risks and data privacy concerns are also to be addressed to generate trust and promote collaboration among supply chain partners. Through these areas, organizations are able to ensure better performance in their supply chains and enhance their competitiveness. In spite of its contributions, this study has some

limitations. The sample size used was also very small and that can influence the external validity of the findings. The research was limited to respondents of a particular geographical region and supply chain practices might be different across regions as well as industries. The cross-sectional design of the study also restricts observing relationship over time with regard to change in adoption of technology and collaboration. Future studies can build on this study with the help of qualitative or mixed-method research to understand ways in which technology implementation and adoptions influence behaviors and organizational factors. The longitudinal research may be used to investigate the long-term influence of advanced technologies on supply chain quality and resilience. Research on the industry might further illustrate the ways various industries embrace and utilize the advantages of advanced supply chain technologies.

References

Al Mashalah, H., Hassini, E., Gunasekaran, A., & Bhatt, D. (2022). The impact of digital transformation on supply chains through e-commerce: Literature review and a conceptual framework. *Transportation Research Part E: Logistics and Transportation Review*, *165*, 102837.

Bai, C., & Sarkis, J. (2020). A supply chain transparency and sustainability technology appraisal model for blockchain technology. *International journal of production research*, *58*(7), 2142-2162.

Baldwin, R., & Freeman, R. (2022). Risks and global supply chains: What we know and what we need to know. *Annual Review of Economics*, *14*(1), 153-180.

Ben-Daya, M., Hassini, E., & Bahroun, Z. (2019). Internet of things and supply chain management: a literature review. *International journal of production research*, *57*(15-16), 4719-4742.

Benton Jr, W. C. (2020). *Purchasing and supply chain management*. Sage Publications.

Bhatia, M. S., & Gangwani, K. K. (2021). Green supply chain management: Scientometric review and analysis of empirical research. *Journal of cleaner production*, *284*, 124722.

Bogdan, M., & Borza, A. (2019). Big data analytics and organizational performance: a Meta-analysis study. *Management and Economics Review*, *4*(2), 1-13.

Charles, V., Emrouznejad, A., & Gherman, T. (2023). A critical analysis of the integration of blockchain and artificial intelligence for supply chain. *Annals of Operations Research*, *327*(1), 7-47.

Chopra, S., & Meindl, P. (2019). Supply chain management. Strategy, planning & operation. In *Das Summa Summarum des Management: Die 25 wichtigsten Werke für Strategie, Führung und Veränderung* (pp. 265-275). Wiesbaden: Gabler.

Christopher, M. (2022). *Logistics and supply chain management*. Pearson Uk.

Delen, D. (2020). *Predictive analytics: Data mining, machine learning and data science for practitioners*. FT Press.

Dewulf, A., Karpouzoglou, T., Warner, J., Wesselink, A., Mao, F., Vos, J., ... & Buytaert, W. (2019). The power to define resilience in social–hydrological systems: Toward a power-sensitive resilience framework. *Wiley Interdisciplinary Reviews: Water*, *6*(6), e1377.

Elofsson, O., & Paulsson, L. (2020). Supply Chain Collaboration: A Framework for Bridging Barriers.

Emon, M. M. H., Khan, T., & Siam, S. A. J. (2024). Quantifying the influence of supplier relationship management and supply chain performance: an investigation of Bangladesh's manufacturing and service sectors. *Brazilian Journal of Operations & Production Management*, *21*(2), 2015-2015.

Gaur, N. (2020). Blockchain challenges in adoption. *Managerial Finance*, *46*(6), 849-858.

Ghadge, A., Er Kara, M., Moradlou, H., & Goswami, M. (2020). The impact of Industry 4.0 implementation on supply chains. *Journal of Manufacturing Technology Management*, *31*(4), 669-686.

Hayakawa, K., & Mukunoki, H. (2021). Impacts of COVID-19 on global value chains. *The Developing Economies*, *59*(2), 154-177.

Hofmann, E., Sternberg, H., Chen, H., Pflaum, A., & Prockl, G. (2019). Supply chain management and Industry 4.0: conducting research in the digital age. *International Journal of Physical Distribution & Logistics Management*, *49*(10), 945-955.

Ivanov, D. (2021). *Introduction to supply chain resilience: Management, modelling, technology*. Springer Nature.

Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International journal of production research*, *58*(10), 2904-2915.

Jia, F., Li, K., Zhang, T., & Chen, L. (2025). Triple A supply chain management and sustainability. *Industrial management & data systems*, *125*(10), 2725-2752.

Joshi, P., Tewari, V., Kumar, S., & Singh, A. (2023). Blockchain technology for sustainable development: a systematic literature review. *Journal of Global Operations and Strategic Sourcing*, *16*(3), 683-717.

Ka, J. M. R., Ab, N. R., & Lb, K. (2019). A review on supply chain performance measurement systems. *Procedia Manuf*, *30*, 40-47.

Kamble, S. S., & Gunasekaran, A. (2020). Big data-driven supply chain performance measurement system: a review and framework for implementation. *International journal of production research*, *58*(1), 65-86.

Kamble, S., Gunasekaran, A., & Arha, H. (2019). Understanding the Blockchain technology adoption in supply chains-Indian context. *International journal of production research*, *57*(7), 2009-2033.

Kosacka-Olejnik, M., & Pitakaso, R. (2019). Industry 4.0: state of the art and research implications. *Logforum*, *15*(4), 475-485.

Longo, F., Nicoletti, L., Padovano, A., d'Atri, G., & Forte, M. (2019). Blockchain-enabled supply chain: An experimental study. *Computers & Industrial Engineering*, *136*, 57-69.

Maheshwari, S., Gautam, P., & Jaggi, C. K. (2021). Role of Big Data Analytics in supply chain management: current trends and future perspectives. *International Journal of Production Research*, *59*(6), 1875-1900.

Manhart, P., Summers, J. K., & Blackhurst, J. (2020). A meta-analytic review of supply chain risk management: assessing buffering and bridging strategies and firm performance. *Journal of Supply Chain Management*, *56*(3), 66-87.

Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SMEs. *Computers in industry*, *121*, 103261.

Min, H. (2019). Blockchain technology for enhancing supply chain resilience. *Business Horizons*, *62*(1), 35-45.

Mofokeng, T. M., & Chinomona, R. (2019). Supply chain partnership, supply chain collaboration and supply chain integration as the antecedents of supply chain performance. *South African Journal of Business Management*, *50*(1), 1-10.

Ning, L., & Yao, D. (2023). The impact of digital transformation on supply chain capabilities and supply chain competitive performance. *Sustainability*, *15*(13), 10107.

Onunka, O., Onunka, T., Fawole, A. A., Adeleke, I. J., & Daraojimba, C. (2023). Library and information services in the digital age: Opportunities and challenges. *Acta Informatica Malaysia*, *7*(1), 113-121.

Park, A., & Li, H. (2021). The effect of blockchain technology on supply chain sustainability performances. *Sustainability*, *13*(4), 1726.

Queiroz, M. M., Telles, R., & Bonilla, S. H. (2020). Blockchain and supply chain management integration: a systematic review of the literature. *Supply chain management: An international journal*, *25*(2), 241-254.

Russell, R. S., & Taylor, B. W. (2019). *Operations and supply chain management*. John Wiley & Sons.

Sartal, A., Bellas, R., Mejías, A. M., & García-Collado, A. (2020). The sustainable manufacturing concept, evolution and opportunities within Industry 4.0: A literature review. *Advances in Mechanical Engineering*, *12*(5), 1687814020925232.

Sawyerr, E., & Harrison, C. (2020). Developing resilient supply chains: lessons from high-reliability organisations. *Supply Chain Management: An International Journal*, *25*(1), 77-100.

Schmidt, C. G., & Wagner, S. M. (2019). Blockchain and supply chain relations: A transaction cost theory perspective. *Journal of Purchasing and Supply Management*, *25*(4), 100552.

Schwab, J. H. (2020). Predictive analytics. *The Spine Journal*, *20*(7), 1152-1153.

Shetty, V. K. (2019). Impact of supply chain management practices on performance of companies. *Journal of Supply Chain Management Systems*, *8*(3), 48-57.

Shrivastava, S. (2023). Recent trends in supply chain management of business-to-business firms: a review and future research directions. Journal of Business & Industrial Marketing, 38(12), 2673-2693.

Shukor, A. A. A., Newaz, M. S., Rahman, M. K., & Taha, A. Z. (2021). Supply chain integration and its impact on supply chain agility and organizational flexibility in manufacturing firms. *International Journal of Emerging Markets*, *16*(8), 1721-1744.

Sinha, A., & Wuest, E. B. R. C. T. (2021). *Digital supply networks*. London, UK:: McGraw Hill-Ascent Audio.

Trushkina, N., Dzwigol, H., & Serhieieva, O. (2020). Development of the Logistics 4.0 Concept in the Digital Economy. *Экономический вестник Донбасса*, (4 (62)), 85-96.

Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. *Resources, conservation and recycling*, *141*, 145-162.

Wong, L. W., Tan, G. W. H., Lee, V. H., Ooi, K. B., & Sohal, A. (2020). Unearthing the determinants of Blockchain adoption in supply chain management. *International Journal of Production Research*, *58*(7), 2100-2123.

Yadav, S., & Singh, S. P. (2020). Blockchain critical success factors for sustainable supply chain. *Resources, Conservation and Recycling*, *152*, 104505.

Zhao, X., Chan, H. K., Ji, G., Qi, Y., Yang, Q., Tan, K. H., & Li, Y. (Eds.). (2022). *Supply Chain Risk and Innovation Management in "The Next Normal": Proceedings of the 15th International Conference on Operations and Supply Chain Management*. Springer Nature.