International Journal of Human and Society (IJHS)

P-ISSN: 2710-4966	E-ISSN: 2710-4958
Vol. 4. No. 02 (April-June) 2024	Page 402-415

Influence of Digital Technologies on Sustainable Supply Chain Performance of Project Base Manufacturing Organization of Pakistan: An Empirical Study Based on Mediating and Moderating Model

Fahad Saddique	Ph.D. Scholar, The Institute of Management Sciences, Gulberg Lahore, Punjab, Pakistan, fahad.sadique@gmail.com
Muhammad Imran Khan	Assistant Professor, Business Administration Department, Institute of Management Sciences, Gulberg Lahore, Punjab, Pakistan dr.imran@pakaims.edu.pk
Khalil Nasir Khan	PhD Scholar, Lincoln university college Malaysia and visiting lecturer university of Layyah. khalilnasir9161@gmail.com

Abstract: *This study investigates the influence of digital technologies on sustainable supply chain performance in project-based manufacturing organizations in Pakistan. The study contributes to the mediating role of digital supply chain integration between digital technologies and sustainable supply chain performance. Furthermore, the study contributes to the moderating role of digital leadership between digital technologies and supply chain integration. The study survey data of 402 professionals was collected from project-based manufacturing organizations in Lahore, Pakistan. The study results indicated that digital technologies have positively influenced sustainable performance in the manufacturing organization of Lahore, Pakistan. The study result shows that digital technologies significantly positively influence sustainable performance in project-based manufacturing organizations in Pakistan. The study contributes a partial positive mediating role of digital supply chain integration between digital technologies and sustainable supply chain performance. Furthermore, the study contributes to the significant moderator role of digital leadership between digital technologies and digital supply chain integration. This study offers valuable information for professionals on improving sustainable performance through digital technologies, integration, and leadership. Specifically, this study shows that implementing digital technologies increases supply chain practices efficiency in terms of sustainability and operation for the long term*

Keywords: Digital Technologies; Digital Supply Chain Integration; Digital Leadership, Sustainable Supply Chain Performance and Project Base Manufacturing Sector in Pakistan

Introduction

With the latest technologies in many sectors, firms now improve their supply chain efficiency (Balfaqih et al., 2016). Supply chains encompass the entire process from sourcing raw materials to delivering goods to customers, so prioritizing them promotes sustainability. Due to rising public awareness of environmental and social laws in industrialized nations, sustainability has emerged (Oubrahim et al., 2022). Global climate change has also raised manufacturer's and customer's sustainability awareness. This recognition has led to a shift from traditional to sustainable supply chains with more environmentally friendly manufacturing activities (Wang et al., 2020; Seuring et al., 2022). SSCP emphasizes social, environmental, and economic goals (Rodriguez et al., 2022). Many professionals say supply chain sustainability is achieved by improving performance (Suhi et al., 2019). Supply chain performance minimizes cost reduction and efficiency. In order to attain optimal and sustained performance levels, adhere to current

technology advancements, be informed about developments in digital technologies, and prioritize operational excellence (Mangla et al., 2022). From both practical and theoretical perspectives, assessing and comprehending SSCP is crucial. Organizations may prioritize customers, foster innovation, and optimize resources and productivity while upholding specific environmental considerations (Junaid et al., 2022). The primary purpose of SSCP is to be associated with the objective of sustainability (Fu et al., 2022). Nevertheless, attaining these goals takes time for decision procedures. In recent discussions on supply chains, two words that have received significant attention are digital technologies and digital supply chain integration (Dudukalov, E. 2020; Schniederjans et al., 2020; Chen et al.,2022; Ataseven et al., A. 2017; Flynn et al., 2010). Digital technologies enhance digital supply chain integration by improving data gathering supply chain management, decreasing expenses, enhancing prompt delivery classifications, and boosting competence (Nayal et al., 2020; Bigliardi et al., 2022). It will probably continue to significantly impact social and commercial activities with the rapid growth of new technology (Mashelkar et al., 2018). Thus, firms have the potential to achieve operational efficiency and reduce cost effects by implementing intelligent internal procedures with the latest technologies (Queiroz et al., 2019). Digital technologies are firm's strategic use of digital skills to revolutionize growth systems (Frederico et al., 2021; Aryal et al., 2020). However, digital integration has gained noteworthy interest in industry and academia in the past twenty years. The competitive market has compelled decision-makers to seek partnership strategies to improve the supply chain and decrease lead time and cost (Di Maria et al., 2022; Qu et al., Z. 2022). Integration from a supply chain is a process that a corporation aligns its practices, operations, and objectives in a collaborative, coordinated, and managed manner to satisfy customer requirements effectively (Huo, B. 2012; v et al.,2019; Oubrahim et al., 2022). Another study discussed digital technologies, integration and SSCP (Liu et al., 2021; Tan et al., 2023; Gupta et al.,2021). Furthermore, Management accepts that leaders drive and engage in the process and are prepared to take risks when implementing digital technologies and the latest technology (Mihardjo et al., 2019). Digital leadership incorporates the latest digital skills and talents to promote sustainability (Amelda et al., 2021). By using digital viewpoints, awareness, and expertise, digitalized leadership may address disruptive problems and drive innovation (Roberts et al., 1999). Digital leadership maximizes technical improvements to boost digital integration and organizational value (Elidjena et al., 2019). Digital leadership uses the benefits of digitalized technology to improve performance (Amelda et al., 2021). Digital leadership in German firms can boost growth by 60% by implementing digital technologies (Hensellek et al., 2020). Knowing how digital technologies and leadership improve digital supply chain integration and sustainability (El Hilali et al.,2020) is needed. This present study suggested the influence of digital technologies on sustainable supply chain performance in project-based manufacturing organizations in Pakistan. The study contributes to the mediating role of digital supply chain integration between digital technologies and sustainable supply chain performance. Furthermore, the study contributes to the moderating role of digital leadership between digital technologies and digital supply chain integration in Pakistan's manufacturing organization.

2. Literature Review:

2.1. Digital Technologies and Sustainable Supply Chain Performance:

Companies must adopt digital technology across supply chains to meet market expectations and stay ahead (Deepu & Ravi, 2021; Ageron et al., 2020). Declining life cycles of products, resource limits, and worldwide rivalry drive this transformation. Digital technology tools improve supply chain information availability, optimized practices, production cost and customer delivery (Happonen et al., 2020). Organizations must prioritize an energy-efficient, ecologically friendly strategy (Uddin et al., 2012). Establishing digital supply chain networks that reduce asset consumption and

industrial emissions can reduce emissions (Sharma et al., 2022). Internal procedures and digital technology can improve operational efficiency and mitigate (Oubrahim et al., 2022). Additionally, DT improves product creation efficiency and consumer value (Dudukalov et al., 2021). Digital technology provides a long-term competitive edge, boosting supply chain performance. According to previous literature assessments, digital technologies significantly impact sustainable supply chains. As (Gupta et al., 2021) suggest, the latest technologies and analytics are effective methods for improving SSCP. (Lee et al., 2022) suggest an association between digital and firm performance in Malaysia's sector. (Dudukalov et al., 2021) Suggest a positive link between DT and SCP. (Nayal et al., 2022) proposed an association adoption of artificial intelligence and SCP in the circular economy. Furthermore, the study suggests that it positively influences organization's SCP. Nevertheless, (Nayal et al., 2021, 2022) have undertaken two further studies. The first study suggests the influence of collaborative advantages, cooperation and coordination, digital technologies and sustainability. The results showed that digital technologies have positive effects on all the variables. Another study suggested that blockchain technology helps SCP progress. Additionally, as (Kim et al., 2021), the digitization procedure has a beneficial impact on social capital, subsequently leading to a good influence on performance. The influence of healthcare digitization on SCP is nominal, with significant help being controlled. As (Sharma et al., 2022) suggested, digitalization's influence positively affects manufacturing firm's sustainability. As (Raut et al., 2021) have suggested, data analysis directly influences the business performance of sustainable supply chains. Furthermore, extensive data analysis positively influences environmental, economic and sustainable supply chains. Their conceptual model incorporates many factors, including BDA, supply chain practices, overall quality management, and sustainable performance. (Kamble et al.,2021) have provided evidence for the idea by stating that BCT technologies have a favorable impact on SSCP. Nevertheless, this association is entirely influenced by SCI. The literature evaluation suggests that digital technologies positively impact the improvement of SCP. More studies are needed to investigate the direct association between DT, DL, and SSCP (Alsufyani et al., 2022; Jabbour et al., 2020). Consequently, the following hypothesis is proposed:

Hypothesis 1 (H1). There is a positive and significant relationship between digital technologies and sustainable supply chain performance.

2.2. Mediating Role of Digital Supply Chain Integration.

Digital technologies aim to improve the performance of organizational processes. Additionally, they can facilitate data exchange within the organization (Lee et al., 2022). Digital transformation encompasses transactions between different organizations and transactions inside the business, all by digital technologies (Stroumpoulis et al., 2022). Integration encompasses Resource Planning, accessing up-to-date records and harmonizing operations using blockchain. Simultaneously, external integration refers to aligning all stakeholders to develop target markets. The most crucial challenges in external integration are information exchange and coordinated planning. However, only digital technology can improve their efficacy (Koçoglu et al., 2011). The latest technologies have improved supply chain integration (Lee et al., 2021). According to several research, digital transformation technologies help firms integrate (Dutta et al., 2020). As (Nayal et al., 2022), artificial intelligence helps increase planning, production, and performance. Wang et al. (2020) studied shows how blockchain improves supply chain integration. Many firms have adopted supply chain integration to improve sustainability and strengthen linkages (Espino-Rodríguez & Taha, 2022). Partners across the supply chain must participate in digital supply chain integration. Supply chain companies must coordinate intra- and inter-organizational processes to mitigate environmental and operational impacts (Kumar et al., 2017). Thus, integration may benefit joint environmental operations (Lee et al., 2022).

Integration approaches can lessen negative implications on sustainable performance. (Tarigan, Siagian, Jie, 2021). Additionally, Supply Chain Integration streamlines internal and external corporate operations and improves customer and supplier efficiency (Flynn et al., 2010). To achieve sustainable performance, synchronize supply chain network information (Espino-Rodríguez & Taha, 2022). Another study presented a conceptual framework for internal, supplier, customer, and SSCP (Al Naqbi et al., 2018). As (Mashat et al., 2024) indicate, suppliers, customers, and internal integration affect supply chain performance. As (Han & Huo, 2020) examined how green integration affects performance. A green internal integration affects customer and supplier integration and performance. A green SC boosts economic output. The previous research only examined how supply chain integration and performance affect overall performance (Erboz et al., 2022). In the above discussion, this hypothesis is proposed.

Hypothesis 2, H2: There are positive influence of digital technologies on digital supply chain integration on manufacturing organization.

Hypothesis 3, H3: There are positive influence of digital supply chain integration on sustainable supply chain performance on manufacturing organization.

Hypothesis 4, H4: There are positive mediating role of digital supply chain integration in between digital technologies on sustainable supply chain performance on manufacturing organization.

2.3 The Moderator Role of Implementation of Digital Leadership:

The digital leader performs better with the adoption of digital technologies. DT encompasses sophisticated and innovative technologies that facilitate connection, communication, and automation, including IoT. According to Zhang et al. (2018), digital technologies allow organizations to implement data-efficient strategies to enhance their competitiveness. Information technology competence is associated with the scope of information technology business operations, where a proactive approach is employed to manage firm innovations using information technologies (Lu et al., 2011; Colwill et al., 1999). Improving IT skills and integrating human competencies with an organization's digital assets requires digital leadership (Mohamed et al., 2022). Thus, leadership and SOP need modern technology to maintain performance. Multiple studies have shown that organizational learning and a culture that embraces digital technologies significantly impact performance (Lu et al., 2011). Digital technologies in an organization's enabling culture may help it understand and succeed (Bustinza et al., 2010). Digital technology is essential to the digital era, and digital integration that encourages organizational learning will impact digital leadership (Robey et al., 2000). Digitizing Standard Operating Procedures and providing digital leadership and guidance are crucial for long-term corporate success. Information technologies help strategic management and firm performance (Tirastittam et al., 2020). As (Basheer et al.,2019) initiate, information technology positively affects the performance of Pakistan's industries. According to (Lisdiono et al., 2022), the relationship between cooperative skills and resilience in Indonesia is affected by the mediating role of digital technology. The study by (Mollah et al., 2023) proposed that the most recent technological advancements have improved learning capabilities and efficiency. As (Lu et al. 2011) investigated the influence of the latest technologies to increase the competence of companies. Therefore, the current investigation proposed the following hypothesis.

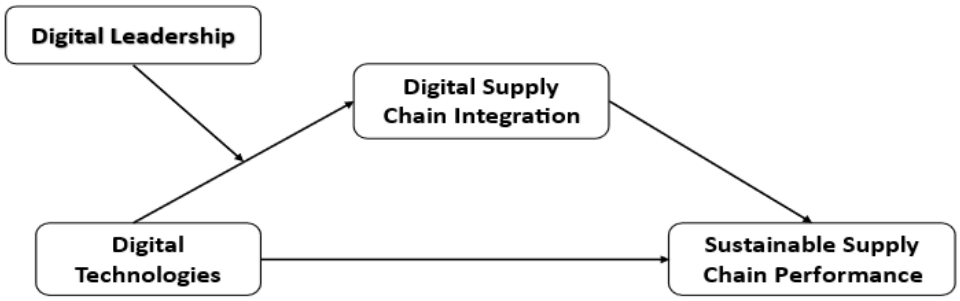
Hypothesis 5 (H5): There is a positive moderator relationship between the implementation of digital leadership in between digital technologies and digital supply chain integration in manufacturing organization.

3. Research Methodology:

3.1. Conceptual Framework

The suggested conceptual framework is derived from a comprehensive analysis of existing literature and insights provided by professionals in the field. The diagram below clearly

illustrates the anticipated connections between DT, DSCI, DL and SSCP.



Conceptual Framework

3.2 Procedures and Participants:

The study's findings are based on the primary data acquired from manufacturing origination in Lahore, Pakistan. The answer provided by the survey respondent was guaranteed to be kept secret. A three-wave lag period with a 30-day interval was included to reduce the inherent bias in data collecting, as suggested by Podsakoff et al. (2003). At Time 1, the measurements were taken for the predictors, digital technologies, and SSCP. The mediating variable "digital supply chain integration" is obtained at Time 2. Data for the moderator variable "digital leadership" were gathered for the third time. The identical personnel at Time 3 were singled out. The 402 respondents reply, resulting in a response rate of 61.85%. Six hundred fifty questionnaires were sent in total, with no variations in demographics and characteristics between the two time periods. The study participants consisted of manufacturing organizations in Lahore, Punjab, Pakistan.

3.3 Measures:

The sustainable supply chain performance was based on a five-item scale by (Ma et al., 2022) from "1 = strongly disagree; 5 = strongly agree". The item is "your organization, sustainable supply chain performance maximizes the profits." In order to measure digital technologies, we completed the five-item questionnaire (Saddique et al., 2023) from ("1 = strongly disagree; 5 = strongly agree"). The item is "Is your company's, digital technologies strategy can improve efficiency and performance of operations?". In order to measure digital supply chain integration, we completed the five-item questionnaire (Su-Yol Lee, 2021) from ("1 = strongly disagree; 5 = strongly agree"). The item stated: "Your organization uses shared order information using digital technologies." In order to measure digital leadership, we completed the six-item questionnaire (Saddique et al.,2023) from ("1= strongly disagree; 5 = strongly agree"). The item is "Supervisor/leader raises awareness of the technologies that can be used to improve organizational processes."

4. Data Analysis

4.1 Respondents Characteristics

Table #, 4.1 Frequency Table:

Sample profile	Frequency %	Cumulative %
Gender:		
Male	276	68.7
Female	126	31.3
Total:	402	100
Age:		
Below 25 years	72	17.9

26-40 years	193	48.0
41 to 55 years	84	20.9
Above 55 years	53	13.2
Total:	402	100
Education:		
Matric	18	4.5
Intermediate	36	9.0
Graduation	175	43.5
Post graduation	173	43
Total	402	100
Professional Experience:		
"Less than 1 year"	56	13.9
"1-5 years"	125	31.1
"6-10 years"	137	34.1
"Above than 10 years"	84	20.9
Total	402	100
Designation:		
Senior Executive	64	15.9
Senior Manager	151	37.6
Manager	87	21.6
First Line Manager	72	17.9
Others	28	7
Total	402	100

At first, the demographic analysis was carried out using SPSS. The age range of 26-40 had the highest professional frequency, with 193 respondents. This indicates that most of the professionals surveyed were sufficiently mature to comprehend the nature of the questionnaire and provide suitable responses. Please refer to Table 1 for more details. Since data were from manufacturing organizations in Pakistan and the specific group being studied was professional, the primary respondents were male. The profession is mainly occupied by men in Pakistan and worldwide. Based on the data gathered in this research (refer to Table 1), there is sufficient education to comprehend the terminology used in this study. For example, out of the total respondents,175 were qualified with graduation. The most professional experience is 137 respondents, who are very experienced people. Most of the employees that our study respondents are senior-level managers.

4.2 Reliability and Correlation Analyses

The values for all variables are 0.70, which is the norm. These results indicate that the metrics may be used for future studies. The average scores for digital integration and digital leadership are high, precisely 4.1522 and 4.2334, respectively. This indicates that professionals demonstrate high levels of performance. Conversely, the mean scores for sustainable performance and digital technologies are 3.187 and 3.919. The standard deviation of all components is generally modest. Our research revealed a noteworthy positive relationship between digital technologies and sustainable supply chain performance ($r = 0.531$, $p<0.01$). Additionally, our research revealed a strong positive relationship between digital technologies and digital integration ($r = 0.850$, $p<0.05$). However, digital technologies and digital leadership have ($r = 0.854$, $p<0.01$); in addition, our research revealed that there is a substantial correlation between digital integration and sustainable performance ($r = 0.542$, $p<0.01$). In addition, our research revealed that there is a substantial association between digital integration and digital leadership ($r = 0.836$, $p<0.01$), as well as between sustainable supply chain performance and digital leadership ($r = 0.496$, $p<0.05$).

Table 4.2: Reliability and Correlation Analyses

Sr #	"Variables"	"Mean"	"Standard Deviation"	Cronbach' Alpha	1	2	3	4
1	Digital Technologies	3.9199	1.064	0.902	1			
2	Digital Supply Chain Integration	4.1522	0.7761	0.735	0.850**	1		
3	"Sustainable Supply Chain Performance".	3.4876	0.866	0.796	0.531**	0.542**	1	
4	Digital Leadership	4.2334	0.710	0.774	0.854**	0.836**	0.496**	1

"**. Correlation is significant at the 0.01 level (2-tailed)".

"*. Correlation is significant at the 0.05 level (2-tailed)".

In order to provide clarification about the assumptions, a regression analysis was performed. The study revealed that the R square value, which indicates the amount of variation explained, was determined to be 0.030 (refer to Table 4.3). The ANOVA table shows the statistical significance of dependent variable digital integration. Based on the regression coefficient, it is evident that digital leadership is statistically significant. Hence, there is a notable interaction impact between digital leadership, digital technologies and sustainability (ß = 0.443, p<0.05). Conversely, digital leadership and technologies interact positively (ß = 0.106, p<0.05). The evidence provides support for the modest assumptions

Table No 4.3: Regression and Moderation Analyses

Variable	β	SE	p-value
Step 1			
Digital Technologies	0.367	0.034	0.00
Digital Leadership	0.443	0.051	0.00
R^2	0.767		
Step 2			
Digital Technologies x Digital Leadership	0.106	0.003	0.00
R^2	0.754		
ΔR^2	0.013		

Note: Digital Supply Chain Integration,

**p<0.05, ***p<0.01

4.3 Mediation Analysis:

By adhering to the four stages proposed by Barron and Kenny for doing mediation analysis, we have determined that all the routes are statistically significant. Step 1, there is a strong association between digital technologies and sustainable supply chain performance (β = 0.433, P<0.01). Within the context of step 2, there is a notable correlation between digital technologies and digital supply chain integration (β = .620, P<0.01). Step 3's flourishing mediating variable links digital supply chain integration to sustainable performance (β = .607, P<0.01). In contrast, the mediating variable, digital supply chain integration, significantly impacts sustainable supply chain performance (β = 0.369, P<0.01). As a result, hypothesis 4, which is connected to mediation, is supported.

Table 4.4: Mediation Analysis:
Mediating Analysis:

Variable	Estimate	S. E	p-value
Step 1			
Digital Technologies ⟶ Sustainable Supply Chain Performance	0.433	0.035	0.000
Step 2			
Digital Technologies ⟶ Digital Supply Chain Integration	0.620	0.019	0.000
Step 3			
Digital Supply Chain Integration ⟶ Sustainable Supply Chain Performance	0.607	0.047	0.000
Step 4			
Digital Technologies ⟶ Digital Supply Chain Integration ⟶ Sustainable Supply Chain Performance	0.369	0.088	0.000

Note: S. E means Standard Errors

5. Discussion:

This research has provided an empirical explanation of the influence of digital technology, digital supply chain integration, and digital leadership on sustainable performance. The results revealed a significant impact of digital technologies on sustainable supply chain performance. Prior studies have emphasized the significance of digital technology as a concept in improving sustainability performance. Prior studies have been done on the Internet of Things, blockchain, digital technologies and sustainable performance (Yousefi & Tosarkani, 2022; Minashkina & Happonen, 2020; García Alcaraz et al., 2022). From an economic perspective, adopting new technology in conjunction with digital technologies may benefit firms and improve their sustainability performance across all levels, from operational to strategic, favorably improving their overall economic performance. By minimizing waste industrial operations, a firm may improve its sustainability, resulting in lower raw materials and water consumption and increased energy efficiency (Auvinen et al., 2020). Furthermore, DT can mitigate and restrict human mistakes, minimize delays, and expedite transaction times. Additionally, they may enhance workers' well-being, improve the working environment, and increase job satisfaction. Furthermore, the findings of the hypothesis testing further demonstrated the mediating influence of digital integration on the association between digital technologies and sustainable performance. This indicates that adopting these latest technologies helps you perform better at work. Therefore, three dimensions of integration, which are all stakeholders, enable the effective implementation of digital technologies to improve overall performance. Companies use internal integration processes to facilitate the exchange of information across different departments inside their supply chain. This included strategic cooperation and collaboration using digital technologies. Simultaneously, external integration allows organizations to establish cooperative partnerships with suppliers and consumers. These issues are essential from a technical perspective because they improve visibility and increase trust (Salmela & Happonen, 2009). In addition, although there have been no prior empirical studies examining the specific influence of digital technologies on integration statistically, this study aligns with existing DT-related literature suggesting that adopting digital technologies positively impacts all three types of integration (Erboz et al., 2022). The use of scientific knowledge and methods has a beneficial effect on sustainable supply chain performance within the setting of a manufacturing organization. Businesses have acknowledged that including internal operations, suppliers, and consumers is a viable option for enhancing the direction of activities and enhancing the performance and sustainability of the supply chain. Integrating internal and external operations helps organizations meet their sustainability performance goals, whether internal or external. It works best when integrated with supply chain network operations (Ketokivi & Mahoney, 2020). Strategic cooperation and partnership help supply chain companies manage environmental and operational impacts. Thus, supply chain integration methods can improve cooperative eco-friendly systems (Ketokivi & Mahoney, 2020). Digital leadership improves and integrates skills with an organization's resources (Mohamed et al., 2022). So, digital leadership positively influences digital technologies and digital integration in manufacturing firms in Pakistan.

6. Study Implications:

6.1. Theoretical Implications:

The study's findings illuminate DT, SCI, DL and

SSCP literature. The suggested research shows that DT improves DSCI and SSCP, and DL has a significant role in DT And DSCI. Prior studies emphasize the role of DT adoption in improving DSCI and SSCP and the role of DL. The investigation also showed that DT adoption can help Pakistan manufacturing enterprises improve their sustainability and economic performance. The results also showed that minimizing manufacturing waste and emissions could improve sustainability. DSCI partially mediates the link between DT and SSCP, showing that DT adoption improves SSCP.

Furthermore, DL has a positive moderator role compared to DT and DSCI. Thus, the three types of DSCI, supplier, customer, and internal, encourage DT adoption to improve SSCP. Otherwise, empirical studies revealed that DSCI improves SSCP. This illustrates that Pakistan manufacturing enterprises use DSCI to improve sustainability performance by linking SC functions. Strategic collaboration and partnership between manufacturing businesses, suppliers, and customers help control environmental and social implications. Hence, DSCI methods may improve sustainability performance. This research is noteworthy because it examines the relationship between the adoption of digital technologies, digital supply chain integration, digital leadership, and sustainable supply chain performance in Pakistani manufacturing, which has not been studied before. Pakistan manufacturing enterprises should benefit most from digital technologies and perform better.

6.2. Practical Implications:

This research supported how DT adoption with DL and DSCI affects SSCP for Pakistan manufacturing enterprises. Analytical results enable decision-makers to adopt digital technology to efficiently increase supply chain network integration. Practitioners must understand that SC partner's integration, trust, and data and information quality directly affect their companies' ability to share, coordinate, and organize. Indeed, DT can improve supplier and customer trust and collaboration (Saddique et al., 2023). DT directly and positively affects SCI. This illustrates that digital technology may dynamically improve integration. Thus, digital technology should be integrated to boost SC efficiency. As rapidly expanding digital technologies improve sustainability performance, Pakistan manufacturing businesses must continue implementing them. DT continually offers new approaches to improve sustainable performance. DT adoption benefits networks by increasing information availability, optimizing, reducing costs, and improving SC function efficiency and effectiveness. Company SC flexibility, visibility, and risk reduction are improved by DT (Ivanov et al., 2019). Furthermore, the digital leader also significantly positively impacts digital technologies and digital supply chain integration. In addition, manufacturing organizations should be more conscious of methods for integrating internal operations, suppliers, and customers, as this is underutilized, considering its competitive advantages. DSCI methods help manufacturing organizations improve sustainable performance by deepening SC function linkages (Saddique et al., 2024). Furthermore, digital leadership also helps in attaining positive with sustainable supply chain performance.

7. Conclusions:

This research expands the existing understanding of the association between digital technologies, digital integration, digital leadership and performance sustainability. This study created a theoretical framework with three hypotheses to scientifically evaluate the influence of digital technologies, digital integration, and digital leadership on sustainable performance in manufacturing enterprises in Pakistan. Based on data collected from senior executives and managers in manufacturing businesses, the research confirms that the suggested model is effective, as all four variable hypotheses are validated. The assumptions that are supported are as follows, digital technologies have a direct and beneficial impact on the overall performance of sustainable supply chains (H1), digital technologies have a direct and substantial effect on the digital integration of the supply chain (H2), The integration of the supply chain has a favorable influence on the overall performance of a sustainable supply chain (H3) and the results of the hypothesis testing also indicated that digital supply chain integration has partially mediates the relationship between digital technologies and sustainable supply chain performance H4 and digital leadership have significant positive moderator role in between digital technologies and digital supply chain integration in manufacturing organization H5. The proposed study and its findings offer novel insights into the specific theoretical advancements and empirical research regarding the requirements for Pakistani manufacturing companies to embrace digital technologies and

integrate their supply chain functions. This integration aims to improve sustainability performance and effectively respond to evolving demands. This research is the first to incorporate and evaluate all these components inside the manufacturing sector. In addition, the research assessed the respondent's impressions of the many components that contribute to the overall performance of sustainability. The primary research considered sustainable supply chain performance's financial, social, and environmental aspects. Furthermore, how digitalization might positively impact the industry's manufacturing sector can be achieved by enhancing and redefining their offerings via digital content, ultimately creating new sources of income essential for their long-term performance.

8. Reference:

Ageron, B., Bentahar, O., & Gunasekaran, A. (2020, July). Digital supply chain: challenges and future directions. In *Supply Chain Forum: An International Journal* (Vol. 21, No. 3, pp. 133-138). Taylor & Francis.

al Naqbi, R. A. K., Yusoff, R. B. M., & Ismail, F. B. (2018). Supply Chain integration and Sustainable supply chain performance: A case of Manufacturing firms from UAE. *International Journal of Engineering & Technology*, *7*(4.7), 424-429.

Alsufyani, N., & Gill, A. Q. (2022). Digitalisation performance assessment: A systematic review. *Technology in Society*, *68*, 101894.

Amelda, B., Alamsjah, F., & Elidjen, E. (2021). Does The Digital Marketing Capability of Indonesian Banks Align with Digital Leadership and Technology Capabilities on Company Performance? *Communication and Information Technology*, *15*(1), 9-17.

Aryal, A., Liao, Y., Nattuthurai, P., & Li, B. (2020). The emerging big data analytics and IoT in supply chain management: a systematic review. *Supply Chain Management: An International Journal*, *25*(2), 141-156.

Ataseven, C., & Nair, A. (2017). Assessment of supply chain integration and performance relationships: A meta-analytic investigation of the literature. *International journal of production economics*, *185*, 252-265.

Auvinen, H., Santti, U., & Happonen, A. (2020). Technologies for reducing emissions and costs in combined heat and power production. In *E3S Web of Conferences* (Vol. 158, p. 03006). EDP Sciences.

Balfaqih, H., Nopiah, Z. M., Saibani, N., & Al-Nory, M. T. (2016). Review of supply chain performance measurement systems: 1998–2015. *Computers in industry*, *82*, 135-150.

Basheer, M., Siam, M., Awn, A., & Hassan, S. (2019). Exploring the role of TQM and supply chain practices for firm supply performance in the presence of information technology capabilities and supply chain technology adoption: A case of textile firms in Pakistan. *Uncertain Supply Chain Management*, *7*(2), 275-288.

Bigliardi, B., Filippelli, S., Petroni, A., & Tagliente, L. (2022). The digitalization of supply chain: a review. *Procedia Computer Science*, *200*, 1806-1815.

Bustinza, O. F., Molina, L. M., & GUTIERREZ-GUTIERREZ, L. J. (2010). Outsourcing as seen from the perspective of knowledge management. *Journal of Supply Chain Management*, 46(3), 23-39.

Chen, C., Feng, Y., & Shen, B. (2022). Managing labor sustainability in digitalized supply chains: a systematic literature review. *Sustainability*, *14*(7), 3895.

Colwill, J., & Townsend, J. (1999). Women, leadership and information technology: The impact of women leaders in organizations and their role in integrating information technology with corporate strategy. *Journal of Management Development*, 18(3), 207-216.

Deepu, T. S., & Ravi, V. (2021). Supply chain digitalization: An integrated MCDM approach for inter-organizational information systems selection in an electronic supply chain. *International Journal of Information Management Data Insights*, *1*(2), 100038.

Di Maria, E., De Marchi, V., & Galeazzo, A. (2022). Industry 4.0 technologies and circular economy: The mediating role of supply chain integration. *Business*

Strategy and the Environment, *31*(2), 619-632.

Dudukalov, E. (2020). Industry 4.0 readiness: the impact of digital transformation on supply chain performance.

Dutta, P., Choi, T. M., Somani, S., & Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportation research part e: Logistics and transportation review*, *142*, 102067.

El Hilali, W., El Manouar, A., & Janati Idrissi, M. A. (2020). Reaching sustainability during a digital transformation: a PLS approach. *International Journal of Innovation Science*, *12*(1), 52-79.

Elidjena, L. W., & Rukmanac, R. A. (2019). Intervening role of innovation management on relationship between digital leadership and dynamic capability accelerated by collaboration. *focus*, *6*(1).

Erboz, G., Yumurtacı Hüseyinoğlu, I. Ö., & Szegedi, Z. (2022). The partial mediating role of supply chain integration between Industry 4.0 and supply chain performance. *Supply Chain Management: An International Journal*, *27*(4), 538-559.

Espino-Rodríguez, T. F., & Taha, M. G. (2022). Supplier innovativeness in supply chain integration and sustainable performance in the hotel industry. *International Journal of Hospitality Management*, *100*, 103103.

Flynn, B. B., Huo, B., & Zhao, X. (2010). The impact of supply chain integration on performance: A contingency and configuration approach. *Journal of operations management*, *28*(1), 58-71.

Frederico, G. F., Garza-Reyes, J. A., Kumar, A., & Kumar, V. (2021). Performance measurement for supply chains in the industry 4.0 era: a balanced scorecard approach. *International journal of productivity and performance management*, *70*(4), 789-807.

Fu, Q., Abdul Rahman, A. A., Jiang, H., Abbas, J., & Comite, U. (2022). Sustainable supply chain and business performance: The impact of strategy, network design, information systems, and organizational structure. *Sustainability*, *14*(3), 1080.

García Alcaraz, J. L., Díaz Reza, J. R., Arredondo Soto, K. C., Hernandez Escobedo, G., Happonen, A., Puig I Vidal, R., & Jiménez Macías, E. (2022). Effect of green supply chain management practices on environmental performance: case of Mexican manufacturing companies. *Mathematics*, *10*(11), 1877.

Han, Z., & Huo, B. (2020). The impact of green supply chain integration on sustainable performance. *Industrial Management & Data Systems*, *120*(4), 657-674.

Happonen, A., Santti, U., Auvinen, H., Räsänen, T., & Eskelinen, T. (2020). Digital age business model innovation for sustainability in University Industry Collaboration Model. In *E3S web of conferences* (Vol. 211, p. 04005). EDP Sciences.

Hensellek, S. (2020). Digital leadership: A framework for successful leadership in the digital age. *Journal of Media Management and Entrepreneurship (JMME)*, 2(1), 55-69.

Huo, B. (2012). The impact of supply chain integration on company performance: an organizational capability perspective. *Supply Chain Management: An International Journal*, *17*(6), 596-610.

Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. *International journal of production research*, 57(3), 829-846.

Jabbour, C. J. C., Fiorini, P. D. C., Ndubisi, N. O., Queiroz, M. M., & Piato, É. L. (2020). Digitally-enabled sustainable supply chains in the 21st century: A review and a research agenda. *Science of the total environment*, *725*, 138177.

Junaid, M., Zhang, Q., & Syed, M. W. (2022). Effects of sustainable supply chain integration on green innovation and firm performance. *Sustainable Production and Consumption*, *30*, 145-157.

Kamble, S. S., Gunasekaran, A., Subramanian, N., Ghadge, A., Belhadi, A., & Venkatesh, M. (2023). Blockchain technology's impact on supply chain integration and sustainable supply chain performance: Evidence from the automotive industry. *Annals of*

Operations Research, *327*(1), 575-600.

Ketokivi, M., & Mahoney, J. T. (2020). Transaction cost economics as a theory of supply chain efficiency. *Production and Operations Management*, *29*(4), 1011-1031.

Kim, H. K., & Lee, C. W. (2021). Relationships among healthcare digitalization, social capital, and supply chain performance in the healthcare manufacturing industry. *International Journal of Environmental Research and Public Health*, *18*(4), 1417.

Koçoğlu, İ., İmamoğlu, S. Z., İnce, H., & Keskin, H. (2011). The effect of supply chain integration on information sharing: Enhancing the supply chain performance. *Procedia-social and behavioral sciences*, *24*, 1630-1649.

Kumar, V., Chibuzo, E. N., Garza-Reyes, J. A., Kumari, A., Rocha-Lona, L., & Lopez-Torres, G. C. (2017). The impact of supply chain integration on performance: Evidence from the UK food sector. *Procedia Manufacturing*, *11*, 814-821.

Lee, K., Azmi, N., Hanaysha, J., Alzoubi, H., & Alshurideh, M. (2022). The effect of digital supply chain on organizational performance: An empirical study in Malaysia manufacturing industry. *Uncertain Supply Chain Management*, *10*(2), 495-510.

Lee, S. Y. (2021). Sustainable supply chain management, digital-based supply chain integration, and firm performance: a cross-country empirical comparison between South Korea and Vietnam. *Sustainability*, *13*(13), 7315.

Lisdiono, P., Said, J., Yusoff, H., Hermawan, A. A., & Abdul Manan, D. I. B. (2022, September). Alliance Management Capabilities and Enterprise Resilience—The Mediating Role of Information Technology Capabilities: The Case of Indonesia's State-Owned Enterprises. *In Proceedings (Vol. 82, No. 1, p. 28). MDPI.*

Liu, K. P., & Chiu, W. (2021). Supply Chain 4.0: the impact of supply chain digitalization and integration on firm performance. *Asian Journal of Business Ethics*, *10*(2), 371-389.

Gupta, H., Kumar, S., Kusi-Sarpong, S., Jabbour, C. J. C., & Agyemang, M. (2021). Enablers to supply chain performance on the basis of digitization technologies. *Industrial Management & Data Systems*, *121*(9), 1915-1938

Lu, Y., & K. (Ram) Ramamurthy. (2011). Understanding the link between information technology capability and organizational agility: An empirical examination. *MIS quarterly, 931-954*

Ma, J. Y., Shi, L., & Kang, T. W. (2022). The effect of digital transformation on the pharmaceutical sustainable supply chain performance: The mediating role of information sharing and traceability using structural equation modeling. Sustainability, 15(1), 649.

Mangla, S. K., Kusi-Sarpong, S., Luthra, S., Bai, C., Jakhar, S. K., & Khan, S. A. (2020). Operational excellence for improving sustainable supply chain performance. *Resources, Conservation and Recycling*, *162*, 105025.

Mashat, R. M., Abourokbah, S. H., & Salam, M. A. (2024). Impact of Internet of Things Adoption on Organizational Performance: A Mediating Analysis of Supply Chain Integration, Performance, and Competitive Advantage. *Sustainability*, *16*(6), 2250.

Mashelkar, R. A. (2018). Exponential technology, industry 4.0 and future of jobs in India. *Review of Market Integration*, *10*(2), 138-157.

Mihardjo, L., Sasmoko, S., Alamsyah, F., & Elidjen, E. J. M. S. L. (2019). The influence of digital leadership on innovation management based on dynamic capability: Market orientation as a moderator. *Management Science Letters, 9(7),* 1059-1070

Minashkina, D., & Happonen, A. (2020). Decarbonizing warehousing activities through digitalization and automatization with WMS integration for sustainability supporting operations. In *E3S Web of conferences* (Vol. 158, p. 03002). EDP Sciences.

Mohamed, S. M. (2022). Employee Performance as affected by the digital Training, the digital Leadership, and subjective wellbeing during COVID-19.

Journal of Positive School Psychology, 540-553.

Mollah, M. A., Choi, J. H., Hwang, S. J., & Shin, J. K. (2023). Exploring a Pathway to Sustainable Organizational Performance of South Korea in the Digital Age: The Effect of Digital Leadership on IT Capabilities and Organizational Learning. Sustainability, *Journal MDPI* 15(10), 7875.

Nayal, K., Kumar, S., Raut, R. D., Queiroz, M. M., Priyadarshinee, P., & Narkhede, B. E. (2022). Supply chain firm performance in circular economy and digital era to achieve sustainable development goals. *Business Strategy and the Environment*, *31*(3), 1058-1073.

Nayal, K., Raut, R. D., Yadav, V. S., Priyadarshinee, P., & Narkhede, B. E. (2022). The impact of sustainable development strategy on sustainable supply chain firm performance in the digital transformation era. *Business Strategy and the Environment*, *31*(3), 845-859.

Oubrahim, I., Sefiani, N., & Happonen, A. (2022). Supply chain performance evaluation models: a literature review. *Acta logistica*, *9*(2), 207-221.

Oubrahim, I., Sefiani, N., Quattrociocchi, B., & Savastano, M. (2022, May). Assessing the relationships among digitalization, sustainability, SC integration, and overall supply chain performance: A Research Agenda. In *2022 14th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA)* (pp. 1-6). IEEE.

Pakurár, M., Haddad, H., Nagy, J., Popp, J., & Oláh, J. (2019). The impact of supply chain integration and internal control on financial performance in the Jordanian banking sector. *Sustainability*, *11*(5), 1248.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of applied psychology*, *88*(5), 879.

Qu, K., & Liu, Z. (2022). Green innovations, supply chain integration and green information system: A model of moderation. *Journal of Cleaner Production*, *339*, 130557.

Queiroz, M. M., Pereira, S. C. F., Telles, R., & Machado, M. C. (2019). Industry 4.0 and digital supply chain capabilities: A framework for understanding digitalisation challenges and opportunities. *Benchmarking: an international journal*, *28*(5), 1761-1782.

Raut, R. D., Mangla, S. K., Narwane, V. S., Dora, M., & Liu, M. (2021). Big Data Analytics as a mediator in Lean, Agile, Resilient, and Green (LARG) practices effects on sustainable supply chains. *Transportation Research Part E: Logistics and Transportation Review*, *145*, 102170.

Roberts, P. W. (1999). Product innovation, product–market competition and persistent profitability in the US pharmaceutical industry. *Strategic management journal*, 20(7), 655-670.

Robey, D., Boudreau, M. C., & Rose, G. M. (2000). Information technology and organizational learning: a review and assessment of research. *Accounting, Management and Information Technologies*, *10*(2), 125-155.

Rodríguez-González, R. M., Maldonado-Guzman, G., & Madrid-Guijarro, A. (2022). The effect of green strategies and eco-innovation on Mexican automotive industry sustainable and financial performance: Sustainable supply chains as a mediating variable. *Corporate Social Responsibility and Environmental Management*, *29*(4), 779-794.

Saddique, F., Mushtaq, N., Nwagwu, U., & Naeem, A. R. (2024). Influence of Artificial Intelligence Technologies on the Organization Performance with Moderator Role of Technological Leadership Support on Construction Organization of Pakistan. *Traditional Journal of Law and Social Sciences*, *3*(01), 47-62.

Saddique, F., Nwagwu, U., Mushtaq, N., Lamiaa, B., & Ali, A. (2023). Implementation of digitalization supply chain helps in gaining of competitive advantages as mediating role in the supply chain performance in construction organization in Pakistan. *Traditional Journal of Humanities, Management, and*

Linguistics, *2*(01), 14-27.

Saddique, F., Patel, K. R., Niaz, M., Chukwu, M. U., & Nwagwu, U. (2023). Impact of Supply Chain Transformation on Supply Chain Performance: The Empirical Study that bases on Mediating Role of Supply Chain Resilience on Construction Organization on Pakistan. *Asian Journal of Engineering, Social and Health*, *2*(9), 1072-1086.

Saddique, F., Ramzan, B., Sanyal, S., & Alamari, J. (2023). Role of digital leadership towards sustainable business performance: A parallel mediation model. *Journal of Infrastructure, Policy and Development*, *7*(3).

Salmela, E., & Happonen, A. (2009, June). Synchronization of demand and supply in a supply chain manufacturing industrial products. In *16th International Annual EurOMA Conference, Göteborg, Sweden* (Vol. 9).

Schniederjans, D. G., Curado, C., & Khalajhedayati, M. (2020). Supply chain digitisation trends: An integration of knowledge management. *International Journal of Production Economics*, *220*, 107439.

Seuring, S., Aman, S., Hettiarachchi, B. D., de Lima, F. A., Schilling, L., & Sudusinghe, J. I. (2022). Reflecting on theory development in sustainable supply chain management. *Cleaner Logistics and Supply Chain*, *3*, 100016.

Sharma, M., Kumar, A., Luthra, S., Joshi, S., & Upadhyay, A. (2022). The impact of environmental dynamism on low-carbon practices and digital supply chain networks to enhance sustainable performance: An empirical analysis. *Business Strategy and the Environment*, *31*(4), 1776-1788.

Stroumpoulis, A., & Kopanaki, E. (2022). Theoretical perspectives on sustainable supply chain management and digital transformation: A literature review and a conceptual framework. *Sustainability*, *14*(8), 4862.

Suhi, S. A., Enayet, R., Haque, T., Ali, S. M., Moktadir, M. A., & Paul, S. K. (2019). Environmental sustainability assessment in supply chain: An emerging economy context. *Environmental Impact Assessment Review*, *79*, 106306.

Tan, C. L., Tei, Z., Yeo, S. F., Lai, K. H., Kumar, A., & Chung, L. (2023). Nexus among blockchain visibility, supply chain integration and supply chain performance in the digital transformation era. *Industrial Management & Data Systems*, *123*(1), 229-252.

Tarigan, Z. J. H., Siagian, H., & Jie, F. (2021). Impact of internal integration, supply chain partnership, supply chain agility, and supply chain resilience on sustainable advantage. *Sustainability*, *13*(10), 5460.

Tirastittam, P., Jermsittiparsert, K., Waiyawuththanapoom, P., & Aunyawong, W. (2020). Strategic leadership, organizational innovativeness and the firm supply performance: The mediating role of information technology capability. *International Journal of Supply Chain Management*, *9*(2), 291-299.

Uddin, M., & Rahman, A. A. (2012). Energy efficiency and low carbon enabler green IT framework for data centers considering green metrics. *Renewable and Sustainable Energy Reviews*, *16*(6), 4078-4094.

Wang, H., Pan, C., Wang, Q., & Zhou, P. (2020). Assessing sustainability performance of global supply chains: An input-output modeling approach. *European journal of operational research*, *285*(1), 393-404.

Wang, M., Wang, B., & Abareshi, A. (2020). Blockchain technology and its role in enhancing supply chain integration capability and reducing carbon emission: A conceptual framework. *Sustainability*, *12*(24), 10550.

Yousefi, S., & Tosarkani, B. M. (2022). An analytical approach for evaluating the impact of blockchain technology on sustainable supply chain performance. *International Journal of Production Economics*, *246*, 108429.

Zhang, M., Zhao, X., & Lyles, M. (2018). Effects of absorptive capacity, trust and information systems on product innovation. *International Journal of Operations & Production Management*, 38(2), 493-512.