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Digital Leadership and Supply Chain Adaptability: Pathways to sustainable Supply Chain Performance

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ABSTRACT
The study explores how digital leadership (DL) influences sustainable supply chain performance (SSCP) and supply chain adaptability (SCA) as a mediating construct. Based on a sample of 250 pharmaceutical distribution firms' managers and executives of Bahawalpur, Pakistan. The study uses the quantitative method of analyzing structural associations among the constructs with SmartPLS. The results show that DL has a significant impact on SSCP and SCA, and the latter has a positive influence on SSCP. Mediation analysis supports the fact that SCA is a partial mediating variable between the two variables, DL and SSCP, which implies that adaptability is a significant yet not the only mechanism by which digital leadership would produce favorable sustainability outcomes. The findings can be added to the expanding literature on the concept of digital leadership and sustainable supply chain performance as they show the dual significance of operational flexibility and leadership vision. In practice, the paper provides recommendations to managers who want to integrate sustainability into the supply chain management, highlight the importance of developing digital leadership skills, and utilize newer technologies, including cloud-based analytics, IoT, and blockchain. Hypothetically, the study contributes to the knowledge of digital leadership and adaptability from the perspective of sustainability and preconditions further studies that will involve contextual, longitudinal, and cross-sector comparisons.

Keywords: *Digital Leadership, Supply Chain Adaptability, Sustainable Supply Chain Performance, Pharmaceutical Distributions*

Introduction
The accelerated pace of the digital transformation has radically restructured international supply chains forcing companies to re-evaluate the strategic value of leadership and flexibility in attaining sustainable performance. Supply chains must be able to endure systemic shocks,

not simply survive them during an era when disruptions occur not just in single countries or regions but across the entire planet, be it pandemic, geopolitical, or climate change, and must shift towards a new state of long-term resilience and sustainability. It is in this context that digital leadership has become a clear enabler that directs the firms towards the implementation of new high-level technologies, encourages innovation Brunner, Schuster et al. (2023), and development of an organizational agility.

Supply chain adaptability refers to the ability to alter processes and structures and strategies to meet changing market demands (Leończuk 2021). Although the adaptability ensures continuity and resilience, its strategic importance is that it would translate the vision of leadership into the sustainable outcomes. In turn, sustainable supply chain performance includes such aspects as environmental stewardship, social responsibility, and economic viability and, thus, the alignment of organizational practices with the wider societal needs (Zhang and Li, 2023). It is the interactive synergy between online leadership and flexibility that thus forms the core of the way in which companies may incorporate sustainability into progressively turbulent environments.

Although there is an increasing academic interest in the nexus of digitalization and sustainability, there are still significant gaps. First, the scope of research that remains is usually large, concomitantly exploring resilience, dynamism, and digitalization, and it dilutes the analytic accuracy and reduces the depth of the empirical research. As an example, despite the correlation between resilience and digitalization and sustainability results, the particular leadership that promotes adaptability is not yet theorized enough (Ye 2025). Second, sustainability indicators are still divided in industries, which hinders comparability and contributes to a lack of external validity to the generalizability of the empirical results (Rahim, Islam et al. 2024). Third, the adoption of the principle of a circular economy into the adaptability and performance is not yet well developed, and a conceptual gap exists in comprehending how the supply chain can shift towards a closed-loop system rather than being linear in its structure (Hazen, Russo et al. 2021).

This research fills these gaps by developing a narrow scope of framework that aligns digital leadership to become the main driver of supply chain adaptability, which subsequently facilitates sustainable performance of a supply chain (Esangbedo, Zhang et al. 2024). The model also recognizes mutual interrelations with reciprocal foundations of leadership capacity being strengthened by adaptability thus forming a process of ongoing enhancement. Based on the modern theories of dynamic capabilities and digital transformation, the study will have a contribution to both the theoretical progress and the practical recommendations.

The concept of digital leadership is becoming an acknowledged factor in determining success in a digital transformation project by organizations (Magesa and Jonathan 2022). The ability to be adaptable requires leaders who are open to digital technologies that lead to innovation, collaboration, and quick decisions (Kawiana 2023). Adaptability, in its turn, enables supply

chains to react to disruptions effectively, make them compatible with the changing expectations of the stakeholders, and integrate sustainability practices in the operations. Adaptability proves to mediate the correlation between digital transformation and sustainable performance Mohaghegh, Blasi et al. (2025), as evidenced by empirical evidence, and the authors note that it is crucial in the long-term value creation .

The issue of sustainable supply chain performance has moved beyond being peripheral to being strategic. The companies have become responsible about their environmental and social effects and the stakeholders are seeking transparency and accountability. Digital leadership and adaptability combine to offer the processes by which firms are able to fulfil these needs. To give an example, digital technology, including artificial intelligence, blockchain, and the Internet of Things, make the visibility and traceability more efficient, allowing leaders to carry out sustainability initiatives in a more productive manner (He, Miao et al. 2025). At the same time, adaptability will guarantee the ability of the supply chains to embrace the circular economy Bag and Rahman (2023), minimize waste and maximize the use of the available resources.

In this regard, this research undertaking seeks the following research questions:

RQ1: What is the effect of digital leadership on sustainable supply chain performance?

RQ2: What is the effect of digital leadership on supply chain adaptability?

RQ3: What is the effect of supply chain adaptability on sustainable supply chain performance?

RQ4: Does supply chain adaptability mediate the relationship between digital leadership and sustainable supply chain performance?

Through these questions, the study helps bridge the gap in literature through the scope limitation, better empirical rigor, and a more holistic approach of sustainability. To practitioners, it provides practical information regarding how digital leadership and adaptability could be used to gain competitive advantage and improve environmental and social goals. Finally, the paper shows that digital leadership and adaptability are not only operational capabilities but strategic avenues to the sustainable supply chain performance in the digital age (Esangbedo, Zhang et al. 2024).

Literature Review

Sustainable Supply Chain Performance

Sustainable supply chain performance has emerged as an endearing issue in the modern supply chain management due to the need to ensure that organizations balance the operational effectiveness with the long-term sustainability goal. SSCP is normally theorized as the ability of supply chains to create value and in the process, meet the environmental,

social and economic responsibility in a coordinated way. Instead of approaching it as an auxiliary or compliance-oriented phenomenon, the latest research highlights sustainability as a strategic factor of competitiveness and strength (Gupte, Shukla et al. 2025).

The changed impact of digitalization on SSCP is emphasized in a growing body of literature. The use of advanced technologies, including blockchain, artificial intelligence (AI), and the Internet of Things (IoT) can increase supply net visibility, traceability, and transparency, thus allowing firms to monitor and enforce sustainability practices more accurately (Mohaghegh, Blasi et al. 2025). Such digital solutions incorporate the aspect of sustainability in the decision-making processes so that the supply chains are not slow to follow regulatory changes and stakeholder expectations. In this regard, digital leadership plays a central role because it promotes innovation and the use of technologies that facilitate sustainable results (Sarfraz, Ivascu et al. 2022).

Adaptability has been defined as a most important mediating process between digital leadership and SSCP (Razzak, Al Kharusi et al. 2025). Empirical data proves that supply chain flexibility can help companies transfer digital transformation efforts into the real sustainability results as it allows responding quickly to disruption and upholding environmental and social undertakings. The findings they came to propose indicate that adaptability is not only an operating ability but also a strategic channel through which leadership vision is practicalized. This supports the hypothesis that there is a dynamic relationship between leadership and adaptability in supporting SSCP as opposed to some isolated interventions of technology.

Although these have been made, there are a number of unanswered questions. One of the main issues is the lack of standard measures of the assessment of SSCP. The existing methods of measurement are somewhat different in industries and prevent the comparability of measurements and the generalizability of empirical results (Liu, Jones et al. 2023). Specialists are increasingly demanding detailed frameworks of integrating environmental, social and economic indicators into single measurement systems. In the absence of such standardization, empirical research runs the risk of generating piece-meal knowledge, which has little practical value. The second gap is connected with a lack of development of incorporation of the principles of the circular economy into SSCP. Though the idea of the circular economy is generally accepted as a force of sustainability, its operationalization in the context of a supply chain performance still is not thoroughly studied (Perano, Cammarano et al. 2023).

More recent contributions also focus on how leadership can be used to instill sustainability in the supply chain strategies (Reynolds 2024). show that companies that possess robust digital leadership can take advantage of the adaptive capability and produce sustainable results, especially when operating in turbulent conditions. Their results emphasize the need to ensure that leaders embrace digital technologies besides developing organizational cultures that focus on sustainability as a paramount strategic initiative. This approach is consistent with the

larger vision that SSCP can be perceived as a dynamic, changing process influenced by the leadership, flexibility and progressive innovation instead of a fixed performance result.

Digital Leadership

The concept of digital leadership has come to be acknowledged as a core competence in the modern-day supply chain management that can help organizations overcome the challenges of digital transformation whilst supporting sustainability goals at the same time. In theory, digital leadership can be understood as a set of abilities that enable leaders to use digital technologies to pursue innovation, collaboration, and organize change in organizations. In volatile and uncertain environments, it is considered as a competitive advantage determinant as well as strategic resilience determinant (Pratono 2022).

Recent research stresses that digital leadership should be applied not only to the adoption of technology. It involves a culture of being agile and adaptable, in which executives foster experimentation, empower staff, and make advanced technologies, including artificial intelligence (AI), blockchain, and the Internet of Things (IoT) part of the supply chain (Holloway 2025). These technologies increase visibility, transparency, and traceability and hence help firms to rigorously track performance and sustainability practices. By so doing, digital leadership plays a direct role in creating resilient and sustainable supply chains.

The importance of digital leadership in terms of organizational outcomes is quite critical as evidenced by empirical studies (Arabiun, Tajpour et al. 2024). As shown leadership, which drives digital transformation initiatives, plays an important role in enhancing sustainable performance, and the mediating mechanism through which this is facilitated is through supply chain adaptability (Yang, Huo et al. 2022). Their results emphasize the role of take a vision in terms of translating the technological investments into operational and sustainability outputs. On the same note, Mohaghegh, Blasi et al. (2025) demonstrate that digital leadership positively impacts the triple-A supply chain abilities of agility, adaptability, and alignment, which are encompassing sustainable performance. Such studies support the thesis statement that leadership is the cornerstone on which digital transformation and sustainability are anchored.

In addition to the results of its operations, digital leadership is a significant stakeholder engagement factor (Senadjki, Au Yong et al. 2024). Through the use of digital platforms to bring about transparency and accountability, leaders would enhance trust in suppliers, customers and regulators. This dimension is especially sensitive to the sustainability context, in which the stakeholders require evidence of practices that are ethical and environmentally responsible. believes that digital leadership plays a significant role in ensuring that the principles of the circular economy are implemented in the supply chain, which will lead firms to minimize waste, optimize the use of resources, and remain sustainable in the long run (Hazen, Russo et al. 2021).

Nonetheless, there are some gaps in the literature in spite of these developments. One of the problems that have not been resolved involves the little studied development of digital leadership in relation to supply chain responsiveness. Although the role of leadership is often understood as the promulgator of flexibility, less research focuses on the interaction, whereby adaptive practices support leadership ability and strategy vision. The second gap is associated with the extent of effects of digital leadership on sustainability. The available literature tends to be based on qualitative-based evaluations or case-studies, and few standardized outcomes they can use to examine the effectiveness of leadership in digital scenarios. Filling in these gaps will be critical towards the development of the theoretical knowledge and practice (Hazen, Russo et al. 2021).

Supply Chain Adaptability

The SCA is currently being viewed as a core competency of the businesses functioning in the dynamic and unpredictable environment. It is the ability of supply chains to redesign processes, structures and strategies based on the dynamic market conditions and external shocks. Adaptability can be used as a foundation of resilience and sustainability as it allows firms to mobilize resources, redesign processes, and actively adapt to changes in demand, technology, and regulation (Jamal 2025).

In the modern literature, the importance of adaptability as an aspect of responding to disruption is stressed, yet it is also suggested that adaptability must be defined as an active ability to foresee the change of the structure (Askar, Bragança et al. 2021). According to Hajarath and Vummadi (2024), flexible supply chains are proactive in aligning processes with expected market changes, thus making it less vulnerable and more prepared to address any market change. Such proactive orientation is especially relevant in the context of sustainability as in this scenario, companies have to constantly adapt to changing environmental regulations and expectations of stakeholders.

Flexibility is often discussed in the context of the larger (so-called) triple-A of supply chain capabilities, i.e., agility, adaptability, and alignment (Leończuk 2021). Show that adaptability, both combined with agility and alignment, help to reduce the effects of significant disruptions by ensuring the ability of supply chains to maintain performance in uncertain situations (Patrucco, Picanço Rodrigues et al. 2025). They find that adaptability is a key resilience mechanism and that through it, supply chains are able to guarantee continuity in operations and integrate sustainability practices in the supply chain structure.

Flexibility is also improved through innovation and integration. It is also empirically indicated that logistics innovation, especially with a high level of integration between the service providers and the users, can enhance adaptability to a large degree (Abdalla 2021). It is through collaborative relationships as well as rational use of digital technologies that enhance the capacity of firms to adapt to the dynamics of the environment. This highlights

the importance of digital leadership in creating a flexible supply chain since leaders who promote innovation and integration create flexible and sustainable supply chains (Esangbedo, Zhang et al. 2024).

Regardless of such improvements, there are still critical gaps in the literature. A gap that has not been addressed is the fact that not much has been done to explore mutual dynamics between leadership and adaptability. Although the idea of leadership is traditionally defined as a force of adaptability, lesser researches explain how adaptive practices are able to give feedback and reinforce the leadership strength and strategic perspective (Boikanyo 2025). The second gap is associated with measurement. The existing literature is often based on qualitative measurement or case-specific measures, and there are not many standardized measures to determine the adaptability of industries. It will be necessary to address these gaps in order to promote the theoretical understanding and allow stronger empirical generalization.

Digital Leadership and Sustainable supply chain performance

Digital leadership is now an aspect of modern supply chain management, especially in developing sustainability success. In theory, it refers to the capacity of leaders to use digital technologies as a source of innovation, collaboration, and change management within the organization. Digital leadership reflects a strategic vision, which combines sustainability and efficiency more than a technical orientation and is therefore a decisive factor in long-term competitiveness (Hamdouna and Khmelyarchuk 2025).

Recent research identifies the use of digital leadership as an enabler of circular economy practices in supply chains. As revealed in digital leaders play a crucial role in the expansion of resource efficiency, waste reduction, and the promotion of closed-loop systems, which leads to improved performance of the sustainable supply chain, sustainable supply chain performance (SSCP) (Esangbedo, Zhang et al. 2024). Leaders enhance transparency and traceability by integrating technologies into blockchain, artificial intelligence (AI), and the Internet of Things (IoT), which guarantee sustainability goals are met consistently in the supply networks.

Digital leadership also enhances the exchange and responsiveness of information, which is vital in the sustainability outcomes. As demonstrated initiatives of digital transformation under effective leadership can improve supply chain responsiveness and information sharing, which leads to improved performance in the environmental, social, and economic aspects (Esangbedo, Zhang et al. 2024). Their results emphasize the need of leadership vision in the process of translating digitalization into sustainable outcomes, especially in the industries that are highly vulnerable to urgent technological and regulation shifts.

The mediating effects of adaptivity in the relationship between digital leadership and SSCP are also justified by empirical evidence. Phakamach, Panjarattanakorn et al. (2023) show that

the supply chain flexibility allows companies to operationalize the digital leadership projects through providing the quick reaction to the disruptions without compromising the sustainability promise. This fact supports the active interaction between leadership, adaptability and sustainability where leadership offers the strategic vision, adaptability is the vision put into practice, and the result is sustainability.

Regardless of these developments, there are still a number of gaps in the literature. Another issue that is yet to be resolved is the fact that there is a little exploration of the reciprocal relationships were sustainability results buttress leadership trustworthiness and capability. Though the majority of the studies use the concept of leadership as having the ability to induce sustainability, there are limited studies that explore how attaining sustainability objectives enhance the legitimacy and impact of leaders. The second gap is associated with measurement. The existing studies are usually based on case-related indicators, and few standardized measures are used to measure the role of digital leadership in sustainability between different industries (Zada, Zada et al. 2025). These gaps will be critical in ensuring that there is improvement on theoretical knowledge and application.

H1: Digital leadership positively influences sustainable supply chain performance.

Digital Leadership and Supply Chain Adaptability

SCA has become an important ability of an organization operating in a dynamic and unpredictable environment. It refers to the ability of supply chains to change processes, structures, and strategies in response to disruptions, appropriate technological changes and changing stakeholder expectations. Digital leadership is central to facilitating this flexibility through encouraging innovation, encouraging collaboration, and leading the digitalization of the supply chain operations (Brunner, Schuster et al. 2023).

Modern research underscores the fact that the digital leadership concept goes beyond the aspect of technology adoption to include the process of developing organizational vision and culture that focuses on flexibility and responsiveness. Digital transformation leaders promote experimentation, enable employees, and enable reconfiguration of supply chain processes when conditions of uncertainty prevail. Senadjki, Au Yong et al. (2024) give empirical evidence that the implementation of digital transformation under the guidance of a strong leadership has a tremendous positive impact on adaptability, which subsequently contributes to sustainable performance. Their results emphasize the adaptability as the channel of operation in which the leadership vision can be converted into the practice.

The association of digital leadership and adaptability is further supported by other empirical studies. Phadnis (2024) reveal that the digital leadership increases the three-A supply chain capabilities, including agility, adaptability and alignment that reduce the consequences of significant disruptive events. Of these, the most important is adaptability, which allows firms to adapt to changes in structure and maintain performance in the uncertain environment. This

highlights the relevance of the leadership in mobilizing the supply chain processes to predict and react to the market changes.

Digital leadership also enhances adaptability because it facilitates innovation and integration. Abdalla (2021) concludes that the adaptability is enhanced greatly through logistics innovation that is backed by the leadership and integration between the service providers and users. The leaders who promote digital platforms and teamwork behaviors create flexible and resilient supply chains. This underscores the interdependence between the concepts of leadership and adaptability: adaptability is propelled by leadership and adaptive practices strengthen the capacity of leadership by offering feedback and learning opportunities.

In spite of these developments, there are significant gaps in literature. The difficulty is that standardized measures of adaptivity are not well explored. The existing research is usually based on qualitative results or industry-specific measurements, so the applicability of the results to other sectors is limited. The other gap is related to the mutuality of the relationship between digital leadership and adaptability (Razzak, Al Kharusi et al. 2025). Although the concept of leadership is often conceptualized as the driver, there is a lack of research focusing on the strengths of adaptability in improving the capabilities of leadership to make better decisions and be strategic. These imperfections will be critical to overcome in order to promote theoretical knowledge and practice.

H2: The digital leadership positively influences supply chain adaptability.

Supply Chain Adaptability and Sustainable Supply Chain Performance

The concept of supply chain adaptability has become an ever-growing important capability of the organization that wants to have a sustainable supply chain performance. Adaptability is defined as a dynamic ability of supply chains to introduce reconfiguring processes, resources and strategies in case of disruption and changing market conditions in such a way that firms can introduce sustainability to operations and stay resilient and competitive (Patrucco, Picanço Rodrigues et al. 2025).

Recent studies highlight the role of adaptability between digital transformation and sustainability results in the form of a mediator. Given that SCA enables companies to operationalize digital leadership efforts to achieve sustainable performance, (Borah, Iqbal et al. 2022) prove that the concept enables companies to respond quickly to disruptions and keep environmental and social promises. Their results point out the adaptability as the functional straddling whereby leadership vision is translated into concrete sustainability results.

The flexibility is another factor that holds a central role in resilience paradigms. Alzate, López et al. (2024) demonstrate that adaptability, as well as agility, and alignment, counteracts the impact of significant disruptions by helping supply chains to maintain performance in uncertainty. Such resilience is directly associated with sustainability because more adjustable

firms are in better positions to incorporate circular economy and cut down on waste and enhance the use of resources. Therefore, adaptability is not just a short-term survival mechanism but a tactical ability that supports the long-term sustainable performance.

The adaptability-sustainability nexus is further supported by innovation and integration. Kolasińska-Morawska, Sułkowski et al. (2022) concludes that logistics innovation and integration between the service providers and users are effective to improve adaptability and lead to sustainable results. Partnering activities fostered by digital platforms help companies to adapt to changing stakeholder demands and regulatory needs to instill sustainability into supply chain activities.

Although these developments have been made, there are still serious challenges. One of the major gaps is related to a lack of standard measures of the impact of adaptability on sustainability. The applied case-specific indicators are frequently used in current studies, which limits comparability and generalizability across industries (Morita and Vieira). The other unresolved problem is associated with the mutual relationship between adaptability and leadership. Although adaptability is often viewed as a mediating factor, there are less studies that research the effects of sustainability outcomes gained by adaptability on reinforcing leadership capacity and strategic foresight. It will be necessary to fill these gaps to promote theoretical knowledge and practice.

H3: Supply chain adaptability positively influences sustainable supply chain performance.

Supply Chain Adaptability as a Mediator between Digital Leadership and Sustainable Supply Chain Performance

The interconnection between digital leadership and sustainable supply chain performance is becoming more and more complex and dynamic, and the supply chain adaptability (SCA) is becoming an important mediating variable. Digital leadership offers the strategic vision and technological direction that is needed to achieve change, yet adaptability actualizes the vision through allowing the supply chains to realign the processes (Reynolds 2024), structures, and strategies in response to the disruptions and changing sustainability requirements.

The adaptability as a mediator role is confirmed by recent empirical studies. As shown by Lin (2025), the efforts of digital transformation under the leadership of influential people can result in a major enhancement of the sustainability performance, yet only when the supply chains have the flexibility to turn technological investments into the actual performance. Their results emphasize that adaptability should be used as the linkage between leadership vision and sustainability outcomes because it is important in dynamic environments.

Adaptability also makes digital leadership effective as it makes sure that the sustainability practices can be integrated into the supply chain operation. As demonstrated by Mohaghegh, Blasi et al. (2025), digital leadership enhances triple-A capabilities of the supply chain agility,

adaptability, and alignment, which act in a way to ensure sustainable performance. Of them, the adaptability is the most decisive one in the mediation of leadership-sustainability relationship as it enables firms to reorganize the resources and processes to achieve environmental and social objectives without losing competitiveness.

The adaptability mediating role is also supported by the research on resilience frameworks. Patrucco, Picanco Rodrigues et al. (2023) state that adaptability reduces the impacts of significant disruptions by allowing supply chains to maintain performance in an uncertain world. This resilience is highly interconnected with the concept of sustainability, since the more a firm is able to adapt, the higher its chances of incorporating the principles of the circular economy and maximizing its resource utilization. Adaptability, therefore, is a factor that will make sure that digital leadership initiatives are not kept as some abstract ideas but are transformed into the practical sustainability results.

Irrespective of these developments there are gaps in the literature. Among these, the fact that reciprocal relationships have rarely been explored is one problem, with adaptability not only mediating but also strengthening leadership ability. Little literature explores the role of adaptive practices in terms of offering feedback to leaders to advance their capability of making informed decisions and reinforce sustainability plans. The other gap is associated with measurement. Existing research tends to use case-specific measures, and few standardized measures are used to assess the mediating effect of adaptability between industries (Mahato and Bhattarai 2025). The gaps will be necessary to bridging the gap in knowledge and practical application.

H4: Supply chain adaptability mediates the relationship between digital leadership and sustainable supply chain performance.

Conceptual Model

The paper focuses on the correlations between the philosophy of digital leadership, supply chain adaptability, and sustainable supply chain performance. The model is based on the Dynamic Capabilities Theory (DCT) that focuses on the ability of organizations to combine, develop, and restructure internal and external competencies according to the fast-changing environment (Ghrbeia and Alzubi 2024). In the scope of the supply chains, the dynamic capabilities are reflected in the form of the vision of the leaders, the adaptive processes, and the sustainability results. Digital leadership is set as the main source of flexibility and sustainability. The digital transformation among leaders will encourage innovation, empower teamwork, and bring cutting-edge technologies, including artificial intelligence (AI), blockchain, and the Internet of Things (IoT) to supply chain management Chowdhury (2025). These technologies increase visibility, transparency, and traceability, which helps firms to entrench sustainability practices in a better way (Islam, 2025). However, leadership vision is not enough, but one needs adaptability to execute and bring strategic intent to practice.

The third construct in this framework is supplying chain adaptability that acts as a mediating construct. Flexibility helps supply chains to reorganize processes and resources when disrupted, regulated, and when the stakeholders change their expectations. (Zhang, Xu et al. 2023) indicate that adaptability converts the digital transformation efforts into sustainable deliverables, and presents the adaptability as the operational interface between the leadership and performance. In a similar way, (Mohaghegh, Blasi et al. 2025) emphasize the adaptability as one of the main components of the triple-A framework, i.e., agility, adaptability, and alignment, which enhances sustainable performance in the face of uncertainty.

The final result of the model is the sustainable supply chain performance. It is a reflection of the composite ability of supply chain to achieve long-term value in balancing efficiency with environmental and social responsibility. Flexibility would make sustainability practices become a part of the operations and digital leadership would allow offering a strategic vision and technological orientation that would result in the achievement of these (Zada, Zada et al. 2025). maintain that flexibility reduces the impact of significant shocks and helps companies to maintain performance and integrate the principles of a circular economy.

Reciprocal relationships are also recognized in the model. Adaptability mediates as well as supports leadership capacity. Adaptive practices give feedback to the leaders as they improve their information-making decisions and reinforce sustainability strategies (Alam, Razzak et al. 2025). This is a dynamic cycle indicating the iterative qualities of the digital transformation process where the leadership and adaptability are in a continual process of shaping each other to deliver sustainable results.

The proposed research adds to the body of knowledge and practice by combining digital leadership, adaptability, and sustainability into a single framework. Theoretically, it enhances the knowledge of the role of the dynamic capabilities in supply chain sustainability. In a practical sense, it provides a guideline to managers who want to use the digital leadership and flexibility to ensure long-term sustainable performance (Khaw, Teoh et al. 2022). In Figure 1, the author shows the correlations between digital leadership, supply chain adaptability, and sustainable supply chain performance.

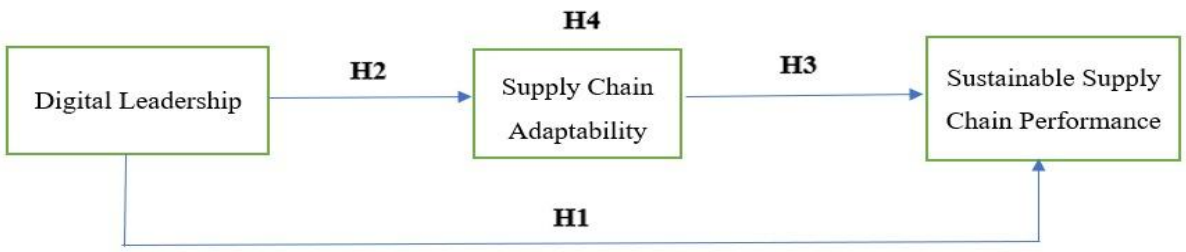

Figure 1: Research Framework

Methods

To investigate the association between digital leadership, supply chain adaptability, and sustainable supply chain performance in the pharmaceutical distribution industry, this research design was quantitative design to study the variables. It also examines the mediating value of supply chain adaptability in the DLand SSCP relationship.

Population and Sampling

This study population includes pharmaceutical distributors based in Bahawalpur and those that have implemented digital technologies and sustainability programs in their supply chain operations. To minimize the chances of sampling a respondent who did not have direct engagement in the supply chain activities, digital leadership and sustainability practices, a purposive sampling method was adopted. The responses were gathered as 250 managers, executives and supply chain professionals in different pharmaceutical distribution firms. This was considered an adequate sample size to warrant the statistical power and generalizability of the study.

Measurement Instrument and Construct Operationalization

Validated scales provided in earlier literature were used to develop the survey tool. All of the questions were rated on a 5-point Likert (1 = strongly disagree, 5 = strongly agree). Digital Leadership: The scale is based on a 5-item scale (scaled with the help of Li et al., 2025) that measures the ability of the leaders to be innovative, to promote collaboration, and to introduce digital technologies, namely AI, blockchain, and IoT, into the supply chain activities. Supply Chain Adaptability: The ability of supply chains to reorganize the processes, change the strategies, and react to changing market conditions and disruption is operationalized with the 3-item scale adapted by Abdalla and Nakagawa (2022). Sustainable Supply Chain Performance: The 11-item scale is based on an adapted version of Lartey and Amikiya (2025) and includes all three aspects, which are environmental stewardship, social responsibility, and economic viability.

Data Collection and Analysis

The structured, paper-based questionnaire was used to gather the data in a face-to-face way to the chosen respondents. Before the high-scale distribution, a pilot test was designed, during which 20 participants were utilized to ascertain the instrument clarity, reliability, and content validity. According to the feedback, minor revisions were performed.

The SPSS was used to perform the demographic analysis and the PLS-SEM analysis with the help of SmartPLS 4.0, which is appropriate when it is necessary to carry out predictive modelling and theory development that involve the intricate relationships between latent

variables. Measurement model was determined using the outer loadings, composite reliability (CR), average variance extracted (AVE) and Cronbachs alpha to determine the reliability of the indicators, internal consistency and convergent validity. The FornellLarcker criterion and the cross-loadings were used to evaluate the discriminant validity. The test of the structural model was conducted to test the relationships that were hypothesized and the mediation by supply chain adaptability. A bootstrapping of 5000 resamples was used to estimate the significance of path coefficients and indirect effects.

Demographic Information

Table 1:

Demographic Information of Respondents

Characteristic	Frequency	Percentage
Gender		
Male	212	71.2%
Female	38	28.8%
Age		
Less than 27	21	8.4%
27 – less than 35	64	25.6%
35 – less than 45	103	41.2%
45 and above	62	24.8%
Education		
FSC/ICS/FA	70	11.2%
PharmD	152	60.8%
M/Phil/PhD	28	28.0%
Designation		
Manager	104	41.6%
Dy. Manager	82	32.8%
Marketing Manager	64	25.6%
Experience		

Less than 10 years	36	14.4%
10 – less than 15	58	23.2%
15 – less than 20	91	36.4%
20 – less than 25	43	17.2%
25 and above	22	8.8%
Other	17	6.8%

The demographics of the recorded 250 respondents indicate that a huge percentage was male (84.8), and the female population had 15.2 percent of the respondents. The majority of the participants were aged 35-45 years (41.2%), then 45 and older (24.8%), then 27-less than 35 years old (25.6), which is a well-experienced workforce. Regarding education level, 60.8% of them had a PharmD degree and 28.0% had FSC/ICS/FA and 11.2% had levels of postgraduate qualification (MPhil/PhD). On the front of professional positions, 41.6% were Managers, 32.8% Deputy Managers and 25.6% Marketing Managers, which is a good indication of mid- and senior-level leadership. The work experience was also high with 36.4 percent having experience of 15 to less than 20 years, and 23.2 percent and 17.2 percent at the 10-15 and 20-25 years respectively. Moreover, the respondents represented a variety of academic specialization as the majority of the respondents were Business Administration (55.6%), then Accounting (23.2%), Social Sciences (14.4%), and other (6.8%). The profile highlights an effective and seasoned respondent population, which is appropriate to investigate the nature of digital leadership, flexibility, and sustainable supply chain performance in pharmaceutical distribution industry.

Measurement Model

Table 2: Outer Loadings, Cronbach's alpha, Composite Reliability, and Average Variance Extracted

Constructs	Items	Outer Loadings	Cronbach's alpha	Composite Reliability
Digital Leadership	DL1	0.828	0.815	0.871
	DL2	0.726		
	DL3	0.715		
	DL4	0.707		
	DL5	0.807		
	SCA1	0.806	0.779	0.871

Supply Chain Adaptability	SCA2	0.816		
	SCA3	0.875		
Sustainable Supply Chain Performance	SSCP1	0.701	0.919	0.932
	SSCP10	0.766		
	SSCP11	0.714		
	SSCP2	0.754		
	SSCP3	0.737		
	SSCP4	0.738		
	SSCP5	0.753		
	SSCP6	0.718		
	SSCP7	0.782		
	SSCP8	0.727		
	SSCP9	0.789		

There are high reliability and convergent validity of the measurement model assessment in all constructs. In the case of Digital Leadership (DL), all five items have acceptable outer loadings of between 0.707 and 0.828. The construct Cronbachs alpha of (0.815) and composite reliability (0.871) are above the suggested coefficient of 0.70 with the mean variance extracted (AVE) of 0.575 which connotes satisfactory convergent validity. Supply Chain Adaptability (SCA) also has strong psychometric properties such as outer loadings ranging between 0.806 and 0.875, Cronbachs alpha is 0.779, composite reliability is 0.871 and high AVE ranging between 0.693 to 1 which confirms strong internal consistency and construct validity. The outer loadings of 0.701 -0.789 are produced by Sustainable Supply Chain Performance (SSCP) which is measured after eleven items. It also has a good internal consistency with a Cronbach alpha of 0.919 and composite reliability of 0.932. The convergent validity of the construct is also indicated by the AVE of 0.554. All these findings support the fact that the measurement model is reliable and valid and this forms a good basis of analysis of the structural model.

Discriminant Validity

Table 3:

Heterotrain-monotrait ratio (HTMT)

	DL	SCA
DL		
SCA	0.626	
SSCP	0.733	0.626

The values of Heterotrait-Monotrait (HTMT) ratios given in the table will evaluate the discriminant validity of three variables namely Digital Leadership, Supply Chain Adaptability (SCA), and Sustainable Supply Chain Performance. All the values of HTMT are significantly lower than the conservative value of 0.85, which shows that all the constructs are empirically different. Particularly, the HTMT value between the pairs of DL and SCA is 0.626, between the pairs of DL and SSCP is 0.733 and between the pairs of SCA and SSCP is also 0.626. These findings prove that the constructs are not multicollinear and the discriminant validity is achieved which justifies the inclusion of the constructs as distinct latent variables in the structural model.

Fornell Larcker Criterion

Table 4:

	DL	SCA	SSCP
DL	0.758		
SCA	0.511	0.833	
SSCP	0.649	0.539	0.744

Discriminant validity is measured by the FornellLarker criterion to determine the square root of the average variance extracted (AVE) of each construct against the construct-construct correlations. As indicated in the table, the square root of the AVE values (indicated on the diagonal) is the following Digital Leadership = 0.758, Supply Chain Adaptability = 0.833, and Sustainable Supply Chain Performance = 0.744. All these values exceed the respective inter-construct correlations: DL- SCA = 0.511, DL- SSCP = 0.649, and SCA- SSCP = 0.539. As the AVE square roots of each construct are more than the correlations of each construct with other constructs, the Fornell-Larcker test has been met, which confirms that the discriminant validity is achieved and all the constructs are empirically different in the model.

Collinearity Statistics

Table 5: Variance Inflation Fator

Items	VIF
DL1	2.267
DL2	1.742
DL3	1.575
DL4	1.528
DL5	1.852
SCA1	1.466
SCA2	1.685
SCA3	1.839
SSCP1	2.116
SSCP10	2.479
SSCP11	2.670
SSCP2	2.753
SSCP3	2.789
SSCP4	2.347
SSCP5	2.863
SSCP6	2.702
SSCP7	2.228
SSCP8	2.645
SSCP9	2.754

The collinearity measures, which are determined by the Variance Inflation Factor values (VIF), show that multicollinearity is not of a problem in the measurement model. The VIF of all the indicators of Digital Leadership (DL), Supply Chain Adaptability (SCA), and Sustainable Supply Chain Performance (SSCP) are much lower than the generally accepted value of 5. In particular, the VIFs of DL items are between 1.528 and 2.267, between 1.466 and 1.839, and between 2.116 and 2.863 are the SCA and SSCP items respectively. These values indicate that the indicators do not have too much correlation with each other and that every item has a unique contribution to its corresponding construct. Accordingly, the model meets the collinearity assumption which justifies the soundness of the structural path estimates in the future analysis.

Hypotheses Development

The conceptual framework was analyzed using the PLS-SEM, and the analysis provided valuable results concerning the path coefficients of the structural model. These coefficients have the same effect in SmartPLS as they would in standardized beta weights of a regression analysis, which show how strong and strong relationships are between the latent constructs. Path coefficients take values between -1 and +1, with values that are nearer to +1 indicating a strong positive relationship, those that are nearer to -1 indicate a strong negative relationship, and those that are nearer to zero do not show a significant association. Table 5 contains the estimated path coefficients and t-statistics, p-values, and standard errors of the estimated path coefficients, which provides a comprehensive overview of the hypothesized relationships and the statistical significance of relationships in the model.

Direct Relationships

Table 6:

Hypotheses	Relationships	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
H1	DL -> SSCP	0.506	0.062	8.112	0.000	Supported
H2	DL -> SCA	0.511	0.058	8.816	0.000	Supported
H3	SCA -> SSCP	0.280	0.063	4.456	0.000	Supported

The empirical results of the structural model give all the hypothesized direct relationships a high empirical support. The path coefficient of 0.506, t-statistic of 8.112 and p-value of 0.000 are in support of hypothesis H1 that Digital Leadership (DL) has a statistically significant and moderately strong positive correlation with Sustainable Supply Chain Performance (SSCP). Hypothesis H2 which implies that there is a positive relationship between DL and Supply Chain Adaptability (SCA) is also supported with a path coefficient of 0.511, a high t-statistic of 8.816 and a p-value of 0.000 which indicates a strong and significant relationship. Finally, Hypothesis H3, which is the hypothesis that SCA has a positive impact on SSCP, is also confirmed with a path coefficient of 0.280, t statistic of 4.456 and a p-value of 0.000. This is a relatively weak impact of DL on SSCP, though it is statistically significant. All of these results confirm the theoretical framework and emphasize the essential role of digital leadership and adaptability in improving sustainable supply chain performance.

Mediation Analysis

Table 7:

Hypothesis	Relationship	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
H4	DL -> SCA -> SSCP	0.143	0.037	3.860	0.000	Partial Mediation

The mediation discussion allows presenting the evidence of the statistically significant indirect impact of Digital Leadership (DL) on Sustainable Supply Chain Performance (SSCP) through Supply Chain Adaptability (SCA). The indirect relationship between DL and SCA has a path coefficient of 0.143, t- statistic of 3.860 and a p-value of 0.000, which indicates that the indirect effect of the relationship between the two variables is positive and significant. Nevertheless, as the direct impact that DL has on SSCP (0.506, $p < 0.001$) also has a significant effect, the mediation is categorized as partial. This implies that although the direct effect of DL on SSCP is positive, it has a complementary effect because of the positive effect it has on SCA. Therefore, SCA is a valuable yet not a sole channel through which digital leadership helps to achieve the sustainable supply chain performance.

Discussion

The statistical result showed that the impact of digital leadership (DL) on the performance of sustainable supply chain (SSCP) is highly positive. This observation highlights the critical role of the presence of a digital-minded leadership in the process of delivering sustainability in the pharmaceutical distribution channels. Active promotion of digital technologies, development of cooperation, and the stimulation of innovation seem to help leaders to improve the environmental, social, and economic performance of supply chains. This finding is consistent with the previous research on the relevance of digital leadership in promoting green innovation and sustainable practices, which, in turn, validates the theoretical assumption that the notion of digital orientation directly leads to sustainability results.

Moreover, the analysis has shown that the effect of DL is significant on supply chain adaptability. The above connection emphasizes that digital leaders can develop flexible and responsive supply chains that can redesign processes and strategies when they become disrupted. The observation connects with previous studies that indicated that digital leadership improves organizational agility and resilience, which allow companies to react to the changes in the market.

The outcomes also proved that SCA has a positive impact on SSCP. Despite the fact that the effect size is lower than that of the direct influence of DL on SSCP, it is statistically significant meaning that adaptability has a significant impact on sustainability outcomes. This implies that agile and responsive supply chains have a better opportunity to engage in

environmentally friendly operations, enhance resource efficiency, and achieve social responsibility objectives.

Another indication of mediation analysis was that SCA has a partial mediating effect of the link between DL and SSCP. This means that although the direct effects of the sustainability performance are positive, the indirect effects are also positive because of the effects that it has on the adaptability. That is, digital leadership is not only an outcome that contributes to sustainability but it enhances supply chain flexibility that, consequently, leads to sustainable performance. The partial mediation indicates that flexibility is a significant but not a unique course, which supports the dual significance of leadership vision and operational flexibility.

Combined, these results support the theoretical framework and outline the interconnected nature of digital leadership and adaptability to attain sustainable supply chain performance. They build on the existing literature by showing that sustainability is not a leadership or adaptability characteristic in the pharmaceutical distribution domain, but rather a product of the interactions, as well as complements of the two.

Conclusions

The findings of this paper indicate that, digital leadership (DL) is a significant contributor to sustainable supply chain performance (SSCP) both directly and indirectly by supply chain adaptability (SCA). The results affirm that the concept of DL promotes flexibility among supply chains, which subsequently leads to sustainable results. More notably, mediation analysis indicated that SCA has a partial mediatory role in the relationship between DL and SSCP, meaning adaptability is a complement and not alternative avenue to leadership influence. This highlights the two-fold significance of the visionary digital leadership and operational flexibility in meeting the sustainability objectives in the pharmaceutical distribution networks.

As a manager, the findings reveal that digital leadership is not only desirable but also the only way to entrench sustainability in the supply chain operations. Digital strategies, including cloud-based analytics, IoT integration, and blockchain-enabled transparency can enable managers to enhance flexibility and make them long-term sustainable. Organizations can extract the complementary outcomes of these constructs by sequencing investments in leadership development and adaptability-enhancing initiatives, which means the financial outlays needed to comply with digital transformation and sustainability guidelines are justified as worthwhile.

Contributions

Practical Contributions

This research offers practical information to managers who aim at enhancing the sustainability of supply chains. To start with, it highlights the need to ensure development of

digital leadership skills in order to create innovation, teamwork, and responsiveness. Second, it underscores flexibility as an imperative process by which digital leadership is converted to sustainable results. Agile processes, collaboration with stakeholders and adoption of technology should therefore be given priority by the managers as a way of increasing adaptability. Lastly, the findings indicate that sustainability efforts are strongest when the leadership vision and adaptive are combined so that the organizations are also responsive to the disruptions as well as addressing the environmental and social demands.

Theoretical Contributions

The research work has a value to the academic literature as it extends current supply chain sustainability frameworks. It shows that, adaptability and sustainability are major consequences of digital leadership, hence the integration of leadership theory and supply chain management literature. The mediation effect of adaptability is partial, which is a plus to theoretical knowledge as it demonstrates that sustainability results are produced by both direct mechanisms of influence of leaders and indirect mechanisms of adaptability. This two-fold mechanism enhances the research on how digital leadership contributes to organizational capabilities and sustainability performance, especially in the volatile and resource-consuming industry like pharmaceuticals.

Future Research Directions

Future research would be interested in the way the relationship between digital leadership, adaptability, and sustainability is moderated by contextual variables like industry type, firm size, and regulatory environment. Longitudinal study would be productive to follow the evolution of digital leadership and adaptability throughout the years and determine the impact on the results of sustainability in various stages of supply chain transformations. Also, cross-sector and cross-geographical comparative studies might offer information on how these relationships are meditated by cultural and institutional conditions. Lastly, the research on the interaction between technological innovation and organizational behaviour could be further extended to understand how the interaction between digital leadership and sustainable supply chain practices is difficult to unravel.

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