

## Examining Multi-Channel Sourcing in Strengthening Supply Chain Persistence with Moderating Role of Advanced Technology Adoption

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### Abstract

**Purpose:** In recent years, supply chain resilience has emerged as a crucial capability for firms which are operating in uncertain and disruption-prone environments, particularly in emerging economies. Manufacturing firms are increasingly required to implement multi-channel sourcing strategies to mitigate risks and enhance supply chain persistence. This study examines the role of multi-channel sourcing in improving supply chain resilience, with advanced technology adoption serving as a moderating variable within the Pakistan context. **Methods:** Data was collected through a cross-sectional survey from 325 individuals, managers of manufacturing firms and operating in four sectors: automotive, electrical and electronics, process, and machinery of Pakistan. Structural equation modeling was employed to test the influence of multi-channel sourcing on supply chain persistence. **Supporting Theory:** Grounded in dynamic capabilities theory, this study adopts an objective, non-manipulative research approach using primary survey data from managers involved in supply chain and operations management. **Results:** The findings confirm that multi-channel sourcing significantly enhances supply chain resilience, and firms with higher levels of advanced technology adoption demonstrate superior capabilities in managing multiple sourcing channels during disruptions. **Conclusion:** The practical implications of this study are very important because it gives evidence-based information to the Pakistani academic and industrial sectors that is useful to their business practices. This research provides valuable data to bridge the current gap in understanding the relationship between multi-channel sourcing and technology adoption in the creation of long-lasting and resilient supply chains in a dynamic and complex business environment.

**Keywords:** Advance Technology Adoption (ATA); Dynamic Capability Theory; Multi-Channel Sourcing (MCS); Structural Equation Modelling; Supply Chain Persistence (SCP)

### Introduction

In the current era, many factors are causing significant challenges and problems, leading to disruptions in supply chains. These things are pandemics, geopolitical tensions, cyberattacks, bad weather and climate change. Global supply chains are being fragile, companies around the world need to make sure their supply

chains can withstand all these problems. For countries like Pakistan that are still developing, this is important to make their supply chain resilient and sustainable. The industries in these countries are easily affected by things that happen outside of their control and by things that are not working well inside the country. Making supply chains strong and able to keep going is not about being better than other countries, it is about making sure the whole economy of the country is stable. Supply chain resilience is very important for Pakistan, and supply chains need to be able to deal with all the problems that are happening. This study looks at two strategies that are connected, multi-channel sourcing and using new technologies. The goal is to understand how these two things work together to help supply chain persistence. Supply chain persistence is about keeping things running smoothly and reliably when bad things happen. It is not about bouncing back from a problem or dealing with it for a little while, it is about keeping the supply chain going steadily over time when things change or get disrupted and it is about being able to adapt and keep moving by multi-channel sourcing and advanced technology adoption. This is especially important for SMEs in developing countries, as multi-channel sourcing can enhance their global competitiveness (Humphrey, 2003). When integrated into a firm's strategy, supply chain diversity can also provide a competitive advantage (Adobor & McMullen, 2007). Moreover, multi-channel sourcing is a key risk mitigation strategy that expands suppliers, markets, and channels (Bode *et al.*, 2011; Brandon-Jones *et al.*, 2014). In Pakistan it is tough to keep things going because of some problems, such as political instability, lack of technology adoption, old logistics practices, lack of storage facilities, and unmatched infrastructure. There is a lack of adequate roads and buildings, with the government taking a slow approach to development. Efficient energy resources are scarce, and there is an over-reliance on a limited number of suppliers, many of whom are located in regions with significant geopolitical tensions. The traditional approach of doing the bare minimum and relying on a single supplier has proven ineffective during challenging times. This has been evident in industries such as textiles, oil and gas, pharmaceuticals, and automotive, where production has come to a halt. This means that Pakistan needs to change the way it does things and find ways of getting what it needs that are stronger and more flexible. Javed *et al.* (2025) analyzes that inclusive leadership impacts numerous organizational outcomes. The sourcing strategies in Pakistan need to be more robust and flexible. Multi-Channel Sourcing (MCS), the practice of procuring materials, components, or products through multiple suppliers or routes, emerges as a foundational tactic for risk diversification.

MCS provides practical solutions that enable businesses to strengthen their supply chain resilience and achieve a competitive advantage by reducing their dependency on any single node and benefit from improved resilience through global literature (Li & Zobel, 2020). In resource-constrained environments such as Pakistan, however, the implementation of MCS is not as simple as introducing a product that solves every problem. Implementing MCS involves creating a few new complexities, such as higher supplier relationship management overhead, increased coordination costs, and issues related to quality consistency. The role of Advanced Technology Adoption (ATA) is of utmost importance. Technologies such as blockchain, which provides traceability and smart contracts, the Internet of Things (IoT) for real-time tracking of assets, artificial intelligence (AI) and predictive analytics, to provide forecasting for risk and dynamic evaluation of suppliers, and cloud computing, for the management of an integrated platform, can fundamentally change the structural complexity of MCS into a highly efficient ecosystem managed through intelligent decision-making. The adoption of such technologies enables organizations to automate routine tasks, leverage real-time data insights, and optimize resource allocation, thereby improving overall productivity and performance (Frank *et al.*, 2019). Using technology, MCS can mitigate its inherent disadvantages through greater visibility across channels, automation of compliance, payment processes and enabling faster rerouting of orders during periods of disruption. Moreover, advanced technologies facilitate greater transparency and connectivity across organizational functions and supply chain networks, enhancing coordination and responsiveness in complex business ecosystems (Kamble *et al.*, 2018).

The purpose of this study is to address the problem of frequent disruption of Pakistan's supply chains, which is due to single-source dependency and the lack of technology adoption, which creates the supply chain

disruptions, lack of optimization, lack of traceability, and lack of visibility of inventory. Multi-channel sourcing can mitigate single-source dependency risks and increase the resilience of the supply chain. In Pakistan's unique operating environment, the absence of empirical data regarding the interplay of these variables inhibits the establishment of resilient and adaptive supply networks.

The significance of this study is very important because it gives evidence-based information to the Pakistan academic and industrial sectors that is useful to their business practices. This research provides valuable data to bridge the current gap in understanding the relationship between multi-channel sourcing and technology adoption in the creation of long-lasting and resilient supply chains in a dynamic and complex business environment. The research results will be beneficial to supply chain managers in terms of their investment decisions and provide guidance to policymakers when developing policy initiatives that support improving the economic resilience of their country.

### **Review of Literature**

Multi-channel sourcing is a key tactic for strengthening a company's supply chain through increased risk-diversification capabilities. It refers to a strategic procurement approach where a firm uses multiple suppliers for the same component or product rather than relying on a single source. This practice aims to reduce risk and increase resilience in the supply chain. This strategy allows businesses to gain resiliency and flexibility within their operational processes due to disturbances in the supply chain (Gupta *et al.*, 2019). Osiyevskyy *et al.* (2020) note that in unstable circumstances businesses benefit from an operating flexibility within the market through a diversified channel system. Wagner and Bode (2014) studied that businesses are also able to leverage their supply chain strategies against each other to pursue reduced costs based on the competitive behavior of both channels. However, Choi and Krause (2006) identified substantial management difficulties associated with this channel strategy, including greater communication and coordination overloads, inconsistent quality and performance factors between channels, increased transaction costs, and so forth. They maintain that without adequate management these complications could negate many of the strategic advantages of the strategy. Additionally, emerging literature has shown that leverage of advanced technologies, such as the Internet of Things (IoT) for tracking and artificial intelligence (AI) for supplier performance evaluation, can significantly mitigate the coordination costs associated with MCS, thereby allowing companies to optimize the benefits of MCS for long-term operational resilience. The relationship between MCS technology and the creation of long-term operational resilience has received insufficient attention, especially within resource-strained developing economies (Dubey *et al.*, 2021). In multi-tier supply networks, sourcing decisions may be suboptimal if considered independently at each tier due to misaligned incentives, upstream sourcing strategies can affect downstream performance through correlated risks (Bimpikis *et al.*, 2018). Wu *et al.* (2019) develop game-theoretic frameworks to analyze multi-sourcing decisions under supply and demand uncertainty, incorporating vertical information sharing and competitive retailer behavior. This line of research examines how risk diversification and pricing competition influence sourcing decisions.

The use of advanced technologies in various sectors is changing the way many supply chains operate, resulting in changes to how businesses operate today. Advanced technologies allow for greater transparency and predictability by utilizing enhanced visibility and analytics. Core technologies, including blockchain and the Internet of Things (IoT), have resulted in providing companies with real-time information regarding their supply chain activity while establishing trust between organizations through an immutable audit trail (Büyükoçkan & Göçer, 2018; Queiroz *et al.*, 2020). The use of Artificial Intelligence (AI) as well as predictive and analytical modeling and decision support systems is enhancing overall risk mitigation through more proactive identification of potential disruptions, better dynamic evaluation of suppliers, optimally allocating available inventory, and increasing the speed of response (Dubey *et al.*, 2020; Wamba & Queiroz, 2022). The combination of these technologies establishes that the highest value is not achieved through technology alone, but rather through the integration of the technology and strategic business practices to create

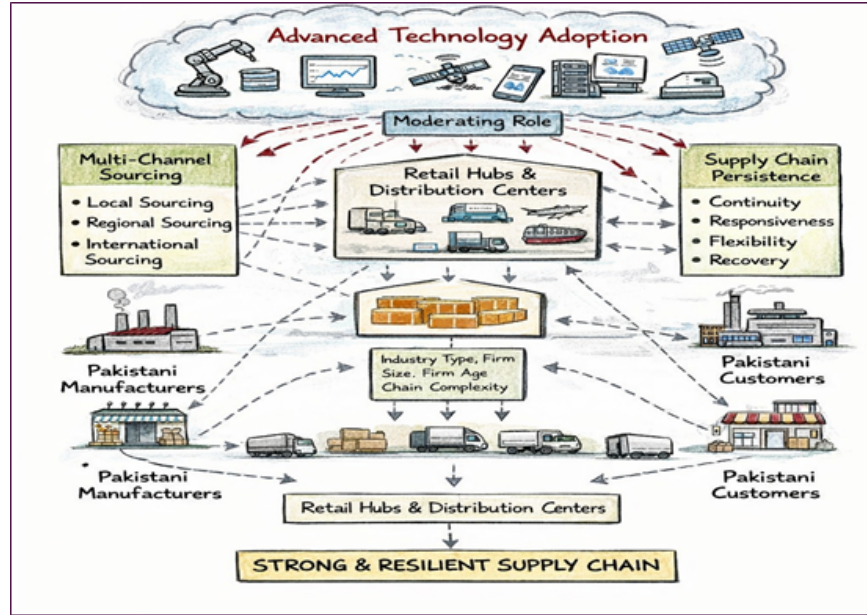
added value. Further, it was found that the use of technology as a moderator and enabler of multi-channel sourcing strategies significantly reduces the costs associated with coordinating operational activities and the fragmentation of information. Specifically, technology provides integrated data and automated processes to resolve the operational complexities associated with the use of MCS strategies and is particularly important in emerging economies where infrastructure constraints can limit access to technology and create inefficiencies (Ivanov *et al.*, 2019).

Supply chain persistence is one advanced and enduring extension of supply chain resilience. Persistence can be defined as the capability to retain high levels of critical operational flows and performance through and beyond disruptive events, whereas the primary focus of most resilience research is the recovery process after a disruptive event (Wieland & Durach, 2021; Ivanov, 2021). Persistence takes these definitions further and incorporates agile and robust supply chain factors while focusing on how to achieve adaptive capabilities over time. The literature on supply chain persistence has characterized it as an outcome of combining strategic design with dynamic capabilities using synergies. Proactive approaches such as multi-channel sourcing create structural redundancies, thus avoiding single points of failure (Sheffi & Rice, 2005). However, simply having such a structure in place does not equate to an activated and managed capability. When paired with various forms of advanced technology, such as those for providing real-time visibility to support rapid re-routing of product flows and predictive analytics to assist in pre-emptive risk mitigation, dynamic capabilities provide opportunities for network learning, adaptation, and sustained operations during periods of stress (Scholten & Stevenson, 2020; Dubey *et al.*, 2021). Hence, an integrated view of persistence is essential, as it implies that persistence does not exist in one specific moment but is constantly occurring through the synergy between diversified network architecture and intelligent technology-driven orchestration of the network.

### ***Impact of Multi-Channel Sourcing on Supply Chain Persistence***

It is proposed that multi-channel sourcing will impact the persistence of supply chains significantly. However, the positive effects of multi-channel sourcing on the persistence of supply chains depend on how well an organization can diversify its risk and manage redundant suppliers to effectively respond to supplier disruptions. It allows an organization to spread its procurement risk between suppliers and delivery points and essentially protects a supply chain and the base of its operations against the failure of any one supplier. Thereby allowing it to remain operational during supplier-specific disruptions, which represents one of the most critical elements of persistence (Li & Zobel, 2020; Sheffi & Rice, 2005). In addition to buffering the supply chain's structural vulnerability to supplier disruptions, MCS provides alternate roadways for sustaining the material flow to keep operating, thereby providing an outlet for interconnections between suppliers and delivery points when the primary source of that material is compromised. However, both the empirical and conceptual literature highlighting the relationship between MCS and supply chain persistence provides cautionary evidence to the effect that the relationship is not consistently positive. The additional complexity that is introduced through managing multiple suppliers can create coordination failures, quality inconsistencies, and transaction costs, all of which can negatively impact supply chain stability and thus hamper an organization's ability to achieve sustained performance (Choi & Krause, 2006). It is therefore logical to conclude that MCS's effect on persistence will be affected by an organization's capabilities in supplier integration, information sharing, and, more importantly, by the organization's adoption of advanced technologies to help to mitigate the coordination penalties associated with managing multiple suppliers (Figure. 1).

*H1: Multi-channel sourcing has a positive impact on Supply Chain Persistence*



**Figure 1:** Advanced Technology Adoption Enhances Multi-Channel Sourcing to Build a Strong and Resilient Supply Chain in Pakistan

### ***Role of Advanced Technology Adoption between Multi-Channel Sourcing on Supply Chain Persistence***

Advanced technology adoption is theorized to be an important positive moderator and facilitator for allowing multi-channel sourcing to fully leverage its structural capabilities and create supply chain stability as a viable continuous operation. Advanced technologies directly address key supply chain impediments. The Internet of Things (IoT) enables real-time visibility of assets, Artificial Intelligence (AI) and Machine Learning (ML) allow predictive analysis of supply chain risks, and Blockchain supports automatic, trustless transactions. Together, they enhance a firm's ability to orchestrate a multi-channel sourcing network. They provide integrated, real-time visibility into sourcing activities. This enables preemptive measures to mitigate supplier delivery risk. These technologies also automate routine coordination tasks (Ivanov *et al.*, 2019; Dubey *et al.*, 2021). Hence, from the perspective of technology adoption, adopting these advanced technologies further strengthens the already existing positive relationship between MCS and supply chain stability. Therefore, firms may continue to benefit from the positive aspects of MCS (e.g., rapid re-routing) while eliminating or minimizing the negative aspects of MCS (e.g., coordination costs) and thus could achieve the greatest level of supply chain stability benefits from a diversified supply base that may have otherwise remained dormant or even been to the detriment of the firm in the absence of this advanced technology context (Wamba & Queiroz, 2022). MCS provides the redundancy necessary for successful operations, however, it also adds significant complexity in terms of coordinating the various parties involved, fragmentation of information, and delays in decision-making, all of which can detract from the continuous operations of enterprises (Choi & Krause, 2006).

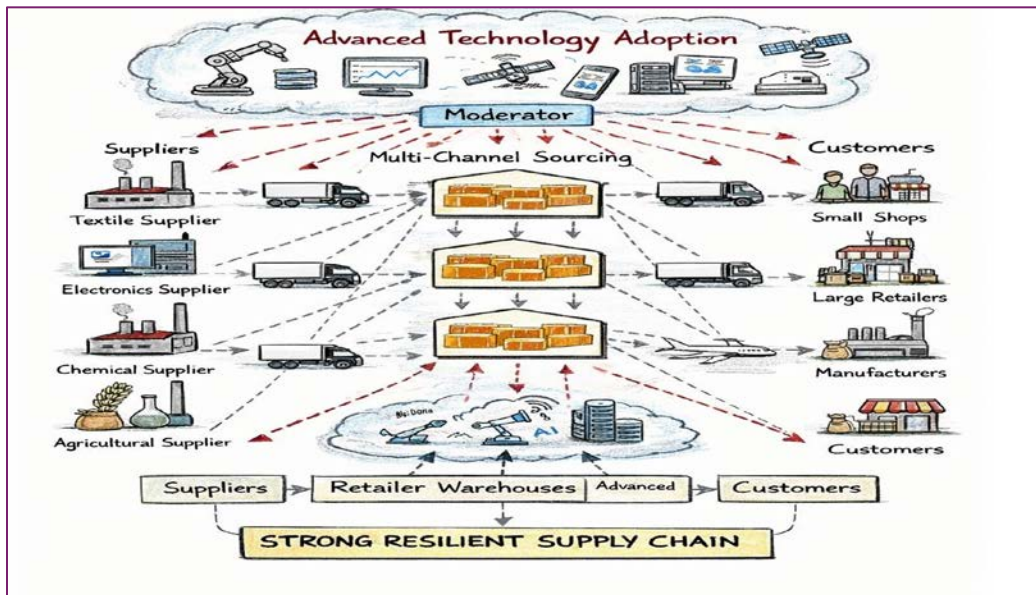
*H2: Advanced Technology Adoption has a positive role in Multi-Channel sourcing and Supply Chain Persistence*

### ***Impact of Advanced Technology Adoption on Supply Chain Persistence***

A ubiquitous convergence of high-technological paradigms, namely artificial intelligence (AI), blockchain, the Internet of Things (IoT), big data analytics, cloud computing, and the next-wave technologies, namely, 5G and digital twin platforms, has radically changed the functionality of supply chains. This change appears

in the form of increased persistence, resilience, visibility, and agility, especially in the multifaceted network of global supply chains. Empirical literature has always shown that such technologies lead to supply-chain persistence through their ability to acquire and process data in real-time to enhance the precision of forecasting and guide decision-making in operations. This will enable companies to react to disruption through more efficient mitigating measures (Samuels, 2025). The AI helps in this paradigm due to its ability to predict, which helps in strong demand forecasting and optimization in inventory. As a result, the inefficiencies would be limited, and the organizations would maintain the continuity of operations during the unstable market conditions (Alshebami, 2025). The integration of the IoT will expand the organizational control of the system through the constant monitoring and tracking of network nodes, increasing the overall system transparency and responsiveness, and thus the continuity in the event of disruptions improves. Persistence is also based on blockchain technology that ensures there is safety and immutability in the exchange of data among stakeholders (Figure. 2). This enhances data integrity and increases trust, traceability, and responsiveness to collaboration qualities that are essential in terms of enduring the disruptions. Furthermore, research studies indicate that conjoined technology ecosystems, including AI, IoT, blockchain, 5G, and cloud computing, deliver synergy-related advantages, allowing a coordinated, data-driven reaction to environmental instability. However, other challenges highlighted in the literature are cyber vulnerabilities, interoperability limitations with old infrastructures, and the need to upskill the workforce and manage change across the board. These aspects can reduce the degree to which the adoption of technology can be converted into a sustained competitive advantage. Finally, though it has been established that advanced technologies do promote supply-chain resilience in predictive resilience, operational flexibility, and real-time visibility, these gains can only be fully realized when integrated organizational strategies are coordinated.

*H3: Advanced Technology Adoption has a positive impact on Supply Chain Persistence*



**Figure 2:** Conceptual framework illustrating the role of advanced technology adoption and multi-channel sourcing in enhancing supply chain resilience

### **Dynamic Capability Theory**

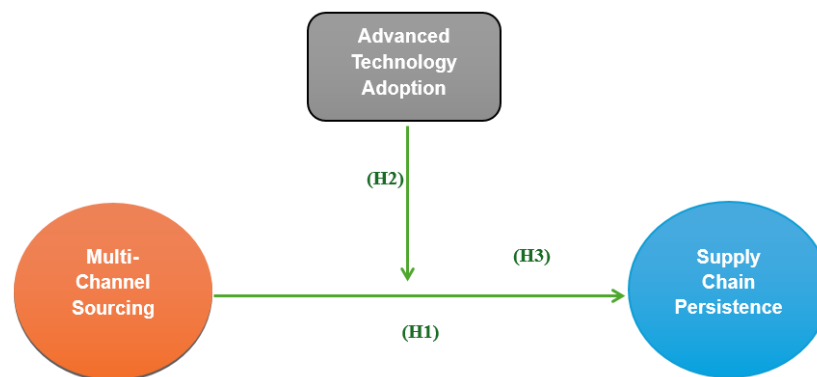
Dynamic Capability Theory serves as the foundation and basis for the proposed model regarding the effect multi-channel sourcing has on supply chain persistence as moderated by advanced technology adoption. According to Teece *et al.* (1997), dynamic capabilities are those created when companies create internal

and external capabilities to enable them to navigate drastically altering environments through their combination, integration, development, and creation of new capabilities. Within this framework, the MCS represents a very high-level strategic resource configuration that provides the opportunity for firms to build and maintain an appropriate set of resources. According to Dynamic Capability Theory, however, merely possessing resources does not lead to a long-term sustainable advantage. It is the firm's ability to leverage these resources through effective orchestration that produces the sustained competitive advantage that Dynamic Capability Theory predicts will be realized when the company invests in Advanced Technology Adoption to develop its orchestration of its resources. Advanced technology, such as artificial intelligence (AI) and the Internet of Things (IoT), enhances the firm's ability to quickly detect disruptions throughout its supplier network, respond to opportunities through dynamic allocation of orders on a continual basis, and drive reconfiguration of the supply chain architecture based upon the utilization of data-driven insights and forms of learning (Teece, 2007). Consequently, the effect of technology can be viewed as the activation of dynamic capabilities, specifically the activation of the capacity to convert an otherwise static, complex resource configuration into an appropriately agile, intelligently coordinated set of resource systems enabling sustained (and, therefore, continuing) operational activity. The research findings support the conclusions regarding supply chain persistence whereby organizations continue to perform when they utilize a variety of MCS options and are able to respond to changes in a prompt fashion and to optimize resources efficiently through the development of new and advanced capabilities enabled through the adoption of advanced technologies. The study posits that Supply Chain Persistence is the performance outcome achieved when a firm's sensing, seizing, and transforming capabilities (enabled by technology) are effectively applied to orchestrate its strategic resource configuration (MCS) in the face of disruptions.

## Methodology

### Research Design

The current study is conducted under a cross-sectional, quantitative research paradigm that is aimed at questioning the direct and moderating relationships between multichannel sourcing, adoption of advanced technology, and operational effectiveness of supply chain persistence. A variance-based structural equation modeling method was used to test the hypotheses and thus provided a rigorous test of predictive validity, path complexities, and interaction effects between the latent constructs.



**Figure 3:** Proposed Research Model

**Table 1: Variables Description and Roles**

Variables Name	Description	Role in Model
Multi-Channel Sourcing	The use of multiple sourcing channels and suppliers (local, regional, international; traditional and digital) to procure raw materials and components, reducing dependency on a single source	Independent Variable
Advanced Technology Adoption	Adoption of advanced digital technologies such as ERP systems, IoT, big data analytics, blockchain, AI, and automation to enhance visibility, coordination, and decision-making in supply chains	Moderating Variable
Supply Chain Persistence	The ability of supply chains to continue operations, adapt, and recover during disruptions, measured through continuity, responsiveness, flexibility, and recovery speed lead time reduction, cost efficiency, and resilience	Dependent Variable

Source: (Bode & Wagner, 2015), *Advanced Technology Adoption* (Frank et al., 2019), *Supply Chain Persistence* (Ambulkar et al., 2015)

### Population and Sampling

The target population of the study included managers, experts, and top-level operational personnel operating in the divisions of logistics, supply chain, manufacturing, logistics, and distribution companies that are engaged in environmentally oriented programs in Pakistan. The participants were selected based on the fact they are directly involved in the sourcing, procurement, and logistics processes and the fact that they take part in the performance reviews. Primary data were collected using a carefully structured sampling system, which guaranteed methodological collection. The criteria included at least three years of professional experience and involvement in the decision-making process related to sustainability. Lastly, the data was filtered to contain only the data that met the strict requirements of excluding missing data, response bias, and outliers.

**Table 2: Demographic Data**

<b>Age</b>	<input type="checkbox"/> Less than 25 <input type="checkbox"/> 26-35 <input type="checkbox"/> 36-45 <input type="checkbox"/> 46 or above	<b>Gender</b>	<input type="checkbox"/> Male <input type="checkbox"/> Female
<b>Qualification</b>	<input type="checkbox"/> Under-Graduate <input type="checkbox"/> Graduate <input type="checkbox"/> Masters <input type="checkbox"/> Doctoral	<b>Type of Organization</b>	Public <input type="checkbox"/> Private <input type="checkbox"/>
<b>Working Experience</b>	<input type="checkbox"/> Less than 5 yrs <input type="checkbox"/> 6-10 yrs. <input type="checkbox"/> 10-20 yrs <input type="checkbox"/> 20 and above		

### Measurement of Variables

Measurement items were adopted from previous and tested studies, and measurement was done based on a 5-point Likert scale of 1 (strongly disagree) to 5 (strongly agree). Multi-Channel Sourcing was measured using a 7-item scale based on Bode and Wagner (2015); Advanced Technology Adoption was measured using a 13-item scale obtained by Frank et al. (2019); and Supply Chain Persistence was measured using a 10-item scale obtained by Ambulkar et al. (2015). The demographic variables included in the questionnaire were age, gender, work experience, and education level. Respondent confidentiality was preserved and anonymity ensured, as stated in the cover letter of the questionnaire, which had a clear interpretation of the purpose of the research.

### **Data Collection Procedure**

Data collection was done through self-administered questionnaires electronically administered to the eligible respondents. They were not compelled to take part, and to avoid the social desirability bias, the participants were reassured that they were confidential. The respondents were made aware that the data that would be obtained would only be used in academic research. Procedural controls to minimize the common method variance were considered, such as accurate instructions, a psychological separation of predictor and criterion variables in the questionnaire, and anonymity. The questionnaire was reviewed strictly before being deployed to make sure that it was conceptually sound and contextual. Since the size of the available population was large, convenience sampling was used; 400 questionnaires were sent out, and 325 valid responses were obtained and used to make the analysis.

### **Data Screening and Preliminary Analysis**

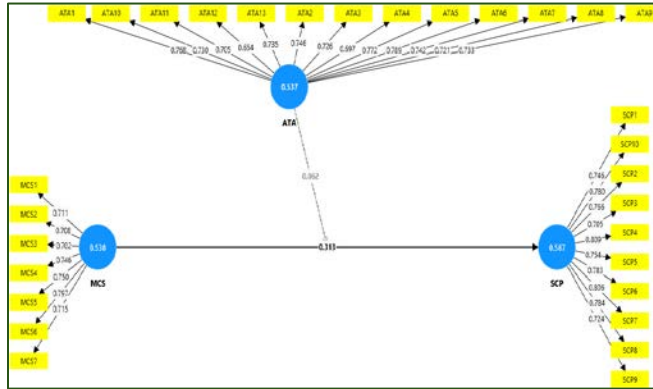
A careful screening of the data was done to reveal missing values, outliers, and non-normality in the data before hypothesis testing. The observations that had anomalous omissions were later dropped. Variance inflation factors were then calculated to determine multicollinearity, and it was ensured that none of the predictor variables were beyond the acceptable range. The next step resulted in the creation of descriptive statistics that provided a brief profile of the respondent demographics and the distribution of the relevant variables.

### **Measurement Model Assessment**

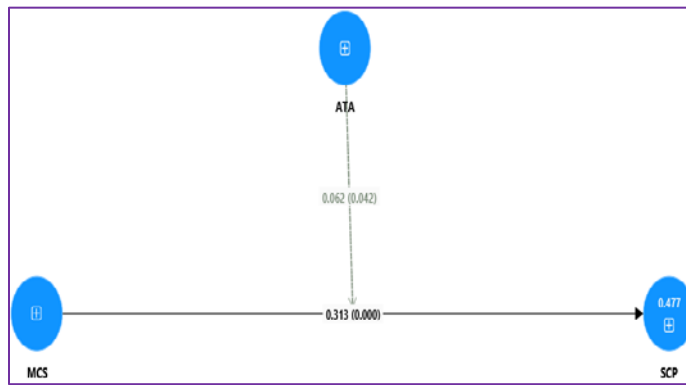
Before considering the structural relationships, the measurement model was reviewed to determine reliability and validity as accurately as possible. Additionally composite reliability coefficients were used to evaluate internal consistency, thus ensuring that each construct was coherent enough. Convergent validity was assessed through factor loadings and average variance extracted, and it was found that the indicators were able to capture the intended constructs sufficiently. Discriminant validity was established as per the set standards, and this process ensured empirical differentiation among all constructs in the model. The structural relations were analyzed after the achievement of good levels of reliability and validity. This sequential method will ensure that the inferential analyses will be based on a solid foundation of measurement, hence maximizing the validity of the results that will be reached.

### **Structural Model Evaluation**

The structural model was strongly tested by path coefficient calculation, t-values, and significance threshold, which were all obtained as a result of a large-scale bootstrapping process with a large number of resamples (Figure 4). Simultaneously, the coefficient of determination was also investigated to determine the general explanatory power available through the contribution of the endogenous constructs to the process of model fitting. The indirect impact of the green logistics infrastructure on the operations of the circular economy through the recycling effectiveness was investigated to scrutinize mediation. This indirect path was established as statistically significant with the help of bootstrapped confidence intervals, thus pointing to the fact that the mediation effect is not just a chance finding of sampling variability. The hypothesis of moderation was formulated, and as a result, an interaction term was built between the recycling efficiency and the ability of the workforce to have skilled capabilities (Figure 5). By recognizing the importance and significance of such interaction, the study aimed to determine whether the relationship between recycling efficacy and performance outcomes is strengthened as the skill level of the workforce increases. Lastly, effect sizes were used to determine the substantive impact of individual predictors. This involved the predictive relevance of the model being investigated as well, thus giving us an opportunity to understand the ability of the model to predict future performance based on the evaluated constructs.



**Figure 4:** Measurement and structural model results with standardized estimates and explained variance ( $R^2$ ).



**Figure 5:** PLS-SEM results showing standardized path coefficients, p-values, outer loadings, and  $R^2$  values for endogenous constructs

**Results**

**Table 3:** Loadings, Composite Reliability and Average Variance Extracted

Construct	Item	Factor loading	Cronbach's $\alpha$	(CR)	AVE
Advance Technology Adoption	ATA 1	0.768	0.928	0.938	0.537
	ATA 2	0.746			
	ATA 3	0.726			
	ATA 4	0.697			
	ATA 5	0.772			
	ATA 6	0.789			
	ATA 7	0.742			
	ATA 8	0.721			
	ATA 9	0.733			
	ATA 10	0.730			
	ATA 11	0.705			
	ATA 12	0.654			
	ATA 13	0.735			
Multi-Channel Sourcing	MCS 1	0.711	0.857	0.891	0.538
	MCS 2	0.708			
	MCS 3	0.702			
	MCS 4	0.746			

Construct	Item	Factor loading	Cronbach's $\alpha$	(CR)	AVE
	MCS 5	0.750			
	MCS 6	0.797			
	MCS 7	0.715			
Supply Chain Persistence	SCP 1	0.746	0.922	0.934	0.587
	SCP 2	0.780			
	SCP 3	0.766			
	SCP 4	0.705			
	SCP 5	0.809			
	SCP 6	0.754			
	SCP 7	0.783			
	SCP 8	0.806			
	SCP 9	0.784			
	SCP 10	0.724			

**Note:** Cronbach's alpha and Composite Reliability (CR) values above 0.70 indicate internal consistency reliability. Average variance extracted (AVE) values above 0.50 indicate adequate convergent validity (Hair et al., 2021).

**Table 4: Discriminant Validity (HTMT Ratio)**

HTMT	Advance Technology Adoption	Multi-Channel Sourcing	Supply Chain Persistence
Advance Technology Adoption			
Multi-Channel Sourcing	0.562		
Supply Chain Persistence	0.684	0.587	

**Note:** Heterotrait-Monotrait (HTMT) values below 0.85 (strict criterion) or 0.90 (liberal criterion) indicate adequate discriminant validity (Henseler et al., 2015).

**Table 5: Discriminant Validity (Fornell - Larcker Criterion)**

	Advance Technology Adoption	Multi-Channel Sourcing	Supply Chain Persistence
Advance Technology Adoption	0.733		
Multi-Channel Sourcing	0.499	0.733	
Supply Chain Persistence	0.643	0.529	0.766

**Note.** Discriminant validity is considered acceptable when the square root of the average variance extracted (AVE) for each construct is greater than its highest correlation with any other construct (Fornell & Larcker, 1981).

**Table 6: Cross Loading**

	ATA	MCS	SCP
ATA1	0.768	0.389	0.537
ATA10	0.730	0.449	0.421
ATA11	0.705	0.453	0.438
ATA12	0.654	0.335	0.412
ATA13	0.735	0.442	0.446
ATA2	0.746	0.308	0.490
ATA3	0.726	0.289	0.460

	ATA	MCS	SCP
ATA4	0.697	0.266	0.427
ATA5	0.772	0.328	0.521
ATA6	0.789	0.334	0.541
ATA7	0.742	0.339	0.530
ATA8	0.721	0.427	0.421
ATA9	0.733	0.436	0.433
MCS1	0.369	0.711	0.422
MCS2	0.328	0.708	0.325
MCS3	0.374	0.702	0.355
MCS4	0.312	0.746	0.360
MCS5	0.387	0.750	0.402
MCS6	0.385	0.797	0.429
MCS7	0.396	0.715	0.401
SCP1	0.495	0.389	0.746
SCP10	0.522	0.506	0.780
SCP2	0.459	0.380	0.766
SCP3	0.365	0.321	0.705
SCP4	0.516	0.420	0.809
SCP5	0.495	0.402	0.754
SCP6	0.492	0.408	0.783
SCP7	0.523	0.370	0.806
SCP8	0.569	0.435	0.784
SCP9	0.449	0.390	0.724

**Note.** Cross-loadings indicate adequate discriminant validity when each indicator loads higher on its associated construct than on all other constructs (Chin, 1998; Hair et al., 2019).

**Table 7: Structural Model Path Coefficients**

Hypothesis	Path	$\beta$	t-value	p-value	CI (5%-95%)	Decision
H1	ATA -> SCP	0.509	9.327	0.000	0.422, 0.603	Supported
H2	MCS -> SCP	0.313	4.507	0.000	0.199, 0.427	Supported
H3	ATA x MCS -> SCP	0.062	1.723	0.042	0.001, 0.115	Supported

**Note.** Path coefficients ( $\beta$ ) were tested using bootstrapping with 5,000 subsamples. Paths are significant at p-value < 0.05 and t-value > 1.65. Confidence Intervals (CI) for path coefficients ( $\beta$ ) were computed using bias-corrected bootstrapping with 5,000 subsamples. Paths were considered significant if the 95% CI did not include zero.

## Discussion

Based on the empirical evidence presented alone, the results show that there is a solid and effective measurement structure and that there is a structural model that can explain the differences in supply-chain persistence jointly. High factor loading, Cronbach alpha values, composite reliability, confidence interval, and average variance extracted have shown that the constructs have a high level of internal consistency and convergent validity, and the values are above recommended levels (Hair et al., 2021). Therefore, the indicators are reliable to measure their desired latent variables (Table 4). Discriminant validity was determined using HTMT ratios, the Fornell-Larcker criterion, and cross-loading analyses. The findings validate that all the constructs are empirically different and there is no problematic overlap (Tables 5, 6, and 7). Testing the structural model indicates that multichannel sourcing has a direct and statistically significant impact on supply chain persistence. Multi-channel sourcing has a strong and most significant impact on the supply chain persistence ( $\beta$  0.313,  $p < 0.000$ ), which is the most significant direction in the model. This connection becomes strategic to the increase in the productivity of resources and sustainable performance.

The moderating effect with the support of the advanced technology adoption suggests that the technology-adoption practices enhance the relationship between the multi-channel sourcing and the supply-chain persistence, which adds to the overall impact on the dependent variable. The development of technology adoption, in its turn, positively influences the persistence of the supply chain to an important extent (0.062,  $p < 0.042$ ). The stability and predictive relevance of the proposed relationships are emphasized by the high path coefficients and nonzero confidence intervals. There is also empirical evidence to support the finding that there is no correlation between the multi-channel sourcing and high-technology adoption frameworks, which are leverage points that drive the supply chain practice (Table 7). Together, these results imply that the achievement of supply chain persistence cannot be controlled via the isolated interventions but instead via the consistent integration of sophisticated technology implementation. Multi-channel sourcing reduces the reliance on individual suppliers, which creates structural redundancy resistant to supplier-specific failures and allows the company to find other routes to transfer materials (Li & Zobel, 2020). Likewise, Song *et al.* (2022) found redundancy as a core competency in which the multichannel operations increase the resilience of the supply chain, thus allowing firms to continue with operations in case of supplier perfections. Artificial intelligence (AI), the Internet of Things (IoT), blockchain, predictive analytics, and additional technologies can be used to increase visibility in real-time, proactively identify risks, and make decisions quickly in complicated supplier networks (Ivanov, 2021; Dubey *et al.*, 2021). The latest empirical studies confirm these interrelations. In the study by Modgil *et al.* (2023), it was established that AI methods substantially increase the adaptability of the supply chain and collaboration, thereby causing a higher level of resilience in the wake of disruptions. These difficulties are addressed by advanced technologies offering coordinated platforms to the suppliers, automated monitoring, and real-time decision-making (Ivanov *et al.*, 2019; Wamba & Queiroz, 2022).

### **Theoretical Contribution**

This research will add to the existing body of knowledge by providing an extension of how companies can maintain supply chain operations in a very uncertain and disruption-prone environment. It builds on existing studies by theorizing on the concept of supply chain persistence as long-term resiliency that extends beyond conventional resiliency and insisting on the fact that the persistence of supply networks is in sustaining supply chain operations over time, instead of merely recuperating post-shock. The paper also gives empirical data that diversified sourcing forms enhance continuity in operations by lessening reliance on individual suppliers and allow alternative supply channels when disruptions occur. Moreover, it also emphasizes the importance of advanced technologies in intensifying the efficiency of diversified sourcing strategies by increasing the visibility and coordination as well as real-time decision-making across the intricate supplier networks. With the incorporation of these aspects into the view of dynamic capabilities, the study shows how the organizations are able to convert structural sourcing configurations into adaptive and sustainable operational capabilities. The results also expand the literature through the provision of empirical evidence in the context of a developing economy in the sense that it improves the theoretical result of how companies with institutional and infrastructural limitations manage to develop more resilient and adaptive supply chains.

### **Practical Implication**

The results of this research offer some practical implications to the managers and decision-makers in charge of supply chain and procurement activities. The findings indicate that the concentration approach to suppliers faces a high risk of operational failure, especially in a situation whereby disruptions are common. Managers ought to look to diversify their channel of sourcing and be able to build relationships with various suppliers so that there is continuity of material flows in case of unforeseen disruptions. Simultaneously, it is noted by the study that the effective coordination and information exchange of multiple suppliers needs to be handled, and advanced digital technologies could enhance this process on a large scale. The financing of data-driven systems, real-time monitoring devices, and integrated digital systems may enable the

organizations to enjoy more visibility in their supplier networks and swift, more informed decision-making in the event of disruption. The joint use of diversified sourcing and the use of a modern technology system allows firms to better stabilize operations and minimize supply-related uncertainties and ensure consistent production levels even in the turbulent market environment.

### **Policy and Managerial Implication**

The results of the current study can have valuable implications not only for the policymakers but for the organizational leaders as well who are concerned with making industrial supply networks more stable. Policy-wise, governments and laws and regulations should promote policy initiatives that compel companies to diversify their sourcing models and use new digital infrastructure that facilitates effective procurement and logistics processes. Firms can enhance coordination through supply networks by creating enabling policies and investing in digital connectivity and easy access to technology, which would minimize weaknesses related to over-dependence on suppliers. At the managerial level, the organizational leaders are supposed to aim at the establishment of flexible procurement systems and endow the cooperation with various suppliers while at the same time investing in digital tools that help to raise the level of transparency, monitoring, and quick decision-making. Through strategic sourcing choices in coordinating with technological capability creation, the firms would be in a better position to deal with disruptions, ensure operational continuity, and enhance the long-term stability of their supply chains.

### **Limitations**

This paper has several limitations, which offer substantive possibilities for future research. To begin with, the cross-sectional paradigm is known to capture relationships at one point in time and hence is not able to reflect the dynamic nature of supply-chain resilience over time during either long-term or repeated disruptions.

### **Conclusion**

This research provides strong arguments that justify multi-channel sourcing as an important factor in improving the persistence and resilience of supply chains in complex and disruption-prone environments, like those experienced in Pakistan. Systematic supplier and sourcing channel diversification enables companies to cushion the operational streams against any unexpected shocks and maintain the continuity in performance. The results also shed light on the fact that the benefits of multi-channel sourcing are significantly enhanced when companies use modern technologies. Artificial intelligence, blockchain, IoT, cloud computing and predictive analytics provide real-time visibility, risk mitigation in advance, and effective communication between a host of suppliers, which can transform what could be a complexity into a strategic edge. Combining multi-channel sourcing with the implementation of advanced technology does not only consolidate the resilience of operations but also contributes to long-term sustainability in the fact that the firms are able to keep adjusting to new situations. On the whole, the study highlights that the achievement of supply-chain persistence is not an activity of the isolated interventions but is a coordinated one that integrates the strategic aspects of sourcing with technological skills. This synthesis has implications for action by managers and policymakers who aim to build strong and flexible supply networks in the emerging economies.

Future studies using longitudinal or event-based designs would better follow the dynamics of development and interactions of multi-channel sourcing and technology-based capabilities over time. Second, the adoption of sophisticated technology as an aggregate construct is a danger to establishing the unique effects of separate technologies. Emerging studies should break down particular digital technologies and integrate relational and behavioral determinants, e.g., the collaboration with suppliers and decision-making practices, to make an account subtler about the long-term operation of the supply chain in the face of disruption. Third, the empirical focus on manufacturing firms in Pakistan limits the extrapolation of the

results to other institutional settings. Inter-country or inter-industry comparisons of countries or industries with different degrees of technological advancement and regulation would provide more contextual information. Lastly, the use of self-reported managerial perceptions can be prone to subjective bias, despite careful instrument construction and a procedure-level precaution. The strengthening of robustness through future research ought to include the inclusion of objective performance metrics both in terms of archival records and digital trace data retrieved through supply-chain information systems.

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### Conflict of Interest

The authors state that they do not know of any competing financial interests or personal relationships that might have manifested themselves in the work that is reported in this paper. This study received no funding from any other organization or agency. The study was performed without connection, and the authors have no interest in any organization or entities, financial or non-financial, in the topic or material to be covered in this manuscript.

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