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FROM COMMUNICATION TO PERFORMANCE: UNDERSTANDING THE PATHWAYS OF TECHNOLOGY ANTICIPATION IN SUPPLY CHAIN EXCELLENCE

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Abstract

The complexity of supply chains is impacted by a number of factors. In an attempt to address some of these factors, businesses have begun to incorporate modern technology, integrated communication, and digital automation on a large scale. This study analyzes the relationships of Communication Level (CL), Use of Technology Level (UTL), and Anticipation of New Technologies (ANT), and their overall effect on Supply Chain Performance (SCP). Pakistan is home to a number of industries that are digitizing and modernizing quickly, and the textile industry is no exception. The relationships of the variables of interest have not been addressed to the extent that is needed, and this study speaks to that gap.

In reference to the Resource-Based View (RBV), the study posits that sustainable advantage lies in the ability to proactively identify, and in turn capitalize on, technological developments. In the Pakistani textile industry, 370 professionals' responses were analyzed using Structural Equation Modeling (SEM).

In the relationship of new technology anticipation and supply chain performance, Anticipation of New Technologies is the only mediator. Respondents' results deemed it imperative to shift a firm's overall strategy from a predominantly reactive to a predominantly proactive approach in order to achieve excellence in SC dynamic technological anticipation.

Introduction:

Background:

Supply chains are becoming increasingly complex in today's business landscape, forcing businesses to incorporate advanced technologies and communication to remain competitive (Bag et al., 2021). New technologies and technological transformations have changed the ways of coordination, information sharing, and response levels to disruptions (Queiroz et al., 2021). Due to the growing need for interconnectedness and dependence on technology, there is an increasing need to understand the mechanisms of coordination, communication, and anticipatory technology (Dubey et al., 2020). This mechanism is of great importance in developing economies, which are undergoing rapid modernization and forced transformation to compete in the global market (Awan et al., 2021).

Pakistan, one of the world's largest exporters, accounts for approximately 60% of the country's total exports and employs over 40% of the industrial workforce (Mufti & Ali, 2024; Rashid, 2025). The Pakistan textile industry has complete supply chains from cotton cultivation to spinning, processing, weaving, and garment manufacturing (Mehar, 2022). However, the industry faces significant challenges, including intense competition in global markets, reduced barriers to entry, greater alternatives, higher production costs, inconsistent quality, and the need to incorporate advanced technologies to meet international standards (Husain et al., 2024).

Global buyers are demanding shorter lead times for the best qualities and greater transparency (Husain et al., 2024). Many organizations in Pakistan are still relying on manual processes, which are causing higher costs and lagging in responsiveness and operational efficiency. However, organizations have now recognized the importance of advanced digital and communication technologies and have begun investing in them (Hyder et al., 2024).

Communication enables coordination among company stakeholders and, therefore, is considered the lifeblood of modern supply chains (Bag et al., 2020). Effective communication is viewed as efficient and enables enhanced operational performance, leading to enhanced overall supply chain performance (Schniederjans et al., 2020). In addition, the quality and frequency of communication play a significant role in enhancing supply chain performance (Wang, 2021).

Organizations that can proactively assess the need for new technologies can position themselves well in advance in the best market positions (Queiroz et al., 2023). The anticipation of new technologies is a capability that distinguishes the best-performing supply chains from competitors (Wamba & Queiroz, 2022). Technology anticipation assesses the need for advancements and the organization's readiness (Fosso Wamba & Akter, 2019).

The use of technology is extensively researched as a critical component of performance outcomes (Attaran, 2020). The introduction of new technologies in a business operation does not solely guarantee improved performance. It is the integration of these systems that creates the operational agility, resilience, and increased overall customer satisfaction (Bag et al., 2021; Büyüközkan & Göçer, 2018). Technologies such as Blockchain, Internet of Things, predictive analysis, artificial intelligence, and virtual reality, among others, have attributed to improvement in accuracy, transparency, and visibility, as well as, reduction in costs (Rejeb et al., 2020).

Communication, anticipation towards technological change, and the usage of technologies in the supply chain is an upcoming trend that most academics have not the explored the literature surrounding them. These elements have been studied in isolation, and very few have studied the interrelationships and the overall effect toward supply chain performance (Dubey et al., 2020). furthermore, the anticipation of emerging technologies has not been studied as a mediating variable (Kaur & Singh, 2019). Lastly, most of the research has been focused on developed countries, so examining these elements in developing countries could help to understand whether the results observed in developed countries apply to emerging markets and would provide valuable insights.

This study looks at how different components of an organization's ability led to the development of different components of an organization's efficiency of their supply chain. Structural equation modeling (SEM) assists with the analysis of different components.

The foundation of this research is based on the resource-based view (RBV) and dynamic capabilities of an organization (Bag et al., 2020). Competitive position is achieved through the development of criteria, and/or conditioning of numerous non-uniform resources and patterns. Effective anticipation of communication and technology helps an organization in sensing changes in the environment and timely repositioning of process reconfiguration (Queiroz et al., 2021).

Findings of the study is of value and practical application for the textile industry of Pakistan and the textile industry in other developing countries. In a research, it is argued that the investment made on communication and coordination technology on textile supply chain is justifiable in terms of the performance gained. (Choi et al., 2022). The mediating role of anticipation of new technologies can guide organizations in timely assessment of their capabilities and new technologies, thereby helping maximize performance and returns (Awan et al., 2021).

For policymakers and industry associations, this research provides evidence to support initiatives to improve communication infrastructure, promote technology awareness, and facilitate technology

adoption across the textile value chain (Javed & Atif, 2021).

Literature Review

Anticipation of New Technologies and Communication Levels

Anticipation of new technology refers to identifying an organization's capability for new technologies and evaluating them to incorporate them promptly (Wamba & Queiroz, 2022). This proactive approach helps organizations shape their future trajectories (Queiroz et al., 2023).

The Fourth Industrial Revolution has posed serious threats to organizations due to the rapidly changing technological landscape (Dubey et al., 2021). Research supports the relationship between communication level and anticipation of new technologies. Research shows that organizations with advanced communication technologies are more aware of technological changes and demands, and are better prepared for new technologies. The anticipation of new technologies in Pakistan's textile industry presents both challenges and opportunities, as organizations must identify rapid technical challenges while facing resource constraints (Iqbal & Su, 2026).

H1: Communication Level (CLIM02) has a significant positive effect on Anticipation of New Technologies (ANT).

Communication Level in Supply Chain Management

Communication level within an organization reflects its capacity to support coordination, networking, and information sharing, and, in turn, effective decision-making (Bag et al., 2020). Digital supply chains have revolutionized communication levels and patterns (Queiroz et al., 2021).

Accuracy of information sharing, relevance, completeness, and timeliness are key elements that describe the quality of communication (Wang, 2021). Enhanced communication levels have significant impacts on operational performance, reducing lead times, minimizing inventory costs, and increasing order fulfillment rates (Bag et al., 2021). Effective and efficient communication also plays a role in knowledge sharing, enabling partners to share best practices in supply chains (Kaur & Singh, 2019).

Pakistan's industrial supply chains are fragmented and vary in technological levels, underscoring the need for effective communication (Hassan et al., 2023; Malik, 2024). Textile firms that integrate enhanced, uniform communication achieve effective coordination across multiple stages of supply chains and enhance quality consistency and production coordination (Kumar et al., 2023).

H2: Communication Level (CL) has a significant positive effect on Supply Chain Performance (SPF).

Use of Technology Level and Technology Anticipation

The adoption and anticipation of new technology are important dynamics, yet they remain unexplored in the supply chain literature. Active utilization of technological competencies allows firms to build absorptive capacity, cultivate a learning organization, and enhance their ability to identify emerging innovations (Fosso Wamba & Akter, 2019). Effective integration of technology into operations provides employees with hands-on experience, thereby deepening their understanding of technological blueprints (Choi et al., 2022). (Dubey et al., 2020) studied that firms that have incorporated big data analytics are more ready to adopt artificial intelligence and other advanced technologies than other firms that have not. In Pakistan's textile industry, firms that implement new AI technologies are better positioned to assess upcoming opportunities and process changes. Given their trajectory toward adopting the latest technologies, firms are better positioned to anticipate new market demands and trends (Hyder et al., 2024; Iqbal & Su, 2026). Technology utilization is considered an antecedent of technology anticipation, as the learning-by-doing mechanism proves more effective in workplaces (Queiroz et al., 2023).

H3: Use of technology level has a significant positive impact on the anticipation of new technologies

Use of Technology Level in Supply Chain Operations

The technology level refers to the degree of integration of technologies within an organization's supply chains and operations (Attaran, 2020). Popular technologies i.e. artificial intelligence, automation, IOT, and block chains are allowing firms to forecast demand, supply, and market conditions in a proactive manner (Queiroz et al., 2023).

A number empirical studies confirm that the use of technology has a positive effect on the performance of supply chains. It is observed that organizations that have integrated big data analytics into their operations are achieving superior performance (Bag et al., 2021). Industry 4.0 technologies are reported to enhance supply chain performance by increasing operational resilience (Choi et al., 2022). The benefits of technology depend solely on effective implementation and integration into processes; otherwise, it may do more harm than good (Dubey et al., 2021).

The Pakistan textile industry is adopting technology differently: big firms are implementing automation, while small organizations are relatively more inclined towards a traditional approach (Hyder et al., 2024).

H4: Use of Technology Level (UTL) has a significant positive effect on Supply Chain Performance (SPF).

Technology Anticipation and Supply Chain Performance

The relationship between anticipation of new technologies and supply chain performance is gaining momentum in recent studies. Organizations that use a proactive approach to assess and anticipate emerging technology needs seem to compete more effectively in the market (Wamba & Queiroz, 2022). (Queiroz & Fosso Wamba, 2024) studied that organizations with positive anticipation capabilities can take strategic decisions and are well ahead in meeting market demands. Compared to reactive firms, the proactive organizations gain benefits like the improvement of service quality, reduction of lead times, and reduction of operational costs, due to benefits of systematic technology forecasting (Choi et al., 2022). From a resource management perspective, proactive organizations have the advantage of risk reduction and the ability to gain benefits from adopting emerging technologies; first mover advantages (Choi et al., 2022; Dubey et al., 2021). In Pakistan's textile sector, the ability to anticipate technological trends, particularly in automation, digital supply chain management, and sustainable production, is linked to enhanced performance and service quality (Hassan et al., 2023; Husain et al., 2024; Hyder et al., 2024; Javed & Atif, 2021). Organizations can focus on technological readiness rather than on competitive pressure to ensure seamless improvements in performance (Bag et al., 2021).

H5: Anticipation of new technologies has a significant positive impact on supply chain performance

The Mediating Role of Technology Anticipation

The evaluation of mediation considers the dependent variables and independent variables through middle variables (Choi et al., 2022). Technology anticipation could explain the mediation of the communication level and performance of the supply chain. Firm communication levels explain the communication channels the firm engages in to obtain knowledge of new emerging technologies and new practices (Schniederjans et al., 2020). On the other hand, technology anticipation assesses the firm's identifications, potential, and situational context related to the absorption and integration of these technologies (Queiroz et al., 2023). An anticipation of emerging technologies supports the firm in utilizing state-of-the -art technologies that are in their profiles and are under-utilized.

In the same way, new technology anticipation may explain the mediation of the performance of the supply chain and the levels of technology utilization. Evidence of meditative relations in the same context is minimal but is apparently there. Bag et al. (2021) posited that the digital readiness of a firm was a mediating factor in the relations of Industry 4.0 enablers and the performance of the supply chain.

From the resource-based view and dynamic capabilities viewpoint, technology anticipation as a mediator can be understood (Fosso Wamba & Akter, 2019). The aforementioned views state that sustained competitive advantage comes from developing valuable, rare, and inimitable resources (Queiroz et al., 2023). Contrarily, technology anticipation as a capability empowers organizations to sense and respond to change and to reconfigure operations (Choi et al., 2022). In the case of the textile industry in Pakistan, the understanding of mediation mechanism can help development of capability and also guide investment focus of resource constrained firms (Awan et al., 2021).

H: Anticipation of New Technologies (ANT) mediates the relationship between Communication Level (CL) and Supply Chain Performance (SPF).

H: Anticipation of New Technologies (ANT) mediates the relationship between Use of Technology Level (UTL) and Supply Chain Performance (SPF).

Research Gaps and Study Contributions

Many researchers have studied these constructs across different setups, but there are still many gaps in this context. Limited attention is given to the collective impact of these constructs on performance in the digital world. Secondly, different ways in which communication can impact performance are seen as incomplete (Schniederjans et al., 2020). Third, and most importantly, is the role of anticipation of new technologies as a mediator that warrants thorough investigation (Mangla et al., 2021).

This study aims to develop a comprehensive understanding of the phenomenon by testing the integrated model, examining direct and indirect relationships among constructs in the Pakistan textile industry. The research also contributes to the theory by providing insights into how developing economies can translate capabilities into performance.

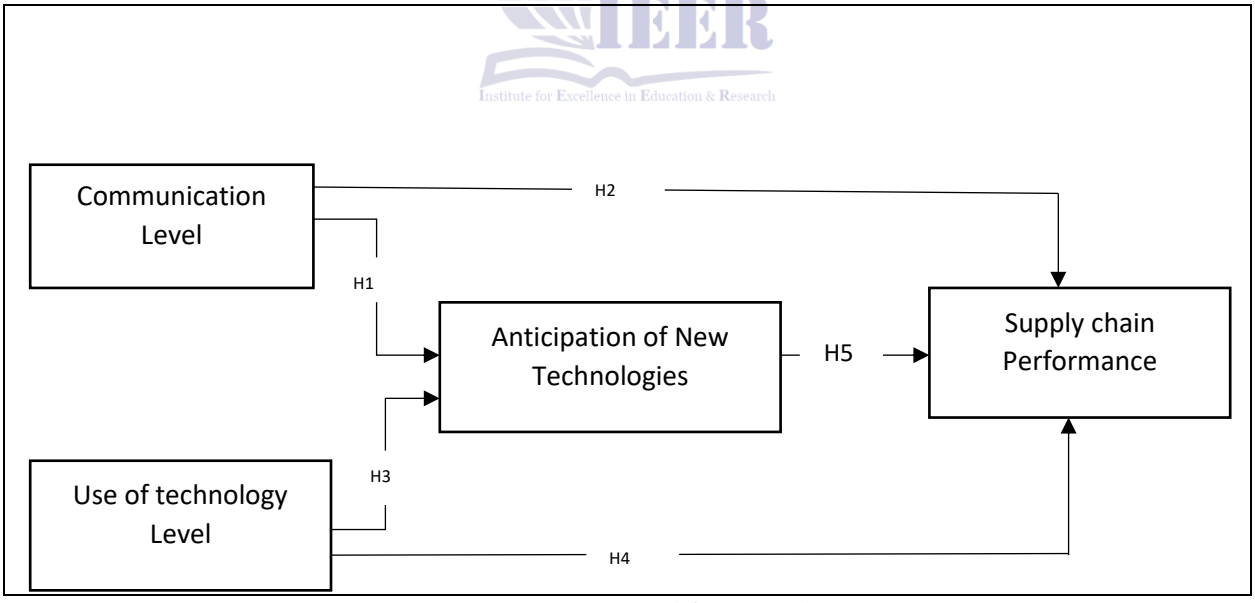

Figure 1 Conceptual framework

Methodology

In this study, we used the Analysis of Moment Structures (AMOS) software. The structural equation model (SEM) is used to depict the relationships among constructs with statistical interdependence (Douma & Shipley, 2023). For SEM analysis, AMOS version24 is used in this study. SEM techniques show the appropriateness of the data in the model. Jackson (2003) suggested that responses between 200 and 400 are

appropriate for SEM analysis in AMOS. We collected 370 responses from the textile industry of Pakistan through a self-administered survey, including operational managers, supply chain professionals, upper management, and middle management. 370 responses were gathered for this analysis.

Effective, operational communication levels help organizations achieve harmony and synchronization in their processes and activities. In this study, measurement items are adopted from Suh et al. (2011) and capture different aspects of communication practices, which best suit our study.

Artificial intelligence, internet of things, blockchains, and many other advanced technologies help enhance supply chain visibility and transparency (Sarkis et al., 2020). Enhanced levels of technology utilization translate into collaborations with supply chain partners, improved operational performance, and greater data visibility for members, which supports effective decision-making. Automation and other digital tools help reduce friction among members, minimize errors, and improve service (Lasi et al., 2014). This study employs measurement items for technology use levels from Singhry (2015)which capture the breadth and depth of technology use across various supply chain processes.

Anticipation of new technologies demonstrates an organization's ability to foresee, assess, and be ready for technological developments (Kang et al., 2021). This proactive approach involves actively monitoring environments and building the organization's readiness to remain competitive in the market (Janböcke & Zajitschek, 2021). In this study, anticipation of new technology is measured through the items adopted from Beheregarai Finger et al. (2014).

Supply chain performance comprises a range of constructs specific to different industries and sectors. Supply chain performance represents a multidimensional construct with measurement criteria that vary across industries and organizational contexts. In the textile industry, supply chain performance encompasses operational efficiency, responsiveness, transparency, service quality, and cost efficiency. The measurement items for supply chain performance are adopted from Singhry (2015).

Analysis

Demographic profile shows diverse work experience, management levels, and age distribution. Below is the profile of respondents in Table 1.

Table 1: Demographic Profile

Variable	Category	%
Work Experience	< 5 years	10.5
	6-10 years	35.0
	11-15 years	39.0
	16-20 years	15.4
Management Level	Staff Line Supervisors	63.2
	Middle Management	27.9
	Top Management	8.8
Gender	Male	77.8
	Female	22.2
Age	< 25 years	3.7
	26-30 years	6.8
	31-35 years	32.8
	36-40 years	22.8
	> 40 years	33.9

Note: N = 370

This study used AMOS 24 software to assess the relationship between constructs, indicators, and dependent variables through SEM (Arbuckle, 2005). Confirmatory factor analysis is used to assess the measurement model (Anderson & Gerbing, 1982, 1988; Hair et al., 1995). Following measurement model validation, causal associations among constructs are incorporated into the structural model to test the hypothesized paths and derive empirical conclusions about the relationships among communication level, technology use level, anticipation of new technologies, and supply chain performance.

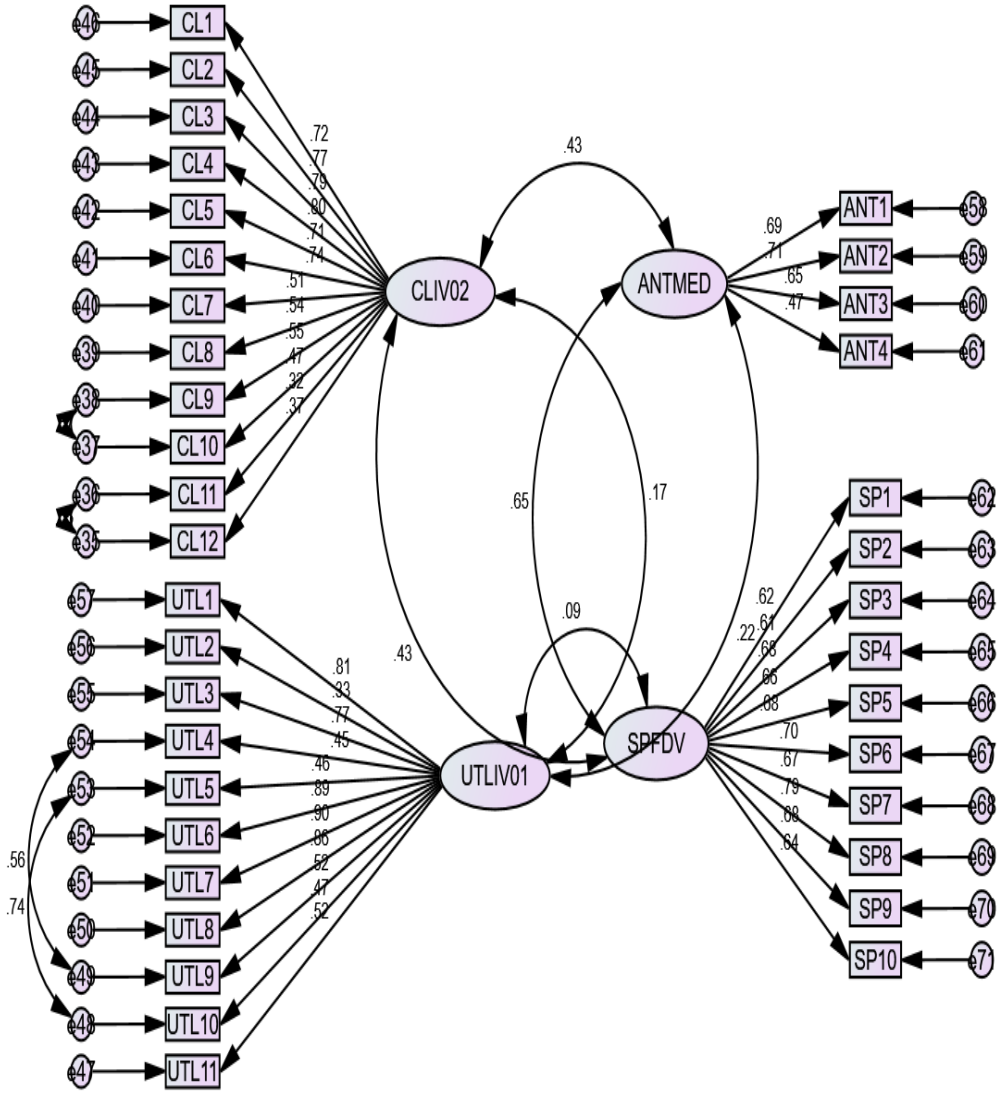

Figure 2 ***CFA output***

This analysis compares three structural equation models to assess how well the default model fits the data. The default model has the chi-square/df ratio of 3.403, which is acceptable as it falls below the recommended threshold of 5.0 (Marsh & Hocevar, 1985; Schumacher et al., 2016).

The fit indices show acceptable performance: NFI = .810, CFI = .874, TLI = .857, and IFI = .876; they exceed .80, which Byrne (2010) considers acceptable. With an RMSEA value of .071, this value is less than .08 which means an RMSEA value of .071 is considered a reasonable fit (Browne et al., 1993). Also, the parsimony indices show reasonable simplicity corresponding to the fit (PNFI = .559, PCFI = .720). This means the default model has reasonable accuracy to the existing data.

The validity of the constructs is assessed and presented in the model validity measure table. In this table and corresponding to the validity of the model, the validity measure of the model is assessed considering multiple criteria of discriminant and convergent validity. Strong internal consistency of the measurement model is displayed, to the measurements model, due to the composite reliability for all constructs exceeding the 0.7 (Hair, 2009 threshold.

The threshold level of Average value extracted AVE is 0.5 (Fornell & Larcker, 1981), and in the measurement model, all values are equal to or exceeding this limit.

For the measurement model to be justified, the maximum shared values MSV should be less than the AVE. In our measurement model, this condition is well satisfied.

Maximum R-squared values 0.9.0, 0.941, 0.745, 0.896 are in the acceptable range. Overall, the model demonstrates acceptable validity, meeting established criteria for both convergent and discriminant validity.

Table 2
Model Validity Measures

	CR	AVE	MSV	MaxR(H)	CLIV02	UTLIV01	ANTMED	SPFDV
CLIV02	0.879	0.593	0.186	0.908	**0.727**			
UTLIV01	0.889	0.544	0.049	0.941	0.167*	**0.766**		
ANTMED	0.727	0.505	0.417	0.745	0.429***	0.222**	**0.737**	
SPFDV	0.891	0.652	0.417	0.896	0.431	0.091	0.646	**0.873**

Table 3 Standardized Direct Effect (Beta)

	UTLIV01	CLIV02	ANTMED	SPFDV
ANTMED	.167	.382	.000	.000
SPFDV	-.063	.203	.575	.000

Table 4 Standardized Indirect Effects (Beta)

	UTLIV01	CLIV02	ANTMED	SPFDV
ANTMED	.000	.000	.000	.000
SPFDV	.096	.220	.000	.000

Table 5 Standardized Direct Effects - Two-Tailed Significance (BC) (P-Value)

	UTLIV01	CLIV02	ANTMED	SPFDV
ANTMED	.012	.000	...	...
SPFDV	.230	.004	.001	...

Table 6 Standardized Indirect Effects - Two-Tailed Significance (BC) (P-Value)

	UTLIV01	CLIV02	ANTMED	SPFDV
ANTMED	...	...	...	...
SPFDV	.009	.000	...	...

This output presents the standardized direct and indirect effects (beta coefficients) along with their statistical significance for a structural equation model.

Results are summarized in Table 7 below:

Table 7 Hypothesis Results

Hypothesis	Path	β Coefficient	p-value	Result
H1	Communication Level → Anticipation of New Technologies	0.382	0.000***	**Accepted**
H2	Communication Level → Supply Chain Performance	0.203	0.004**	**Accepted**
H3	Use of Technology Level → Anticipation of New Technologies	0.167	0.012*	**Accepted**
H4	Use of Technology Level → Supply Chain Performance	-0.063	0.230	**Rejected**
H5	Anticipation of New Technologies → Supply Chain Performance	0.575	0.001***	**Accepted**
H6	ANTMED mediates CL → SPF relationship (Indirect Effect)	0.220	0.000***	**Accepted**
H7	ANTMED mediates UTL → SPF relationship (Indirect Effect)	0.096	0.009**	**Accepted**

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Discussion

The results of this study provide empirical support for the role of communication level and use of technology level on supply chain performance.

Communication level significantly impacts the anticipation of new technologies, and it is supported by the perspective proposed by (Hult et al., 2003). Research emphasizes that enhanced communication supports knowledge sharing and organizational readiness for innovation (Hult et al., 2003). Inter-organizational communication creates an environment that makes it easier for organizations to adopt innovations (Min et al., 2005). The positive impact of communication level on supply chain performance is supported by Moberg et al. (2002), who argued that communication level influences efficiency and operations within the organization.

The use of technology at a given level positively affects the anticipation of new technologies, as supported by Venkatesh and Davis (2000). Research shows that current technology adoption shapes organizational competence towards new competitive innovations (Venkatesh & Davis, 2000). However, contrary to expectations, the direct effect of technology use level on supply chain performance was not significant, rejecting H4. This unexpected outcome resonates with the "productivity paradox" described by Brynjolfsson and Hitt (2000), who argued that technology investment, if not supported by organizational capabilities, knowledge, adaptability, and relevant skills, is insufficient.

The positive relationship between anticipation of new technologies and supply chain performance is supported by Teece (2007), who argues that a firm's ability to sense and seize technological opportunities is itself a competitive advantage. This finding extends that of Wu et al. (, who emphasized that technological foresight enables proactive supply chain reconfiguration.

The significant partial mediation of anticipation of new technologies in the relationship between communication level and supply chain performance confirms Baron and Kenny (1986) mediation framework, which suggests that communication enhances performance both directly and indirectly through fostering technological anticipation. This dual pathway supports the study of Paulraj et al. (2008), who argued that communication engenders both short-term operational advantages and long-term strategic advantages through the organization's readiness to innovate.

Most importantly, the mediation of technology anticipation in the relationship between technology use and performance ($\beta = .096$, $p = .009$) indicates full mediation, given that the direct path was non-significant. This is crucial because it implies that technology use boosts performance only through improved anticipation rather than direct operational mechanisms. This also affirms that IT capabilities primarily create value through the organization's ability to enhance its dynamic capabilities and not through direct automation effects as argued by Sambamurthy et al. (2003).

The findings go against a particular study in which the assertion is that technology adoption and performance have a direct relationship. They shift the focus to the organization's ability to anticipate and harness newly emerging technologies (Devaraj & Kohli, 2003) and instead emphasize the importance of developing organizational capabilities to anticipate and leverage emerging technologies. This supports the resource-based view and adds to it by recognizing the anticipation of emerging technologies as a distinctive, inimitable, and valuable organizational capability that integrates communication and technology utilization to achieve performance (Barney, 1991)

Additionally, the observed partial mediation for communication and full mediation for technology use indicate different pathways through which these antecedents impact performance, adding nuance to Cao and Zhang's framework for supply chain collaboration. While communication has both direct benefits for coordination and indirect benefits for innovation, technology use seems to function solely through the development of capabilities, underscoring the greater significance of strategic technology management.

Future Research Directions

This study has examined the interrelationships among communication, anticipation of technologies, actualization of technologies, and the performance of supply chains in the textile industry in Pakistan. Nevertheless, the findings and limitations of this analysis open the door to continued scholarship. First, the study of time, and the development of communication, anticipatory technologies, and the performance of supply chains in the study, are brief and will probably represent a set of dynamic processes that an organization undergoes in order to continually lever to acquire and sustain competitive advantage. Second, research examine the untested mediators and moderators of the variables described in the study, such as organizational culture, leadership, steady state vs. dynamic environments, competitive moderation, resource availability, and communication and technology. What do and do not work to improve performance, by context, are the variables. Third, research that examines a single phenomenon in diverse industries in Pakistan, or a single phenomenon in diverse industries in the Third World, will help describe the boundary borders of the areas that support such relationships so that the theory can be built to provide better guidance. Finally, research that examines a single phenomenon in diverse industries in Pakistan, or a single phenomenon in diverse industries in the Third World, will help describe the boundary borders of the areas that support such relationships so that the theory can be built to provide better guidance. Finally, research that examines the processes by which organizations

acquire technology, the contrasts in communication, and the organizational practices that support the theory, the better guidance.

Lastly, upcoming research ought to focus on the particular technologies that are most pertinent to textile supply chains and look into the anticipation and use of varying categories of technologies (e.g., automation, digital, sustainability) and how these impact differing, respective, and specific components of supply chain performance, such as efficiency, flexibility, sustainability, and resilience.

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