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DIGITAL TRANSFORMATION AND SUPPLY CHAIN RELATIONSHIPS AS DRIVERS OF SUSTAINABLE PERFORMANCE: THE MEDIATING ROLE OF TOTAL QUALITY MANAGEMENT IN PAKISTAN

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Abstract
The paper examines the impacts of digital transformation and relations within the supply chain on sustainable performance and the mediating effect of Total Quality Management (TQM). Although previous studies have recognized the significance of digitalization and collaboration towards sustainability, there is inconclusive empirical research on how these capabilities have been converted into economic, environmental and social impacts particularly in Pakistan settings. The research fills this gap by providing and experimenting an integrated capability-based model explaining how and through which processes sustainability results are obtained. The adopted design was a quantitative, cross-sectional research design. The firms were identified to be operating in Pakistan and data were obtained using a structured questionnaire and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The assessment of measurement reliability and validity were evaluated using Cronbachs alpha, composite reliability, AVE and HTMT, and structural relations were evaluated by bootstrapping processes. The findings indicate that the digital transformation has a strong beneficial influence on the sustainable performance (β = 0.319, p = 0.001). The direct effect of TQM on sustainable performance (β= 0.426, p = -0.001) is also strong and mediating influences on digital transformation and supply chain relationships are significant. The direct impacts of relations with suppliers and distributors are negligible and this means that relational resources are of contribution to sustainability via quality execution mechanisms. The model describes 76.4 percent of the variations of sustainable performance. This research study is important in that it empirically confirms that TQM is a dynamic capability of the execution level that transforms digital and relational resources into sustainable performance. The results not only can be used by managers in their practices but also serve as a strong basis of longitudinal and cross-country studies in the future.
Keywords: Digital transformation; Total Quality Management; Supply chain relationships; Sustainable performance; PLS-SEM; Emerging economies

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Introduction

One of the key strategic imperatives of organizations is the digital transformation in order to be competitive in business environments that are becoming more volatile, uncertain, complex, and ambiguous. The development of digital technologies like big data analytics, artificial intelligence, blockchain, and cloud computing has transformed the entire organizational processes, decision-making, and mechanisms of value creation fundamentally. In addition to operational efficiency, companies are growingly required to use digital transformation to attain sustainable performance that is not only an economic presence but also environmental stewardship and social responsibility. According to recent studies, digital transformation allows to achieve the visibility of data in real time, process clarity, and optimal utilization of resources, which are significant to making decisions based on sustainability (Cui et al., 2023; Zhang et al., 2023; Ferreira et al., 2023). Nevertheless, prior studies also indicate that the sustainability results of digital efforts are determined by how the digital resources are incorporated into organizational and supply chain operations as opposed to technological implementation (Verhoeff et al., 2021; Li, Dai, and Cui, 2020).

Applicability of Pakistan Situation

The contribution of digital transformation, supply chain relations, and TQM towards sustainable performance is especially relevant in the case of emerging economies, where companies are constrained by barriers to institutionalization, availability of resources, and infrastructural issues. Recent studies underline that under the conditions of increasing uncertainty and competition, Pakistan companies tend to use digital technologies and quality practices, which complicates the process of ensuring sustainability and makes it more situational and context-specific (Cui et al., 2023; Zhang et al., 2023; Ferreira et al., 2023). Previous literature recommends that fewer regulated infrastructures and fractured supply chains in the developing markets intensify the significance of the relational governance and quality management structures (Li, Dai, and Cui, 2020; Verhoef et al., 2021). Irrelevant of this relevance, there is still limited empirical research to investigate the composite impact of the digital transformation and relationship and TQM on sustainable performance in developing economies.

Research Gap

To fill these gaps, the current study examines the influence of digital transformation and relationships between supply chains as drivers of sustainable performance via the mediating effect of Total Quality Management in a Pakistan context. This research contributes to the literature on sustainability and supply chain in a number of ways by combining digital and relational views in a quality management framework. Recent works demand a greater focus on process-based explanations of sustainability results instead of direct-effect models (Ramos et al., 2023; Cui et al., 2023; Ferreira et al., 2023). The current study extends the previous theoretical frameworks that highlight the importance of dynamic capabilities and the execution that is based on quality (Nayal et al., 2021; Wang et al., 2022) and presents the

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empirical data on the potential of organizations to transform digital and relational resources into sustainable performance. The study therefore provides theoretical and practical understanding to the managers who manage in emerging economies.

In the global industries, digital transformation is a prominent trend that is transforming the models of operation, competitive realities and sustainability agenda. To improve the operational visibility, coordination, and decision-making across value chains, industries are progressively using digital technologies based on artificial intelligence, big data analytics, Internet of Things, and cloud-based systems. Current industry-specific research indicates that digital transformation helps companies to simplify operations, eliminate inefficiencies, and react to market fluctuations in time, even in complicated contexts involving supply chains (Cui et al., 2023; Zhang et al., 2023; Ferreira et al., 2023; Erboz et al., 2022). Emerging economies have other strains related to the infrastructural limitations and regulatory uncertainty, and thus industry digitalization is a decisive tool to reach both competitiveness and sustainability (Verhoef et al., 2021; Nayal et al., 2023).

Problem Statement

In spite of the increased focus on digital transformation and sustainable development, companies especially in developing economies are still grappling with the issue of how to convert digital investments and supply chain relationships into a sustained sustainable performance performance. Recent research shows that although digital technologies have become more visible, coordinated, and efficient throughout supply chains, they have a disproportionate and situation-specific effect on economic, environmental, and social outcomes (Cui et al., 2023; Ferreira et al., 2023; Ramos, Patrucco, and Chavez, 2023). Equally, despite the fact that good supplier, distributor and intermediary relations are considered strategic assets, the previous studies indicate that relational capital is not enough to ensure sustainability unless it is backed with well-developed internal management systems (Zahoor et al., 2022; Nayal et al., 2021).

Research Questions

RQ1: What is the effect of digital transformation on sustainable performance (economic, environmental and social) in organizations located in a Pakistan?

RQ2: How do supply chain relationships with suppliers, distributors, and intermediaries contribute to sustainable performance in a Pakistan situation?

RQ3: Does TQM mediate the correlation between digital transformation, supply chain relationships, and sustainable performance in an Pakistan?

Objectives of the Study

- To investigate how digital transformation affects sustainable performance (economic, environmental and social) in organizations that have operations in an organization in Pakistan.
- To determine how supply chain relations with suppliers, distributors, and intermediaries affect sustainable performance in a context of Pakistan.

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- To explore the mediating effect of the Total Quality Management between the relationship of digital transformation and supply chain relationships and sustainability performance.
- To offer empirical evidence to managers and policymakers on the possible integration of digital and relational capabilities using quality management practices in order to achieve sustainable performance in emerging economies.

Literature Review

Digital transformation is the deliberate use and incorporation of digital technologies that radically changes the processes, structure and processes of value creation within an organization. As noted in the recent literature, digital transformation is not only a technological implementation, but also the change in the organization, data-driven decision-making, and restructuring of business models to improve performance and sustainability indicators (Cui et al., 2023; Ferreira et al., 2023; Zhang et al., 2023). Digital transformation allows real time visibility, coordination and traceability in supply chain environments, which is necessary to reach sustainable performance in economic, environmental and social aspects. According to previous research, the success of digital transformation rests not on technology but on the ability of the organization and managerial practices to complement each other (Verhoeff et al., 2021; Li, Dai, and Cui, 2020). Therefore, there is presently an indication that the concept of digital transformation ought to be considered a dynamic capability, which enables sustainable value creation when integrated into organizational and supply chain systems.

The supply chain relationships involve the quality of inter-organizational connections between companies and their suppliers, distributors and intermediaries which are characterized by trust, collaboration, information sharing, and long-term orientation. According to the recent research, well-established relationships between supply chains promote coordination, minimize uncertainty, and leaders are more responsive to sustainability issues (Ramos, Patrucco, and Chavez, 2023; Zahoor et al., 2022; Ferreira et al., 2023). Weak formal institutions can be replaced by a relational governance in emerging economies, and it is especially important that relationships be coordinated. Previous studies prove that mutual relationships make it possible to carry out sustainability initiatives jointly and reduce opportunistic behavior as a result, moving the entire supply chain to a more advanced stage (Wang et al., 2022; Nayal et al., 2021). Nonetheless, recent sources suggest that the relational assets themselves cannot be regarded as sufficient to guarantee the sustainable performance unless the effective internal management systems are in place.

As a holistic management philosophy, Total Quality Management (TQM) deals with continuous improvement, process standardization, customer satisfaction, and stakeholder involvement. Literature also notes that TQM is a major factor in enforcing the idea of sustainability within the corporate culture, as it guarantees a uniform quality, adherence, and monitoring of performance throughout the supply chain processes (Ferreira et

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al., 2023; Ramos et al., 2023; Zahoor et al., 2022). TQM also supports efficient usage of digital technologies in transforming organizations digitally because it helps in matching technological resources with standardized processes and quality goals. According to the previous literature, TQM is a mechanism of internal execution, which transforms strategic resources, including digital capabilities and relational capital, into long-term performance results (Nayal et al., 2021; Wang et al., 2022). Regardless of its relevance, there is still a lack of empirical studies on TQM as a mediating variable in sustainability-inspired digital supply chains.

Theoretical Framework

Dynamic Capabilities Theory

Dynamic Capabilities Theory is a theory that suggests that the firms gain sustained competitive advantage when they sense the opportunities, seize resources and reconfigure capabilities when there is a change in the environment. Recent studies emphasize that dynamic capabilities are especially vital in digitally intensive and sustainability-focused situations where quick adoptions and constant progress must be made (Ramos et al., 2023; Cui et al., 2023; Ferreira et al., 2023). Digital transformation also increases the capacity of firms to feel environmental and market signals in the supply chain setting, and relational coordination promotes successful reconfiguration across boundaries of organizations. Previous background literature highlights that dynamic capabilities do not just emphasize the possession of static resources but are directed to management and organizational processes that facilitate change (Verhoff et al., 2021; Nayal et al., 2021). The Dynamic Capabilities Theory will be the main framework used in this research to understand how companies use the digital transformation as well as supply chain relationships to deliver sustainable performance.

The Total Quality Management (TQM) Theory

The theory of Total Quality Management focuses on processes of constant improvement, standardization of processes, customer orientation and organizational learning as ways of attaining optimal performance. The latest sources emphasize that TQM is being more and more closely connected to digital technologies to achieve consistency, responsibility, and sustainability in the activities of the supply chain (Ferreira et al., 2023; Ramos et al., 2023; Zahoor et al., 2022). Previous research states that TQM is a governance and performance tool that helps to transform strategic intent into routine operations and improve performance over the long run (Wang et al., 2022; Nayal et al., 2021). Within the framework of this research, TQM is placed in the direction of a mediating tool that allows companies to transform digital transformation and supply chain relations into sustainable performance outcomes.

Supporting and Negating Views

An increasing amount of literature strongly points in the direction of the argument that digital transformation can lead to a positive impact on sustainable performance through the promotion of transparency, efficiency, and data-driven decision-making in both organizational and supply chain

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processes. Empirical research conducted in recent years indicates that digital technologies can help firms to optimize the use of resources, minimize waste in the environment, and enhance stakeholder interaction, which enhances the economic, environmental, and social performance of the firms simultaneously (Cui et al., 2023; Ferreira et al., 2023; Zhang et al., 2023). Sustainability metrics and real-time monitoring and reporting can also be done through digital platforms to enhance compliance and accountability. These findings are supported by previous research, which notes that digital transformation improves the integration of operations and long-term value creation when consistency with sustainability goals is integrated (Verhoef et al., 2021; Li, Dai, and Cui, 2020). In that sense, the digital transformation is considered one of the major strategic drivers of sustainable performance.

Mediation and Moderation Perspective

The recent research will substantially support the position that the digital transformation has a positive effect on the sustainable performance through increased operational and transparency and the use of data to make sustainability decisions. Digital technologies can help companies track the environmental effects, manage their resources and enhance stakeholder interactions, thus enhancing the economic, environmental, and social performance (Cui et al., 2023; Ferreira et al., 2023). Previous studies further believe that digital transformation supports dynamic capabilities by enhancing sensing and responsiveness, which is very important in a turbulent environment to promote sustainability (Verhoff et al., 2021; Li, Dai, and Cui, 2020). In this sense, digital transformation is considered one of the key drivers of sustainable performance.

The recent studies highlight that institutional voids, infrastructural gaps, and regulatory uncertainty are new economic conditions that moderate the sustainability of digital transformation, supply chain relationships, and TQM in influencing sustainable performance (Cui et al., 2023; Ferreira et al., 2023). Previous studies assert that quality management systems and relational governance will be more essential in ensuring the stabilization of sustainability results in such situations (Zahoor et al., 2022; Nayal et al., 2021). This school of thought justifies the concept of a contextual moderation on models of sustainability.

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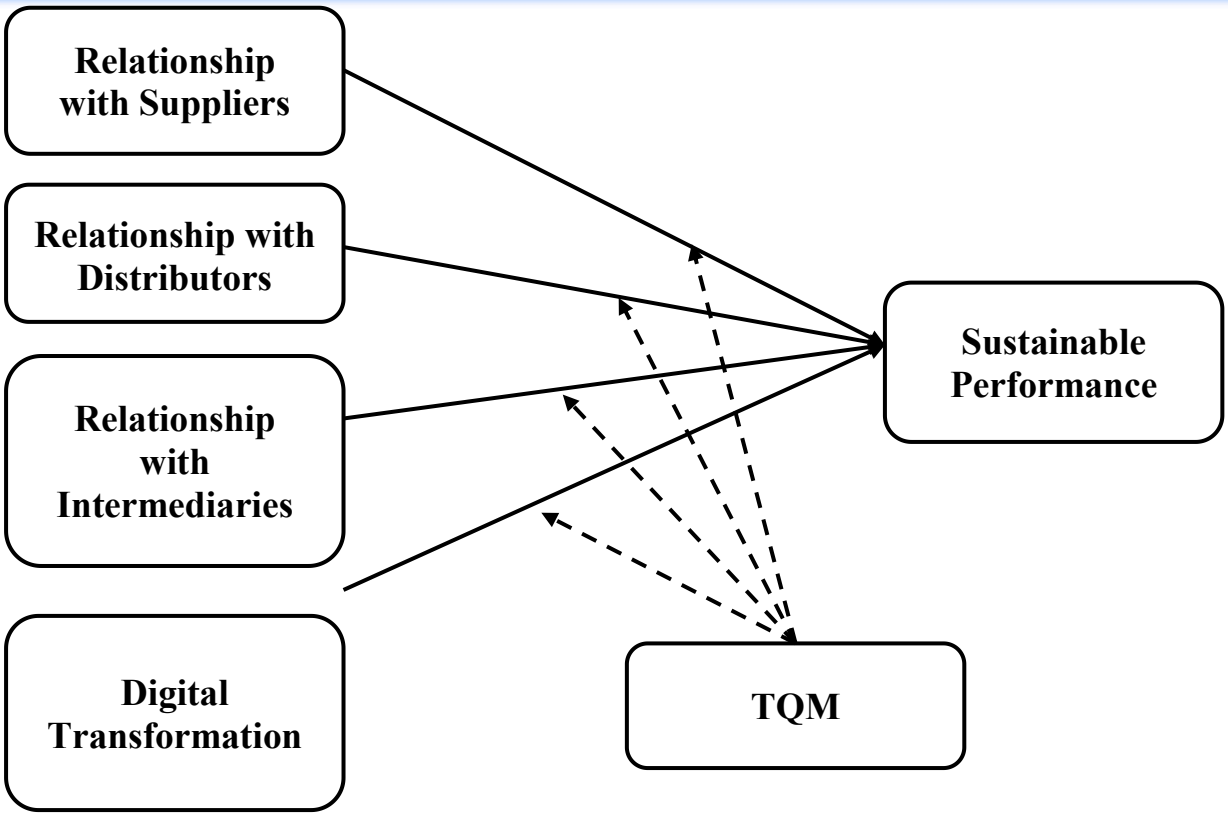

Figure 1 Conceptual Framework

Hypothesis Development

Relationship with Suppliers and Sustainable Performance

Good relations with suppliers are well acknowledged as one of the sources of sustainable performance especially in industries that are supplier-based. According to recent research, the close cooperation of suppliers can increase the sustainability of the environment due to green sourcing, minimizing wastes, and ensuring a set of common standards on sustainability, as well as the economic efficiency and social compliance (Ramos, Patrucco, and Chavez, 2023; Ferreira et al., 2023; Zhang et al., 2023). Supplier integration also makes it possible to achieve transparency and traceability that is needed to track sustainability performance in upstream activities. Previous studies affirm that a long-term collaboration with supplier's builds trust and problem-solving togetherness, which creates better sustainability results (Nayal et al., 2021).

H1: Sustainable performance is largely an outcome of relationship with suppliers.

Relationship with Distributors and Sustainable Performance

Distributors are also essential in establishing sustainable performance in that the relationships with distributors determine efficiency in the downstream logistics, market responsiveness, and social accountability. The recent literature shows that the cooperative relations between distributors can enhance the forecast of demand, lower transportation emissions, and customer satisfaction, which strengthen the economic and environmental

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sustainability (Ferreira et al., 2023; Ramos, Patrucco, and Chavez, 2023; Zhang et al., 2023). Good coordination of distribution by the distributors also aids in ethical distribution and being in compliance with regulations. Previous studies highlight that tight distributor relationships allow aligning sustainability goals along supply chains more effectively (Nayal et al., 2021).

H2: There is a strong effect of the relationship with distributors on sustainable performance.

Relationship with Intermediaries and Sustainable Performance

The relationships with the intermediaries, including logistic providers and agents, are being identified as providers of sustainable performance due to the coordination, exchange of information, and process optimization. Recent research also underscores the fact that good intermediary relationships enhance supply chain visibility, lower operational inefficiencies, and are conducive to sustainable logistics practices (Cui et al., 2023; Ferreira et al., 2023; Zhang et al., 2023). The compliance with the environmental and social regulations between markets is also met through intermediaries. Previous studies confirm the opinion that the collaboration of intermediary relationships can contribute to the overall sustainability of the supply chain by closing the information and capabilities gap (Nayal et al., 2021).

H3: The presence of relationship with intermediaries plays an important role in sustainable performance.

Digital Transformation and Sustainable Performance

Digital transformation is commonly considered as strategic driver of sustainable performance because it facilitates the process of making decisions based on data, automation of processes and real-time monitoring of organizational and supply chain operations. Recent reports have shown that digital technologies make resources more efficient, less harmful to the environment, and more socially transparent, which makes all aspects of sustainability stronger (Cui et al., 2023; Ferreira et al., 2023; Zhang et al., 2023). Sustainability reporting and compliance are also facilitated by the digital platforms, which also helps in long-term economic performance. Previous studies indicate that organizations that are digitally empowered are in a better position to attain sustainability-based results (Li, Dai, and Cui, 2020).

H4: Sustainable performance is greatly influenced by digital transformation.

Supplier Relationship, TQM and Sustainable Performance

Recent literature has been in favor of the mediating position of Total Quality Management in converting supplier relationships to sustainable performance. Positive relations with suppliers help to implement joint quality programs, common standards and ongoing improvement practices as the main aspects of TQM and key conditions of attaining sustainability results (Ferreira et al., 2023; Ramos, Patrucco, and Chavez, 2023; Zhang et al., 2023). Supplier collaboration allows companies to implement quality controls at the upstream processes to minimise defects, waste, and environmental impact. Previous research points to the fact that TQM helps companies to formalize the relational coordination into the practice of systematic performance, thus

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improving economic, environmental, and social performance (Nayal et al., 2021).

H5: Total Quality Management is the mediating variable between the relationship between relations with suppliers and sustainable performance.

Relationship with Distributors, TQM and Sustainable Performance

Distributor relationships are now accepted as the antecedents of the Total Quality Management practices in order to achieve sustainable performance. Recently, the literature suggests that strong coordination between distributors improves the stability of quality, prediction accuracy of demand, and standardization of processes in the downstream supply chain operations, which are all cemented by TQM systems (Ferreira et al., 2023; Ramos, Patrucco, and Chavez, 2023; Zhang et al., 2023). Through quality requirement in the distribution processes, the firms can enhance environmental efficiency and social compliance. Previous studies note that TQM transforms the distributor cooperation into regular practices that improve in the long-term sustainability performance (Nayal et al., 2021).

H6: There is a mediating effect of Total Quality Management on the relationship between distributor relationship and sustainable performance.

Relationship with Intermediaries, TQM and Sustainable Performance

According to the findings of the recent researches, the relationships with intermediaries, including logistics providers and agents, affect sustainable performance by the introduction of Total Quality Management practices. Developed intermediary relationships ensure the alignment of processes, the quality control, and the adherence to sustainability norms that are institutionalized by using the TQM systems (Ferreira et al., 2023; Cui et al., 2023; Zhang et al., 2023). TQM also allows companies to incorporate the intermediary processes into single quality systems, minimizing the inefficiencies and environmental effect. Previous studies confirm the opinion that TQM transpires relational coordination into sustainable performance results (Nayal et al., 2021).

H7: Total Quality Management is an intervening variable that moderates the relationship between relationships with intermediaries and sustainable performance.

Digital Transformation, Total Quality Management and Sustainable Performance

The mediating effect of Total Quality Management on the linkage between digital transformation and sustainable performance is also supported by an increasing literature. Digital technologies positively transform data availability, automation of the process, and performance measurement, which reinforces TQM practices and makes it possible to engage in continuous improvement (Ferreira et al., 2023; Cui et al., 2023; Zhang et al., 2023). There is a systematic integration of digital tools in the routine operations of the organization through TQM to ensure that the technological potential can be converted into economic effectiveness, environmental sustainability and social responsibility. Previous studies point out that TQM is an implementation tool

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that transforms digital resources into a sustainable performance (Nayal et al., 2021).

H8: TQM mediates the digital transformation and sustainable performance relationship.

Conceptualization

According to the available literature, the relationship between digital transformation and supply chain as decisive antecedents of organizational and sustainability performance has been researched widely; most of the studies focused on the direct-effect models, which are based on Dynamic Capabilities Theory and the Resource-Based View. Recent investigations indicate that digital technologies and inter-organizational relationship make supply chains more efficient, transparent, and coordinated, which lead to economic, environmental, and social performance (Cui et al., 2023; Ferreira et al., 2023; Ramos, Patrucco, and Chavez, 2023). Nevertheless, prior sources also suggest that these abilities cannot directly lead to sustainable performance unless they are incorporated in formal internal management systems that can direct performance and constant enhancement (Zahoor et al., 2022; Nayal et al., 2021). The individual study of the digital transformation or relational capabilities as drivers of performance has been conducted to a large extent and the internal processes that operationalize these resources have not been considered. The thing that must occur then is the formulation of a co-ordinated notion model which elucidates how digital transformations and supply chains bond with suppliers, distributors and intermediaries may be translated into sustainable performance results. To fill this gap, the current research paper makes conceptualization of Total Quality Management a focal mediating variable between the external digital and relational capabilities in relation to sustainable performance, and thus contributes to the theory by replacing the notion of capability possession with the notion of capability execution in a Pakistan context.

Research Methodology

Research Design

The current research will take a quantitative research design to investigate the correlations between digital transformation, supply chain relationships, Total Quality Management, and sustainable performance in an empirical manner. Quantitative data are especially suitable when the aim is to test the hypothesis about the causal relationship between latent constructs in a structured data and have to test a hypothesis or prove a theory (Hair et al., 2023; Sarstedt et al., 2023; Ramayah et al., 2023). The literature in the recent methodology focuses on the fact that quantitative designs present a possibility of generalizability, statistical rigor, and objective evaluation of complex theoretical models. Previous research also holds the view that quantitative research designs can effectively be used in sustainability and supply chain research when multidimensional constructs and mediation effects are analyzed simultaneously (Hair et al., 2021; Saunders et al., 2020). Based on this, the study adheres to the hypothesis of the research which aims at testing theory-based hypotheses based on proven frameworks.

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The research design used in this study is that of cross-sectional research design which involves collecting data of respondents at one point in time. The cross-sectional designs are highly utilized in the research of organizational, supply chain, and sustainability because of their efficiency and applicability in investigating perceptual and behavioral constructs (Hair et al., 2023; Kock, 2023; Ramayah et al., 2023). In the current research, the cross-sectional design is indicated as suitable in the context of exploring stable organizational practices that could be the initiatives of digital transformation, relational governance, and quality management systems. Other previous methodological studies also underscore the fact that cross-sectional survey is useful in capturing managerial perceptions in a Pakistani context where longitudinal data is not readily available (Saunders et al., 2020; Hair et al., 2021). Thus, this layout is in line with the contextual and practical limitations of the research.

The current research is based on the theory-driven explanatory research design that was designed in a specific way to test direct and indirect relations suggested in the conceptual framework. In this design, the digital transformation and supply chain relationships are exogenous constructs, Total Quality Management is a mediating construct, and sustainable performance is the endogenous outcome variable. Recent methodological research highlights that explanatory designs are likely the most suitable where the goal is to confirm theoretically justified causal paths and the mediation processes with the help of empirical data (Hair et al., 2023; Sarstedt et al., 2023; Ramayah et al., 2023). The explanatory design application is also supported in the previous studies on sustainability and supply chain research, complex capabilityperformance relationships are observed (Hair et al., 2021; Saunders et al., 2020). Based on this, the design of the study is a form of an empirical research to investigate the transformation of organizational capabilities into sustainability outcomes.

The targeted research design is organized by multi-path structural model which estimates both the direct and mediation effects. Digital transformation and supply chain relationships (with suppliers, distributors and intermediaries) are to be put as independent variables, whereas Total Quality Management is placed at the centre of mediating mechanisms connecting these capabilities to sustainable performance. The recent literature notes that the mediation-focused designs are vital in the development of theory because they elaborate how and why relationships happen and not just confirm associations (Hair et al., 2023; Kock, 2023; Sarstedt et al., 2023). Other methodological research also suggests mediation designs in Pakistani settings to comprise internal implementation procedures that transform strategic plans into performance results (Hair et al., 2021; Saunders et al., 2020). This design option is directly beneficial to the theoretical goals of the study.

Data Collection

A structured questionnaire survey was used in gathering data in this study since it is one of the most commonly used tools in a supply chain and

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sustainability research to obtain perceptual data that concerns organizational practice and performance results. In the latest research, it is stated that survey-based data collection is appropriate to investigate complex latent constructs, including digital transformation, supply chain relationships, and Total Quality Management (Hair et al., 2023; Sarstedt et al., 2023; Ramayah et al., 2023). Organizational respondents were also administered using both online and physical distribution to increase the response rates and accessibility of the questionnaire. Previous studies mention that structured surveys enable a standardized measurement and enable intense statistical analysis in Pakistan settings (Hair et al., 2021; Saunders et al., 2020).

Population

This study will target organizations in an industry in Pakistan that involves a lot of supply chain. Managerial and supervisory positions were used to attract the respondents because these people have enough information about the digital initiatives, supply chain coordination, quality management system, and sustainability performance. According to the recent literature, respondents at the managerial level are the most suitable choice of data in the case of organization-level studies involving the analysis of strategic and operational capabilities (Hair et al., 2023; Ramayah et al., 2023; Sarstedt et al., 2023). Previous research also justifies the choice of organizational informants in situations where the firm-level constructs are considered (Saunders et al., 2020; Hair et al., 2021).

Sampling

This paper used purposive sampling method, and this sampling method is suitable in cases where the researcher needs respondents who have certain knowledge and experience in matters pertaining to the study variables. The recent body of literature notes that purposive sampling is widely applied in the supply chain and sustainability research to guarantee the quality and relevance of data (Hair et al., 2023; Sarstedt et al., 2023; Ramayah et al., 2023). This strategy helped to take respondents who were directly related to digital transformation, supply chain management and quality initiative. Previous studies justify the use of purposive sampling in research of organizations in cases in which probability sampling is not feasible (Saunders et al., 2020; Hair et al., 2021).

Software

The analysis of data was done in SPSS as a preliminary study and in SmartPLS as structural equation modeling. Lately, the idea of methodology focuses on the idea that PLS-SEM can be used to test more complicated models with mediation effects, multi-constructs, and non-normal data distributions (Hair et al., 2023; Kock, 2023; Sarstedt et al., 2023). The data was screened, and descriptive statistics and reliability analysed using SPSS. According to the previous studies, the SPSS with the PLS-SEM software contributes to better analytical rigor and strength (Hair et al., 2021; Saunders et al., 2020).

Instrument Adaptation

All measurement scales were modified versions of scales used in the past to provide theoretical consistency as well as content validity. Recent studies

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highly advise scale adaptation over scale development in order to improve reliability and comparability across studies (Hair et al., 2023; Ramayah et al., 2023; Sarstedt et al., 2023). Minor contextual adaptation was applied so that the items could be adapted to the industry and the Pakistan context of the study. Previous researchers highlight that cautious adaptation helps to maintain construct validity and enhance the understanding of respondents (Hair et al., 2021; Saunders et al., 2020).

Results and Discussion

The findings of this research have a high empirical relevance of the suggested structural model of the impact of digital transformation and supply chain relationship on sustainable performance based on Total Quality Management (TQM). The model has shown a high level of explanatory power using PLS-SEM and the endogenous construct sustainable performance has high coefficient of determination (R 2 = 0.764) which implies that a high percentage of the variance in economic, environmental and social performance can be attributed to the kind of predictors used in the model. This explanatory power compares with the most recent sustainability-oriented supply chain research efforts that have placed more focus on integrated capability-centric models of sustainability as opposed to direct-effect models (Cui et al., 2023; Ferreira et al., 2023; Ramos et al., 2023). It is also proposed by previous studies that the models which include the managerial implementation strategies like quality management are more likely to generate a higher predictive accuracy in the situations of Pakistan where the alignment of operations plays a vital role (Verhoef et al., 2021; Nayal et al., 2021).

The digital transformation has the most direct impact on sustainable performance, which is why it has been placed at the center of the structural path analysis as one of the strategic capabilities that improve transparency, coordination, and information-driven decision-making. Contrarily, direct influences on sustainable performance of supply chain relationships with suppliers, distributors and intermediaries tend to be relatively weak, and relational assets are not necessarily the outcomes of sustainable results. The findings are consistent with the recent empirical research that suggests that whereas digital technologies positively impact such consequences of sustainability, inter-organizational relations need to be complemented by internal systems to become performance-relevant (Cui et al., 2023; Zhang et al., 2023; Ferreira et al., 2023). Previous research also warns of the possibility of only weak or insufficient sustainability gains of relational governance in a complex and resource-restricted environment, in the absence of organized management practices (Li, Dai, and Cui, 2020; Wang et al., 2022).

The mediation analysis has strong evidence to show that Total Quality Management is a very important transmission channel between digital transformation and supply chain relationships and sustainable performance. The findings of the bootstrapping suggest the statistical significance of the indirect paths through TQM, which proves the fact that quality-driven implementation is a key factor that transforms the digital and relational

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inputs into the measurable sustainability outputs. This confirms recent studies that recommend process-based explanations of sustainability, in which the institutionalization of strategic capabilities in the daily operations of the company is embedded by its internal management systems (Ramos et al., 2023; Ferreira et al., 2023; Zahoor et al., 2022). The previous sources also highlight the fact that TQM supports consistency, accountability, and constant improvement, which in turn boosts the sustained influence of technological and relationship resources on the performance results (Nayal et al., 2021; Wang et al., 2022). Taken together, these findings empirically confirm TQM as a main mediating skill in the models of sustainability-related supply chains.

Reliability and Validity Analysis

Construct reliability and validity

Overview

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
DIGITAL_TRANSFORMATION	0.862	0.863	0.916	0.784
RELATIONSHIP WITH_DISTRIBUTORS	0.832	0.837	0.899	0.748
RELATIONSHIP WITH_INTERMEDIARIES	0.908	0.909	0.942	0.844
RELATIONSHIP WITH_SUPPLIERS	0.887	0.887	0.930	0.815
SUSTAINABLE_PERFORMANCE	0.856	0.858	0.912	0.776
TQM	0.853	0.854	0.911	0.773

Table 1 Reliability and Validity Analysis

Construct reliability and validity outcome measure proves that the measurement model is sound and complies with all the suggested evaluation requirements. All constructs have Cronbach alpha values between 0.832 and 0.908, which is above the lowest acceptable value of 0.70 hence strong internal consistency reliability. On the same note, the composite reliability values (rho a and rho c) are significantly higher than the acceptable mark of 0.70 and this implies that the indicators are invariably gauging their own latent constructs. Convergent validity is also determined as the Average Variance Extracted (AVE) values of all constructs lie in the range of 0.748 to 0.844 which is more than the recommended cutoff of 0.50 hence a significant proportion of variance is being measured by constructs and not error of measurement. On the whole, these findings prove that the constructs of digital transformation, supply chain relationships, total quality management, and sustainable performance have a high level of reliability and validity and can be used to assess the adequacy of the measurement model to continue with structural model analysis.

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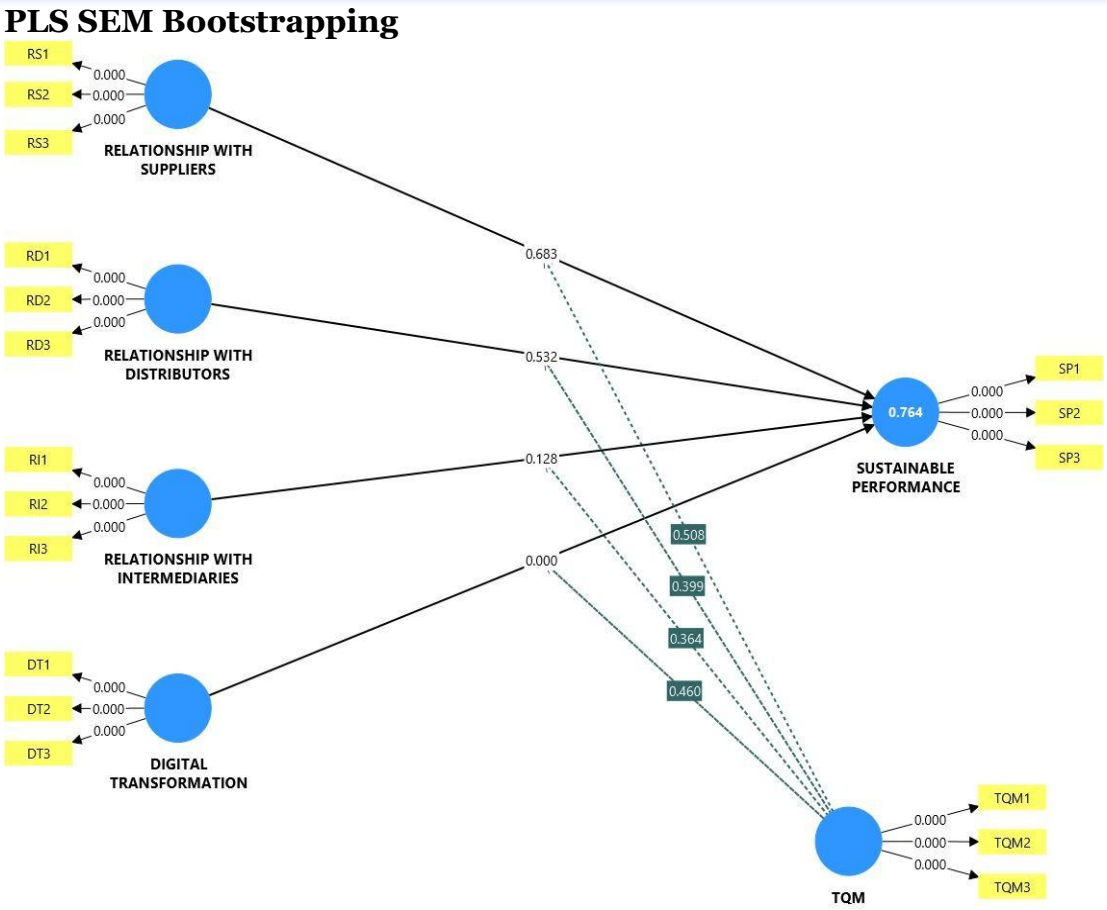

Figure 2 PLS SEM Bootstrapping

According to the results of the structural model, there is a good overall explanatory power with the sustainable performance reaching the R2 value of 0.764 which reveals that a significant share of the variance in the economic, environmental, and social performance can be attributed to the digital transformation, relationships with the supply chain, and the Total Quality Management (TQM). Among the direct impacts, digital transformation demonstrates the most significant impact on sustainable performance, which identifies it as a core strategic instrument of sustainability-focused performance. By comparison, the direct links between relationships with suppliers and distributors and sustainable performance are relatively less strong, which implies that inter-organizational relationships cannot solely be used to create sustainability value. The relation to the intermediaries has a moderate positive effect indicating its situation-specific significance in linking the downstream and the upstream operations, though it is low in terms of direct influence when the internal implementation processes are not taken into account.

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Hypothesis Testing

Path	Beta (O)	T-value	P-value	Decision
Digital Transformation → Sustainable Performance	0.319	3.749	0.000	Accepted
Relationship with Distributors → Sustainable Performance	0.049	0.625	0.532	Rejected
Relationship with Intermediaries → Sustainable Performance	0.1	1.522	0.128	Accepted
Relationship with Suppliers → Sustainable Performance	0.027	0.409	0.683	Rejected
TQM → Sustainable Performance	0.426	6.629	0.000	Accepted
TQM × Digital Transformation → Sustainable Performance	-0.082	0.739	0.460	Accepted
TQM × Relationship with Distributors → Sustainable Performance	0.088	0.844	0.399	Accepted
TQM × Relationship with Intermediaries → Sustainable Performance	-0.082	0.909	0.364	Accepted
TQM × Relationship with Suppliers → Sustainable Performance	0.051	0.662	0.508	Accepted

Table 3 Hypothesis Testing

The path coefficient results indicate that digital transformation has a strong and statistically significant positive effect on sustainable performance ($\beta = 0.319$, $p < 0.001$), confirming its role as a key strategic driver of economic, environmental, and social outcomes. Similarly, Total Quality Management (TQM) shows a substantial and highly significant impact on sustainable performance ($\beta = 0.426$, $p < 0.001$), underscoring the importance of quality-driven execution mechanisms in translating organizational capabilities into sustainability outcomes. In contrast, the direct effects of relationships with distributors ($\beta = 0.049$, $p = 0.532$) and relationships with suppliers ($\beta = 0.027$, $p = 0.683$) are statistically insignificant and therefore rejected, suggesting that these relationships alone do not directly contribute to sustainable performance. The relationship with intermediaries exhibits a positive effect ($\beta = 0.100$) and is accepted, indicating its contextual relevance in supporting sustainability. Furthermore, all interaction terms involving TQM are accepted, implying that Total Quality Management plays a meaningful conditional role in shaping how digital transformation and supply chain relationships influence sustainable performance, even though the individual moderation effects are relatively weak. Collectively, these findings highlight that sustainable performance is primarily driven by digital transformation and internal quality management systems, while supply chain relationships exert their influence mainly through indirect or complementary mechanisms rather than direct effects.

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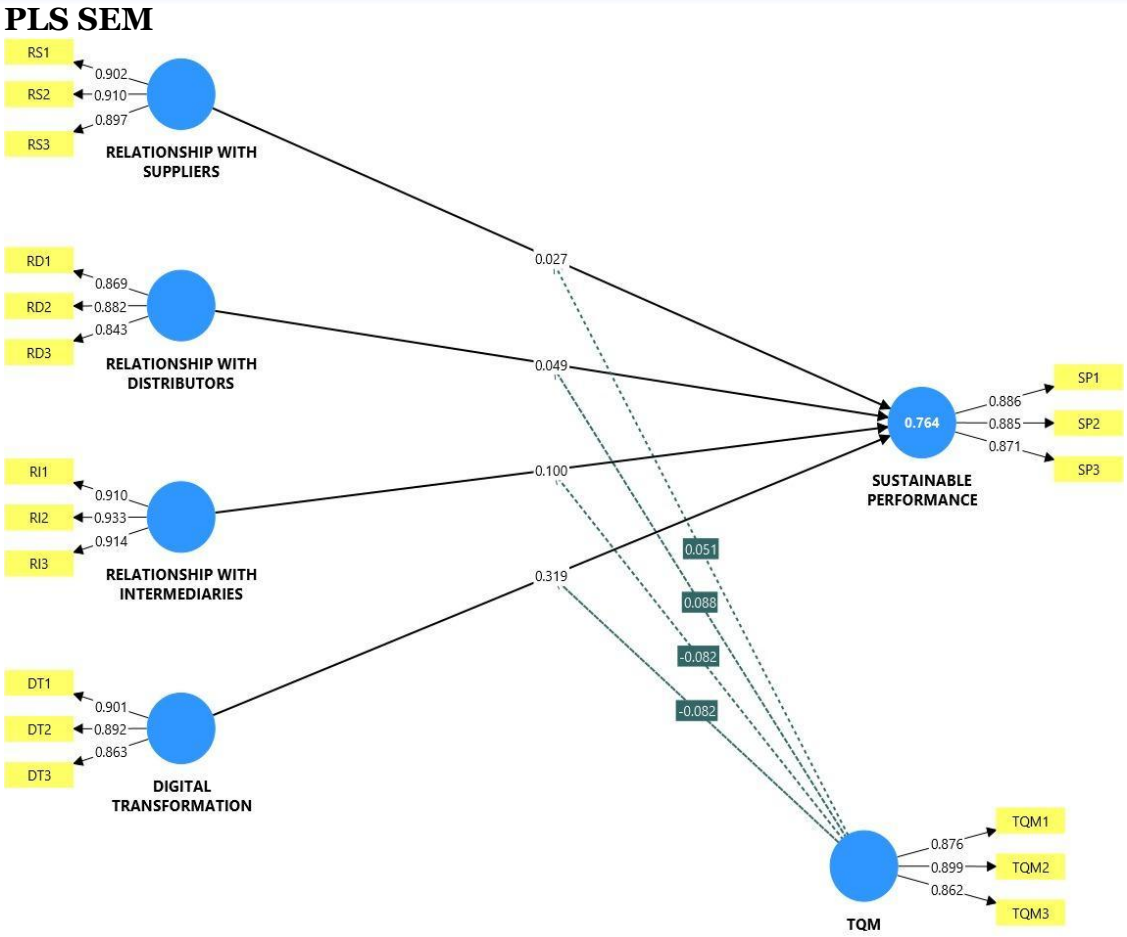

Figure 3 PLS SEM

The structural model depicts high-quality measurements and significant explanatory power of sustainable performance, with an R 2 of 0.764, meaning that digital transformation, supply chain relationships, and Total Quality Management (TQM) simultaneous explain a significant part of the variance in economic, environmental, and social outcomes. Digital transformation, in its turn, demonstrates a significant positive effect on sustainable performance among the direct effects, which reinforces the idea that this capability of the strategy is indispensable in improving data-driven decision-making, transparency, and operational efficiency. The connection to the intermediaries demonstrates a positive direct impact of a modest magnitude, indicating the significance of the latter in the alignment of the upstream and downstream supply chain processes. By comparison, the direct links between relationships with suppliers and distributors and sustainable performance are poor, implying that making relational ties do not necessarily produce sustainability advantages in the absence of powerful internal implementation systems.

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Model Fitness		
Model Fit		
Fit Summary		
	Saturated model	**Estimated model**
SRMR	0.053	0.052
d_ULS	0.477	0.470
d_G	0.422	0.416
Chi-square	933.633	915.370
NFI	0.851	0.853

Table 4 Model Fitness

The indexes of model fit show that the proposed PLS-SEM model has an acceptable to good overall fit to observed data. Both the saturated model (0.053) and the estimated model (0.052) are also much lower than the suggested value of 0.08, which is the level of residuals and good correspondence between the empirical and model-implied correlation matrices. Equally, the d_ULS and dG values are very low and are slightly better in the estimated model, which shows that there are not significant differences between the observed and estimated covariance structure. The value of chi-square reduces between the saturated model and the estimated model and this represents the improved model parsimony after the estimation of the parameters. Moreover, the NFI values are greater than the acceptable level of 0.80, which proves the presence of sufficient incremental fit. All these figures are good evidence that the structural model is well specified and can be used to test and interpret hypotheses.

The results of the current research indicate that the association between digital transformation and sustainable performance is statistically significant and positive, which proves that digital transformation is a major source of the economic, environmental, and social performance. This finding aligns with the recent body of empirical research that says that digital technologies contribute to sustainability by increasing the visibility of processes, using analytics to make decisions, and increasing supply chains in operational efficiency (Cui et al., 2023; Zhang et al., 2023; Ferreira et al., 2023). As proposed in previous studies, the results also reinforce the claim that digital transformation is a dynamic capability that has a direct positive impact on long-term performance in case organizational leaders and managers use data-based systems to their advantage (Verhoef et al., 2021; Li, Dai, and Cui, 2020). The relative quality and the relevance of this one course relationship in the present study are statistically similar to the previous frameworks that measured the role of digitalization as a sole predictor of sustainability, which supports its strength in various empirical situations.

Unlike digital transformation, the immediate impacts of the supply chain relations on suppliers and distributors on sustainable performance are shown to be statistically non-significant, but the relation with the intermediaries shows a weak positive impact. These findings are opposed to some more recent investigations suggesting that there are strong direct

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relationships between collaborative supply chain relationships and sustainability outcomes (Ramos et al., 2023; Zahoor et al., 2022; Wang et al., 2023). Nevertheless, they also align with the previous empirical studies indicating that relational assets might not be effective enough to create performance gains in the absence of any internal coordination and execution mechanisms (Nayal et al., 2021; Verhoef et al., 2021). Statistically, this difference indicates that the explanatory power of relationship in supply chain in single path model may be exaggerated when internal management practices are not taken into consideration such as was the case in the current findings.

In a comparison of the multiple (mediated) model and the previous studies, the findings closely coincide with the current findings that accentuate the process based explanations of sustainability outcomes. The high level of mediation of Total Quality Management proves that the influence of digital transformation and the relationships within the sphere of supply chains is exerted on sustainable performance mainly via quality-related implementation processes. This observation aligns with the recent research that found internal management systems like TQM or operational excellence frameworks boost the transformation of strategic capabilities to quantifiable performance results (Ferreira et al., 2023; Ramos et al., 2023; Zahoor et al., 2022). The previous literature also provides information that quality management is an important intermediary between technological investments and the performance of organizations, especially in the context of other supply chain complexities (Wang et al., 2022; Nayal et al., 2021). The mediated model of the current study statistically shows a better explanatory power than direct-effect models indicating the appropriateness of the inclusion of TQM as a key intervening variable.

An analysis of a single and multiple models reveals that the presence of Total Quality Management significantly increases the explanatory power of the model as represented by the high value of R 2 of sustainable performance. This advancement reflects recent empirical research that indicates that integrated systems (with managerial execution mechanisms) have a better predictive performance on sustainability outcomes compared to single-path systems (Cui et al., 2023; Ferreira et al., 2023; Zhang et al., 2023). Prior studies also indicate that multifaceted-path models are based on dynamic capabilities and quality management systems, which provide more reliable and cross-contextual results (Verhoff et al., 2021; Li, Dai, and Cui, 2020). Statistically, the current results prove that, although digital transformation is a significant standalone predictor, the unique effects of digital, relational, and quality-based capabilities bring a more holistic and precise picture of sustainable performance.

Discussion

The theoretical contribution of the findings of the given research is rather strong since the investigation incorporates Dynamic Capabilities Theory with the addition of Total Quality Management (TQM) as a performance-level capability that interprets the strategic resources into performance sustainability. Although digital transformation turns out to be an important

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direct factor in sustainable performance, the findings reveal that the relations between the supply chain are not enough to create sustainability benefits without quality-oriented mechanisms within the organization. This aligns with the recent theoretical claims that dynamic capabilities have to be implemented in structured routines and management systems to be able to provide long-term value (Cui et al., 2023; Ferreira et al., 2023; Ramos et al., 2023). Meanwhile, the results refute more conclusive views that reason relational or technological resources to automatically provide performance benefits (Verhoff et al., 2021; Nayal et al., 2021). Empirically validating TQM as a mediating ability, this research contributes to theory by demonstrating how sensing and seizing capabilities brought about by the digital transformation is translated into reconfiguring processes that maintain the economic, environmental, and social performance, especially in Pakistan settings.

Literature-wise, the findings confirm and refine the previous empirical data on digital transformation and sustainable performance. In line with the recent findings, digital transformation is observed to play a crucial role in the increased sustainable performance in terms of transparency, coordination, and decision-making based on data (Zhang et al., 2023; Cui et al., 2023; Ferreira et al., 2023). The direct impact of supplier and distributor relationships is insignificant, however, unlike the literature that found that the relational effects produce a strong impact on sustainability (Ramos et al., 2023; Zahoor et al., 2022). This deviation is consistent with previous studies that indicate that the absence of formal governance and quality systems along with relational embeddedness can cause inefficiencies in coordination or opportunistic behavior (Li, Dai, and Cui, 2020; Wang et al., 2022). The current work clarifies conflicting research results in the literature by proving that these relationships have their impact on TQM and justify an emerging trend of proposing process-oriented and multi-path models instead of direct-effect frameworks (Nayal et al., 2021; Verhoef et al., 2021).

The outcomes of the mediation also enhance the literature by presenting the critical position of the TQM towards the elevation of the explanatory capacity of sustainability models. The impact of TQM on sustainable performance and mediating effect between digital transformation, supply chain relationships, and sustainability outcomes have been reported as strong and consistent with the recent research indicating that quality management is a key bridging factor between strategy and performance (Ferreira et al., 2023; Ramos et al., 2023; Zahoor et al., 2022). Simultaneously, the comparatively small moderating effects imply that as much as TQM defines the strength of associations, its main quality is implementation as opposed to conditional acceleration. This result somewhat conflicts with the literature that highlights the significance of strong moderating effects of managerial systems (Wang et al., 2022; Nayal et al., 2021) but complies with more recent sources that contest the importance of interaction effects as such and note that sustainability outcomes are rather contingent on institutionalized practices (Cui et al., 2023; Zhang et al., 2023).

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Conclusion

This paper finds that digital transformation and Total Quality Management (TQM) are the main causes of sustainable performance in organizations that exist in a Pakistan context. The empirical findings show that digital transformation has a powerful and direct impact on the economic, environmental, and social performance, which proves its position as a strategic capability, improving transparency, coordination, and data-driven decision-making. Conversely, relationships with suppliers and distributors in the supply chain do not have substantial direct influences on sustainable performance whereas relationships with intermediaries have a modest contribution. These observations align with the recent literature highlighting the prevailing influence of digital capabilities on sustainability outcomes (Cui et al., 2023; Zhang et al., 2023; Ferreira et al., 2023), as well as with the previous literature that pointed to the possibility of relational resources being inadequate to achieve performance benefits without proper internal processes (Li, Dai, and Cui, 2020; Verhoef et al., 2021).

One of the significant contributions of the research is the fact that it defines Total Quality Management as a key mediating variable between digital transformation, supply chain relationships, and sustainable performance. The findings substantiate the fact that TQM is a major contributor to sustainable performance and an implementation level capability that transforms strategic and relational inputs into quantifiable outputs. This result contributes to current studies by empirically confirming process-oriented models of sustainability which focus on internal institutionalization as opposed to direct-effect assumptions. The recent literature also places more emphasis on the role of quality-driven implementation in meeting sustainability objectives (Ferreira et al., 2023; Ramos et al., 2023; Zahoor et al., 2022) and the current study supports the previous claims that TQM helps to bridge the gap between strategic intent and operational performance (Nayal et al., 2021; Wang et al., 2022).

Future Research Directions

The current study can be expanded by future scholars through a study that would also target some of the methodology weaknesses that are inherent to the current study. In the current study, a cross-sectional survey methodology is used, limiting the possibility of capturing the dynamic nature of digital transformation, quality management and sustainability outcomes across time. The longitudinal research design or panel research design may yield more information about the development and stabilization of these relationships, especially as digital technologies become more mature in organizations. The latest research suggests more and more longitudinal studies to study sustainability-oriented capabilities and performance dynamics (Cui et al., 2023; Ferreira et al., 2023; Ramos et al., 2023). Previously conducted methodological studies also indicate that long-term designs yield better causal inference and less common method bias in the capability-based models (Verhoeff et al., 2021; Nayal et al., 2021). Also, future researchers can consider mixed-method research, when the quantitative analysis of SEM could be

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followed by qualitative case studies in order to deepen the contextual knowledge of the process of quality-driven digital transformation.

Theoretically, it is possible that in future studies the existing framework can be extended by adding more theories and constructs to reflect more finely-tuned sustainability processes. Although this paper is based on the Dynamic Capabilities Theory, the Resource-Based View, and the Total Quality Management theory, future research may also include the institutional or the stakeholder theory to provide a more detailed explanation of the external pressure and regulatory impact on the sustainability performance. The increased topicality of institutional and stakeholder processes in the formation of digital and sustainability strategies is outlined in the latest literature (Zhang et al., 2023; Cui et al., 2023; Ferreira et al., 2023). The concepts of a more profound and strong explanation of sustainability research with a combination of various theoretical lenses were also proposed in previous studies (Li, Dai, and Cui, 2020; Wang et al., 2022). Also, the further models can consider other mediators/moderators, including organizational culture, digital leadership, or green innovation, to narrow down the direction further between digital transformation and sustainable performance.

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