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LEVERAGING QUALITY CULTURE TO STRENGTHEN THE EFFECT OF TQM PRACTICES ON SUPPLY CHAIN EFFICIENCY

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A B S T R A C T

The paper explores how integrated Total Quality Management activities affect supply chain effectiveness within the interplay of the quality culture in the Pakistan manufacturing industry. Based on the empirical evidence found in the construction of various manufacturing companies, the study focuses on the role of the systematic adoption of TQM components such as process standardization, continuous improvement, and involvement of employees in fostering improved coordination, minimized delays in the operation, and performance of the supply chain. Based on a quantitative research design, data was collected through a cross-sectional survey from 330 individuals, managers, engineers and supply chain professionals of organizations who works in manufacturing sector of Pakistan, and processed with the use of structural equation modeling. The present study is based on the assumptions of the Supply Chain Integration Theory that clarify the reasoning of how aligned the internal operations and the strategic corporate strengths create improved operational results. The Supply Chain Integration Theory has played a theoretical foundation in the understanding of how the alignment of internal processes and external partners amplify the process flow, exchange information, and general efficiency in the supply chain. The results show that although the TQM practices have a considerable influence on the efficiency of the supply chain, the existence of a robust quality culture intensifies such an influence whereby a shared set of values, responsibility, and initiative towards quality issues across the organizational borders are encouraged. The study can provide useful information to managers who are interested in integrating quality initiatives with the supply chain goals, attaching significance to the long-term strategy of developing the culture that promotes decision-making based on quality. This study also sheds light on the interaction between structured TQM and organizational culture by shedding light on how internal quality frameworks can facilitate supply chain efficacy in emerging industrial conditions.

1. INTRODUCTION

The growing complexity of international production networks has rendered the concept of quality a new meaning; in this case, the perceived quality is no longer an internal issue of operation but a strategy-level ability to cross the boundary. Systemic thinking, process control, and managerial responsibility were the pillars of organizational excellence highlighted by the early quality gurus like W. Edwards Deming and Joseph M. Juran. Modern research goes further than the company level, claiming that total quality management is only realized to

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its maximum when integrated into supply chain relationships (Flynn, Huo, & Zhao, 2010; Kaynak, 2003). With a number of independent actors being combined in supply chains, the variation in performance is often caused by a mismatch in standards, process controls, and disjointed communication processes (Robinson &Malhotra, 2005). In turn, combined total quality management behavioral patterns, such as connecting the leadership commitment, commitment among suppliers, cross-functional coordination, routine of continuous improvement, and the use of data-based decision systems, have become critical in the promotion of efficiency of a supply chain, but not the internal-only benefits.

Supply chain efficiency includes the cost structure optimization, minimization of the lead-time variability, inventory harmonization, and improvement of the delivery reliability (Beamon, 1999; Gunasekaran & Kobu, 2007). The empirical research proves that quality-based process management minimizes defects and rework that subsequently minimize the transaction costs and improve throughput among the interconnected processes (Hendricks and Singhal, 2001; Kannan and Tan, 2005). Moreover, the supplier development and joint quality planning contribute to the upstream consistency, reducing the disruption and ensuring the flow of materials and information (Prajoko, Oke, and Olhager, 2016). Nonetheless, the transformation of integrated quality practices into real supply chain efficiency results is not automatic and standardized. The differences in the institutional support, managerial orientation, and workforce engagement may either enhance operational advantages of quality systems or diminish them (Sila, 2018; Zu et al., 2010). The manufacturing industry in Pakistan is an area that is characterized by infrastructure volatility, energy cuts, bottlenecks in logistics, and non-homogeneous supplier ability. Despite the fact that a lot of companies mainly strive to ensure a formal compliance with global standards within the frames of the models elaborated by the International Organization of Standardization, official certification does not always indicate a profound penetration of the idea of quality philosophy on the levels of the supply chain. The pre-existing studies propose that shallowness in implementation will lead to ceremonial adoption, whereby the documented procedures are observed, but little internalization of the culture is made (Ahire and O'Shaughnessy, 1998; Talib et al., 2011). Quality culture is an important explanatory perspective that offers a critical explanation of this variation. The good quality culture will help to create shared ownership of process improvement, initiative to avoid errors, open communication, and learning orientation. These cultural features strengthen the technical aspects of the integrated total quality management by making sure that the quality norms are not seen as a form of compliance but rather the principles of operation. It is analyzed that those firms that have strong institutionalized quality cultures have greater alignment between strategic goals and operational implementation that results in their continuous performance gains (Sadikoglu & Zehir, 2010; Chenhall, 2010). The concept of cultural alignment in the settings of supply chains is further expanded to encompass the collaboration between firms and interdepartmental cooperation, affecting both the process of trust-building, information transparency, and the cooperative problem-solving tools. The levels of quality culture diffusion between organizational levels combined with the resources and limitations may be influenced by hierarchical management structures, centralized decision-making patterns, and resources within Pakistan. The case of leadership commitment is especially resolute in conveying the strategic significance of quality integration, whereas the practice of employee empowerment defines whether the application of continuous improvement practices is indeed applied. Where internalization of quality values among the supply chain partners exists, integrated practices will be more likely to lead to shorter cycle times, high supplier reliability, and coordinated production schedules. On the other hand, poor cultural reinforcement may establish separations between written quality systems and day-to-day supply chain processes, interfering with the results of efficiency regardless of structural investment. The foundation of this study is the fact that integrated total quality management practices not only affect the efficiency of supply chains due to the standardization of the procedure but also make the execution culturally embedded. The study fills a knowledge gap in the operations and supply chain literature by analyzing the moderating effects of quality culture in the manufacturing environment in Pakistan in relation to the influence of socio-cultural dynamics in determining the successfulness of technical management systems. The research adds value to the literature in terms of its theoretical explanation of the boundary conditions within which quality integration will lead to efficiency payoffs and adds value to the field in terms of the provision of context-specific knowledge to the firms that aim to increase their competitiveness in the domestic and external markets. With this point of focus, this work contributes to the current knowledge of the relationship between structural integration and cultural alignment, where joint effort to define the performance path of supply chains in emerging economies takes place.

At the same time, contemporary manufacturing systems are increasingly influenced by digitalization and the growing use of integrated information platforms in supply chain operations. Tools such as enterprise resource planning systems, real-time data monitoring, and analytics are gradually reshaping how organizations coordinate processes, share information, and manage operational quality across supply chain partners. In such an environment, Total Quality Management should not be viewed only as a traditional quality control approach, but also as a managerial practice that supports operational innovation and more coordinated industrial systems. Therefore, examining the combined role of TQM practices and quality culture in shaping supply chain efficiency contributes not only to the operations

management literature, but also to the broader understanding of how organizations strengthen performance and adaptability in modern industrial environments.

2. LITERATURE REVIEW

2.1 Impact of TQM Practices on Supply Chain Efficiency

The TQM practices have become generally accepted as critical drivers of the supply chain efficiency, which operates in systemic, structured, and culturally ingrained functions. A fundamental TQM practice such as leadership commitment has been demonstrated to implement a strategic direction, consistent application of quality levels, and alignment within cross-functional teams, which will ultimately lead to reliability of the process implemented and coordination of operations throughout the supply chain (Flynn, Schroeder & Sakakibara, 1994; Kaynak, 2003; Prajoko & McDermott, 2005). Customer focus makes the supply chain processes sensitive to market requirements, leading to timely and quality supply and value co-creation with external partners, which directly leads to better efficiency metrics (Kannan & Tan, 2005; Li, 2006). Process management minimizes variability, standardizes processes and waste, and establishes stable and predictable processes that have a smooth flow of materials and information (Hendricks & Singhal, 2001; Sousa & Voss, 2002). The management of supplier quality expands the quality concept beyond firms to improve trust, cooperation, and collective solutions with upstream suppliers to enhance supply chain integration and eliminate disruptions (Robinson & Malhotra, 2005; Prajoko, Oke, & Olhager, 2016). The participation of the employees enables the staff to integrate into decision-making, problem-solving, and continuous improvement efforts and inculcate a sense of responsibility and teamwork within their daily activities (Ahire & O'Shaughnessy, 1998; Sadikoglu & Zehir, 2010). Operational adaptability and process optimization through constant improvement practices as routines of learning and refinement are the drivers of responsive and efficient supply chains (Anand, Ward, Tatikonda, & Schilling, 2009; Flynn, Huo, & Zhao, 2010). Lastly, the use of technology and information such as integrated IT systems, real-time monitoring, and decision-making that is based on the data increases the visibility, coordination, and synchronization among the supply chain nodes; lead times are reduced, errors are minimized, and resource use is enhanced (Gunasekaran & Ngai, 2004; Gunasekaran, Patel, & Tirtiroglu, 2001). Hence, the literature indicates that these TQM practices have a synergistic effect, influencing the processes of operations as well as the dynamics of relationships and eventually resulting in increasing supply chain efficiency and a sustainable competitive advantage.

H1: TQM practices has a positive impact on Supply Chain Efficiency.

2.2 Impact of Quality Culture on Supply Chain Efficiency

The quality culture has become a decisive factor in the efficiency of supply chains as a behavioral and cognitive model that affects decision-making, cooperation, and compliance with processes both on the organizational and inter-organizational levels. The classical studies of W. Edwards Deming and Joseph M. Juran were instrumental in helping the world recognize that sustainable performance excellence was not merely about technical systems but also the need to ensure a set of common values, mindsets of continuous improvement, and responsibilities were instilled in the daily operations of organizations. Empirical research indicates that a strong quality culture in organizations has a high degree of standardization of processes, lower variability, and proactive problem-solving that directly impacts the operational performance and throughput in supply chains (Hendricks & Singhal, 2001; Prajogo & McDermott, 2005; Chenhall, 2010). In the supply chain networks, quality culture creates a culture of trust, transparency, and open communication, and this allows the creation of synchronized planning, reliable execution, and quick responses to environmental disruptions (Flynn, Huo, & Zhao, 2010; Gunasekaran & Ngai, 2004; Li, 2006). The culture of leadership commitment, which is enforced as a norm, guarantees the continuity of quality practices and interdepartmental and inter-firm alignment; employee empowerment ensures knowledge sharing, collaborative problem-solving, and cross-functional coordination (Ahire & O. Shaughnessy, 1998; Sadikoglu & Zehir, 2010). It is assumed that inclusive leadership has effects on a continuum of outcomes in an organization (Javed, 2025). Further, the routines of continuous improvement became embedded in the culture and promote gradual improvement of the processes, cut waste, and maximize the use of resources, reducing the operational costs and the cycle times (Anand, Ward, Tatikonda, & Schilling, 2009; Sousa & Voss, 2002). The adoption of technologies combined with quality culture improves the visibility, real-time tracking, and decision-making processes based on the data, which contributes to the stability of performance at all supply chain nodes (Flynn, Schroeder & Sakakibara, 1994; Gunasekaran, Patel & Tirtiroglu, 2001). Literature, in general, highlights that quality culture is a strategic facilitator that enhances the impact of technical and managerial interventions related to supply chain efficiency by discerning internal operations and extended supply chain relationships about shared responsibility, process discipline, and adaptive learning (Zu, Robbins & Fredendall, 2010; Prajoko, Oke & Olhager, 2016; Robinson & Malhotra, 2005).

H2: Quality Culture influences the positive impact on Supply Chain Efficiency.

2.3 Impact of Quality Culture between TQM Practices and Supply Chain Efficiency

Quality culture has gained more acceptance as a strategic enabler of the relationship between total quality management practices and supply chain efficiency, and empirical evidence has been accumulated to support this moderating role. Quality culture offers the mutuality of shared norms, values, and behavioral expectations that contour the manner in which quality initiatives are socialized and implemented throughout all organizational levels, which generates a setting that is favorable to collective intentions and learning, which forms the core of effective supply chain coordination (Tarí, 2005; Naveh & Marcus, 2005). The research demonstrates that operational performance is affected by leadership commitment much more when integrated into a quality culture; leaders who act as continuous communicators of quality and upholders of quality-related behavior contribute to decreasing internal friction, thereby simplifying the process of inter-firm relations and synchronization of decisions across the supply chain partners (Schein, 2010; Dahlgaard & Dahlgaard, 2009). Likewise, the effect of customer focus on supply chain efficiency is stronger with the culture of quality that strengthens the significance of the value of external stakeholders and leads to a better alignment of organizational routines with market expectations and the responsiveness of inter-organizational ones (Liu, 2016; Jabnoun & Sedrani, 2005). When quality culture promotes transparency and knowledge sharing and collective problem-solving, which are essential in decreasing cycle times and removing variability across supply chain nodes Process management and supplier quality management are more effective in reducing the number of defects and ensuring homogeneous standards of performance (Flynn, Huo, & Zhao, 2010; Vickery, 2014). The greater dividend of employee involvement (including both empowerment and participation) will be achieved when the quality culture results in psychological ownership and shared responsibility, thus enhancing initiative-taking and cross-functional collaboration, which is literally influenced in terms of throughput and operational integration (Verma & Seth, 2012; Naveh, Marcus & Lee, 2015). The adaptive learning and resilience in complex supply chain environments are fuelled by continuous improvement practices such as systematic feedback loops and quality circles, and the positive impacts on efficiency in such firms are magnified by quality culture values such as experimentation, error learning, and long-term improvement over short-term cost reduction (Sila, 2007; Acur, 2003). Furthermore, the efficiency of supply chains is also substantially amplified by technology and information utilization such as advanced analytics, real-time tracking, and integrated information systems, whose culture of quality promotes information transparency, sharing information across organizations, and trust when dealing with supply chain variability in demand (Zhang, 2015; Youssef, Dah & Zairi, 2015). Altogether, what has been emphasized in the literature is that quality culture does not just coexist with TQM practices but moderates their success, turning designed quality campaigns into quantifiable efficiency benefits in supply chain operations by strengthening the alignment, relationship trust, joint problem-solving, and shared performance objectives across internal and networked inter-organizational boundaries.

H3: Quality Culture influences the positive impact between TQM practices and Supply Chain Efficiency.

2.4 Supply Chain Integration Theory

The supply chain integration theory is expressed in the alignment and coordination of internal functional units and external supply chain partners to generate value by sharing processes, flow of information, and strategic alignment in order to enhance overall operational performance. As initial conceptualizations, integration was understood to go beyond transactions, and relational processes like trust, interdependence, and joint problem-solving among suppliers, manufacturers, and customers are needed to increase responsiveness and minimize uncertainty in interconnected networks (Simatupang & Sridharan, 2002; Frohlich & Westbrook, 2001). Internal integration is the process whereby the internal purposes of a firm are systematically aligned by removing functional silos to improve decision-making processes and relieve administrative roles within the firm as well as the divisions. External integration, on the other hand, extends these links to the suppliers and distributors and develops cooperation in planning, information sharing, and coordination of implementation (Flynn, Huo & Zhao, 2010; Hallgren & Olhager, 2009). Theoretical literature proposes that high information transparency, technological compatibility, and institutionalized routine, which encourages cross-organizational coordination and shared learning, are necessary to achieve effective integration (Stank, Keller & Daugherty, 2001; Cao & Zhang, 2011). Besides, relational factors like trust with each other and long-term orientation toward partnership enhance integration by minimizing opportunistic actions and by making joint investment in quality and efficiency improvement (Koufteros, Vonderembse & Doll, 2002; Lee, Padmanabhan & Whang, 1997). Integrated supply chains are in a better position to match the production with the market demand, shorten the lead times, minimize inventory expenses, and react efficiently to disruptions, thus providing better performance results (Li, 2006; Prajoko, Oke, & Olhager, 2016). Applying to the quality management field, the supply chain integration theory assumes that the conformity of quality practices among partners increases reliability of operations and establishes a unified culture of performance excellence that allows firms to harness the efficacy of collaborative strategies as well as their flexibility and competitive edge in their operations (Kannan & Tan, 2005; Vickery, 2014).

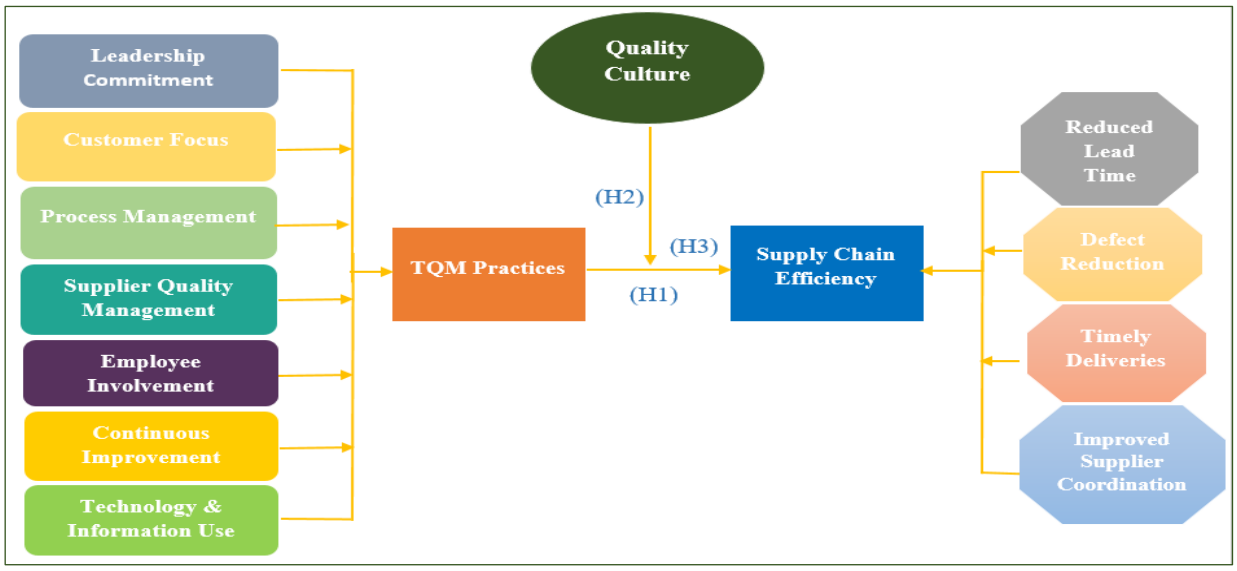

Figure 1. Proposed Research Model

3. RESEARCH METHODOLOGY

3.1 Research Design

The research design applied in the current study is a cross-sectional, quantitative research study that aims at challenging the direct and moderating relationships between total quality management practices, quality culture, and operational effectiveness of the supply chain. The hypotheses were tested through a variance-based structural equation modeling approach and hence offered a stringent test of predictive validity, complexities of paths, and interaction effects between the latent constructs. Proposed Research Model is presented on the Figure 1.

3.2 Population and Sampling

The study targeted managers, experts, and top-level operational personnel working in the divisions of supply chain, manufacturing, logistics, and quality experts that are involved in environmentally oriented programs in Pakistan. The participants were chosen as they are directly concerned with quality management and manufacturing, and they participate in the quality performance reviews. A well-designed sampling system was used to collect primary data, thus ensuring a methodological gathering. The requirements were the three-year working experience and engagement in the process of making decisions concerning sustainability. Finally, there was a filtering of the data based on the strict criteria of the exclusion of any missing data, response bias, and outliers.

3.3 Measurement of Variables

Items of measurement were taken from previous and tested studies. Research and measurements were carried out using a 5-point Likert scale with points of 1 (strongly disagree) to 5 (strongly agree). A 14-item scale based on Aichouni (2024) was used to measure TQM practices; a 10-item scale that was received by Zubair (2025) was used to measure quality culture; and a 7-item scale that was received by Waseem (2024) was used to measure supply chain efficiency. The demographic components that were incorporated in the questionnaire were age, gender, work experience, and education level. The standard of confidentiality and anonymity of the respondents was still maintained, and the purpose of the research was clearly interpreted as outlined in the questionnaire cover letter.

3.4 Data Collection Procedure

The self-administered questionnaires were collected electronically by the use of self-administered questionnaires for the eligible respondents. No one was forced to participate in the study, not even to prevent the social desirability bias; the participants were assured that they were confidential. It was made clear to the respondents that the data to be obtained would be confined to academic research. Some of the procedural controls to reduce common method variance were considered, which include correct instructions, psychological separation of predictor and criterion variables in the questionnaire, and anonymity. The questionnaire was screened and only then handed over to ensure that it was conceptually adequate and relevant. The available population was large, so the convenience sampling was applied, and 330 valid responses were received and utilized in order to conduct the analysis.

3.5 Data Screening and Preliminary Analysis

Hypothesis testing involved a close screening of the data to identify missing values, an outlier, and non-normality of the data. The data that contained abnormal omissions were subsequently disregarded. The variance inflation factors were then computed in order to identify multi collinearity, and it was made sure that none of the predictor variables exceeded the acceptable range. The second stage led to developing descriptive statistics, which gave the short profile of the respondent.

3.6 Measurement Model Assessment

The measurement model was checked before taking into account the relationship between the structural aspects to ensure that the measurement model is reliable and valid as far as possible. In addition, internal consistency was measured with composite reliability coefficients, hence making sure that the coherence of each construct was sufficient. Convergent validity was measured using factor loadings and average variance extracted, and it was discovered that the indicators could measure the intended constructs adequately. Loadings, composite reliability and average variance extracted is presented on Table 1.

Table 1. Loadings, Composite Reliability and Average Variance Extracted

Construct	Item	Factor loading	Cronbach's α	(CR)	AVE
Quality Culture	QC1	0.769	0.909	0.924	0.550
	QC10	0.626			
	QC2	0.712			
	QC3	0.755			
	QC4	0.776			
	QC5	0.793			
	QC6	0.757			
	QC7	0.766			
	QC8	0.790			
	QC9	0.651			
Supply Chain Efficiency	SCE1	0.788	0.878	0.906	0.581
	SCE2	0.745			
	SCE3	0.813			
	SCE4	0.827			
	SCE5	0.783			
	SCE6	0.680			
	SCE7	0.684			
TQM Practices	TQMP10	0.767	0.914	0.927	0.515
	TQMP11	0.673			
	TQMP12	0.719			
	TQMP13	0.744			
	TQMP2	0.646			
	TQMP3	0.709			
	TQMP4	0.683			
	TQMP5	0.694			
	TQMP6	0.724			
	TQMP7	0.741			
	TQMP8	0.753			
	TQMP9	0.746			

Note. Cronbach's alpha and composite reliability values above 0.70 indicate internal consistency reliability. Average variance extracted (AVE) values above 0.50 indicate adequate convergent validity (Hair & Alamer, 2022).

Table 2. Discriminant Validity (HTMT Ratio)

HTMT	Quality Culture	Supply Chain Efficiency	TQM Practices
Quality Culture			
Supply Chain Efficiency	0.784		
TQM Practices	0.676	0.554	0

Note. HTMT values below 0.85 (strict criterion) or 0.90 (liberal criterion) indicate adequate discriminant validity (Henseler, 2015)

The discriminant validity was achieved according to the established standards, and it guaranteed the empirical distinction between all the constructs in the model (Table 2 and Table 3). The achievement of a good level of reliability and validity was followed by the analysis of the structural relations. Such a staged approach will make sure that the inferential analyses will have a firm foundation of measurement, thus maximizing the validity of the results that will be achieved. Cross loading is givven in Table 4.

Table 3. Discriminant Validity (Fornell - Larcker Criterion)

	Quality Culture	Supply Chain Efficiency	TQM Practices
Quality Culture	0.741		
Supply Chain Efficiency	0.733	0.762	
TQM Practices	0.619	0.501	0.717

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

Table 4. Cross Loading

	QC	SCE	TQMP
QC1	0.769	0.506	0.557
QC10	0.626	0.694	0.301
QC2	0.712	0.431	0.498
QC3	0.755	0.455	0.470
QC4	0.776	0.472	0.493
QC5	0.793	0.489	0.474
QC6	0.757	0.472	0.427
QC7	0.766	0.471	0.451
QC8	0.790	0.491	0.496
QC9	0.651	0.709	0.436
SCE1	0.570	0.788	0.356
SCE2	0.550	0.745	0.331
SCE3	0.566	0.813	0.353
SCE4	0.574	0.827	0.349
SCE5	0.554	0.783	0.346
SCE6	0.542	0.680	0.466
SCE7	0.546	0.684	0.468
TQMP10	0.443	0.364	0.767
TQMP11	0.479	0.417	0.673
TQMP12	0.484	0.402	0.719
TQMP13	0.469	0.396	0.744
TQMP2	0.367	0.283	0.646
TQMP3	0.414	0.350	0.709
TQMP4	0.384	0.287	0.683
TQMP5	0.439	0.356	0.694
TQMP6	0.443	0.336	0.724
TQMP7	0.454	0.375	0.741
TQMP8	0.451	0.344	0.753
TQMP9	0.467	0.356	0.746

Note. Cross-loadings indicate adequate discriminant validity when each indicator loads higher on its associated construct than on all other constructs (Henseler et al., 2015).

3.7 Structural Model Evaluation

The structural model analysis highlights the existence of a strong and theoretically sound model that connects the Total Quality Management Practices, Quality Culture, and Supply Chain Efficiency (SCE) concepts. The direct effect of quality management practices on the supply chain efficiency is enormous, as the path coefficient between TQMP and SCE is (0.588, $p < 0.05$) and significant (Table 5). Such close association highlights the fact that the adoption of TQMP has a significant positive contribution to the operational performance of the supply chain. When the direct route is taken via Quality Culture, the coefficient is smaller and statistically significant (0.288, $p < 0.05$), indicating a rather partial moderating effect. Although QC have a positive effect on SCE, as the path coefficient between QC and SCE is (0.214, $p < 0.05$), which points to the fact that Quality Culture is a significant factor in the TQMP-SCE relationship, but the direct impact of TQMP still remains the major one. The loading of all the observed indicators is high; most of the indicators have high loadings of approximately above 0.7, which indicates excellent convergent validity and internal consistency among constructs. Both TQMP and SCE have high levels of construct reliability, which validates the fact that the latent variables are well-measured using the items used to measure them. The model has a consistent structural fit, with all the expected relationships being confirmed by the data and no weak and unstable paths being evident. Hence, this structural model confirms the importance of total quality management practices in improving the performance of the supply chain, and the quality culture

is a reinforcing but support mechanism. These findings give good empirical evidence to encourage managers to focus on quality practices as a strategic instrument of operational excellence as they develop organizational commitment to maintain performance gains (Figure 2 and Figure 3).

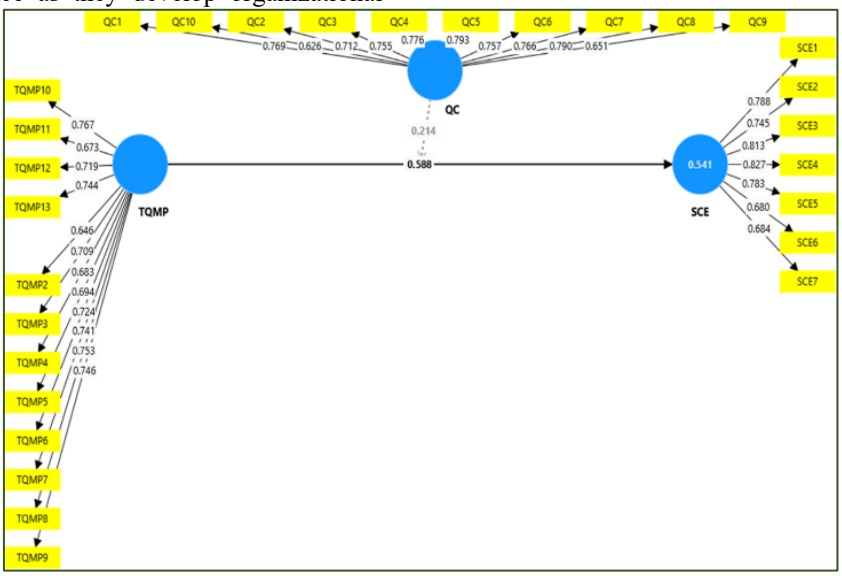

Figure 2. Measurement and structural model results with standardized estimates and explained variance (R^2).

Table 5. Structural Model Path Coefficients

Hypothesis	Path	β	t-value	p-value	CI (5%-95%)	Decision
H1	TQMP -> SCE	0.588	3.614	0.000	0.101, 0.378	Supported
H2	QC -> SCE	0.288	15.670	0.000	0.618, 0.763	Supported
H3	QC x TQMP -> SCE	0.214	2.571	0.008	0.127, 0.301	Supported

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

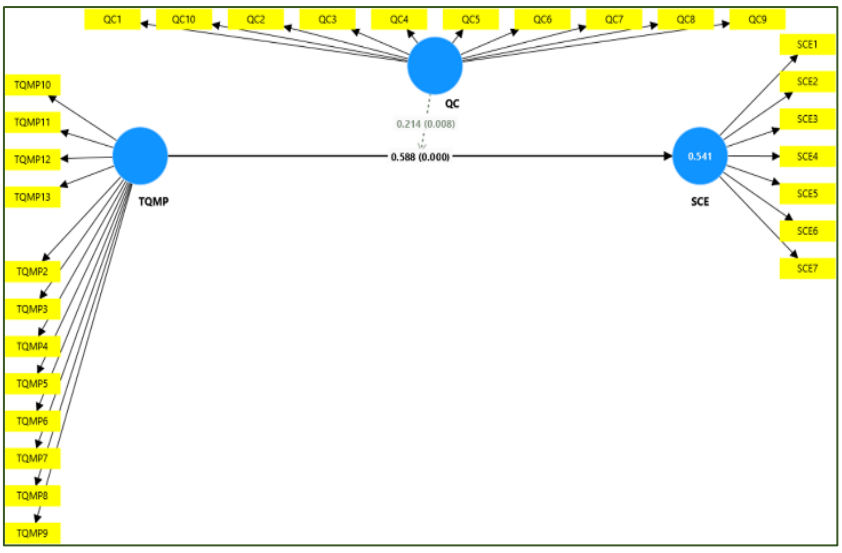

Figure 3. Structural and measurement model results obtained through PLS-SEM, showing standardized path coefficients with associated p-values, outer loadings, and R^2 values for endogenous constructs.

4. RESULTS AND DISCUSSION

The measurement model demonstrated high reliability and validity: all the factor loadings were over 0.60, Cronbach alpha was over 0.87, composite reliability was over 0.90, and the average variance extracted was over 0.51. Discriminant validity was determined by HTMT ratios that are less than 0.85 and satisfaction of the Fornell-Larcker criterion. Each of the three hypotheses was empirically justified. TQM practices had a significant positive impact on supply chain efficiency (0.588, $p < 0.001$), and this confirms that systematic quality management improves the supply chain performance by standardizing the processes and managing the suppliers and the leaders who have commitment. Quality culture showed that there was a strong positive direct impact with supply chain efficiency ($\beta = 0.288$, $p < 0.001$), which displays that common values of quality have a positive influence on operation performance. More importantly, quality culture moderated the correlation between TQM practices and supply chain efficiency in a positive manner (0.214, p 0.008), indicating that TQM practices have increased benefits where organizations have well-ingrained quality values and norms. Such results support the fact that even though the TQM practice creates the structural base of the supply-chain improvements, quality culture serves the crucial role of multiplying the procedural compliance into the significance of the meaningful efficiency improvements. In the case of Pakistani manufacturers that are working in the context of infrastructure volatility and difference in supplier capability, to realize sustainable performance of the supply-chain, one needs to invest in both the technical quality systems as well as cultural development. Managers must realize that quality culture makes it possible to internalize quality culture more, solve problems together and coordinate across functions, which spreads the benefits of formal quality practices.

5. LIMITATIONS & DIRECTION FOR FUTURE RESEARCH

A number of limitations associated with this investigation need to be noted, since it is outlined clear directions of what could be explored further. The focus on the manufacturing sector of Pakistan limits the externalizability of the findings. Cross-country research of emerging economies would shed light on whether the observed relationships are based on contingency of contextual variables or have universal validity. Use of self-reported measures brings in the element of bias. Future studies should also include objective productivity measures, including delivery lead times, inventory turnover ratios, and defect incidence rates as retrieved through enterprise information systems, to come up with triangulation of the data and reduce subjective distortions. The formulation of the quality culture as a unidimensional tool is a simplistic concept. By creating multidimensional scales, the future scholars would be able to identify the particular cultural factors that have the most potent effect on the effects of TQM initiatives (Figure 4). Another issue is underrepresentation of small and medium enterprises. Future researchers must intentionally sample companies occupying the entire range of organizational sizes to determine whether the size of firms moderates the examined relationships. Information sharing and trust building are some of the mediating variables that have not been studied extensively. Research into these directions would help understand how these quality orientations can be translated into quantifiable improvements in operation efficiency. With the emergence of Industry 4.0 technologies, new opportunities for research emerge. A formal study of the intersection of digital transformation and the practice of TQM, whether these technologies will accelerate cultural spread across supply lines, would make a significant contribution to knowledge.

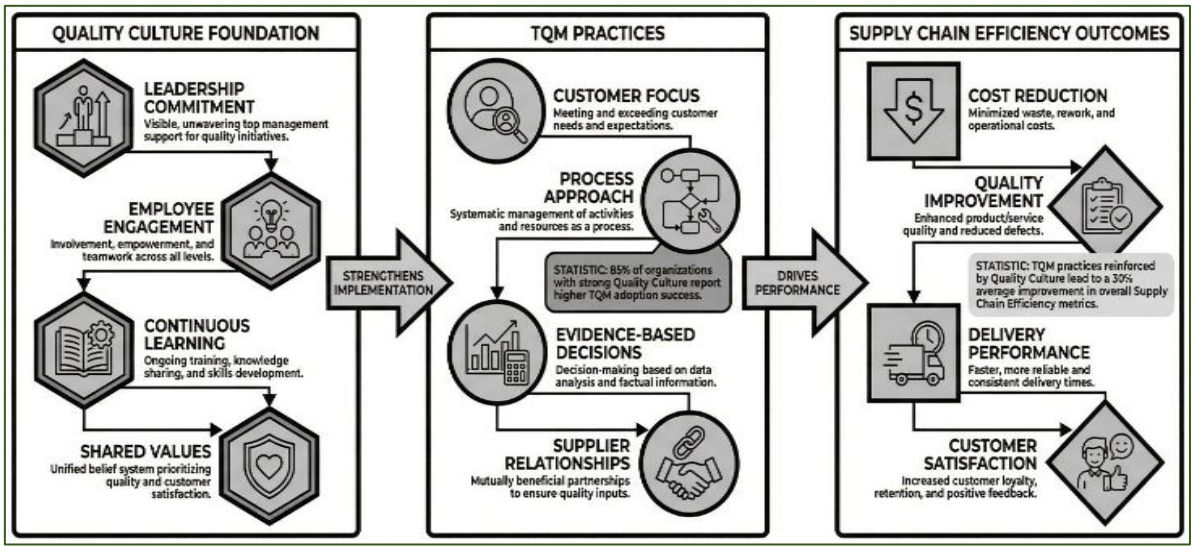

Figure 4. A visual framework illustrating how a strong Quality Culture foundation enables TQM Practices to drive key Supply Chain Efficiency outcomes

6. CONCLUSION

The current study supports the fact that the Total Quality Management (TQM) activities significantly enhance the efficiency of the supply chain in the manufacturing sector of Pakistan, and the quality culture acts not only as a direct driver but also as a critical moderator that magnifies this association. The empirical findings show that properly designed quality-management systems provide the necessary framework to enhance operations in terms of standardization of processes, strong supplier management, and uncompromising leadership dedication. With such structural mechanisms, coupled with well-established values of quality, the amplified impacts are seen as high levels of collective ownership, cross-functional coordination, and problem-solving behavior that goes beyond organizational boundaries. To executives leading the companies in the frequently volatile industrial environment in Pakistan, these results remind them that investment in technical quality systems should be strategically matched with deliberate cultural development to achieve the ultimate potential of the performance of the supply chain.

Beyond the immediate empirical results, the findings also suggest that quality-oriented managerial practices can represent an important source of organizational improvement and operational innovation in manufacturing systems. As companies increasingly adopt digital technologies and integrated information systems within their supply chains, the presence of a strong quality culture becomes even more relevant for ensuring that these technological capabilities are effectively translated into operational efficiency. For managers, this implies that investments in digital tools and supply chain technologies should be accompanied by efforts to strengthen shared quality values and collaborative problem-solving practices across the organization and its partners. Such alignment between managerial practices, organizational culture, and evolving technological infrastructure can play a key role in sustaining long-term competitiveness in industrial environments.

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