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Revolutionizing quality performance through digitization, technology management, and environmental management: a cutting-edge PLS-SEM model analysis with organizational agility as mediator and culture as moderator

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In today's era of increasing environmental awareness, organizations need to consider the environmental economics and management perspective in addition to quality performance. Recent societal changes have led to a significant digital revolution that has made it challenging for industrialized nations to manage technology transfer. Organizations must integrate digitalization, technology, culture, and environmental sustainability to survive in this highly competitive climate. This study examines the relationship between digitalization and technology management and their impact on Total Quality Management (TQM) performance in Pakistani businesses, considering the environmental economics and management perspective. A quantitative approach was taken, and senior executives from the public and private sectors were surveyed to obtain information. The data was analyzed using SMART PLS 3, which utilized Partial Least Squares Structural Equation Modeling (PLS-SEM). The study found that digitalization and technology management significantly enhanced TQM performance, with organizational agility mediating and organizational culture moderating. The organizational agility also played a crucial role in mediating the relationship between technology management and TQM performance. The findings of this study offer valuable insights for quality management practitioners and policymakers, highlighting the importance of incorporating environmental economics and management practices into an overall quality performance.

KEYWORDS

digitalization, technology management, organizational agility, TQM performance, organizational culture, PLS-SEM modeling, environmental management

1 Introduction

The adoption of digital technologies has become critical for organizations to remain competitive in the modern business environment. According to a report by the World Economic Forum, the digitalization of the global economy could add up to $16 trillion to the global GDP by 2030 ("The global economy will be $16 trillion bigger by 2030 thanks to AI.," 2020). In Pakistan, the government has recognized the importance of digitization. It has launched initiatives such as the Digital Pakistan Vision and the e-Government Strategy to promote technology adoption in various sectors. The importance of digitization in modern business is well-documented in the literature. Researchers have found that digitization can improve productivity and reduce costs, leading to increased competitiveness (Brynjolfsson and McAfee, 2014; Chesbrough, 2010). The use of digital solutions can also enhance communication and collaboration within an organization and with external stakeholders, enabling organizations to respond more quickly to changes in the business environment (Allee, 1997). The COVID-19 pandemic has accelerated the need for digitization, with many organizations transitioning to remote work and virtual operations. A (Bughin, Deakin, & O'Beirne, 2019) study found that companies that had invested in digital technologies before the pandemic were better equipped to respond to the crisis, with higher levels of employee productivity and customer satisfaction.

Quality performance is another critical factor in the success of organizations. A study by the American Society for Quality (ASQ) found that organizations that prioritize quality see an average of 10% improvement in profitability (Quality, 2017). However, improving quality performance can be complex, requiring organizations to adopt innovative strategies and utilize digital technologies effectively. In the context of Pakistani environmental economics and management, organizations need to adopt digital solutions to monitor and manage their environmental impact more efficiently. According to the State of the Environment Report for Pakistan (Survey, 2015-16) the country faces significant environmental challenges, including air and water pollution, deforestation, and climate change. Digitization can provide organizations with the tools to monitor and manage their environmental impact more effectively, enabling them to make data-driven decisions to reduce their environmental footprint.

In the context of environmental economics and management, digitization can provide organizations with the tools to monitor and manage their environmental impact more effectively. For example, sensors and IoT devices can provide real-time data on energy consumption, water usage, and waste management, enabling organizations to make data-driven decisions to reduce their environmental footprints (Manavalan, Jayakrishna and Engineering, 2019). The use of digital solutions can also improve the transparency of environmental reporting and enable stakeholders to track an organization's progress towards sustainability goals (ElMassah and Mohieldin, 2020). Overall, the benefits of digitization are numerous and have become increasingly important in the modern business environment. Organizations that fail to embrace technology risk falling behind their competitors as the world becomes digital.

Quality performance refers to the ability of organizations to consistently deliver high-quality products or services that meet or exceed customer expectations (Quality, 2017). Digitization, on the other hand, involves adopting digital technologies to improve business processes, enhance communication and collaboration, and provide organizations with the tools to make data-driven decisions (Guo and Xu, 2021). Technology management is managing technology within an organization to ensure that it is used effectively to support business goals (Malik et al., 2010). Organizational agility refers to an organization's ability to quickly adapt to changes in the business environment and remain competitive (Nafei, 2016). Culture, in the context of organizations, refers to the shared values, beliefs, and practices that shape the behaviour of employees and influence the way work is done (Xie, Wang and García, 2021).

There is a direct correlation between an organization's level of technical management, organizational agility, and culture, and its level of quality performance in today's dynamic business environment. These concepts are interdependent and interconnected. Adoption and incorporation of digital technologies within an organization are contingent upon effective technology management, a crucial step in the digitization process. In contrast, digitalization is indispensable to the success of technology management in terms of both creativity and efficiency. Digital businesses with greater technological proficiency are better able to respond to and adapt to changes in their environment, which increases their overall agility.

Organizational culture has a significant impact on the success of digitalization and technology management initiatives. If a company's culture values creativity, collaboration, and continuous learning, it may be more adept at utilizing new technologies, exhibiting agility, and producing high-quality work. Digitization, technical management, organizational adaptability, and a supportive culture all contribute to outstanding performance. Businesses that effectively digitize their operations, manage their technical resources, maintain their agility, and cultivate a positive culture can provide consumers with products and services that meet or exceed their expectations for quality. In conclusion, businesses that effectively overcome the obstacles of digitization, technology management, organizational agility and culture, and quality performance will reap the rewards of increased competitiveness, innovation, and overall corporate performance.

The study is set on the following objectives.

- To investigate the effect of technology management on the relationship between digitization and quality performance.
- To analyze the mediating effect of organizational agility on the relationship between digitization, technology management, and quality performance.
- To evaluate the moderating effect of culture on the relationship between digitization, technology management, organizational agility, and quality performance.
- To develop a cutting-edge PLS-SEM model to understand the relationships between digitization, technology management, organizational agility, culture, and quality performance in Pakistani organizations.

The purpose of the study is to make a significant contribution to the body of knowledge concerning the relationship between digitalization, technology management, and quality performance, with a particular emphasis on Pakistan's environment economics and management environment. By analyzing the moderating and mediating effects of organizational agility and culture, the purpose of this study is to shed light on how Pakistani businesses can use digital technology to improve their quality performance in a dynamic economic environment. This study advances our understanding of the factors that influence organizational quality performance by examining these relationships and taking into consideration the moderating and mediating effects of organizational agility and culture. This exhaustive analysis can provide practitioners, policymakers, and academics with valuable information for enhancing the deployment of digital technologies and achieving quality performance improvements in the Pakistani business environment. Considering the challenges posed by digitalization, technology management, organizational agility and culture, and quality performance, the study's findings can serve as a guide for businesses seeking to boost their competitiveness, innovation, and overall business success.

2 Literature review

Growing concerns about environmental sustainability have led many organizations to focus on integrating environmental management practices into their quality management initiatives. This literature review will examine the role of digitization, technology management, and environmental management in driving quality performance, using an advanced PLS-SEM model analysis with organizational agility as a mediator and culture as a moderator. The review will explore the key findings and insights from existing literature and identify areas for further research to enhance our understanding of the complex relationships between these critical factors and their impact on quality management performance.

2.1 Digitalization and TQM performance

Digitization refers to converting analogue information into digital form, which can be stored, manipulated, and transmitted electronically (Frenzel, Muench, Bruckner and Veit, 2021). Digitization can include converting text, images, audio, and video and developing digital tools and platforms that facilitate communication and collaboration (Bilyalova, Salimova and Zelenina, 2020). Digitization has been identified as a critical component of technology management and can provide various benefits to organizations, including enhanced efficiency, improved communication, and more effective decision-making (Sieber and Sustainability, 2019). In addition, digitization has been linked to improved quality management processes and outcomes, enabling more effective data collection and analysis and facilitating the development of more effective communication and collaboration strategies (Hermansyah, Titisari, & Sudaryanto, 2019). Overall, digitization is a key factor in the evolution of modern organizations and is a critical component of successful technology management and quality management practices.

The literature on digitalization and TQM performance has shown that digital tools and technologies can significantly enhance quality management processes and outcomes. Digitalization refers to converting analogue information into digital form, which can be stored, manipulated, and transmitted electronically (Frenzel et al., 2021). From an environmental economics and management perspective, digitalization has the potential to reduce waste, increase efficiency, and promote sustainability (Rivard, 2004). For example, digital technologies such as the Internet of Things (IoT) and big data analytics can enable more effective resource management and waste reduction (de Sousa Jabbour et al., 2014). In addition, digital tools can facilitate more effective collaboration and communication among employees, leading to improved quality management processes and outcomes (Khanam, Siddiqui, Talib, Talib and Technology, 2016).

While the benefits of digitalization for TQM performance are clear, there are also potential challenges and drawbacks associated with these technologies. One concern is the potential for data privacy and security breaches, which can undermine trust in digital systems and compromise quality management efforts (Quashie and Chileshe, 2006). In addition, the rapid pace of technological change and the high costs associated with technology adoption can create significant barriers to entry for small and medium-sized enterprises, limiting their ability to compete effectively with larger firms (Haseeb, Hussain, Ślusarczyk and Jermsittiparsert, 2019). From an environmental economics and management perspective, the potential benefits of digitalization for resource management and sustainability are significant. Some studies have found that digital technologies can enhance quality management processes. However, there is still a need for more empirical research to fully understand the mechanisms through which these technologies impact TQM performance.

Despite the clear benefits of digitization for TQM performance, we also highlight potential challenges and drawbacks associated with these technologies. The rapid pace of technological change and the high costs associated with technology adoption can create significant barriers to entry for small and medium-sized enterprises, limiting their ability to compete effectively with larger firms (Haseeb et al., 2019). Although the literature on digitalization and TQM performance provides valuable insights into the potential benefits of digital technologies for resource management and sustainability, there remains a need for more empirical research to fully understand the mechanisms through which these technologies impact TQM performance. Specifically, future studies should investigate the role of organizational culture as a moderator and organizational agility as a mediator in the relationship between digitization, technology management, and TQM performance. By addressing these research gaps, we can provide a more comprehensive understanding of how digitization and technology management can revolutionize quality performance in modern organizations.

2.2 Technology management and TQM performance

Technology management is the strategic use of technology to achieve organizational goals and objectives (Sharif & change, 1999).

It involves planning, implementing, and monitoring technological resources and processes to drive innovation, enhance efficiency, and create competitive advantage (Chang, 2016). According to (Galliers and Leidner, 2014), technology management has become increasingly important as technological advances have created new opportunities and challenges for organizations. Effective technology management requires a combination of technical expertise and business acumen, including identifying and implementing the most appropriate technology solutions for the organization while ensuring that these solutions are aligned with the organization's overall goals and objectives (Chang, 2016). Technology managers must also be able to anticipate and respond to technological changes while keeping a close eye on the potential risks and challenges associated with new technologies (Sharif & change, 1999). Additionally, successful technology managers must possess strong leadership and communication abilities, working collaboratively with other organizational stakeholders, including senior leaders, technology teams, and end-users, to ensure that technology solutions are effectively implemented and utilized (Stair, 2011).

Additionally, the literature indicates that several key technologies can be particularly effective in supporting TQM performance. For example, a study by (X. Li et al., 2022) found that using blockchain technology can significantly improve quality management processes by enhancing transparency, accountability, and traceability. Similarly, using artificial intelligence and machine learning technologies can enable more effective quality control and predictive maintenance (Lee, Lee and Kim, 2019). Leadership promotes technology adoption and integration (Bernstein, McCreless and Cote, 2007; Gürfidan, Koç and Bilim, 2016) and strategic technology usage to accomplish corporate goals (Alenezi and Technologies, 2017; Chang, 2016). Blockchain, AI, and machine learning can improve TQM (Muruganandham, Venkatesh, Devadasan, Harish and Excellence, 2023). Knowledge management, real-time data and feedback, and staff interaction are also important for TQM effectiveness (J. Zelbst, W. Green, E. Sower, & D. Abshire, 2014). Technology in supply chain management boosts TQM performance (Basheer, Siam, Awn and Hassan, 2019). Despite existing literature findings, research gaps remain. Technology management and TQM success may vary by industry and organization. More study is needed. Filling these knowledge gaps may help us comprehend the relationship between technology management, TQM performance, and other organizational factors, leading to more effective quality improvement strategies.

2.3 Mediating role of organizational agility (OA)

Organizational agility has been explored in various academic and business fields, including organization theory, strategic management, and information systems. (Daft, 2015). identifies several key factors that contribute to organizational agility, including a shared sense of purpose, employee empowerment, a culture of experimentation and learning, and the use of technology to enable rapid decision-making and collaboration. In addition to these factors, (Edmondson, 2018), emphasizes the importance of creating a psychologically safe workplace for learning, innovation, and growth. It means providing employees with the confidence to experiment, take risks, and learn from failures without fear of negative consequences. In addition to the definitions and factors mentioned earlier, several other scholars have also defined organizational agility in their works. For example, (Augier and Teece, 2016; Elali, 2021), define agility as "the ability to make strategic and operational changes quickly and efficiently.

The growing digitalization trend has been recognized as a key factor in improving organizational performance in many industries. Digitalization can improve the effectiveness and efficiency of Total Quality Management (TQM) practices by enhancing the organizational agility and responsiveness to environmental changes. Several studies have highlighted the positive impact of digitalization on TQM performance (Ali and Johl, 2022; Lepistö, Saunila and Ukko, 2022; Shen, Wang, Boussemart, Hao and Change, 2022).

Organizational agility has also been identified as a critical factor in enhancing TQM performance. According to (Harraf, Wanasika, Tate and Talbott, 2015), agile organizations can better adapt to changes in their environment and respond to customer needs, leading to improved TQM performance. Similarly, (Aquilani, Silvestri, Ruggieri and Gatti, 2017), found that organizational agility positively impacts TQM performance by enabling faster decision-making and better employee coordination. There is also growing evidence that organizational agility mediates the relationship between digitalization and TQM performance.

2.4 Moderating role of organizational culture

The impact of organizational culture on Total Quality Management (TQM) has been widely investigated in the literature. In a study conducted by (Cheng, Liu and Environment, 2007), they found a relationship between organizational culture and TQM implementation in construction firms. They argued that successful implementation requires a clear understanding and agreed approach to achieving quality goals, and a mismatch between culture and TQM can lead to failure. (Roldán, Leal-Rodríguez and Leal, 2012). confirmed the relationship between quality culture types and TQM program performance using a survey and structural equation modeling. Meanwhile, (Pun, 2001), found no strong evidence to verify the influence of Chinese culture values on TQM adoption in the organizations studied, suggesting that successful adoption depends on managing cultural dynamics and organizational complexities. (Alghamdi, 2018). showed that organizational culture plays a moderating role in the relationship between TQM and organizational performance, with a positive correlation between the two.

(Irani, Beskese and Love, 2004) highlighted the need for an appropriate culture to support TQM and found a synergy between continuous improvement and innovation under the right corporate culture, leading to substantial improvements in business performance. (Yuan, 2012). found a positive relationship between clan, adhocracy, and market cultures and TQM implementation, but a negative relationship between hierarchy culture and TQM implementation. In earlier works, (Bright and Cooper, 1993),

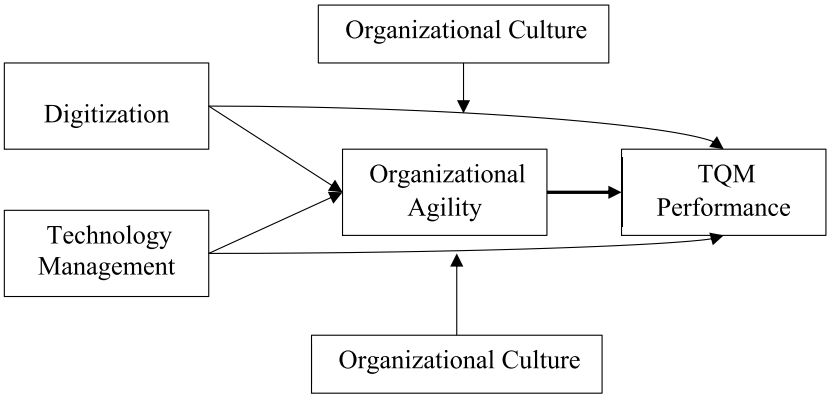

FIGURE 1
Theoretical framework.

argued that TQM makes assumptions about organizational culture and that a culture perspective can challenge some basic assumptions found in TQM literature. Lastly, (Klein, Masi, Weidner and Management, 1995), found significant relationships between organizational culture and various factors, such as control distribution, culture, service quality, and employee performance, ultimately suggesting that investments in training and culture change efforts can result in improved organizational performance and service quality.

The reviewed studies highlight the importance of organizational agility, creativity, strategic flexibility, green knowledge management, and technological innovation in affecting corporate environmental performance and Total Quality Management (TQM). The authors (Arsawan et al., 2022) have emphasized the importance of agility in responding effectively to a volatile corporate environment. This is consistent with our contention that agility serves a mediating role in enhancing Total Quality Management (TQM) through digitalization and technology management. In a similar vein, (Arsawan et al., 2023; Sahoo, Kumar, Upadhyay and Environment, 2023), have emphasized the importance of integrating environmental concerns and sustainability into operational processes to improve performance. In addition (H. Li et al., 2023), conducted a thorough analysis of the effects of technological innovation and company size on organizational structure and performance. This is consistent with the primary objective of our study, which is to investigate the impact of technology management on Total Quality Management (TQM). Our research study provides additional support for the necessity of integrating digitalization, technology management, and environmental management techniques in order to improve qualitative performance. In addition, our findings indicate that organizational agility acts as a mediator, whereas culture acts as a moderator in this relationship.

2.5 Theoretical framework

Figure 1 presents theoretical frameworks that include digitization and technology management as exogenous constructs and organizational agility as a mediator between exogenous and endogenous constructs. These can provide valuable insights into how firms can achieve superior TQM performance. Organizational culture can also be critical in moderating the relationship between digitization and technology management as exogenous constructs and TQM performance as endogenous constructs. These frameworks draw on a range of theoretical perspectives, including the resource-based view of the firm, which emphasizes the role of technology as a key resource in achieving TQM performance (M. J. J. o. c. p. Ghobakhloo, 2020). Service-dominant logic also highlights the importance of technology in facilitating effective communication and collaboration with customers, which can contribute to better quality management processes and outcomes (Vargo and Lusch, 2016). Finally, institutional theory suggests that firms may be motivated to adopt digitization and technology management practices to conform to external norms and expectations (Scott, 2013). These theoretical perspectives guide future research on the relationship between technology management, digitization, and TQM performance and inform the development of effective strategies for achieving superior quality management outcomes.

In recent years, the importance of incorporating environmental considerations in business decision-making has gained traction. Environmental economics and management scholars argue that integrating sustainability practices into organizational operations can improve overall performance and enhance competitiveness (Ozorhon and Oral, 2017; Schaltegger, Wagner, & environment, 2011). For instance, scholars have found that digitalization can enable environmental sustainability by reducing energy consumption and carbon emissions (Agustí-Juan and Habert, 2017; Isensee, Teuteberg, Griese and Management, 2023). Technology management can also support sustainability by promoting eco-innovation and green supply chain management (Brent and Pretorius, 2008). Organizational agility can facilitate sustainable practices by enabling firms to adapt to changing environmental regulations and customer preferences (Bhatti, Santoro, Khan and Rizzato, 2021; Ahmed, Bhatti, Gölgeci, Arslan and Change, 2022). Finally, organizational culture can play a vital role in fostering an environmental sustainability mindset among employees and promoting sustainable practices (Tsui, Wang, Xin and Review, 2006). Total Quality Management (TQM) performance

is taken as the endogenous construct, and organizational culture is proposed to play a moderating role in the relationship between exogenous and endogenous constructs. Our framework is deeply rooted in the resource-based view (RBV) theory, which underscores the value of technology as a critical resource for optimizing TQM performance (M. J. J. o. m.t. m. Ghobakhloo, 2018). This theory posits that firms can attain a competitive edge and enhance their performance by optimally leveraging their valuable, rare, inimitable, and non-substitutable resources - in our context, digitalization and technology management capabilities. Moreover, the framework resonates with the service-dominant logic (S-D logic) that highlights the role of technology in fostering efficient communication and collaboration with customers, thus aiding improved quality management processes and outcomes (Vargo and Lusch, 2016). In line with S-D logic, our study acknowledges that firms transitioning from goods-dominant logic to service-dominant logic can employ technology to co-create value with their customers, thereby amplifying TQM performance. Institutional theory provides another theoretical underpinning to our study. This theory suggests that firms may adopt practices like digitalization and technology management to comply with prevailing external norms and expectations (Scott, 2013). Thus, external institutional pressures can motivate firms to implement technology management and digitalization strategies, impacting TQM performance. The following hypotheses have been developed from the theoretical framework to be evaluated using robust empirical methods and data.

H1. Digitalization has a positive and significant relationship with TQM performance.

H2. Technology management positively and significantly affects TQM performance.

H3. The relationship between digitalization and TQM performance is mediated by organizational agility.

H4. The relationship between technology management and TQM performance is mediated by organizational agility.

H5. Organizational culture moderates the relationship between digitization and TQM performance.

H6. Organizational culture moderates the relationship between technology management and TQM performance.

3 Research method

3.1 Research design

We conducted a cross-sectional quantitative survey utilizing closed-ended questions. We collected data from administrative personnel of diverse companies and social media professional groups involved in the organization's management activities. The survey method is a critical component to consider as it is an essential step in tailoring the survey questions and goals (Fink, 2019). Our research philosophy is empirical, and our research process is causal, generating hypotheses based on established theories. A quantitative research design was appropriate for this type of study. Our methodology focused on collecting data on variables only once per period, allowing us to understand them better. This cross-sectional analysis utilized the individual as the unit of analysis. To ensure ethical considerations were met, we treated the data collected from employees of various organizations as confidential and evaluated any ethical concerns that arose during the study.

3.2 Population and sampling

The study population in this research comprised senior managers and top leaders in the Pakistan service industry. The service industry in Pakistan is a rapidly growing sector and is considered one of the key drivers of the country's economy. According to the Pakistan Bureau of Statistics, the service sector contributed 60.1% to the country's gross domestic product (GDP) in the 2019-2020 financial year (Government of Pakistan, 2020). The service industry in Pakistan includes a diverse range of sub-sectors, such as telecommunications, banking and finance, healthcare, retail, and hospitality. We selected telecommunications, transportation, healthcare, and hospitality sector companies.

We employed a convenient sampling strategy. Convenience sampling is a non-probability method used in research studies where researchers select participants based on their availability and accessibility. There are several reasons why we choose to use convenience sampling. First, it is a practical and time-efficient way to gather data, especially when the research needs to be completed quickly, or the target population is hard to reach. Second, convenience sampling is a cost-effective way to gather data, eliminating the need for complex and expensive sampling methods. Third, convenience sampling can be useful in pilot studies as it allows researchers to evaluate their research instruments and procedures in a small sample before conducting a larger study. Finally, convenience sampling may be appropriate for small populations, where researchers can easily identify and contact all potential participants. So, we received completed questionnaires from 440 respondents out of 500. We recognize that convenience sampling has its limitations, but we have made a concerted effort to account for these shortcomings in our study. By addressing potential confounding factors and conducting thorough analyses, we strive to provide meaningful insights into our research question, despite the limitations of our sampling method. This sample size is considered outstanding and provides a strong representation of the population of interest. Our sample size and the diversity of our sample suggest that the results of this study are relevant and applicable to a broad range of organizations within the Pakistan service industry.

3.3 Measures in the study

In this study, scales were adopted from previous studies. Adopting established scales helped to maintain consistency with previous research, allowing for better comparison of the results. The 5-point Likert scale we adopted for data collection has been shown to provide acceptable measurements for the scale under consideration.

TABLE 1 Summary of questionnaires.

Questionnaire	Quantity	(%)
Distributed	500	100
Returned	20	04
Screened out	40	08
Useable	440	88

TABLE 2 Demographic profile of respondents.

Characteristic	Frequency	Percentage
Gender		
Male	264	60
Female	176	40
Age (Years)		
18–24	110	25
25–34	176	40
35–44	110	25
45–54	33	7.5
55 and above	11	2.5
Educational Level		
High School	88	20
Associate degree	60	13.6
Bachelor's Degree	158	36
Postgraduate Degree (Masters)	110	25
Doctorate Degree	31	7
Others (e.g., professional)	13	3

Furthermore, using recognized scales based on previous literature can improve the validity and reliability of the data collected in the study. All received information was kept confidential To ensure privacy.

The scales we used were adopted from previous studies, including the scale of digitization from (Westerman, Bonnet and McAfee, 2014) and the TQM performance scale from (Kaynak, 2003). We borrowed the 7-item computerized scale from (Jayachandran, Sharma, Kaufman and Raman, 2005) to measure the impact of technology management. We also utilized the 7-item Technology management measure developed by (Bergeron, Raymond, Rivard, & management, 2004). We measured organizational agility using the (Tallon and Pinsonneault, 2011), which also consisted of seven items. We measured organizational culture using an eight-item scale adapted from (Dawson, Abbott and Shoemaker, 2011). Overall, the use of established scales and measures in this study provided several benefits, including increased validity and reliability of the data collected and consistency with previous research, allowing for better comparison of the results.

TABLE 3 Common latent factor (CLF) method.

Latent factor > variable	Path coefficient	*p*-value
CLF - > D1	0.03	0.58
CLF - > D2	0.04	0.52
CLF - > D3	0.05	0.48
CLF - > D4	0.03	0.57

The survey data in Table 1 shows the results of a questionnaire distributed to 500 individuals. Out of these 500 questionnaires, 20 were returned, representing a response rate of 4%. Of the 20 returned questionnaires, 40 were screened out, meaning they did not meet the criteria for inclusion finally. It represents a screening rate of 8% (40 out of 500). After the screening process, 440 questionnaires were deemed useable, representing an 88% response rate (440 out of 500). These 440 questionnaires were used finally. Overall, this survey achieved a response rate of 4% and a screening rate of 8%, resulting in an 88% useable rate. According to American Association for Public Opinion Research, a response rate of at least 60% is acceptable for most surveys. A 70% or higher response rate is particularly good (Dillman, D. A., Smyth, J. D., & Christian, L. M. 2014).

Table 2 showcases the demographic profile of the respondents in terms of gender, age, and educational level. The gender distribution reveals that 60% of respondents were male (264 individuals), while 40% were female (176 individuals). In terms of age, the participants were spread across various age brackets: 25% were aged between 18 and 24 years old, 40% were between 25 and 34 years old, 25% were between 35 and 44 years old, 7.5% were between 45 and 54 years old, and 2.5% were 55 years old or older. The educational background of the respondents was also diverse: 20% held a high school diploma, 13.6% had an associate degree, 36% possessed a bachelor's degree, 25% had a postgraduate (Masters) degree, 7% held a doctorate degree, and 3% had other types of educational qualifications such as professional certifications. The table highlights the diversity within the respondent sample in relation to gender, age, and education, offering valuable context for understanding the survey results.

In this Table 3, the *p*-values are above 0.05, suggesting non-significant paths from the latent factor to the variables, indicating no common method bias.

3.4 Utilizing SEM PLS and bootstrapping analysis with smartpls for robust model evaluation

We used the SEM PLS approach for analyzing the model. The benefits of utilizing Smartpls and SEM modelling with bootstrapping approaches for this study are numerous. Using Smartpls, the study evaluated the statistical significance of PLS-SEM outcomes such as path coefficients, Cronbach's alpha, HTMT, and R2 values, which are important indicators in assessing the strength of relationships between variables

TABLE 4 Descriptive statistics for constructs (N) = 440.

Construct	Items	Mean	Median	Min	Max	Standard deviation	Excess kurtosis	Skewness
Digitalization (D)	D1	3.83	4	1	5	1.222	−0.387	−0.829
	D2	3.43	4	1	5	1.27	−0.765	−0.569
	D3	3.71	4	1	5	1.155	−0.318	−0.712
	D4	3.55	4	1	5	1.172	−0.634	−0.522
	D5	3.68	4	1	5	1.198	−0.203	−0.808
	D6	3.62	4	1	5	1.202	−0.521	−0.629
Organizational Agility (OA)	OA1	3.82	4	1	5	1.281	−0.41	−0.863
	OA2	3.61	4	1	5	1.133	−0.227	−0.708
	OA3	3.58	4	1	5	1.143	−0.554	−0.508
	OA4	3.6	4	1	5	1.134	−0.671	−0.527
	OA5	3.68	4	1	5	1.15	−0.437	−0.65
	OA6	3.66	4	1	5	1.139	−0.343	−0.649
Organizational Culture (OC)	OC1	3.86	4	1	5	1.272	−0.237	−0.933
	OC2	3.59	4	1	5	1.166	−0.495	−0.618
	OC3	3.6	4	1	5	1.105	−0.312	−0.631
	OC4	3.72	4	1	5	1.124	−0.422	−0.661
	OC5	3.63	4	1	5	1.172	−0.536	−0.598
	OC6	3.66	4	1	5	1.075	−0.168	−0.71
	OC7	3.74	4	1	5	1.104	−0.344	−0.659
Technology Management (TM)	TM1	3.65	4	1	5	1.292	−0.643	−0.673
	TM2	3.63	4	1	5	1.157	−0.417	−0.634
	TM3	3.5	4	1	5	1.136	−0.576	−0.49
	TM4	3.64	4	1	5	1.104	−0.427	−0.588
	TM5	3.57	4	1	5	1.138	−0.551	−0.493
	TM6	3.66	4	1	5	1.105	−0.294	−0.66
	TM7	3.5	4	1	5	1.164	−0.57	−0.497
TQM performance (TQM)	TQM1	3.76	4	1	5	1.226	−0.449	−0.736
	TQM2	3.77	4	1	5	1.241	−0.475	−0.671
	TQM3	3.46	4	1	5	1.167	−0.558	−0.479

(Purwanto, Sudargini and Research, 2021; Sarstedt, Hair Jr, Cheah, Becker and Ringle, 2019). The bootstrapping approach used in the analysis allowed for robust and accurate estimation of standard errors, which helped to provide a more precise evaluation of the measurement and structural models. PLS-SEM is a flexible data analysis method that can be applied to small and large datasets. Its ability to be used for both exploratory and confirmatory research has contributed to its widespread adoption (Hair et al., 2011). In this project, we evaluate the potential use of the PLS-SEM method and Smart PLS 3 software. The first steps in analyzing the results of a PLS-SEM-based study are model measurement and structural model evaluation, which will be conducted once the data has been collected and analyzed. However, it is worth noting that a complete PLS-SEM analysis also involves assessing the data's quality and examining the model's stability and reliability, in addition to model measurement and structural model evaluation. The study also utilized mediation analysis in Smartpls to assess the mediation effect of organizational agility and the product indicator approach to evaluate the moderation effect. The product indicator approach was used since all the constructs in the model were reflective, and the moderation was run using a bootstrapping method with a one-tailed test. These methods are commonly used in SEM modelling and provide researchers with powerful tools to analyze complex relationships among variables.

TABLE 5 Factor loadings, cronbach alpha, CR, average variance extracted (AVE).

Constructs	Items	Statement	Loadings	α	CR	AVE
Digitalization (D)	D1	Provides sales force in the field with customer information	0.71	0.721	0.795	0.56
	D2	Assigns leads and prospects to appropriate sales personnel	0.72			
	D3	Provides customized offers to salespeople in the field	0.80			
	D4	Provides customers access to a knowledge base of solutions. To commonly occurring problems	0.79			
	D5	Schedules and tracks service delivery	0.76			
	D6	Can customize service scripts to customers' needs	0.72			
Organizational Agility (OA)	OA1	React to new product or service launches by competitors	0.74	0.75	0.841	0.515
	OA2	Introduce new pricing schedules in response to changes in competitors' prices	0.81			
	OA3	Expand into new regional or international markets	0.71			
	OA4	Adopt new technologies to produce better, faster, and cheaper products and services	0.74			
	OA5	Respond to changes in aggregate consumer demands	0.78			
	OA6	Switch suppliers to avail of lower costs, better quality, or improved delivery times	0.80			
Organizational Culture (OC)	OC1	The organization is employee focused	0.78	0.73	0.835	0.57
	OC2	The organization supports, empowers, and rewards their employees	0.81			
	OC3	The organization constantly reinforces the company's culture	0.73			
	OC4	Training is important within the organization	0.67			
	OC5	The organization treats mistakes as opportunities to learn	0.81			
	OC6	An organization where there is an entrepreneurial spirit among the managers	0.74			
	OC7	An organization where cultural diversity is a reality	0.72			
Technology Management (TM)	TM1	Have the organization the capacity and ability to perform technology Identification	0.65			
	TM2	Have the organization capacity and ability to perform Acquisition	0.64			
	TM3	Have the organizational capacity and ability to perform Exploitation	0.54			
	TM4	Have the organization capacity and ability to perform protection	0.74	0.723	0.806	0.60
	TM5	Have the organization capacity and ability to Learn about new technologies	0.72			
	TM6	Have the organization capacity to overcome the employee work burden with technology	0.81			
	TM7	Have the organization innovation strategy is clearly communicated to support engaged and effective participation for better performance and innovative outcome	0.83			
TQM performance (TQM)	QM1	Our plant has superior quality of product and service, compared to its competition in our industry, on a global basis	0.59	0.729	0.852	0.5
	QM2	Our customers have been well satisfied with the quality of our products, over the past 2 years	0.76			
	QM3	Our plant has superior customer relations, compared to its competition in our industry, on a global basis	0.77			

4 Results and discussion

4.1 PLS SEM measurement model

In this section, we present the measurement model for our study using Partial Least Squares Structural Equation Modeling (PLS-SEM). Table 4 provides descriptive statistics for the dataset, indicating that the measures used in the study have good psychometric properties. Table 5 presents the results of the factor analysis, which includes factor loadings, internal consistency reliability, composite reliability, and average variance extracted for each construct and its indicators. The results suggest that the constructs are reliable measures of the indicators used in this study. Table 6 shows the discriminant validity test using the Fornell-Larcker criterion, which establishes that the constructs are distinct and do not overlap or measure the same concept. These findings support the validity and reliability of the measures used in this study and provide a strong foundation for our subsequent analysis of the relationships between the constructs.

Based on the responses from 440 observations, Table 4 provides descriptive statistics for various constructs. The table contains the mean, median, minimum, maximum, standard deviation, excess kurtosis, and skewness for each construct item. Items D1 to D6 have mean scores ranging from 3.43 to 3.83 on the Digitalization construct, indicating a moderate level of digitalization. Similarly, the mean scores of items OA1 to OA6 within the Organizational Agility construct range from 3.58 to 3.82, indicating a moderate level of organizational agility. Items OC1 through OC7 on the

TABLE 6 Discriminant validity Fornell-Larcker criterion test.

Constructs	1	2	3	4	5
1. TQM performance	0.707				
2. Digitalization	0.391	0.789			
3. Organizational agility	0.373	0.527	0.715		
4. Organizational culture	0.38	0.455	0.545	0.756	
5. Technology management	0.388	0.562	0.502	0.5	0.776

Organizational Culture construct have mean scores ranging from 3.59 to 3.86, indicating a relatively positive organizational culture. Items TM1 through TM7 have mean scores ranging from 3.50 to 3.66 on the Technology Management construct, indicating a moderate level of technology management. The TQM performance construct yields mean scores ranging from 3.46 to 3.77 for TQM1 to TQM3 items, indicating a moderate level of TQM performance.

The skewness values range from −0.933 to −0.49, indicating a slightly negatively biassed distribution for most of the constructs, except for the Organizational Culture construct (OC1), which has a skewness value of −0.933. The excess kurtosis values range between −0.863 and −0.49, indicating a leptokurtic distribution for most constructs. The descriptive statistics provide a general overview of the distribution and central tendencies of the observed data for each construct.

Table 5 displays factor loadings, Cronbach's alpha, Composite Reliability (CR), and Average Extracted Variance (AVE) for each research construct. Items have loadings between 0.71 and 0.80 for the Digitalization (D) factor. The value of 0.721 for Cronbach's alpha indicates adequate internal consistency. At 0.795%, CR is trustworthy. With an average of 0.56, digitalization explains 56% of indicator variance. Organizational Agility (OA) factor loadings range between 0.71 and 0.81, indicating a moderate to strong association with the construct. The alpha value of 0.75 indicates strong internal consistency. CR = 0.841 represents dependability. The construct explains 51.5% of the variation in the indicator, which is slightly below the acceptable threshold of 0.50.

Organizational Culture (OC) factor loadings range between 0.67 and 0.81, indicating a moderate to strong association with the construct. The alpha value of 0.73 indicates strong internal consistency. CR = 0.835 demonstrates dependability. According to its AVE of 0.57, Organizational Culture accounts for 57% of indicator variance. Technology Management (TM) factor loadings range between 0.64 and 0.83. The Cronbach's alpha is 0.723, indicating that internal consistency is acceptable. CR = 0.806 represents dependability. Using an AVG of 0.60, Technology Management explains 60% of indicator variance. The TQM performance factor loadings range between 0.59 and 0.77, indicating moderate to significant associations with the construct. The value of Cronbach's alpha is 0.729, which indicates adequate internal consistency. CR = 0.852 suggests dependability. The AVE for TQM performance is 0.5, which meets the acceptable standard. Digitalization, Organizational Culture, and Technology Management all possess favourable factor loadings, reliability, and AVE. Nonetheless, the Organizational Agility construct falls slightly below the acceptable AVE level, indicating the need for additional research and measurement refinement.

Table 6 shows the findings of the Discriminant Validity Fornell-Larcker Criterion Test, which examines the distinctiveness of the study's conceptions. The lower triangle of the table shows the correlations between the constructs, while the diagonal shows the square root of the Average Variance Extracted (AVE) values from Table 5. The diagonal numbers for each construct represent the square root of the mean absolute deviation, which shows the proportion of variation explained by the construct itself. For TQM performance, the square root of the AVE is 0.707, indicating that the TQM performance construct explains 70.7% of the variance in its indicators. The correlations between the constructs are shown in the lower triangle. These correlations show the connections between two distinct constructs. A correlation of 0.527, for example, implies a relatively good association between Digitalization (Construct 2) and Organizational Agility (Construct 3).

The table depicts the constructs' discriminant validity. Correlations between constructs and their own indicators (diagonal elements) should be stronger than correlations between constructs and other constructs (off-diagonal elements). This demonstrates that the constructs are separate and measure different features of the event under investigation. The constructs have discriminant validity based on the values in Table 5 because the diagonal elements (square roots of the AVE) are stronger than the correlations with other constructs. This shows that the constructs are sufficiently distinct from one another to measure separate elements of the variables under consideration.

4.2 Evaluation of the inner structural model

The evaluation of the structural model was a critical step in the SEM analysis. Figure 2 depicts the output model showing direct relationships between exogenous and endogenous constructs. The evaluation process is comprised of 2 stages evaluating direct and indirect paths separately. In the first stage, we evaluated the inner model by examining the direct interaction of exogenous and endogenous constructs shown in Figure 2. The results showed that Digitization and technology management significantly impacted TQM performance in organizations. In the second stage, we evaluated the model's overall performance by including exogenous, mediating, and endogenous constructs shown in Figure 3. Figure 3 shows that all the paths were significant. These results are robust and provide valuable insights for researchers and practitioners alike.

Table 7 presents the results of the hypothesis testing using the SEM PLS approach for the proposed relationships between digitization, technology management, and total quality management performance. The results support hypothesis H1, which posits that digitalization has a positive and significant relationship with TQM performance. The direct path coefficient for digitization (D) to TQM is 0.251, with a standard deviation of 0.057 and a t-statistic of 4.397, which is significant at $p < 0.05$. This finding is consistent with previous research, suggesting that the implementation of digital technologies can positively impact various aspects of an organization, including quality management

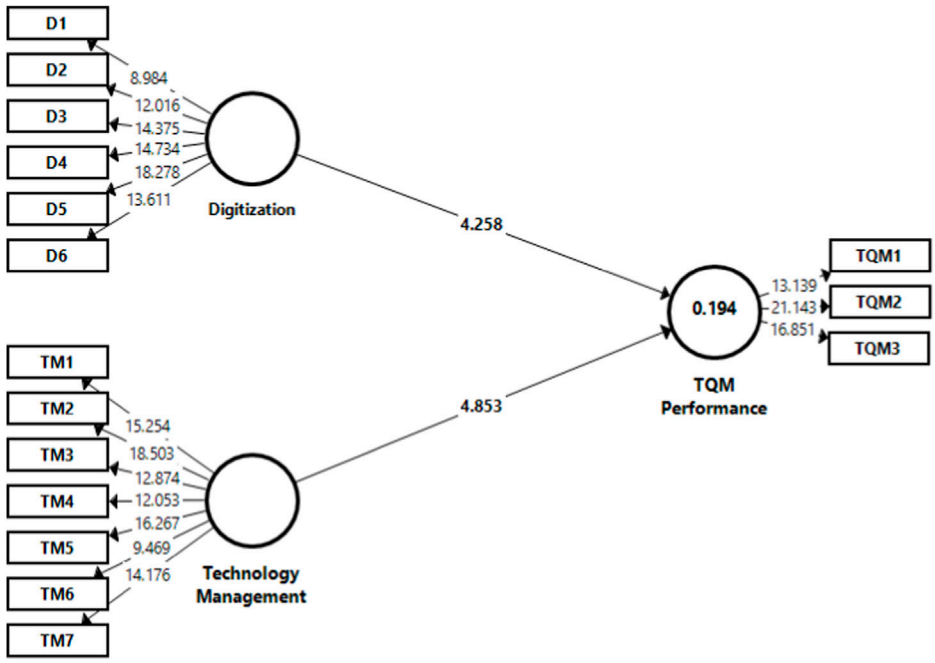

FIGURE 2
The direct impact of digitization and technology management on TQM performance.

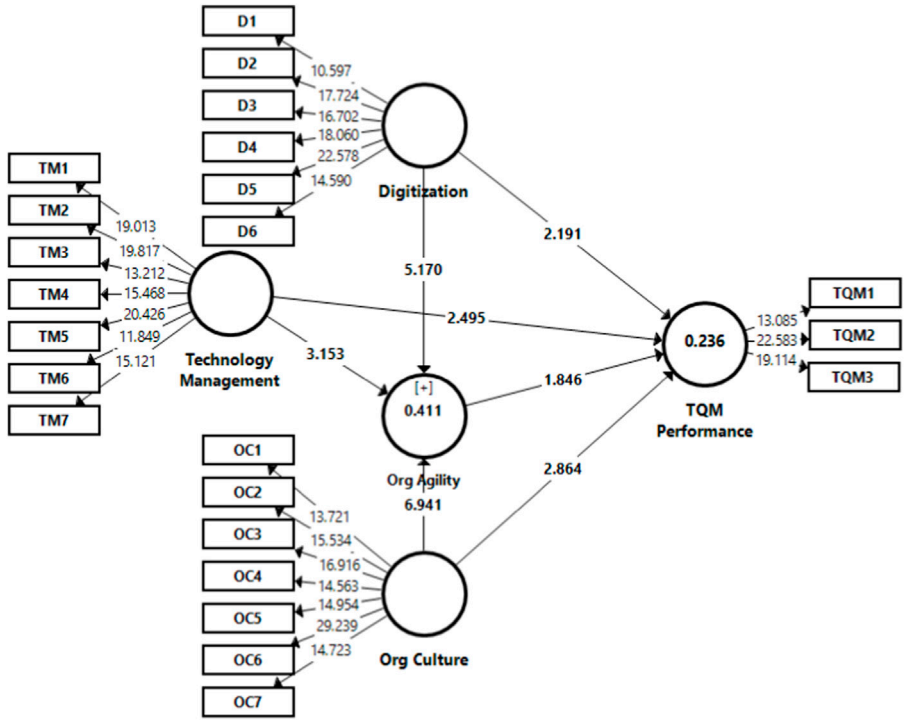

FIGURE 3
Mediating organizational agility between technology management, digitization, organizational culture and TQM performance.

(Bolatan et al., 2016). Similarly, the results also support hypothesis H2, which states that technology management positively and significantly affects TQM performance. The direct path coefficient for technology management (TM) to TQM is 0.261, with a standard deviation of 0.061 and a t-statistic of 4.217, which is significant at $p < 0.05$. Moreover, previous studies have found a

TABLE 7 Hypothesis outcome direct path.

Indicators	(M)	(STDEV)	T statistics	*p* values	Results	F-square	R-Square
H1. D > TQM	0.251	0.057	4.397**	0.001	Accepted	0.052	0.43
H2. TM > TQM	0.261	0.061	4.217**	0.001	Accepted	0.057	

Note. OA, organizational agility, D= digitization, TQM, total quality management performance; TM, Technology management.

TABLE 8 Results mediation analysis.

Path	(M)	(STDEV)	T statistics	*p* values	Result
H3. D - > OA- > TQM	0.533	0.041	13.81**	0.001	Mediation
H4. TM - > OA- > TQM	0.511	0.049	10.438**	0.001	Mediation

Note. OA, organizational agility, D= digitization, TQM, total quality management performance; TM, technology management.

TABLE 9 Moderation of organizational culture (OC).

Path	(M)	(STDEV)	T statistics	*p* values	Result
H5. Mod-OC-D* D - > TQM	0.005	0.054	0.109	0.000	Supported
H6. Mod-OC-TM* TM- > TQM	0.028	0.054	0.416	0.678	Not Supported

Note. OA, organizational agility, D= digitization, TQM, total quality management performance; TM, technology management.

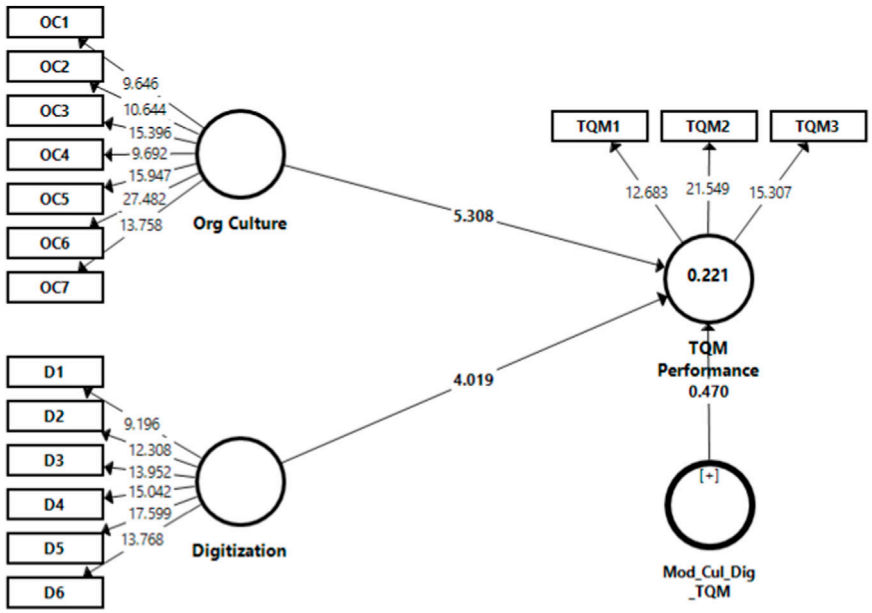

FIGURE 4
Moderation analysis of organizational culture between digitization and TQM performance.

positive relationship between technology management and digitization, suggesting that these two factors are mutually reinforcing (Kwahk, Lee, & management, 2008). In conclusion, the results from Table 7 indicate that both digitization and technology management are positively related to total quality management performance. This suggests that implementing digital technologies and effective technology management practices can contribute to the overall improvement of an organization's products or services in terms of quality.

Table 8 presents the results of a structural equation modeling (SEM) mediation analysis, examining the indirect effects of digitization (D) and technology management (TM) on total quality management (TQM) performance through the mediating variable of organizational agility (OA).

For hypothesis H3 (D> OA > TQM), the coefficient estimate is 0.533, with a standard deviation of 0.041, a t-value of 13.81, and a *p*-value of 0. This indicates a significant indirect effect of digitization on TQM performance through the mediating variable of

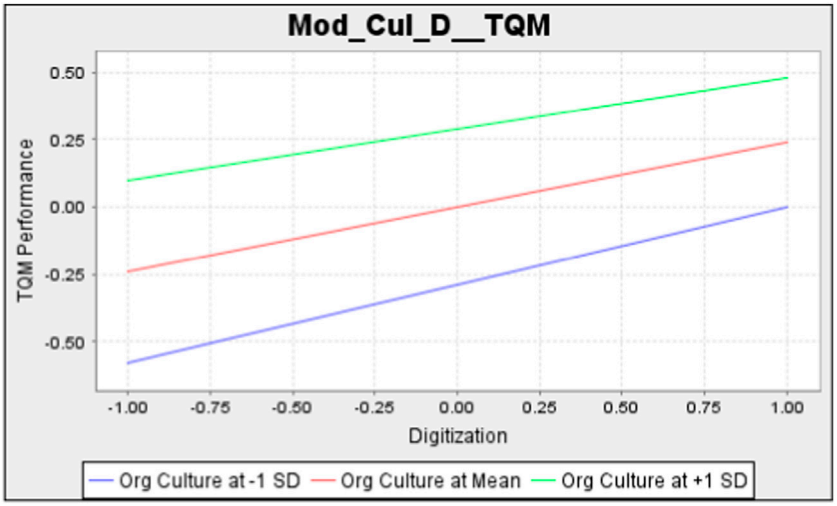

FIGURE 5
Graphical depiction of moderation of organizational culture between digitization and TQM performance.

TABLE 10 Model Fit indices.

Indices	Saturated model				Estimated model			
	Original sample (O)	Sample mean (M)	95%	99%	Original sample (O)	Sample mean (M)	95%	99%
SRMR	0.06	0.05	0.06	0.06	0.06	0.05	0.06	0.06
d_ULS	1.82	1.27	1.43	1.52	1.82	1.27	1.42	1.48
d_G	0.37	0.29	0.33	0.35	0.37	0.30	0.33	0.36

Note. 95% and 99% are the confidence intervals.

organizational agility. The mediation effect is significant at a high confidence level ($p < 0.001$), confirming that organizational agility fully mediates the relationship between digitization and TQM performance. For hypothesis H4 (TM > OA > TQM), the coefficient estimate is 0.511, with a standard deviation of 0.049, a t-value of 10.438, and a p-value of 0. This also indicates a significant indirect effect of technology management on TQM performance through the mediating variable of organizational agility. Similar to the first path, the mediation effect is significant at a high confidence level ($p < 0.001$), confirming that organizational agility fully mediates the relationship between technology management and TQM performance. In conclusion, this table provides evidence of the significant mediation effects of organizational agility on the relationship between digitization, technology management, and TQM performance. The results of this SEM mediation analysis align with previous research that found similar relationships between agility, digitization, and performance outcomes (Bolatan et al., 2016). These findings suggest that organizational agility is important in explaining how digitization and technology management affect TQM performance.

Table 9; Figure 4 present the results of the moderation analysis using organizational culture as a moderator variable. The results reveal that the interaction effect of organizational culture (OC) on the relationship between digitization (D) and total quality management performance (TQM) is significant (H5). The direct path coefficient between D and TQM is 0.005, with a standard deviation of 0.054 and a t-statistic of 0.109, which is significant at $p < 0.05$. This indicates that the relationship between digitization and TQM is strengthened when there is a higher organizational culture. Research has shown that an organizational culture can greatly impact the success of digital transformation efforts, and a culture that values innovation, flexibility, and adaptability can help support the adoption of new digital technologies (Innerhofer, Pechlaner, Borin and Entrepreneurship, 2018; Hussain and Papastathopoulos, 2022). Moreover, an organizational culture that emphasizes quality and continuous improvement can ensure that digital technologies drive positive change and enhance overall performance. However, the interaction effect of organizational culture on the relationship between technology management (TM) and total quality management performance (TQM) is not significant (H6). The direct path coefficient between TM and TQM is 0.028, with a standard deviation of 0.054 and a t-statistic of 0.416, which is insignificant at $p < 0.05$. This indicates that the relationship between technology management and TQM is independent of the level of organizational culture in the organization. In summary, the results suggest that organizational culture significantly strengthens the relationship between digitization and total quality management performance, highlighting the importance of promoting a culture that values quality and innovation when implementing digital technologies. However, the moderation effect

of organizational culture on the relationship between technology management and total quality management performance is not supported by the data.

Figure 5 shows the moderating effect of organizational culture between digitization and TQM performance. The output file shows that organizational culture significantly affects the organization's TQM performance with a linear relationship.

Table 10 presents the model fit indices for the saturated model and the estimated model, with the original sample (O) and the sample mean (M) values. The model fit indices provide information on how well the model fits the data. The first index, SRMR (Standardized Root Mean Square Residual), measures the average discrepancy between the sample covariance matrix and the model-implied covariance matrix, standardized by the square root of the average variance of the observed variables. In this study, the SRMR values for both the saturated and estimated models are 0.06, which indicates a good model fit according to Hu and Bentler (1999) guidelines. The second index, d_ULS (unweighted least squares), is a measure of the model's goodness of fit, with smaller values indicating better fit. The d_ULS values for both models are 1.82, which are above the sample mean of 1.27, suggesting that the estimated model has a poorer fit than the saturated model. The third index, d_G (geodesic discrepancy), measures the difference between the geodesic distances in the model and the observed data. Lower values indicate a better fit. The d_G values for both models are 0.37 and 0.30, respectively, which are lower than the sample mean of 0.33, indicating a good fit for both models. Overall, the SRMR values suggest a good fit for both models. However, the d_ULS values indicate that the estimated model has a poorer fit than the saturated model. The d_G values indicate a good fit for both models.

5 Conclusion

In conclusion, this study highlights the important role of digitalization, technology management, and organizational agility in achieving total quality management (TQM) success. The results show that digitalization and technology management are important sources of information for achieving TQM performance. The findings of this study are consistent with previous research that has highlighted the importance of digital transformation, technology management, and organizational culture in driving successful quality management initiatives. Moreover, the finding that organizational agility mediates the relationship between digitalization, technology management, and TQM performance is consistent with previous research that has emphasized the importance of agility in driving successful digital transformation initiatives. The study also highlights the importance of developing and supporting the corporate culture in digitalization and technology management. This is consistent with (Leso, Cortimiglia, Ghezzi and Work, 2023), who found that organizational culture plays a critical role in digital transformation initiatives. This study provides important insights into the relationship between digital transformation, technology management, organizational agility, and TQM performance. The findings suggest that businesses need to focus on enhancing digital transformation, technology management, and organizational agility while promoting a culture of agility to achieve TQM success.

The academic contributions of this study lie in its contribution to the literature on total quality management (TQM) and the role of digital transformation, technology management, and organizational agility in driving successful quality management initiatives. Specifically, the study highlights the importance of digitalization and technology management in achieving TQM success and the mediating role of organizational agility in this relationship. The study adds to the existing body of research that has emphasized the importance of digital transformation, technology management, and organizational culture in driving successful quality management initiatives. Moreover, the study contributes to the literature on the role of organizational culture in digital transformation initiatives, emphasizing the importance of simultaneously developing and supporting the corporate culture in digitalization and technology management. This study's findings provide important insights for businesses looking to improve their TQM performance by enhancing digital transformation, technology management, and organizational agility. These insights are particularly relevant for service sector businesses in Pakistan, which face challenges in terms of quality management, environmental sustainability, and digital transformation. By incorporating the findings of this study into their operations, service sector businesses in Pakistan can enhance their performance and become more competitive. Overall, this study's contributions to the literature provide important insights into the complex relationships among digital transformation, technology management, organizational agility, and TQM performance. The study's findings emphasize the importance of simultaneously addressing these factors and promoting a culture of agility to achieve TQM success.

This study's novelty lies in identifying the critical role played by digitalization, technology management, and organizational agility in achieving total quality management success. The study provides important insights into the relationship between these constructs, highlighting the need to simultaneously develop and support corporate culture in digitalization and technology management. While previous studies have emphasized the importance of digital transformation, technology management, and organizational culture in driving successful quality management initiatives, this study specifically highlights the mediating role of organizational agility in the relationship between digitalization, technology management, and TQM performance.

The study on Total Quality Management (TQM) performance in the service sector in Pakistan focuses on the role of digitalization, technology management, organizational agility, and organizational culture in achieving TQM success. The findings contribute to the existing literature by emphasizing the importance of digital transformation and technology management in achieving TQM performance, and by extending previous research on the role of organizational agility as a mediator between digitalization, technology management, and TQM performance. Moreover, the study highlights the critical role of organizational culture in digital transformation and technology management, aligning with existing research while presenting a novel focus on simultaneously developing both corporate culture and technology management. These findings have important implications for the service sector in Pakistan, which is rapidly growing and an essential contributor to

the nation's economy. However, the sector faces challenges in quality management, environmental sustainability, and digital transformation.

Businesses in the service sector can improve their performance by emphasizing digitalization and technology management, enabling them to streamline operations and enhance TQM performance. Additionally, encouraging organizational agility can help businesses adapt to the rapidly changing market environment and respond effectively to customer needs. Furthermore, promoting a culture of quality and sustainability is essential for long-term success, especially given the increasing environmental challenges. Incorporating environmental management practices into business operations is also necessary to address concerns regarding climate change and environmental degradation. By applying these insights, businesses in Pakistan's service sector can develop strategies that simultaneously address quality management, digital transformation, and environmental sustainability, thus contributing to their long-term success and resilience.

The findings underline the importance of digital transformation and tech-savvy management in enhancing Total Quality Management (TQM) performance, with organizational agility playing a mediating role, and culture a moderating one. Additionally, it highlights the relevance of environmental economics and management practices for overall quality performance. The study's application of Partial Least Squares Structural Equation Modeling (PLS-SEM) adds a novel perspective to similar research areas. Finally, by focusing on Pakistani businesses, it provides valuable theoretical implications for understanding business practices and quality management in developing economies.

The area for future research could be to explore the digital technologies and tools that are most effective in supporting TQM performance, as well as the mechanisms through which these technologies impact quality management processes and outcomes. In addition, future research could explore digitalization's potentially negative environmental impacts, particularly regarding electronic waste and energy consumption. Further investigation is also needed to understand the role of organizational culture in driving successful digital transformation and TQM initiatives and how this can be effectively developed and supported. Finally, more research is needed to identify effective strategies for managing the potential challenges and drawbacks associated with digitalization and technology management, such as data privacy and security concerns and the high costs of technology adoption for small and medium-sized enterprises.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Author contributions

MI conceptualized the idea. ZB collected data and wrote the first draft. MI and ZB analyzed the data and wrote the final draft. All authors contributed to the article and approved the submitted version.

Conflict of interest

DF was employed by the China Automotive Technology and Research Center Co., Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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