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Implementation of Quality Management Practices and Firm's Innovation Performance: Mediation of Knowledge Creation Processes and Moderating role of Digital Transformation

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ABSTRACT

Presently, Industry 4.0 (I4.0) revolution is transforming operations and businesses of organizations through technological advancements.These digital technologies are hugely impacting the technological innovations (TIs) and execution of total quality management (TQM) in the organizations. Existent literature on TQM and firm's innovation performance (IP) relation has shown mixed findings exclusively, in manufacturing companies. Desptie strategic significance of both TQM and innovation (INN) to improve sustainable competitive gain, this is an under-researched area in I4.0 context. Additionally, the Quality 4.0 is also new concept and role of I4.0 tchnologies in transformation of trational TQM function hasn't been researched so far. Despite strategic significance of role of knowledge creation processes (KCPs) towards firm's IP and performance in I4.0, there is dearth of research addressing integrative framework TQM, KC and IP exclusively in progressing country context. Considering these prevailing gaps in literature, current study is an attempt to develop and test a model in context of Pakistan in relevance to I4.0. The proposed framework examines the influence of executing quality management or QM practices (QMP) on innovation performance (IP). Additionally, mediating role of knowledge creation processes (KCPs) and moderation of digital transformation (DIT) is also explored in QMP-IP relation. Data of 265 respondents were obtained from ISO 9001 certified manufacturing firms of Pakistan through structured questionnaire on Likert Scale. Data were analysed through SPSS 23.0 and Hayes process macro applying statistical tests (reliability, correlation, and regression analysis). Study results revealed that all variables were positively correlated. Quality management practices (QMP) had positive and significant impact on firm's IP. Results supported partial mediation effect of organizational knowledge creation processes (KCPs) in QMP-IP relationship. While, moderating impact of digital transformation (DIT) in QMP-IP relation was also supported. Study findings has implications for both and academia, management and practitioner. This study contributes to prevalent literature as it empirically tests a proposed framework to address under-researched area of QMP- IP relation in relevance to DIT and KCPs in Pakistan context and I4.0.

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1. Introduction

Total quality management (TQM) is described as, the system of management which appraises quality as the strategy of business. It is directed towards satisfying a customer

through engagement of entire members of the organization from leadership to workforce. It relates to generating a culture of quality, which enables organizational workforce to satisfy its customers (Yusuf, 2023). TQM is company-wide integrative philosophy aimed at continually improving product, service, or process quality to fulfil expectations of the customer (Al-Ali & Abu-Rumman, 2019). Both TQM and QMP are being applied for a long duration in the firms (Al Shraah, Abu-Rumman, Al Madi, Alhammad, & AlJboor, 2022). TQM had been initially applied in generally manufacturing sector, but afterwards it also recognized among the most crucial criterion to gain competitive gain in service industry and other fields or disciplines as well (Niyi Anifowose, Ghasemi, & Olaleye, 2022). It has extensively been known operational philosophy and the main driving factor to attain organizational competitive gain in a market (ul Hassan, Mukhtar, Qureshi, & Sharif, 2012). Quality management or QM practices (QMP) provide support in applying set of tools and managerial concpets with an objective of engaging both workforce and management to achieve consistent improvement in performance. Nimfa, Latiff, and Wahab (2020) defines innovation (INN) as, commercializing the novel ideas. Innovation (INN) also refers to adopting, generating, or incorporating a novel conception in services or goods, managerial methods, or work processes (Niyi Anifowose et al., 2022). For a longer duration, Innovation has been identified as a crucial determining factor for sustainable growth and competiveness in a business (Fan, Zhao, Zhang, Wang, & Shao, 2023). United Nations (UN) SDG 9 focuses on fostering innovation in entire sectors of the economy. Empirical research reveals that TQM has capability to act as a vigorous foundational resource, which reinforces firm's innovation performance (Ahinful, Opoku Mensah, Koomson, Nyarko, & Nkrumah, 2023).

Despite being district disciplines, both TQM and innovation (INN) have similarities in many aspects (like standardization, human, technological, and organizational). Exclusivley, this relation hasn't been well applied and documented in the literature (Naidoo & Govender, 2023). Several scholars Martínez-Costa, Jiménez-Jiménez, and Dine Rabeh (2019); Ooi, Lin, Teh, and Chong (2012); Sadikoglu and Zehir (2010) have supported TQM-innovation relationship (Al-Sabi, Al-Ababneh, Masadeh, & Elshaer, 2023). Demand for knowledge creation (KC) is growingly being considered a necessity for companies, as their businesses are adjusting to constantly rapid market turbulence and technological advancements. KC is recognized as the catalyst in I4.0 to remain competitive in the world. Future of organization's business is relied upon KC to sustain competitive gains (Tung, Dorasamy, & Ab Razak, 2022). According to Nonaka and Takeuchi (1995), innovation and competitive gain are stemmed from KC in the organizations (Rattanawichai, Wiriyapinit, & Khlaisang, 2023). Companies adapting strategic KC have potential to achieve innovativeness and advance their processes. Hence, KC-Innovation relation has huge impact on product innovation and firm's processes (Alshanty, Emeagwali, Ibrahim, & Alrwashdeh, 2019). Grimsdottir and Edvardsson (2018) also point out that organizations can view KC as initial stage for both innovation and KM. While, few researchers argue that process of KC exclusively results in radical innovation (Alqahtani, Hawryszkiewycz, & Erfani, 2023). Both TQM and processes of KM have drawn attention of researchers due to their huge impact on strategic competitiveness of the organization. But, majority of relevant research is lacking adequate empirical support for relation in above constructs (Yusr, Mokhtar, Othman, & Sulaiman, 2017). Honarpour, Jusoh, and Md Nor (2018) pointed out that organizations can see TQM as a significant resource or dominant setting. Companies can utilize it to enhance processes linked with knowledge towards the innovation. Marchiori and Mendes (2020) argue that companies can bring innovation through effectively using knowledge and paying more attention to the TQM (Barua, 2021).

Digital Transformation (DIT) is a change and disruption process, wherein value is created by the companies utilizing the strategic responses (Deroncele-Acosta, Palacios-Núñez, & Toribio-López, 2023). DIT is bringing the wave of transformation in all industries and countries of the world through application of digitalized technology to stimulate superior quality development, exclusively related to sustainable organizational objectives (L. Wang & Yan, 2023). Digital technologies (like IoT, big data) are producing deep impact on organizational processes, activities, and directing towards modification in mechanisms of value delivery and creation (Ancillai, Sabatini, Gatti, & Perna, 2023). In management research, more attention is being paid to Innovation as it is a key tool to attain sustainable growth. Hence, it is highly valuable to investigate effect of DIT on innovation (Chen & Kim, 2023). DIT is recognized as the main drive to stimulate firm's technological innovation (TIN). Organizations

can use DIT as the external motivator to encourage TIN, which is internal requirement of companies to realize DIT (H. Liu, Wang, & Li, 2021). Only few researched have directly investigated association between DIT and innovation (Chen & Kim, 2023). Quality 4.0 (Q4.0) is emergent theme which aligns QM practices with I4.0 emerging competencies of improving efficiency, time, and refines quality of product (H.-C. Liu, Liu, Gu, & Yang, 2023). Q4.0 is referred to future of both quality and excellence in the organization which narrowly aligns with I4.0. It assures performance, efficiency, integrates technology and data to utilize for employee's innovativeness and enhances performance in terms of quality (ASQ, 2022; Suhaimi, Mustapha, & Shaik, 2023). Currently, Q4.0 is in originating development phase. Q4.0 has been utilized to integrate I4.0 features with QMP. In simple words, it is integration of conventional QM approaches with advanced technologies (of I4.0) which results in new optimum levels in product/service quality (Zulfiqar et al., 2023). Above arguments reveal that QMP, KCPs and DIT are crucial antecendents of firm's IP in I4.0 era.

1.1. Research Gaps, Research Problem, Study Objectives, and Significance

Expectations of the consumer regarding quality have increased in present years. This forces (both manufacturing and service sector) companies for adapting practices or principles of TQM and fulfil promptly demands of the consumer. But, earlier research studies to examine performance effects of QMP have mostly paid attention to firms' financial performance in manufacturing companies (Acquah, Quaicoe, & Arhin, 2023). Literature is evident that preceding researches on TQM and firm's innovation performance (IP) association have revealed mixed results (Shuaib & He, 2023). Nonetheless, few researchers have pointed out unclear link between QMP-IP relations (Masrom, Daut, Rasi, & Lo, 2022). Despite inconsistent research findings in the literature, researchers argue that various QMP (like customer focus, leadership) support organizational innovation (García-Fernández, Claver-Cortés, & Tarí, 2022). Though, many researches addressing TQM and IP relation in diverse industries have shown substantial disagreement, exclusively in manufacturing firms (Arrfou, 2019). But, researchers show consensus on significance of this area, and plenty of space is present in this domain for further research. As only few researchers have addressed this relation, and TQM impacts towards innovation is under-researched area in literature Jiménez-Jiménez, Martínez-Costa, and Para-Gonzalez (2020); Yusr et al. (2017), which needs to be explored further (García-Fernández et al., 2022). One of the reason for inconsistent findings is that majority of researches conducted on this association have suggested direct association, and neglect prospective variables which would also impact this relation (Escrig-Tena, Segarra-Ciprés, García-Juan, & Beltrán-Martín, 2018).

The major gap in literature which hasn't been addressed TQM and IP domain, is considering prospects of I4.0 and Q4.0. Although, many researches point out significance of current revolution of digital technology, but evidence is limited regarding digital transformation (DIT) support in firm's performance .Only few researches have investigated Q4.0 elements which support or obstruct DIT. But, studies on QMP- IP relation are recent someway and less wide-ranging as compared to investigating QMP and firm's performance relational studies (Al-Sabi et al., 2023; Long, Abdul Aziz, Kowang, & Ismail, 2015). Saihi, Awad, and Ben-Daya (2023) argue that more research studies are required to address the integration and mapping of QMS: 9001 and features of I4.0. Despite several researches addressing QMP-IP relation in manufacturing context, there is dearth of research in prevalent literature to address this relationship. Presently, I4.0 revolution will drive strategic progress with focus on investment towards innovative capabilities and firm's performance, while using practices of TQM effectively (Naidoo & Govender, 2023). A firm may attain improved operational performance by incorporating smart technology developments. The literature reveals the prospective advantages of I4.0 in total quality management (TQM). But, empirical evidence is lacking in support of such arguments (Mushtaq, Akhter, & Nadeem, 2022). Finally, earlier studies which addressed TQM, KC and organizational performance in integrative models were mostly conducted in context of progressed countries. Thus, progressing country context was missing focus and also didn't explore findings of execution in relevance to organizational performance enhancement. Considering prevailing competitive industrial context, understanding integrative nature and role of TQM-KM in the organization is much needed (Barua, Zaman, & Urme, 2020). Many arguments suggest the crucial role played by KC in firm's competitive gain. From perspective of resource advantage, knowledge is tacit and transferability or dissemination is difficult. Hence, KC is required by organizational business to

generate innovation to translate its resources of knowledge into sustained competitive gain (Yu, Zhang, Lin, & Wu, 2017).

Regardless of numerous studies addressing KM-Innovation relation, researches explaining above association are scarce in progressing county perspective (Teixeira, Oliveira, & Curado, 2020; Turulja & Bajgorić, 2020). According to R. Y.-Y. Hung, Lien, Fang, and McLean (2010), despite the fact that KM impact on Innovation is prevalent in related literature, this evidence is yet not strong enough to be concluded. Hence, re-investigation of KM influence on firm's IP would provide a firm basis to facilitate decision-making bodies in answering the crucial question "how to transform their firm into an innovative company (Yusr et al., 2017). Additionally, most of the appraisals and evaluations executed in context of Pakistan, ninety percent (90%) didn't pay attention on executing the TQM models to evaluate industrial competitiveness and progress in Pakistan. Existent evaluations predominantly paid attention to apply financial models to appraise overall performance. But, completely relying on these models to appraise isn't sufficient. Hence, the integration of TQM models with financial is much needed to understand effectiveness of manufacturing and construction companies in Pakistan (Zafar, Arshad, & Siddique, 2023). Considering above gaps in literature, current study was conducted with the aim of proposing and testing a conceptual model addressing execution of QMP and firm's IP in ISO 9001 certified manufacturing firms in Pakistan context. It also examined mediating role of KCPs and moderating of DIT in relevance to I4.0 and Q 4.0. It was conducted with following key objectives:

1. To explore whether execution of TQM and its practices (QMP) hinder or foster firm's innovation g performance (IP).
2. To investigate whether organizational knowledge creation processes (KCPs) have mediating effect between QMP and firm's IP relationship.
3. To investigate whether digital transformation (DIT) has moderating effect between QMP and firm's IP relation.
4. To propose and empirically test a model considering above constructs to address TQM and innovation relationship in Pakistan context.

This study is significant form academicians, management and practitioner perspective. As it proposes and empirically test a comprehensive model to address debatable TQM and Innovation relationship. The research findings will provide insights regarding execution of TQM practices to attain enhanced innovation performance (IP) by considering important factors like digital transformation, KCPs in Industry 4.0 digital era. As integrating TQM and I4.0 to enhance firm's IP would open novel debatable gaps and research areas among academicians. Furthermore, it would also facilitate them to assess the effect of diverse I4.0 dimensions on both total quality management (TQM) and firm's IP in Pakistan (Mushtaq et al., 2022).

2. Literature Review and Hypotheses Formulation

2.1. Total Quality Management and Quality Management Practices

Total Quality Management (TQM) has been recognized as an integrated philosophy of management which aims at enhancing product and process quality to satisfy the customer (Vuppalapati, Ahire, & Gupta, 1995). Quality management or QM practices (QMP) are the set of procedures and techniques which companies apply applied to assure that products/services meet or exceed expectations of its customers (Al-Sabi et al., 2023). QMP are described as arrangement of activities which engage entire manpower in quality processes with the objective of continuously improving techniques and operations of production to assure client satisfaction and zero defect level (Kumar, Sharma, Verma, Lai, & Chang, 2018). Organizations implement QMP to enhance the prospects of organizational survival. This objective is achieved through integration of continual improvement and quality into firm's strategic primacies (Lehyani, Zouari, Ghorbel, Tollenaere, & Sá, 2023). Different researchers have given different classification of QMP and most famous is soft and hardQMP. 'Soft QM' focuses upon engagement of workface, market-leadership comparatives, and partnerships. Soft elements encourage human factors and develop systems of quality to enable organizations in adjustment to environmental turbulence and continual improvement. While, hard QM which is mechanistic, it focuses upon conformity, discipline, and stability. These practices also include processes like SPC and job design. 'Hard QM' are related to controlling product/process which confirm to standards, uniformity, and specification of manufacturing (Patmawati, Dewi, &

Asbari, 2023). Literature recognizes various QM practices which include, leadership and management support, employee engagement,, customer's focus, continuous improvement , Information and data Management; and process management (Al-Ali & Abu-Rumman, 2019; Alshourah, 2021; Hussain, Alsmairat, Al-Maaitah, & Almrayat, 2023; Sawaean & Ali, 2020). As a result of growing awareness of consumers regarding quality, companies are adopting practices of QM (which is a pervasive phenomenon) to continually improve in fast-moving industries (Sawaean & Ali, 2020).

2.2. Innovation and Innovation Performance

Innovation is recognized among the key driving factors for economic development and productivity in the business. It includes knowledge transformation to novel products/services/processes (Patmawati et al., 2023). Innovation is defined by various scholars Daugherty, Chen, and Ferrin (2011); Zawawi et al. (2016) as a concept/idea, objective or practice, which a person perceives as 'new' or any other adopting unit (Chib & Sehgal, 2019). It is recognized one of the most crucial capability of the company to sustain competitive gain (Castaneda & Cuellar, 2020). Guler and Nerkar (2012) define firm's innovation performance (IP) as an improvement in organizational productivity which shows as an outcome/output once resources of firm are introduced as an input into the system of innovation (Y. Wang et al., 2023). Porter (1990) considers innovation (INN) among the critical factors for effectual operational results in the organization (Rattanawichai et al., 2023). Literature recognizes various types of innovations. OCDE (2005) segregates innovation into 4 classes including process, product, organizational, and marketing innovation. Henderson and Clark (1990) segregated innovation as radical and increment. While, Nelson and Rosenberg (1993) classified as non- technological and non-technological innovation (Castaneda & Cuellar, 2020). Non-technological include organizational and marketing types. While, technological comprises of product and process types (Yu et al., 2017). Current study only considers technological innovations. As companies are struggling to search various approach to attain competitive gain in current age. Hence, Innovation has been recognized as a crucial pre-requirement for sustainable gain in the competitive market (Chib & Sehgal, 2019). Due to accelerated worldwide integrated processes, external surrounding of organizations has become more dynamic and complex. Hence, organizations are required to progress and survive in intense market competitiveness through generating innovation (Fan et al., 2023).

2.3. Association between Execution of Quality Management Practices and Innovation Performance

Both TQM and innovation (INN) constructs are known worldwide to improve competitive gains, performance, and literature revealed presence of positive correlation between these constructs (Naidoo & Govender, 2023). Previous studies Mushtaq and Peng (2020); Yusr (2016) support that QMP can largely be observed as the basis to innovate the business, and hence directing towards enhanced sustained competivementss and performance. Literature (on subject of TQM and firm's innovation relation) includes research studies highlighting that few scholars have stumbled at the TQM-innovation relationship. While, few consider that TQM is a hurdle for firm's innovation (Lebedeva, Yakovlev, Kepp, & Ikramov, 2019). A vital reasoning for contradictory study findings and research results (regarding TQM-Innovation relation) is the difference in way to operationalize, conceptualize or/and research technique (Gambi, Lizarelli, Junior, & Boer, 2020). There are few studies in the literature that analyse the relationship between TQM and innovation empirically. However, Researchers like Singh and Smith (2004) didn't identify positive association between TQM-Innovation relations in manufacturing companies of Australia Martinez-Costa and Martínez-Lorente (2008). Proponents of this negative view argued that TQM confines firm's innovativeness to fulfilling organizational current customers' needs or to the incremental innovations only. Proponents of negative view argue that standardization involved in execution of TQM becomes an obstacle for firms' innovativeness (Bathaei, Awang, & Ahmad, 2021; Butt & Yazdani, 2021; Escrig-Tena et al., 2018; Kim, Kumar, & Kumar, 2012). Contrary to this, few authors argue that techniques of QM positively associate with firm's innovations (Lebedeva et al., 2019). Several scholars Antunes, Mucharreira, Texeira Fernandes Justino, and Texeira Quirós (2018); Arrfou (2019); Jiménez-Jiménez et al. (2020); Taddese (2017); Yusr et al. (2017) emphasise on significance of executing QMP to promote environment of innovativeness in order to launch new product/service development (García-Fernández et al., 2022).

Several research studies Aoun and Hasnan (2013); R. Y. Y. Hung, Lien, Yang, Wu, and Kuo (2011); Zehir, Müceldili, Zehir, and Ertosun (2012) have confirmed that practices of QM (QMP) and firm's IP are positively associated (Thuy & Hue, 2023). While, recent research studies also support positive and significant impact of QMP on firm's IP. For example, Lizarelli, Toledo, Gambi, and Gonçalves (2023) study in Brazilian manufacturing firms identified significant effect of process continuous improvement on firm's IP. Lim (2023) analyzed soft QMP and firm's innovation (INN) relation along with mediating role of knowledge sharing (KS), Data was collected from 222respondents of manufacturing companies. Result indicated higher positive and significant impact of soft QMP on innovation and KS. Gambi et al. (2020) examined impact of QMP (hard and soft) on IP by utilizing data from132 manufacturing firms of Brazil. Their findings supported that soft QMP had positive and significant impact of IP via practices of innovation. Shuaib and He (2023) study results in 459 Nigerian manufacturing firms also indicted that both types of QM practices (soft and hard) had positive and significant relation with firm's innovation. Naidoo and Govender (2023) research on companies in South Africa identified positive and significant association between QMP (leadership, strategy, people management, customer focus, strategy) and firm's IP. Thi et al. (2023) research study in Veitnam context also revealed an association between Practices of QM and IP. From above arguments and support from the literature, following hypothesis is formulated.

H1: There exists a positive and significant association between implementation of quality management (QM) practices and firm's innovation performance (IP).

2.4. Mediating Role of Knowledge Creation Processes (KCPs) in QMP and IP Relation

According to Payne and Huffman (2005), knowledge creation (KC) in the organization is the process of individual knowledge amplification and conversion to the organizational knowledge. It takes individual knowledge and connects it to the organizational system of knowledge (Talaskou & Belhcen, 2019). Processes of knowledge and their dynamics are representative of a foremost research theme in discipline of management. The interpretation of the diverse techniques and tools facilitate knowledge generation/creation which has significance to attain innovation in the organizations (Canonico, De Nito, Esposito, Iacono, & Consiglio, 2020). Nonaka and Von Krogh (2009) consider knowledge as an input and a crucial enabler for innovation (Woodfield & Husted, 2022). Knowledge results in creating novel or Innovative products/services to fulfil competitive demands of the consumers. Organizational capability of exploiting tacit knowledge of its workers and consumers' knowledge can generate novel products/services. Tacit form of knowledge is critical factor for creating novel products/services (Jayasekera, Ahmad, & Azam, 2022). Innovation (INN) is primarily dependent upon new knowledge generation/creation in the organization Chib and Sehgal (2019). According to Nonaka and Takeuchi (1995), procedure of innovative activities in organization takes places through interplay and transformation between tacit and explicit mode of knowledge. Such transforming of knowledge is called knowledge creation process or KCP. Review of literature discloses that process of KM has origin in KCP, which is also called SECI process/model. This process stimulates innovation behaviour in the organization, and also recognized as main driving factor for innovation and competitive gain (Rattanawichai et al., 2023). SECI is fundamentally recognized as the framework of innovation which describes the process of value creation in the organization (Nonaka & Yamaguchi, 2022).

In SECI process/model, two types of knowledge (explicit, tacit) and new knowledge creation/generation occurs as a result of interplaying between these two modes of knowledge. 'Explicit' articulates by means of language in form of manuals and particular action. While, 'Tacit' embedded in form of personal experience involves intangible characteristics like values and beliefs. Such interplay between two modes structures in 4 conversion processes of knowledge which include: socialization, externalization, combination, and internalization (Woodfield & Husted, 2022). Several research studies recognize knowledge generation/creation as the basis and precedent of firm's innovation Rattanawichai, Wiriyapinit, and Khlaisang (2022). Alshanty et al. (2019) examined mediating role of KCPs between capability for market sensing and product/process innovation by obtaining data of 304 employees from Jordan SMEs. Findings supported mediation role of KCPs and also revealed a positive impact of KCPs on both types of innovations. From the theoretical standpoint, both TQM and KC disciplines have numerous differences and commonalities. Hence, organization

can complimentarily adopt both TQM and KC (Mas-Machuca, Marimon, & Malbašić, 2020). According to Asif, de Vries, and Ahmad (2013), diverse knowledge can be generated or created through QMP (like process management, continuous improvement, customer's satisfaction). Such knowledge is created/generated by interplay between tacit and explicit modes which results in 4 KCPs. KC occurs at all organizational levels and is foundation of exploration in the firms.Barua (2021) examined impact of QM on KCPs by obtaining data of 450 managerial employees of the organization in Bangladesh. Findings of empirical investigation revealed significant and positive association between few QMP practices (like leadership, customer focus, employee empowerment, IT) and knowledge creation in the organizations.

Yusr et al. (2017) study results from 800 manufacturing firms in Malaysian context supported that QMP had significant and posit impact on KM processes. Jayawarna and Holt (2009) study results also identified that QMP increased creation and transformation of the knowledge in R and D setting (Honarpour et al., 2018). Research findings by Mas-Machuca, et al. (2020) also revealed that QM and KC had positive and significant effect on firm's performance. Shan, Zhao, and Hua (2013) research study on Chinese Aviation firms concluded that few QM practices (like design of product, employee's training) had significant effect on KCPs in the organization. Al Shraah et al. (2022) empirical investigation of Jordan companies also revealed that practices of QM had significant effect on organizational KM processes. From above arguments and support from the literature, following hypotheses are formulated.

H2: There exists a positive and significant association between implementation of quality management (QM) practices and knowledge creation processes (KCPs) in the firms.
H3: There exists a positive and significant association between knowledge creation processes (KCPs) and firm's Innovation performance (IP).
H4: knowledge creation processes (KCPs) have mediating effect in association between implementation of QM practices and firm's innovation performance (IP).

2.5. Moderation of Digital Transformation in QMP and IP Relation

According to Vial (2019), digital transformation (DIT) is a process where organizations react to emergent environmental changes through digitalized technologies to produce innovative ways of creating value. Companies outline DIT as a related structural modification in the direction of technologies like cloud computing and big data (L. Wang & Yan, 2023). Current industrial revolution, I4.0 has opened up prospects for digitalized transition. AI, IoT, data mining, cloud computing, cyber security, E-commerce are important domains in I4.0 (Tung et al., 2022). Along with organizational digital transformation (DIT), I4.0 has also transformed QM through application of technology to manage quality effectively (Bag, Gupta, & Kumar, 2021; Zulfiqar et al., 2023). The new paradigm of quality management (QM), Q4.0 focuses on adoption of latest technologies by upgrading conventional approaches of quality. For example, application of big data to obtain consumer's perception and insights (Amat-Lefort, Barravecchia, & Mastrogiacomo, 2023). Q4.0 is referred to applying technology of I4.0 in systems and techniques of QM. Q4.0 is considered as the sub-set of I4.0 with objective of quality improvement, cost reductions, and refinement of operational efficiency in terms of quality (Suhaimi et al., 2023). Jacob (2017) coined Q4.0 term for applying DIT and advanced technology In I4.0 context. Q4.0 is referred to future of both organization's excellence and quality. Quality prospect in future is not limited to optimization of present system, but generating completely novel solutions through integrating emergent technology and digital systems (Zulfiqar et al., 2023).

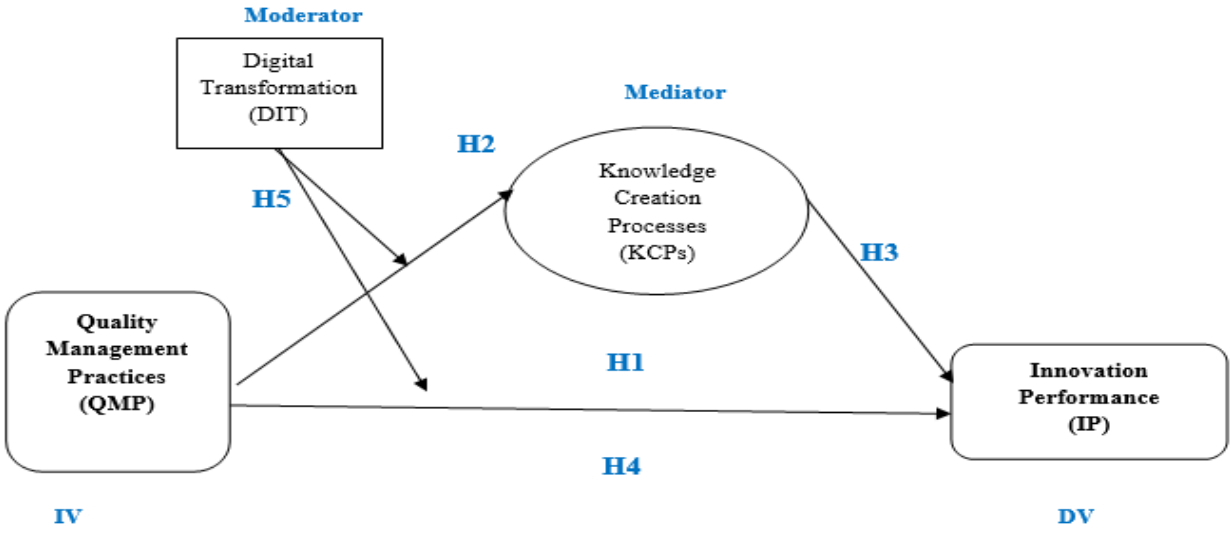
Thekkoote (2022) recommend that more can result in developing understanding about new factors of effective execution of Quality 4.0 (Q4.0) in DIT age. It can also support companies to develop novel approaches of Q4.0 execution. Q4.0 is featured by utilizing technologies of I4.0, management of big data (BD), integration and digitalization (Maganga & Taifa, 2022). Javaid, Haleem, Singh, and Suman (2021) argued that ultimate outcome of Q4.0 should be constant development which supports a competitive organizational strategy with focus on innovation and quality (Suhaimi et al., 2023). Moreover, adoption of QM along with I4.0 will facilitate companies to apply technology for controlling quality of their process. It would result in effective resource utilization and eventually direct toward improved sustainable performance (Saha, Talapatra, Belal, & Jackson, 2022). Marutschke (2023) studied application of DIT on managing quality and consumers' perceptions of quality regarding automotive

mobility of car brands. Research findings concluded that DIT resulted in improving product brand's appeal and provided new prospects to efficiently inspect vehicles. In DIT process, digitalized technology is applied for upgrading and transforming industry to stimulate technological innovations (TIN) in more effective way. It transforms companies from conventional mode of innovation to a novel mode of development which is digitally driven (H. Liu et al., 2021).

Niu, Wen, Wang, and Li (2023) analysed influence of DIT on organizational innovation (INN) by obtaining data from listed firms in China (2007-2009).Their study findings revealed that DIT had positive effect on innovation. Moreover, this effect was greeter in high-tech and more competitive firms (Harish, Mansurali, & Krishnaveni, 2023). Chen and Kim (2023) examined DIT and innovation relation by taking company data between periods covered 2009-2019. Findings indicated that DIT promotes innovation and the impact of DIT was higher in companies which were not high-tech and not highly polluted. Wan, Gao, and Hu (2022) conducted study on listed manufacturing companies in China for period covered 2016 to 2019.Research findings revealed that utilization of block-chain DIT technology enhanced collaborative firm's IP. Additionally, positive effect of social trust was also strengthened on innovation. L. Wang and Yan (2023) research on listed companies of China and findings supported that DIT had significant and increasing impact on product's IP. Additionally, time-lagged impact on both types of IP (process and product) was also identified and DIT effect across various industries was heterogeneous. From above arguments and review of literature, following hypothesis is formulated:

H5: Digital transformation (DIT) has moderating effect in association between implementation of QM practices and firm's innovation performance (IP).

Figure 1: Conceptual Model



3. Methodology

3.1. Research Approach and Design

Current study adopted deductive approach using survey instrument. Researchers adopt this approach to test/modify theory (Bryman & Bell, 2015; Naseem & Ali, 2023). The study also utilizes quantitative method under Positivist paradigm. In quantitative technique, results/conclusions are derived from analysing the data applying statistical methods (Akhtar & Butt, 2022). Quantities technique is considered appropriate in an empirical study if it tests and verifies research hypotheses (Ahmad, Athar, Azam, Hamstra, & Hanif, 2019; Butt, 2023). A structured survey instrument was utilized to obtain the data from respondents employed in manufacturing firms in this study.

3.2. Study Respondents and Unit of Analysis

In current study, Unit of analysis is individual (organizational employee) who is currently employed in ISO 9001 certified manufacturing companies.

3.3. Sampling technique and sample size

Various researchers recommended different criteria to determine sample size. Sekaran (2000) recommended 20 participants/respondents for every study factor to conduct multivariate analysis (Butt & Yazdani, 2021). According to Hair Jr, Matthews, Matthews, and Sarstedt (2017) recommendation, a ratio in range of 5-10 is tolerable (M. Zhang, Nazir, Farooqi, & Ishfaq, 2022). Considering above criteria of 1:5 ratio (lower limit) and number of questionnaire items, sample size of 265 respondents was determined for current study. Moreover, researchers consider sample size above 200 adequate as this sample size lowers the prospects of normality issues with data (Hair Jr et al., 2017; Nazir, Ahmed, Waris, Usman, & Nawaz, 2022). Sample size was selected applying probability stratified random sampling (SRS) technique from various sectors of the companies. Stratified random sampling (SRS) is probability sampling technique in which entire study population is divided into small (homogenous) subgroups or strata. Each stratum or group is formed on the basis of common attributes or traits. In this study, PSX listed manufacturing companies of Pakistan were segregated into different strata or sub-groups like pharmaceutical, textile, chemical eta. From the specified strata, respondents were chosen from randomly selected organizations. Approximately 379 manufacturing firms comprising of 21 sectors are listed with SECP (PSX) of Pakistan (Jalil, Shafiq, Rehman, & Akram, 2017).

3.4. Instrumentation and Measures

A structured instrument (written in English) was utilized to obtain data from participants of the study. Instrument comprised of following parts. First part of scale comprised of demogtsphic characteristics of respondents.It comprised of basic information of participants (like work experience, company, job experience, education etc).Remaining four (4) parts comprises of measurement scale items which were adopted from previsous researches on a scale of 7 (1=strongly disagree to 7=strongly agree) as follows.

3.4.1. Quality Management Practices (QMP)

measures included 24 items (comprising of soft and hard QM practices.These items were adopted from previous researches (Barua et al., 2020; Prajogo & Sohal, 2006; Valmohammadi & Roshanzamir, 2015; Yusr et al., 2017).

3.4.2. Knowledge Creation Processes (KCPs)

measures included 6 items which were adopted from previous researchers (Ramírez, Morales, & Rojas, 2011; Schulze & Hoegl, 2008).

3.4.3. Innovation Performance (IP)

measures included 10 items (comprising of process and product IP).These items were adopted from previous researches (Jimenez-Jimenez & Sanz-Valle, 2008; Le & Lei, 2018; Prajogo & Sohal, 2006).

3.4.4. Digital Transformation (DIT)

measures included 6 items which were from previous researchers (Antony, Sony, McDermott, Jayaraman, & Flynn, 2023; Nwankpa & Roumani, 2016).

3.5. Pilot Testing the Instrument and Data Collection

Pilot testing of the research scale is conducted to assess its practicability (M. Zhang et al., 2022). A pilot study was performed on a sample of 50 respondents on an identical study setting. After confirmation of face/content validity of respondents' feedback, scale internal consistency was further r tested through Cronbach's Alpha. All scale items were within acceptable limit >.70 indicating good construct internal consistency (Butt & Yazdani, 2021; Nunnally, 1978). After pilot study, questionnaire was circulated to the respondents of selected companies using both modes (online and hard copies). Survey method was applied to obtain data from respondents.

3.6. Techniques of Statistical Analysis

Data were coded and entered into SPSS version 23.0 software and analyzed applying both descriptive and inferential statistics. Descriptive statistics was applied to describe basic characteristics of data (frequency distribution, mean, stad. deviation.). Internal consistency/ reliability of research instrument was tested applying Cronbach (1951) co-efficient of Alpha (α) test. Common variance/response (CMV) bias was tested applying Harman's single factor test.

Correlation among variables was tested through Pearson Correlation test. Mediation and moderation regression analysis were performed through Hays process Macro SPSS (Hayes, 2017).

4. Analysis and Results

4.1. Respondents' Profiles

Table 1 presnets respondents' profiles which shows that total sample of 265 includes majority of female (52.5%) the respondents were female. Majority of participants (43.8%) belong to 25-35 year age group. Qualification profiles showed that most (57.4%) had MS/master degree. Designation profiles indicated that most of them (30.2%) were assistant/deputy managers. Similarly, majority (37.0 %) of respondents belong to 1-5 year work experience group. Organizational information represents that most participants belong to other category (16.2%), followed by 14.0 % working in textile sector. Majority of participants (20.0%) are working in quality assurance department. In most of the firms (35.5%), duration of ISO 9001 certification was above 7 years.

Table 1: Respondents' Profiles

Demographic Factor	Frequency	Percent (%)	Demographic	Frequency	Percent (%)
Gender			Organizational Sector		
Male	126	47.5	Textile	37	14.0
female	139	52.5	Chemical	18	6.8
Total	265	100.0	Pharmaceutical	38	14.3
Age			Food & Beverage	40	15.1
less than 25	78	29.4	Construction	20	7.5
25-35 year	116	43.8	Electronics	34	12.8
36-45 year	47	17.7	Automobile	20	7.5
46-55 year	19	7.2	Machinery/Hardware	15	5.7
Above 55 year	5	1.9	Any other	43	16.2
Total	265	100.0	Total	265	100.0
Qualification			Department/ Operational Area		
Bachelor/BS	103	38.9	Quality Assurance	53	20.0
Master/MS	152	57.4	Finance/Audit	32	12.1
PhD	10	3.8	HRM	17	6.4
Total	265	100.0	Production/Operation	35	13.2
Designation			R & D	27	10.2
Quality Professional	51	19.2	Information Technology	16	6.0
Assistant/Deputy Manager	80	30.2	procurement/Supply Chain	8	3.0
Manager/Head of Dept.	50	18.9	Marketing	40	15.1
Director/General Manager/CFO/CEO	20	7.5	Administration	27	10.2
Other	64	24.2	Any Other	10	3.8
Total	265	100.0	Total	265	100.0
Work Experience			ISO 9001 Certificate Duration		
Less than 1 year	16	6.0	Less than 1 year	63	23.8
1-5 years	98	37.0	1-3 years	56	21.1
6-10 years	71	26.8	4-7 years	52	19.6
11-15 years	36	13.6	above 7 years	94	35.5
above 15 years	44	16.6	Total	265	100.0
Total	265	100.0			

4.2. Reliability Statistics

Cronbach (1951) co-efficient of Alpha (α) test value through SPSS 23.0 software was applied to check scale reliability. It is the measurable action for internal consistency and equilibrium which is recognized as reliability of the scale.This measure also evaluates the fitness of purpose (Taber, 2018; M. Zhang et al., 2022). Using this test, the reliability of the scales was QMP= .917; IP=.894; KCPs= .799; DIT= .863; and Overall items=.947. According to Nunnaly (1978), a value of $\alpha > 0.70$ indicates good internal consistency/reliability of the scale Butt (2023) and within acceptable limits (Umair, Amir, Bilal, & Butt, 2023).

Table 2: Scale Reliability

Components	Cronbach's Alpha(α)	Items
QMP	.917	24
IP	.894	10
KCPs	.799	6
DIT	.863	6
Overall	.947	46

According to Taber (2018), its lower admissible limit is .70 (M. Zhang et al., 2022). The test results revealed α-value (> .70) in all factors and overall scale items. These results were also supported by Gliem and Gliem (2003) which indicates α-value >.70=acceptable (Butt & Yazdani, 2021). Table 2 presents test results.

4.3. Harman's Single Factor Test, Descriptive Statistics, and Correlation Analysis

Table 3 presents Harman's single-factor test, descriptive statistics, and Pearson correlation analysis.

4.3.1. Common method error/variance (CMV) for Response Bias

Harman's single-factor test founded on conceptions by Harman (1976) is applied to overcome response-bias/CMV .CMV may arise when the data are obtained from one/single source which results in response-bias (Fuller, Simmering, Atinc, Atinc, & Babin, 2016). CMV is the tendency of participants to give favourable/positive response (Lindell & Whitney, 2001; G. Zhang & Lee, 2010). The test results in table 3 indicated value of 28.769%. .Hence, there is no issue of CMV or error of measurement with the data as value is <50%prescribed limit (Akhtar & Butt, 2022; Harman, 1976).

4.3.2. Descriptive Statistics

indicates that majority of the participants have given responses in favour of scale items as mean scores (MS) in all factors lies above cut-off point 4 on a 7-point Likert-scale. Results also show that mean scores (MS) lie between 5.022- 5.477 and highest MS reported in QMP and least in KCPs.

4.3.3. Pearson Correlation

test was performed through SPSS 23.0. Test values indicated that correlation was statistically significant and positive in all factors. Values of correlation coefficient (r) lie between +1 to -1, and zero (0) value represents absence of relation between two (2) variables. While, (+) value > 0 indicates positive correalation (Wassan et al., 2022). Positive and significant correlations were reported between KCPs and DIT (r=.622), QMP and KCPs (r=.595, p<.05), between Kcps and IP (r=.581), between DIT and IP (r=.577), between QMP and IP (r=.517), QMP and DIT (r=.499). Positive correlation indicates that increase in one factor would result in increase in other factor or vice-versa (Wassan, Memon, Mari, & Kalwar, 2022). The test results supported that data was suitable to conduct regression analysis.

Table 3: Harman's Single Factor Test, Descriptive Statistics, and Correlation Analysis

Factor	N	Harman's Single Factor Test	Descriptive		Pearson Correlation*			
			Mean	SD	QMP	IP	KCPs	DIT
QMP	265		5.477	.757	1			
IP	265		5.210	1.003	.517*	1		
KCPs	265		5.022	.948	.595*	.581*	1	
DIT	265		5.169	1.053	.499*	.577*	.622*	1
Harman's Single Factor Test		28.769%						

* Correlation is significant at the 0.01 level (2-tailed).

4.4. Regression Analysis and Hypotheses Testing

For hypotheses (H1-H5) testing, regression analysis was conducted using SPSS 23.0 and Hayes process macro applying Model 1 and 4 for moderation and mediation analysis respectively. Next sub-sections present results and findings of data analysis.

4.4.1. QMP, IP and KCP Interactions: H1 to H3 Testing

Table 4 presents regression and mediation analysis results which showed significant and positive impact of QMP on IP (B=.6848, p<.05, CI [.5470, .8225]), as zero wasn't contained within both confidence intervals (LLCI, ULCI). This result supports H1. Additionally, QMP contributes 26.70 %variance (R^2=.2670, F (1,263) =95.8098, p<.05). Results also supported significant positive impact of QMP on KCPs (B=.7450, p<.05, CI [.6227, .8673]), and zero (0) wasn't contained within both CIs. These results supported H2. While, QMP contributes approximately 35.36% variance (R^2=.3536, F (1,263) =143.8553, p<.05). Results also revealed that KCP has positive and significant impact on IP (B=.4472, p<.05, CI [.3214, 5729]) as 0 wasn't contained within CIs. This result supported H3. From results it is evident that both QMP and KCPs contribute approximately 38.26% variance in outcome variable IP (R^2=.3826, F (2,262) =81.1669, p< .05).

Table 4: QMP, IP and KCPs Interactions

	R	R^2	MSE	F	B	SE	t	p	LLCI	ULCI
QMP effect on IP										
Model Summary	.5167	.2670	.7396	95.8098	-	-	-	.0000		
Constant- IP	-	-	-	-	1.4603	.3868	3.7755	.0002	.6987	2.2218
QMP					.6848	.0700	9.7882	.0000	.5470	.8225
QMP Effect on KCPs										
Model Summary	.5946	.3536	.5831	143.8553	-	-	-	.0000		
Constant- KCPs					.9418	.3434	2.7425	.0065	.2656	1.6180
QMP					.7450	.0621	11.9940	.0000	.6227	.8673
QMP, Kcps effect on IP										
Model Summary	.6185	.3826	.6254	81.1669				.0000		
Constant- IP					1.0391	.3607	2.8808	.0043	.3289	1.7494
QMP					.3516	.0800	4.3947	.0000	.1941	.5092
KCPs					.4472	.0639	7.0020	.0000	.3214	.5729

*95% confidence Level for all CI in output

4.4.2. Mediation Impact in Presence of KCPs: H4 Testing

In table, 5 mediation analysis results showed that total effect of QMP on IP was significant and positive (B=.6848, p<.05, CI [.5470, .8225]), as 0 wasn't contained within both CIs. Direct effect of QMP was also positive and significant (B=.3516, p<.05; [.1941, .5092. Likewise, Indirect effects of QMP on IP was also significant and positive (B=.3331, CI [.2188, .4542]), as o wasn't contained within both CIs. These results supported mediation hypothesis H4. These results support the partial mediation effect as QMP remains significant after controlling for KCPs.

Table 5: Mediation Effects in presence of KCPs

	B	SE	t	p	LLCI	ULCI
Direct Effect of QMP on IP	.3516	.0800	4.3947	.0000	.1941	.5092
Indirect Effect of QMP on IP	.3331	.0600	-	-	.2188	.4542
Total Effect of QMP on IP	.6848	.0700	9.7882	.0000	.5470	.8225

*95% confidence Level for all CI in output

4.4.3. Moderation of Digital Transformation (DIT): H5 Testing

Moderation hypothesis (H5) was tested applying two steps. In first step regression analysis was conducted to check significant impact of QMP on IP. The results are already presented and supported under table 4. QMP contributed approximately 26.7% variance in IP. In second step, moderating effect of DIT was tested through Hays SPSS process model 1. Results under table 6 indicated that approximately 45.59% variance in IP (R^2=.4559, F (3,261) =72.8963, p<.05) was explained by QMP and DIT and model was significant. Additionally, incremental variance contributed by interaction term (QMP * DIT) was also significant (ΔR^2= .0532, F (1, 261) = 25.5106, p<.05). Effect size of interaction term (QMP * DIT) was also significant and positive (B= .2662, P<.05, CI [.1624, .3700]), as 0 wasn't contained between the two CIs. Hence, results support moderation of DIT (H5) hypothesis.

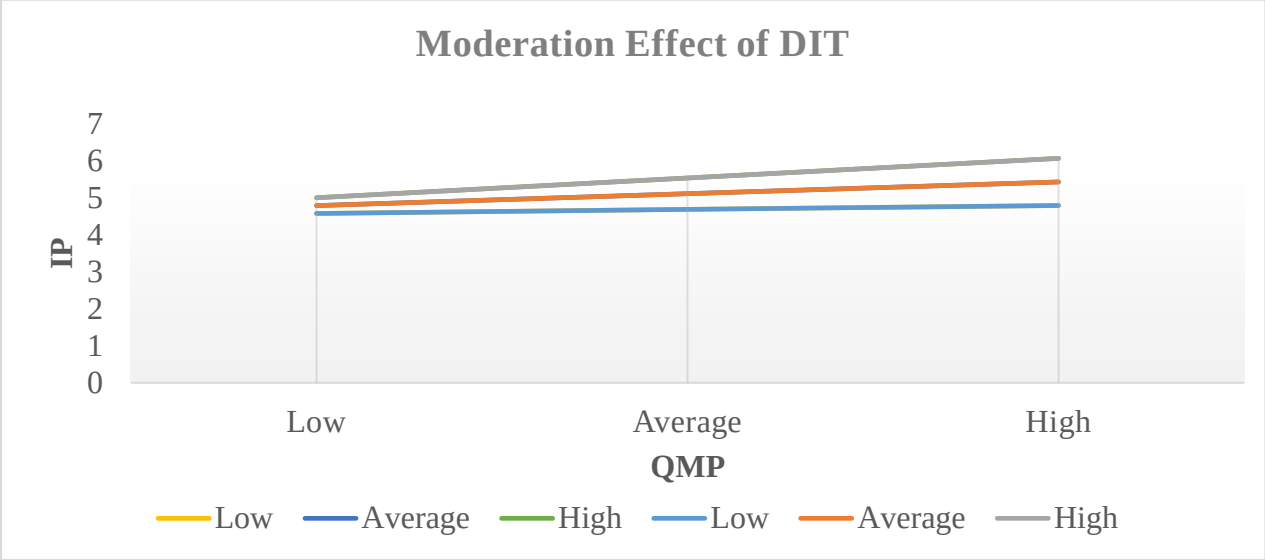
Table 6: Moderation Analysis with DIT

Model Summary	R	R²	ΔR2	MSE	F	df1	df2	P
Model Summary	.6752	.4559		.5533	72.8963	3	261	.0000
Model								
		B		SE	t	p	LLCI	ULCI
Constant-IP		8.2438		1.4920	5.5254	.0000	5.3059	11.1816
QMP		-.9537		.2777	-3.4349	.0007	-1.5004	-.4070
DIT		-1.0545		.2932	-3.5961	.0004	-1.6319	-.4771
(QMP * DIT)		.2662	-.0532	.0527	5.0508 - 25.5106	.0000 1	.1624 261	.3700 .0000

*95% confidence Level for all CI in output

Figure 2 presents conditional effect of predictor QMP on IP at values of moderator DIT which shows that conditional effect was insignificant when DIT was low as 95% bootstrap CI contained 0 within both CIs (B= .1418, p>.05, CI [-.0294, .3130]).While, conditional impact was significant when DIT was high as 95% bootstrap CIs didn't contain 0 (B= .7024, p<.05, CI [.5222, .8826]). Conditional effect was also significant at moderate levels (B= .4221, p<.05, CI [.2844, .5598]). These findings support moderation of DIT.

Figure 2: Moderation Effect of Digital Transformation



5. Discussion, Implications, Limitations and Future Directions

5.1. Discussion sand Conclusion

Current study was aimed at developing and testing a framework/model to explore association between execution of quality management practices (QMP) and firm's innovation performance (IP) in developing country context (Pakistan).Additionally, mediating role of knowledge creation processes (KCPs) and moderating influence of digital transformation (DIT) was also tested in above model in relevance to I4.0 and Q 4.0. First, hypothesis (H1) tested direct relation between QMP and IP, and findings supportive positive and significant impact of QMP on firm's IP. These results are consistent with past findings of research studies (Ahinful et al., 2023; Escrig-Tena et al., 2018; Kulenović, Veselinović, Šunje, & Cero, 2022; Mahmud, Hilmi, Mustapha, & Abu Karim, 2019; Martinez-Costa & Martínez-Lorente, 2008; Mushtaq & Peng, 2020; Ooi et al., 2012; Schulze & Hoegl, 2008; Shuaib & He, 2023; Wu, Wu, & Harrigan, 2019). Hence, results supported positive view and favorable impact of execution of QM on organizational IP. But, study findings aren't aligned with proponents of earlier studies who reported no or negative relation Leavengood and Anderson (2011); Singh and Smith (2004) between QMP and IP.

This study also examined and tested mediation of knowledge creation processes (KCPs) in QMP-IP relation. Findings also supported H2 and H3 as there was significant positive impact of QMP on KCPs (H2), and impact of KCPs on IP was also positive and significant (H3). While, results also supported H4 as partial mediating impact of KCPs in QMP-IP relation was found. Though, mediating role of KCPs in above relation has rarely been examined in earlier studies.

But results are aligned from previous studies which explored either QMP- KCPs relation or KCPs and Innovation association. For example, Yu et al. (2017) study findings on industrial companies in China concluded that KCPs support to develop technological capabilities of innovation which may direct to achieve sustained competitive gain for the organization. While, Esterhuizen, Schutte, and Du Toit (2012) also emphasised that KCPs act as an enabler/vehicle to enhance firm's innovation. Results also find support from researchers Asif et al. (2013); Barua (2021); Chamba-Rueda, Dávila, and Pardo-Cueva (2023) who investigated association between QM and KCPs. The results identified significant positive relation of QMP and KCPs. Findings are also aligned with Colurcio (2009) who examined execution of QM in knowledge generation based on SECI framework in 21 companies. Their findings concluded that QM acts as an effectual enabler for knowledge creation in the organizations. QM tools and policies (like employee engagement, team working etc.) facilitate in creating and disseminating knowledge in organizations.

Current study also assessed moderating role of digital transformation (DIT) in QMP-IP relation in context of I4.0, and results also supported moderation hypothesis (H5). But, moderating impacts were significant at higher level and insignificant at lower level. This factor hasn't been tested earlier in above association. Considering the crucial role of DIT in prospects of I4.0 and Q4.0, current study tests this factor in developing countries (Pakistan) context. Few recent studies on DIT support its role in improving technological IP of the organization. For example,Li, Wen, Zeng, and Liu (2022) study findings from listed companies in China concluded that DIT significantly improved the efficiency of technological innovation (TIN) in the enterprise. Study findings of H. Liu et al. (2021) also supported that DIT had single thresh-hold impact on efficiency of TIN in agricultural firms. While, role of DIT in relevance to QM can't be negated. According to Thekkoote (2022) findings, Q4.0 relates to QM in I4.0 era. Exclusively, it is dependent upon digital technologies to assure and deliver superior quality products/services to the client and also enhance capabilities of the organization. Overall findings support that QMP is significant predictor of IP and KCPs. KCPs also have significant impact on firm's IP. While, KCPs partially mediates positive relation between QMP and IP. Moreover, DIT has also plays moderating role in QMP-IP relation. Lastly, as concluding remarks, it is evident from the literature that there is dearth of research in domain of QM and IP to explore this under research area exclusively in emerging economies like Pakistan in era of I4.0. Due to strategic implications of both QMP and IP, there is extensive need of exploring the factors like KCPs and DIT in above framework to boost innovation performance (IP) in I4.0 context. The framework need to be explored in both progressing and developed Nations in diverse high-tech sectors as well to attain competitive gain in context of I4.0 and Q 4.0.

5.2. Theoretical and Practical Contributions

Current study has implications for academia, management and policymakers. First, majority of the studies tested direct association between QMP and IP. This study develops and empirically tests a model/framework considering KCPs and digital transformation (DIT) in relevance to I4.0 in progressing countries (Pakistan) context. DIT hasn't been considered as moderator in a framework to the researcher's knowledge in above relation. Secondly, QMP is also under-researched area in I4.0 and DIT has crucial role due to the relevance of QM with Q 4.0.There's also dearth of empirical investigation on TQM domain and KCPs considering SECI framework in literature. Though, literature provides support that TQM execution facilitates knowledge generation in the firms. Also, Knowledge creation processes (KCPs) act as enabler of firm's IP which is also evident in literature. Therefore, findings also fill this gap in the literature. The proposed framework combines QMP with digital transformation (DIT) and KCPs to boost firm' IP in I4.0. Transformation of QM system through digital technology is exclusively required in innovation oriented companies in all its operations and functions. As Q4.0 is at its nacent phase in I4.0 and aligning qualitymanagement practices (QMP) with I4.0 technologies will facilitate companies to bring innovations and enhance organizational efficiency and performance.Finally, the study also contributes to the literature as there is dearth of research in progressing countries context regarding empirical investigation addressing QMP, KCPs and IP in an integrative framework. This research study presents a comprehensive framework to address and understand the nature of unclear TQM and firm's innovation relation. As it considers moderating factor like digital transformation and mediating role of firm's knowledge creation processes (KCPs) in relevance to I4.0 and quality 4.0. The findings of the study will facilitate practitioners and management of the companies in Pakistan and other countries to

execute critical practices of QM and identified factors to foster the innovation performance and thus attain the competitive gain in industry 4.0 era.

5.3. Study Limitations and Directions for Further Research

Like all other researches, current study isn't without limitation which should be addressed by future researchers. First, research framework/model presented in current study is tested in emerging country (Pakistan) context. Future researchers may replicate this study in advanced countries to examine impact of factors like DIT), KCPs in QM-IP relation in relevance to I4.0. Secondly, data were obtained only from ISO 9001 certified manufacturing companies which are implementing QMP standards and practices in Pakistan. Future researches should also include both ISO certified and non-certified companies in the sample to evaluate any difference in innovation performance (IP) of the companies. Third, Future studies can also be replicated considering service industries with this framework in context of DIT and I4.0. Fourth, future researchers should also consider other moderating and mediating factors like culture 4.0, market orientation, market sensing in the above framework.Anohter dimension would be considering control variables like firm size, age etc. Fifth, the future researchers may consider non-technological innovations like marketing and administrative innovation in the framework and examine the impact of TQM execution on various types of innovations. Sixth, future researchers may consider individual practices or dimensions of TQM (like leadership, customer's focus, engagement of people, operations etc.) in the model to identify which of the dimensions are more critical in relevance of firm's IP in I4.0 era. As research studies on dimensionality of TQM still lags behind in I4.0 context. Seventh, this study considered cross-sectional design. The future researchers may consider time-lagged data or multiple respondents in their study sample. Finally, future researches may also consider other integrated frameworks like SCQM (supply chain and Quality management) and their impact on firm's IP and sustainable performance. Researchers may also apply MBNQA and EFQM frames works of QM practices in future studies.

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