How Institutional Pressures Shape Human-Centric Industry 5.0 and ESG: Insights from the China-Pakistan Economic Corridor

Abstract

Purpose:- In the digital transformation era from Industry 4.0 to Industry 5.0 (I5.0), firms face numerous challenges, especially balancing technology with human-centric and sustainable development. Existing studies investigate the interplay between institutional forces, digitalisation and ESG (Economic, Social & Governance) performance. However, limited evidence has been available in I5.0. Thus, this study investigates the direct impact of institutional forces on the I5.0 transformation (people, technology, and business) and ESG performance. Moreover, this study examines the mediating role of I5.0 business transformation in these relationships.

Design/methodology: A theoretical framework has been developed based on institutional theory (INT) and sociotechnical systems theory (STS). A cross-sectional survey approach was employed to collect 277 responses from manufacturing and service firms located along the western route of the China-Pakistan Economic Corridor (CPEC), which were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM).

Findings: The study's findings indicate that institutional forces significantly drive people-centric I5.0 transformation. Furthermore, the results highlight that coercive forces are dominant in adopting the I5.0 transformation. Moreover, the findings highlight that multifaceted I5.0 transformation emerges as a mediating construct between institutional forces and ESG performance.

Originality/value: This study integrates institutional and STS theories to explain how external pressures and socio-technical factors jointly enable human-centric Industry 5.0, which ultimately promotes ESG performance in an emerging economy context.

Keywords: Industry 5.0, Institutional forces, Sociotechnical systems, ESG performance

Introduction

In the era of rapid technological development, artificial intelligence (AI) has become a driving force in reshaping industrial systems and laying the groundwork for new industrial transformations (Rezzani et al., 2025). Based on these technological developments, organisations are now transitioning from Industry 4.0 (I4.0) to Industry 5.0 (I5.0). Fundamentally, I4.0 focuses on automation and technology integration, whereas I5.0 emphasises a human-centric philosophy, focusing on the association between humans and advanced technologies like AI (Ali & Johl, 2024; Citybabu & Yamini, 2025). The European Commission (2021) contended that I5.0 represents an evolution of I4.0, integrating three core principles: human-centric, resilience, and sustainability. Moreover, I5.0 highlights the linkages between humans and AI, ethical AI integration, and a more substantial commitment to the principles of environmental, social, and governance (ESG) (Yadav et al., 2024). Additionally, I5.0 marks a significant departure from its predecessor by integrating ESG principles into its core framework (Asif et al., 2023; Jain & Malhotra, 2025). This indicates that I5.0 focuses on sustainability, ensuring digital transformation aligns with human values and societal norms (Yan and Teng, 2025). Moreover, ESG in I5.0 extends beyond regulatory compliance, embedding core digital strategies such as AI-driven analytics for carbon neutrality (Ojstersek et al., 2024), resource optimisation, and fostering a socially responsible business model (Olsson et al., 2025). Conclusively, the multifaceted role of Industry 5.0 and its impact on ESG principles is crucial for navigating the opportunities and challenges in the new industrial era (Mukhtar et al., 2024).

The transition to I5.0 highlights substantial challenges for people, technology, and business. At the people level, the human-centric aspect of I5.0 necessitates reskilling people to minimise the digital gaps (Schmager et al., 2025). Moreover, ethical concerns related to AI in decision-making raise social challenges. At the technology level, applying advanced technologies like AI raises significant challenges related to cybersecurity, data privacy, and governance (Giannakos et al., 2025). From a business perspective, organisations face high operational costs when implementing advanced technologies. In a nutshell, the multifaceted I5.0 transformation requires a holistic framework to achieve ESG performance without compromising sustainability. Institutional forces play a significant role in mitigating these challenges, especially in the I5.0 era. In line with past studies (Bennich, 2024; Arranz et al., 2022), the institutional forces are conceptualised as an Isomorphic process and divided into coercive, mimetic, and normative forces. To mitigate the ESG challenges in I5.0, coercive forces drive organisations to adopt sustainable ESG practices and digital governance policies

(Asif et al., 2023). For instance, regulatory bodies mandate environmental and ethical digital practices to promote fair and equitable ESG practices. On the other hand, normative forces encourage firms to integrate ESG practices in digital transformation to meet stakeholder expectations. Ultimately, the mimetic force prompts firms to adopt ESG practices by emulating industry leaders who have successfully integrated these practices during the industrial transformation era. Consequently, as a pioneer firm in ESG and digital transformation, it aims to gain stakeholder trust and remain competitive in the 4.0 landscape. By leveraging these Isomorphic forces, firms can mitigate the ESG challenges and transition towards a human-centric and resilient future.

In the prior literature, the interplay between institutional forces, digitalisation, and ESG performance has been thoroughly examined. For instance, Bennich (2024) examined the role of institutional pressures to promote digitalisation in the water sector. Chen and Zuo (2024) highlight the role of institutional pressures in promoting the strategic direction of tourism firms in China. Likewise, Liu et al. (2024) examined the linkages between institutional pressures and digital transformation in China. Extending beyond the Chinese context, Rana et al. (2024) highlighted how institutional forces interact with ethical principles and Generative AI to enhance firm performance in technology-enabled Indian firms. Ye et al. (2024) studied the role of institutional forces in promoting green digital fusion and sustainable performance in China. On the other hand, the concept of ESG has been well-studied through panel and time-series analyses. For instance, Deng and Karia (2025) examined the relationship between resilience and ESG performance among Chinese publicly listed firms. Santos Jhunior et al. (2025) examined the panel dataset of state institutions on ESG performance in emerging markets. Likewise, Jin and Wu (2024) examined the interplay between the institutional environment, digital transformation, and ESG performance among A-share firms. Similarly, Lanzalonga et al. (2025) investigate the role of ESG performance on intangible assets and intellectual capital among European food and beverage firms. Finally, Subramanian et al. (2024) examined the necessary condition logic of ESG practices on innovation under the moderating role of institutional forces in multinational life sciences firms. Although, prior studies have extensively examined the relationship between institutional forces, digitalisation, and ESG performance. There remains limited empirical evidence on how these dynamics unfold within the multifaceted context of I5.0. To fill this void, this research examines the impact of institutional forces on the I5.0 transformation (people, technology, business) on ESG performance. Moreover, this study examined the mediating role of I5.0 transformation in the relationship between institutional forces and ESG performance.

Past studies examined the association between institutional forces, digitisation, and ESG performance. There is nuanced evidence about the dynamic interplay within the multifaceted I5.0 framework. This research fills this gap by integrating institutional theory with STS theory to elucidate how external forces interact with internal socio-technical factors (people, technology & business) to promote ESG performance. By doing so, this study extends prior digital transformation and ESG frameworks, which have mainly focused on I4.0 efficiency and compliance. Instead, this study highlights how I5.0 embeds human-centric, resilience and sustainability principles with ESG performance. Moreover, the China-Pakistan Economic Corridor (CPEC) provides a unique insight. For instance, the CPEC is an emerging economy corridor, shaped by regulatory enforcement, resource constraints, and geopolitical importance (Waheed et al., 2025). It offers conditions that differ markedly from those in developed regions (Ahmed & Chaudhry, 2025). Thus, the unique study setting enables others to uncover context-specific mechanisms that are not readily generalizable elsewhere.

Theoretical framework and hypotheses development

Institutional theory

In this study, institutional theory (INT) is a theoretical foundation for understanding how institutional forces promote I5.0 transformation and ESG performance. The institutional theory posits that external pressures help firms adapt to industrial transformation, enabling them to remain competitive in the long run (DiMaggio & Powell, 1983). Moreover, this theory posits that firm actions are primarily influenced by their external environment rather than being solely driven by economic initiatives (DiMaggio & Powell, 1991). DiMaggio and Powell (1991) highlight the external forces as "institutional isomorphism." Even though the firm is an independent unit, societal values, norms, and shared cognition transform the organisation (Ye et al., 2024). In a resource-constrained environment, organisations proactively strive for societal legitimacy and acceptance (Lee et al., 2024). Consequently, the pressure exerted by external groups helps reshape the firm's strategic direction (Ye et al., 2024). From an institutional theory perspective, there are three types of external forces: coercive force (CF), normative force (NF), and mimetic force (MC) (DiMaggio & Powell, 1991). The coercive force (CF) arises from legitimate and regulatory bodies that stimulate the firm's behaviour to transform its digital footprint, especially in Industry 5.0. Meanwhile, normative force (NF) originates from external stakeholders, including customers and suppliers. In the digital transformation era, customers and suppliers are more aware of technological aspects and their potential sustainable impacts (Ye et al., 2024). To survive in the digital transformation era,

firms cannot overlook the demands of customers and suppliers (Rana et al., 2024). Lastly, mimetic force (MC) originates from uncertain circumstances. To overcome uncertainty, the organisation tends to imitate the successful practices of its competitors, a phenomenon commonly referred to as competitive pressure (Ye et al., 2024). Thus, this research highlights that these three pressure forces drive firms towards the I5.0 transformation that ultimately promotes ESG performance.

Institutional Theory (INT) postulates have been well-grounded in past studies. For instance, Bennich (2024) investigate the association between institutional pressures and digitalisation through the lens of INT. Chen and Zuo (2024) examined the role of institutional pressures to promote smart servitization through the lens of INT. Conclusively, institutional theory provides a solid foundation for developing the linkages between institutional forces, digital transformation (Liu et al., 2024; Rana et al., 2024; Ye et al., 2024), and ESG performance (Lee et al., 2024; Subramanian et al., 2024).

Sociotechnical systems (STS) theory

Apart from institutional theory, this research is also underpinned by sociotechnical systems (STS) theory. STS theory posits that the interaction between social and technical aspects must be jointly optimised (Davis et al., 2014; Kessler, 2013). Before explaining the STS theory, it is necessary to understand the social and technical systems. The social systems highlight human and employee-related factors, such as attitude, knowledge, and social relationships (Ali & Johl, 2024). At the same time, technical systems consist of processes, machines, and materials that transform input into output (Kessler, 2013). Fundamentally, STS theory posits that a firm must combine social and technical aspects to create a successful system, particularly in the context of digital transformation. For instance, Ali and Waheed (2025) highlight the STS perspective of quality management to promote I4.0 practices. Likewise, Marcon et al. (2024) indicate that organisations must develop and implement an STS perspective to promote a higher adoption rate of I4.0.

On the other hand, the theoretical underpinnings of STS have gained attention in the 5.0 context. For instance, Ali and Johl (2024) highlight the STS perspective of quality management to achieve sustainable performance in Industry 5.0. Marcon et al. (2024) recently emphasised the STS perspective toward technology adopters in Industry 4.0, which laid the foundation for Industry 5.0. Likewise, Margherita and Braccini (2021) affirmed the role of STS theory in I4.0 and I5.0, highlighting that I4.0 is more inclined towards technical factors, whereas I5.0 is more inclined towards STS and sustainability aspects. Asif et al. (2023) argued that I5.0 provides a

prevailing context for understanding the role of human-technology interaction in promoting ESG. Conclusively, STS theory provides a solid foundation for the multifaceted I5.0 transformation; yet, there is nuanced research, especially in the ESG domain. Thus, this research is the pioneer in examining the role of institutional forces in promoting the STS perspective of I5.0 transformation to achieve ESG performance.

In brief, three significant gaps have been identified in the existing literature. First, although I4.0 research emphasises automation and efficiency, I5.0 is at the embryonic stage of exploring how resilience, human-centric, and sustainability aspects transform firms' ESG performance. Second, although INT and STS have been applied separately, nascent work integrates them to explain how external institutional isomorphism interacts with internal socio-technical factors to shape ESG outcomes. Third, prior evidence originates from developed economies, whereas contexts such as the CPEC corridor, with its resource constraints and regulatory asymmetries, remain underexplored. Addressing these gaps, this study advances theory by combining INT and STS, empirically testing their integration in the I5.0 era, and contextualising findings in an emerging economy industrial corridor.

Hypotheses development

Institutional forces and people (socio) transformation in I5.0

Based on institutional theory (INT), external forces or institutional isomorphism affect the organisation's social structure (Ali & Johl, 2023). Generally, these forces are categorised as coercive, normative and mimetic (DiMaggio & Powell, 1983). The coercive force (CF) arises from regulatory, governmental, and professional bodies to implement strategic change at all organisational levels (Ali & Johl, 2023). Dubey et al. (2019) affirmed that firms are on the path to transforming their social and technical aspects. McAfee et al. (2012) affirmed that to transform the firm at the people and process levels, the reskilling and upskilling of the workforce is necessary. Jawad et al. (2021) claimed that people-related skills, such as creativity, people management, and critical thinking, are more important for transformation in Industry 4.0. Ali and Johl (2023) contend that there is a positive association between institutional forces (coercive, normative, & mimetic) and I4.0 intangible resources. In the same vein, Abayomi et al. (2020) argued that institutional forces affect the behavioural intention to adopt mobile banking in China. Likewise, Bag et al. (2021) claimed that institutional forces (CF, NF, & MF) have a positive and significant impact on workforce skills, promoting sustainability and the circular economy. Kam et al. (2019) argued that pressure from external forces encourages firms to increase their efforts in raising information security awareness. Lin

et al. (2020) stated that institutional forces help stimulate individual behaviour intention for e-business transformation. To implement their sustainability goals, Wang et al. (2018) found that institutional forces, with top management support and perceived work benefits, facilitate the implementation of environmental management accounting in China. Finally, Liu et al. (2010) argued that there is an association between institutional forces (CF & NF) and a firm's intention to adopt internet-enabled supply chain management systems.

Conclusively, the above discussion supports the arguments that institutional forces (CF, NF, & MF) drive the transformation of new and innovative strategies and technology. Furthermore, these forces positively link social and people-related factors, such as intention, skills, and commitment. However, there is nuanced evidence related to institutional forces and people transformation in I5.0. To fill the void, the following hypotheses have been proposed.

H1a: Coercive force has a positive impact on people's transformation in I5.0.

H1b: Normative force has a positive impact on people's transformation in I5.0.

H1c: Mimetic force has a positive impact on people's transformation in I5.0.

Institutional forces and technology transformation in I5.0

From the institutional theory perspective, external forces (CF, NF, & MF) exert pressure to adopt advanced technologies. Rana et al. (2024) argued that regulatory and government bodies influence firms to transform their existing process and techniques. Moreover, Dubey et al. (2019) argued that institutional forces (CF, NF, & MF) help to promote technical resources and advanced digital technologies. Similarly, Ye et al. (2024) affirmed that external forces (regulatory, customer, and competitors) help shape digital green technologies and sustainable performance. Likewise, Rana et al. (2024) affirmed that CF, NF, and MF help organisations use advanced generative AI, enhancing firm performance. Liu et al. (2024) argued that Chinese state-owned institutions play a vital role in promoting digital transformation. Similarly, Chen and Zuo (2024) claimed that institutional forces promote innovative servitization strategies in tourism firms in China. Bennich (2024) stated that external and social forces shape firms to respond to technological transformation. Bag et al. (2021) affirmed the positive association between institutional forces (CF, NF, & MF) and tangible resources to achieve digital transformation and sustainability indicators. Finally, Ali and Johl (2023) highlight the significant association between institutional pressures and tangible resources to achieve I4.0 readiness and sustainable performance in Malaysia. Conclusively, the past literature affirmed that an association exist between institutional forces (CF, NF, & MF) and technical aspects of

digital transformation. However, there is nuanced evidence on the role of institutional forces in transforming the technological aspects of I5.0. Thus, the following hypotheses have been proposed.

H2a: Coercive force has a positive impact on technology transformation in I5.0.

H2b: Normative force has a positive impact on technology transformation in I5.0.

H2c: Mimetic force has a positive impact on technology transformation in I5.0.

Relationship between I5.0 transformation factors

Based on the STS theory, social/people and technical factors are vital to implementing advanced digital technologies (Ali & Johl, 2024). Furthermore, Ali and Waheed (2025) argued that both must be co-integrated to implement digitalisation. Nitlarp and Mayakul (2023) contended that solely focusing on people factors and ignoring technology factors may not generate long-term competitive advantages and vice versa. Therefore, STS theory highlights that both people and technological factors are vital and jointly optimised and interdependent.

Prior literature highlights the association between people and technology factors to enhance business transformation in the digital era. For instance, Beier et al. (2020) highlight the importance of I4.0 from a socio-technical perspective to achieve sustainability targets. Likewise, Davies et al. (2017) affirmed that it is necessary to implement STS to implement I4.0 successfully. From qualitative aspects, Li et al. (2020) argued that the main driver in I4.0 is the people factors, which require new and advanced digital skills. From a quantitative point of view, Marcon et al. (2022) affirmed that firms that pay attention to social and technical aspects generally have higher I4.0 adoption rates. Makarius et al. (2020) argued that social AI factors laid the foundation for the AI technical process to transform firms in the I4.0 era. Finally, Sony and Naik (2020) affirmed that the successful application of I4.0 requires both social and technical aspects. Furthermore, integrating external stakeholders may affect the smooth transformation in I4.0. In a nutshell, empirical evidence exists that the co-integration of people and social, technical, and technological factors is vital to transforming the firm in the digital era. However, there is nuanced research on how people and technological factors transform the business in I5.0. Therefore, the following hypotheses have been proposed.

H3: People transformation has a positive relationship with technology transformation in I5.0.

H4: People transformation has a positive relationship with business transformation in I5.0.

H5: Technology transformation has a positive relationship with business transformation in I5.0.

Relationship between I5.0 transformation and ESG performance

Based on the institutional and STS theories, implementing digital transformation in I5.0 positively impacts ESG performance. Generally, ESG is a multifactor variable consisting of environmental, social, and governance (Deng & Karia, 2025; Jin & Wu, 2024). Lu et al. (2024) contend that digital transformation is a systematic way to effectively change the firm's social and technical factors to improve its ESG performance. Moreover, digital transformation has a resource-empowering effect, providing technical support to improve ESG performance (Lu et al., 2024). Furthermore, digital transformation has a regulatory effect, which means it enhances the firm's ability to process large amounts of data as well as transparency. Consequently, it can minimise the top management's hostile behaviour towards social and environmental factors. Therefore, digital transformation can enhance ESG performance.

Prior literature supports the relationship between digital transformation (DT) and ESG performance. For instance, Wang et al. (2023) proposed a digital ESG (DESG) framework to examine the role of digital transformation in promoting Chinese manufacturing firms' ESG performance. Qi et al. (2024) argued that digital transformation has a moderating role in promoting ESG performance to achieve corporate performance. Huang et al. (2023) argued that the association between digitalisation and ESG performance is more pronounced in non-manufacturing firms. Ding et al. (2024) argued that DT directly promotes ESG performance, where the indirect effect is limited. At the same time, Wang and Esperança (2023) affirmed that digital resources positively and indirectly promote ESG performance. Zhou and Liu (2023) contend that higher spending on digital resources is positively associated with investing in ESG practices. Fang et al. (2023) argued that digitalisation enables firms to minimise agency costs and enhance governance. Moreover, Fang et al. (2023) claimed that DT promotes social aspects and has no relationship with environmental scores. Finally, Lu et al. (2024) affirmed that the relationship between DT and ESG performance is more pronounced in non-state, manufacturing, and hi-tech firms.

Conclusively, there is profound evidence that digitalisation positively and significantly affects ESG performance. However, there is nuanced evidence of the relationship between multifaceted I5.0 transformation and ESG performance. To fill this void, the following hypotheses have been proposed.

H6a-c: Business transformation in I5.0 positively and significantly affects ESG performance (environment, social, and governance).

The mediating role of I5.0 transformation

Under institutional and STS theories, I5.0 transformation mediates institutional forces (CF, NF, & MF) and ESG performance. From an INT perspective, organisations respond to external pressures to transform their social and technical process. STS theory highlights the interaction between social and technical factors in shaping firm outcomes. Under these perspectives, the I5.0 transformation facilitates ESG performance by enabling firms to comply with external forces (regulatory, customer, and competitors).

Prior literature supports the notion that DT mediates between exogenous and endogenous variables. For instance, Rawashdeh et al. (2024) affirmed that DT partially mediates between strategic agility and environmental sustainability. Tuyen et al. (2023) affirmed that DT mediates between corporate social responsibility and firm innovation. Moreover, Wu et al. (2023) highlight the mediating role of DT as a strategic response to cope with the social crises during the COVID-19 pandemic. Finally, Chen et al. (2024) claimed the mediating role of DT between fintech and Chinese firm green innovation. Conclusively, past studies support the mediating role of DT between various exogenous and endogenous constructs. However, there is a lack of evidence relating to the mediating role of I5.0 transformation between external forces and ESG performance. To fill this void, the following hypotheses have been proposed. Moreover, Figure 1 highlights the research framework.

H7a-f: Business transformation mediates between people, technology, and ESG performance.

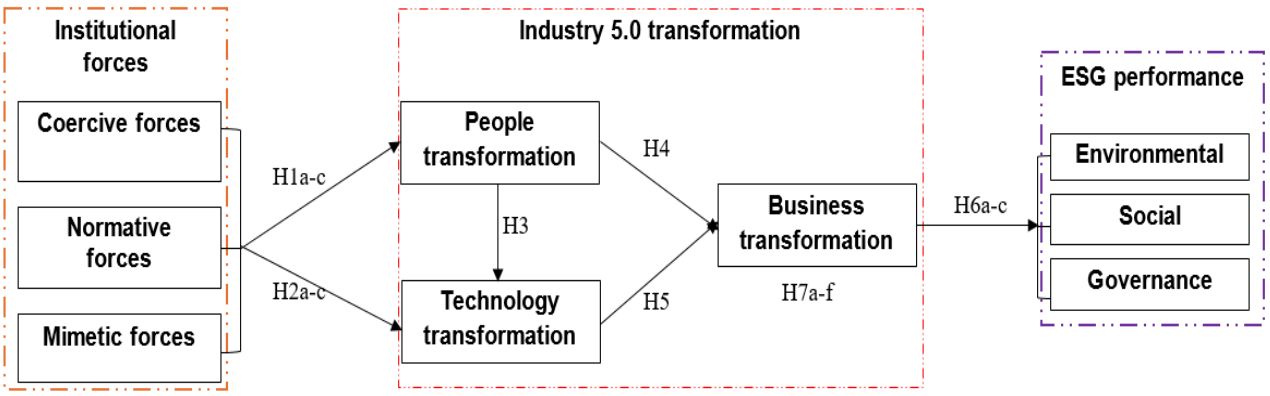

Figure 1. Theoretical framework (Source: Authors own work)

Methodology

To achieve the study objectives, this research follows a "research onion" approach proposed by Saunders et al. (2019). According to Saunders et al. (2019), a research onion consists of six layers. The first layer adopted a positivist research philosophy since the data

collection was predetermined and structured. In the 2nd and 3rd layers, this research employed a deductive approach through a mono-quantitative method. According to Saunders et al. (2019), there is a link between positivist philosophy, the deductive approach, and quantitative research design. In the 4th and 5th layers, a cross-sectional survey strategy was adopted. The final layer highlights the data collection and analysis. In this regard, the research primarily focused on the manufacturing and services firms located in the western Corridor of the CPEC (China-Pakistan Economic Corridor). Similar to the prior literature, this research focuses on the manufacturing and services firms located in three industrial estates (Hayatabad, Hattar & Gadon) of Khyber Pakhtunkhwa (KP) in Pakistan (Rahman et al., 2023). The western CPEC corridor passes through KP province to justify the context. Moreover, CPEC is a transformative initiative to strengthen the Pakistani economy and infrastructure. Furthermore, it serves as a catalyst for industrial modernisation. According to Rahman et al. (2023), the sample frame of firms located in these industrial estates is missing. Thus, this research employed G*Power software to calculate the sample size. Based on the input parameters of effect size = 0.15, alpha 0.05, power = 0.95 and predictors =6, the minimum sample size is 146. Due to the absence of a reliable and complete sampling frame; a convenience sampling technique was adopted. In the current study context, firms are dispersed across industrial estates, and no publicly accessible database or registry provides an extensive list of potential respondents (Hassan et al. 2022). Therefore, probability sampling techniques like simple random sampling are not feasible; they require a well-defined population list (Saunders et al. 2019).

Before the actual data collection, both pre-testing and pilot testing steps were performed. In pretesting, face and content-related validities were performed by academic and industry experts. After that, pilot testing was performed to refine the survey items so that respondents would have no problems completing them. To collect the data from the sampled population, the authors physically visited the industrial estates to explain and disseminate the adapted questionnaire. In this study, the potential respondents were owners and/or operations managers. To comply with the ethical standards, a cover letter was provided to explain the study's purpose and ensure their confidentiality. Data was collected in two waves. In the 1st wave, 800 survey questionnaires were distributed. In the second wave, the authors approached an already distributed survey. After the reminder calls and follow-ups, 277 final questionnaires were finalised for further analysis with a response rate of 34.62%. Ali et al. (2020) argued that the average response rate of a face-to-face survey falls between 26 and 36 per cent. After that, the study employed the Partial Least Squares (PLS) technique through SmartPLS software. It is a

second-generation statistical software and is compatible with small sample sizes and non-normality assumptions (Rahman et al., 2023; Hair et al., 2023).

Measures

All the items related to study constructs were adapted from prior studies. The institutional forces constructs were categorised into coercive force (CF), normative force (NF) and mimetic force (MF). CF dimension was measured with three items, NF was also measured with three items and a three-item scale of MF was adapted from Rana et al. (2024) and Ali & Johl (2023). On the other hand, the I5.0 transformation construct has three dimensions: people transformation (PT), technology transformation (TT), and business transformation (BT). A three-item scale was adapted to measure the PT, four items for TT and four items for BT. All items were adapted from Nitlarp and Mayakul (2023). Finally, ESG performance is categorised into environmental, social and corporate governance performance (EP, SP, & CGP). EP dimension was measured with four items, SP was also measured with four items and a four-item scale of CGP was adapted from Zhou et al. (2023). Furthermore, all the study items are self-reported perceptions to capture the firm's strategic orientation. A seven-point Likert scale was used.

Result & analysis

Demographic analysis and CMB

This section presents the demographic and common method biases (CMB) analysis. First, Table 1 highlights the demographic analysis of the sample firms in terms of age, type, and number of employees. Table 1 reveals that 52 (19%) firms are in the young age category, 73 (26%) firms are in the 6-10 year age category, 86 (32%) firms are in the 11-15 years age category, and 63 (23%) are in the more than 16 years age category. Moreover, most sample firms fall in the manufacturing category (154, 56%), followed by the services category (123, 44%). Finally, the sample data indicate that 115 (42%) firms have 5-100 employees, 98 (35%) firms have 101-200 employees, and only 64 (23%) firms have more than 200 employees.

Before the SEM analysis, a common method bias statistic was used. To mitigate the CMB problem, Podsakoff et al. (2003) suggested procedural and statistical precautions. From a statistical standpoint, Harmon's single-factor test was performed. The outcomes reveal that the highest variance of a single factor was 35%, which is less than the threshold value of 50% (Podsakoff et al., 2003).

Table 1. Demographic analysis (Source: Authors own work)

Items		Freq.	Percentage
Firm age	≤ 5 Years	52	19%
	6-10 years	73	26%
	11-15 Years	89	32%
	More than 16 years	63	23%
Firm type	Manufacturing	154	56%
	Services	123	44%
Number of employees	5-100 employees	115	42%
	101-200 employees	98	35%
	More than 200	64	23%

Structural equation modelling (SEM)

To statistically analyse the framework, "Partial least square structural equation modelling," or the PLS-SEM approach, was adopted (Hair et al., 2019). Hair et al. (2019) suggested that PLS-SEM consists of measurement and structural analysis, as explained below.

Measurement model analysis

Reliability and convergent validity

Reliability and convergent validity tests were performed in the PLS-SEM measurement analysis. Hair et al. (2023) suggested that Cronbach's alpha, CR, and rho_A analyses were performed to measure the construct's reliability. Hair et al. (2019) affirmed that the threshold value of all reliability indicators is≥0.70. Table 2 shows that all the reliability analysis values of study variables are above the threshold limit. It highlights that variables are reliable for further analysis. Moreover, the average variance extracted (AVE) was used to measure the convergent validity. Hair et al. (2019) suggested that a threshold value of ≥0.50 is considerably acceptable. Table 2 highlights that the AVE of all study variables is above the threshold limit. Furthermore, Figure 2 depicts the reliability and convergent validity analyses.

Table 2. Reliability and convergent validity (Source: Authors own work)

Variables	Loading	VIF	Cronbach's alpha	rho_A	CR	AVE
CF	0.886	2.20	0.872	0.872	0.922	0.797
	0.893	2.34				
	0.899	2.48				
NF	0.827	1.47	0.727	0.737	0.845	0.645
	0.821	1.43				
	0.761	1.40				
MF	0.793	1.34	0.725	0.726	0.845	0.645
	0.817	1.52				
	0.799	1.48				
PT	0.867	1.84	0.821	0.825	0.893	0.736

	0.853	1.91				
	0.854	1.78				
TT	0.785	1.75	0.845	0.861	0.896	0.682
	0.805	1.81				
	0.856	2.08				
	0.856	1.93				
BT	0.866	2.40	0.894	0.895	0.926	0.758
	0.872	2.35				
	0.870	2.45				
	0.876	2.48				
EP	0.819	1.85	0.860	0.864	0.905	0.704
	0.840	2.14				
	0.855	2.08				
	0.843	2.00				
SP	0.813	1.73	0.834	0.840	0.889	0.666
	0.811	1.82				
	0.825	1.71				
	0.816	1.91				
CGP	0.756	1.54	0.769	0.770	0.853	0.592
	0.802	1.62				
	0.795	1.61				
	0.722	1.33				

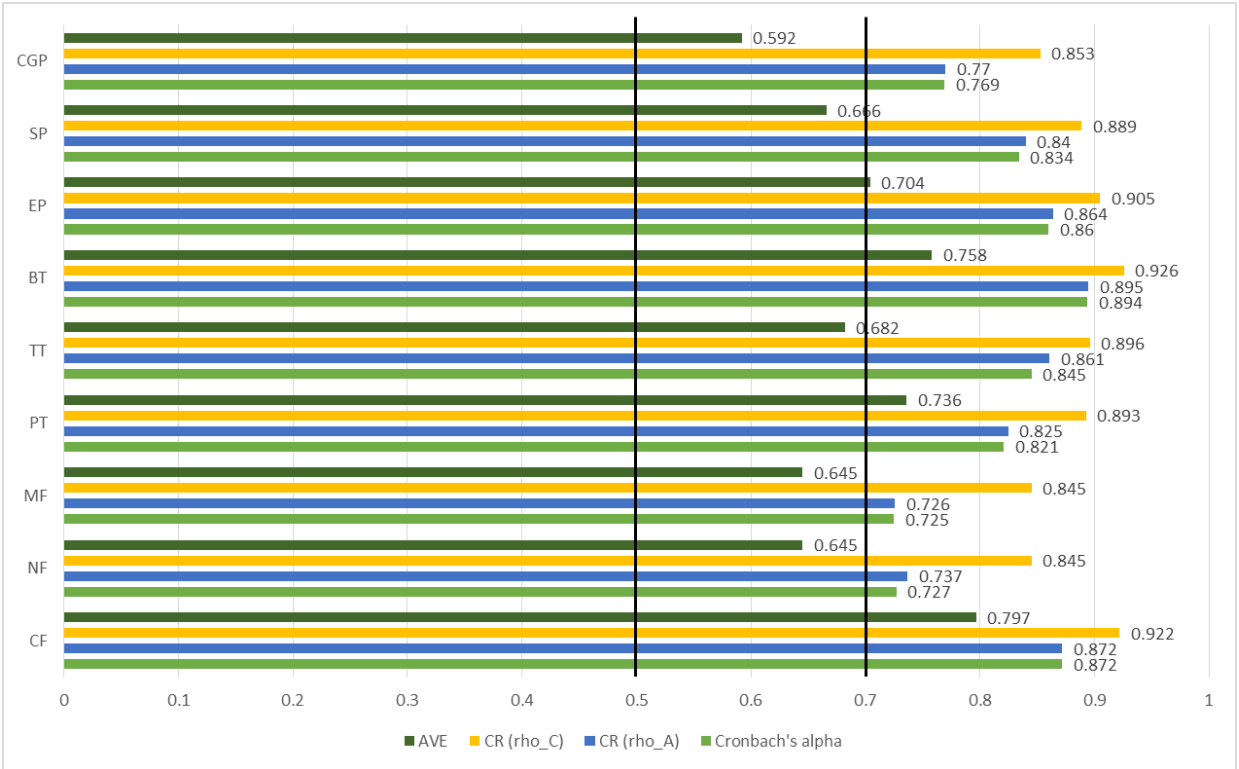

Figure 2. Reliability and validity (Source: Authors own work)

Discriminant validity

The measurement analysis used various indicators like cross-loading, Fornell-Larker, and "Heterotrait-monotrait ratio of correlation" (HTMT) to measure discernment validity. Hair et al. (2019) suggested that HTMT is a more appropriate indicator for discernment validity. The threshold limit of HTMT is less than 0.90. Table 3 shows that the HTMT of all the study variables and the HTMT values are less than 0.90.

Table 3. Discernment validity (HTMT) (Source: Authors own work)

Variables	**CF**	**NF**	**MF**	**PT**	**TT**	**BT**	**EP**	**SP**	**CGP**
CF									
NF	0.463								
MF	0.499	0.179							
PT	0.503	0.658	0.714						
TT	0.479	0.352	0.349	0.188					
BT	0.436	0.676	0.692	0.454	0.369				
EP	0.565	0.39	0.429	0.418	0.393	0.547			
SP	0.547	0.575	0.647	0.572	0.427	0.538	0.594		
CGP	0.523	0.485	0.493	0.462	0.382	0.38	0.306	0.531	

Structural model analysis

As suggested by Hair et al. (2019), the second step in PLS-SEM is to analyse the structural model. In this research, both direct and indirect analyses are performed and explained below.

Direct analysis

Henseler et al. (2015) recommended using the bootstrapping technique with 5000 resamples to evaluate the direct hypotheses, as shown in Table 4. Based on the direct structural analysis, institutional forces (CF, NF & MF) positively transform the people (PT) in I5.0. The association between CF→PT (β=0.238, t-value=3.870, p=0.001), NF→PT (β=0.168, t-value=2.046, p=0.040), and MF→PT (β=0.328, t-value=3.836, p=0.001) are support the hypotheses. Therefore, H1a-c has been supported. Surprisingly, institutional forces have an insignificant relationship with technology transformation in I5.0, except for coercive force. The direct analysis indicates that the relationship between CFTT (β=0.387, t-value=5.878, p=0.001) is supported, and H2a was accepted. On the other hand, the relationship between NF→TT (β=0.137, t-value=1.642, p=0.100) and MFPT (β=0.080, t-value=0.870, p=0.380) is not supported. Thus, H2b-c was rejected. Unexpectedly, the association between PT and TT was negative and insignificant (β=-0.119, t-value=1.817, p=0.069). Therefore, H3 was not supported. Furthermore, the analysis indicates that the relationship between PT→ BT (β=0.347, t-value=6.048, p=0.001) and TT→ BT (β=0.270, t-value=4.364, p=0.001) is positive and

significant. Thus, H4 and H5 were accepted. Finally, the direct analysis exhibits that BT has a positive and significant association with ESG. The SEM results depicted that the relationship between BT→EP (β=0.483, t-value=9.980, p=0.001), BT→SP (β=0.470, t-value=8.950, p=0.001) and BT→ CGP (β=0.315, t-value=5.545, p=0.001) are positive and significant. Therefore, the H6a-c were supported.

Table 4. Hypotheses analysis (Direct) (Source: Authors own work)

Hypothesis	β-value	T-statistics	CI [2.5%-97.5%]	p-value	Decision
H1a: CF→PT	0.238	3.870	[0.117-0.358]	0.001	Supported
H1b: NF→PT	0.168	2.046	[0.006-0.330]	0.040	Supported
H1c: MF→PT	0.328	3.836	[0.159-0.493]	0.001	Supported
H2a: CF→TT	0.387	5.878	[0.254-0.512]	0.001	Supported
H2b: NF→TT	0.137	1.642	[-0.027-0.299]	0.100	Not Supported
H2c: MF→TT	0.080	0.870	[-0.109-0.255]	0.380	Not Supported
H3: PT→TT	-0.119	1.817	[-0.245-0.013]	0.069	Not Supported
H4: PT→BT	0.347	6.048	[0.230-0.455]	0.001	Supported
H5: TT→BT	0.270	4.364	[0.151-0.390]	0.001	Supported
H6a: BT→EP	0.483	9.980	[0.380-0.572]	0.001	Supported
H6b: BT→SP	0.470	8.950	[0.358-0.566]	0.001	Supported
H6c: BT→CGP	0.315	5.545	[0.198-0.419]	0.001	Supported

Mediation analysis

Apart from the direct analysis, Table 5 exhibits the mediation role of BT between exogenous and endogenous (ESG) variables. The analysis depicted that the relationship between PT→ BT→CGP (H7a: β=0.109, t-value=3.658, p=0.001), PT→ BT→EP (H7b: β=0.168, t-value=4.701, p=0.001), and PT→ BT→SP (H7c: β=0.163, t-value=4.405, p=0.001) are positive and significant. Thus, H7a-c were accepted and supported relationships. The analysis highlights that the relationships between TT→ BT→EP (H7d: β=0.130, t-value=3.843, p=0.001), TT→ BT→SP (H7e: β=0.127, t-value=3.573, p=0.001), and TT→ BT→CGP (H7f: β=0.085, t-value=3.104, p=0.002) are positive and supported. Thus, H7d-f was accepted. Finally, Figure 3 shows the PLS structural model.

Table 5. Mediation analysis (Source: Authors own work)

Hypothesis	β-value	T-statistics	p-value	Decision
H7a: PT → BT → CGP	0.109	3.658	0.001	Supported
H7b: PT → BT → EP	0.168	4.701	0.001	Supported
H7c: PT → BT → SP	0.163	4.405	0.001	Supported
H7d: TT → BT → EP	0.130	3.843	0.001	Supported
H7e: TT → BT → SP	0.127	3.573	0.001	Supported
H7f: TT → BT → CGP	0.085	3.104	0.002	Supported

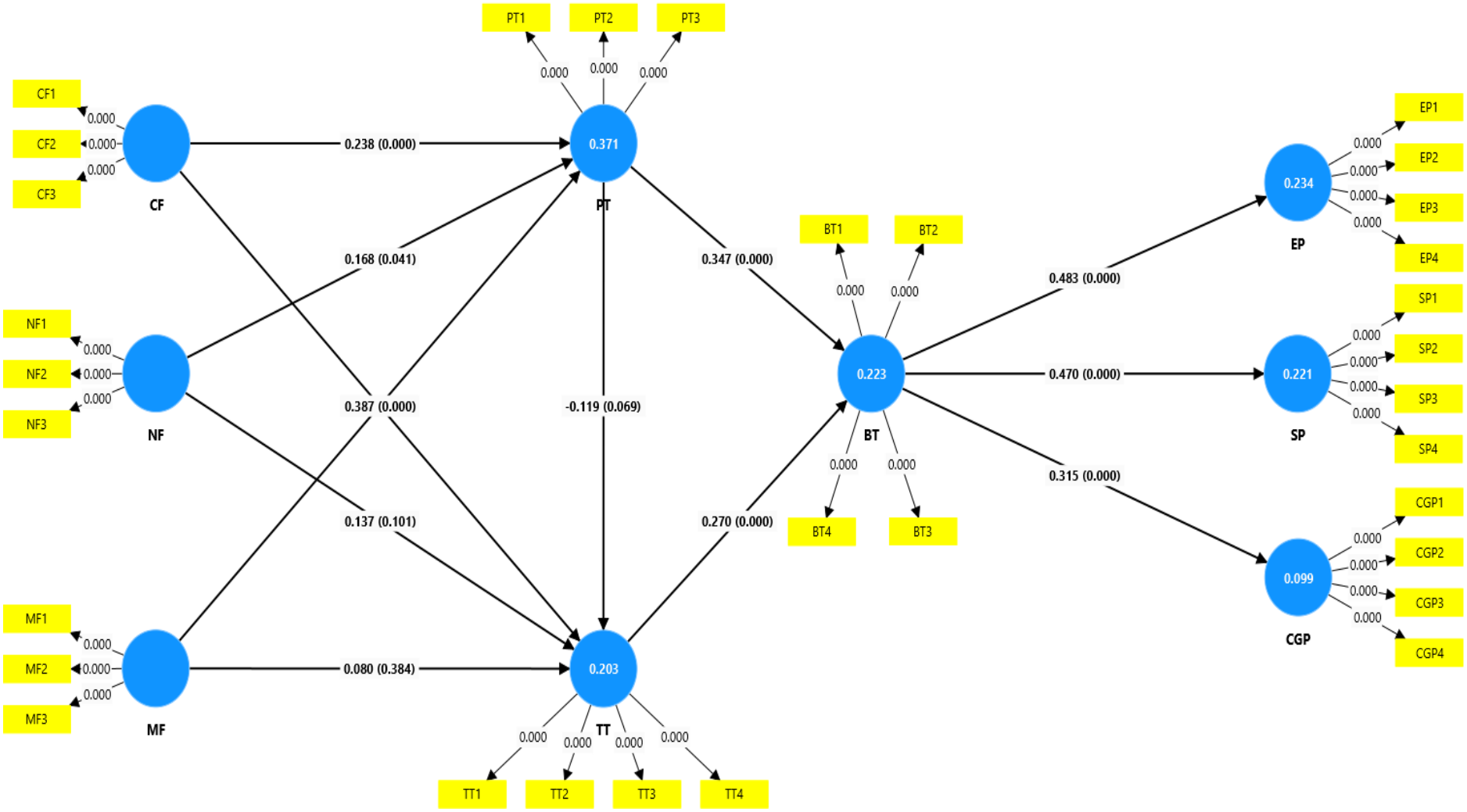

Figure 3. PLS structural model ((Source: Authors own work through SmartPLS)

Findings and discussion

The purpose of this study is to examine the direct impact of institutional forces (CF, NF, & MF) on multifaceted I5.0 transformation (people, technology, and business) to achieve ESG performance (environment, social, and governance) at the firm level in Pakistan. Furthermore, this study investigates the mediating role of I5.0 transformation between institutional forces and ESG performance. Based on the institutional theory (INT) and sociotechnical systems (STS) theory, hypotheses were formulated to achieve both direct (H1-6) and indirect associations (H7).

The first research objective indicates a direct relationship between institutional forces, I5.0 transformation, and ESG performance. To achieve this, six hypotheses have been proposed (H1-6). The first hypothesis affirmed that institutional forces (CF, NF & MF) positively and significantly impact I5.0 people transformation (PT) and formulated three hypotheses: H1a, H1b, and H1c. Based on the statistical analysis, CF, NF, and MF positively and significantly affect the I5.0 people's transformation. The study findings are supported by past studies (Ali & Johl, 2023; Bag et al., 2020; Dubey et al., 2019). To justify the outcomes, Ali and Johl (2023) argued that firms operating in developing economies lack the financial resources to transform their technical and technological capabilities. Thus, firms emphasise people/social resources (Abayomi et al., 2020; Lin et al., 2020). Moreover, Dubey et al. (2019) argued the importance of human resources, which can effectively orchestrate different technologies. Therefore, H1a-c was accepted. Furthermore, the findings highlight that institutional forces (CF, NF & MF) have a positive impact on I5.0 technology transformation and develop three hypotheses, H2a, H2b, and H3b. The empirical findings indicate that CF has a positive and significant impact on I5.0 technology transformation and is supported by past studies (Dubey et al., 2019; Bennich, 2024; Chen and Zuo, 2024). Thus, H2a was accepted. Unexpectedly, the statistical findings highlight that NF and MF have an insignificant effect on I5.0 technology transformation. The study outcomes are supported by past literature (Ali and Johl, 2023; Hsia et al., 2019). This indicates that regulatory pressures or CF dominate the technology adoption in the CPEC. A possible justification for this inconsistency is that limited technological readiness and heterogeneous peer practices may deteriorate the influence of normative expectations and imitation. Additionally, these outcomes may be explained by the fact that only regulatory and government bodies can effectively enforce the digital transformation, especially operating in emerging regions. Thus, H2b & H2c were rejected.

Surprisingly, the statistical analysis indicates that the association between people and technology in I5.0 was insignificant. To justify the results, Ghobakhloo et al. (2023) argued that the implementation of I5.0 might be hindered by limited technology access, especially for firms operating in developing regions. Consequently, it may create a disconnected relationship between people and technology factors (Slavic et al., 2024). However, the human-technology interaction is the core of I5.0. However, the implementation of I5.0 principles may face challenges due to existing social and economic inequalities. As a result, it could further obscure the relationship between people and technology (Gamberini and Pluchino, 2024). Thus, H3 was rejected. On the other hand, the findings indicate that both people and technological aspects positively and significantly promote the business transformation in I5.0. The outcomes are supported by past studies (Ali and Johl, 2023; Dubey et al., 2019; Nitlarp and Mayakul, 2023). Thus, H4 and H5 were accepted.

Furthermore, the statistical results indicate that the I5.0 transformation has a significant and positive impact on ESG performance (H6a-c). The study findings are supported by past studies (Jin and Wu, 2024; Huang et al., 2023; Fang et al., 2023; Ding et al., 2023; Deng and Karia, 2025). To justify the results, past literature affirmed that the human-machine interaction of I5.0 enhances the social dimension by promoting ethical work practices and working conditions. Moreover, I5.0 technologies are designed to minimise the resource consumption and environmental impact. Furthermore, the transformation in I5.0 further promotes governance by emphasising accountability and transparency through reporting and data management, which is vital for effective ESG performance. Conclusively, the empirical findings affirmed that multifaceted I5.0 transformation improves the ESG performance across all dimensions. Thus, H6a, H6b and H6c were accepted.

Finally, the second objective indicates that the I5.0 business transformation has a mediating role between institutional forces (CF, NF & MF) and ESG performance (H7a-f). The study outcomes are supported by past literature (Al-Omoush et al., 2025; Chen et al., 2024; Lee et al., 2024; Tuyen et al., 2023; Wu et al., 2023). Chen et al. (2024) argued that digital transformation is a vital link between fintech and firm green innovation. Moreover, Lee et al. (2024) contended that digitalisation capability strengthens the association between institutional pressure on sustainability and ESG strategy. Furthermore, Rawashdeh et al. (2024) argued that digital transformation has a mediating role between organisational strategic agility and environmental sustainability. Tuyen et al. (2023) affirmed the mediating role of digital transformation between corporate engagement and firm innovation. Finally, Wu et al. (2023) affirmed the mediating role of digital transformation as a strategic response in the social crisis

era. Conclusively, the above discussion supports the mediating role of I5.0 business transformation between institutional forces and ESG performance. Thus, H7a-f were supported and accepted.

Research contributions

Theoretical contributions

To put the findings into context, this research has several theoretical and practical contributions. From theoretical perspectives, this study has a fourfold theoretical contribution by integrating institutional (INT) and STS theories to explain the role of external forces in driving multifaceted I5.0 transformation and ESG performance. Firstly, the study findings contribute to the INT theory by demonstrating how CF, NF & MF influence multifaceted I5.0 transformation (people, technology, & business) to reshape the firm's sustainability strategies. Secondly, the study outcomes advance STS theory by highlighting the interplay between socio (people-centric) and technical (technology) factors in I5.0. This study emphasises that firms that solely focus on technology aspects are unable to gain competitive advantages. Thus, a human-centric nature of I5.0 is a more viable solution to gain competitiveness. Thirdly, this study is novel in integrating the institutional and STS theories. This study's theoretical highlights a novel perspective on how external forces and internal factors (people & technology) interact to drive sustainable industrial transformation, filling a critical gap in ESG and I5.0 literature. Finally, the results contribute to the growing body of literature on ESG performance by empirically validating the mediating role of multifaceted I5.0 in the relationship between institutional forces (CF, NF, & MF) and ESG performance. Thus, this study offers a comprehensive framework to understand how digitalisation and sustainability concepts are evolving in I5.0.

Practical contributions

Apart from theoretical contributions, this research has manifold practical implications. Firstly, managers should proactively align their firm's operations and strategies with external forces by adopting digital governance frameworks to ensure compliance with ESG and ethical AI practices. Secondly, the study offers that the organisation should incorporate a human-centric approach in I5.0 by reskilling employees, fostering human-machine collaboration and ensuring social development through fair labour practices. Third, organisations should adopt an adaptive strategy by benchmarking against industry leaders, embracing sustainability principles to maintain a competitive edge in the I5.0 era. Furthermore, by aligning external forces with STS advancements, firms can drive digital sustainability while achieving long-term

ESG performance. From policy aspects, the policymakers in emerging economies can leverage coercive factors like procurement standards, disclosure requirements and regulatory incentives to promote ESG-oriented digitalisation. Additionally, public recognition schemes may further strengthen normative and mimetic forces. Finally, from societal aspects, I5.0 should be framed not only as a technological agenda but also as a social contract, emphasising decent work, digital equity, and inclusive upskilling.

Limitations and Future Research Avenues

Although this study has notable contributions, it still has limitations that open the avenues for future research. Theoretically, the research framework is underpinned by institutional (INT) and sociotechnical systems (STS) theories to explain the role of external forces for I5.0 transformation and ESG performance. Thus, this study does not account for other theories like Stakeholder and Dynamic capabilities theories. Future research could incorporate other theories to understand how firm dynamic capabilities promote ESG performance in I5.0. Moreover, this study framework highlights the institutional forces as the primary external factors of I5.0 transformation. Nevertheless, there are other factors like top management/ leadership commitment, technological readiness, and firm culture that may also affect ESG performance. Future research may develop a more holistic approach by integrating internal organisational factors. From a methodology perspective, this research adopts a cross-sectional survey approach, which hinders the long-term effect of the I5.0 transformation on ESG performance. Thus, future research may employ a longitudinal research design to provide a deeper insight into how firms evolve in I5.0 from external forces. Furthermore, the sample frame is based on manufacturing and services firms operating on the CPEC route, which may limit the generalizability. Therefore, future studies may expand the geographical and sectoral scope to examine the applicability of the proposed framework in various economic contexts.

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