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27 **Introduction**

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

48 The transition to I5.0 highlights substantial challenges for people, technology, and
49 business. At the people level, the human-centric aspect of I5.0 necessitates reskilling people to
50 minimise the digital gaps (Schmager et al., 2025). Moreover, ethical concerns related to AI in
51 decision-making raise social challenges. At the technology level, applying advanced
52 technologies like AI raises significant challenges related to cybersecurity, data privacy, and
53 governance (Giannakos et al., 2025). From a business perspective, organisations face high
54 operational costs when implementing advanced technologies. In a nutshell, the multifaceted
55 I5.0 transformation requires a holistic framework to achieve ESG performance without
56 compromising sustainability. Institutional forces play a significant role in mitigating these
57 challenges, especially in the I5.0 era. In line with past studies (Bennich, 2024; Arranz et al.,
58 2022), the institutional forces are conceptualised as an Isomorphic process and divided into
59 coercive, mimetic, and normative forces. To mitigate the ESG challenges in I5.0, coercive
60 forces drive organisations to adopt sustainable ESG practices and digital governance policies

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

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

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

108 **Theoretical framework and hypotheses development**

109 **Institutional theory**

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

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

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

141 **Sociotechnical systems (STS) theory**

142 Apart from institutional theory, this research is also underpinned by sociotechnical
143 systems (STS) theory. STS theory posits that the interaction between social and technical
144 aspects must be jointly optimised (Davis et al., 2014; Kessler, 2013). Before explaining the
145 STS theory, it is necessary to understand the social and technical systems. The social systems
146 highlight human and employee-related factors, such as attitude, knowledge, and social
147 relationships (Ali & Johl, 2024). At the same time, technical systems consist of processes,
148 machines, and materials that transform input into output (Kessler, 2013). Fundamentally, STS
149 theory posits that a firm must combine social and technical aspects to create a successful
150 system, particularly in the context of digital transformation. For instance, Ali and Waheed
151 (2025) highlight the STS perspective of quality management to promote I4.0 practices.
152 Likewise, Marcon et al. (2024) indicate that organisations must develop and implement an STS
153 perspective to promote a higher adoption rate of I4.0.

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

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

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

176 **Hypotheses development**

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

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

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

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

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

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

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

208 *Institutional forces and technology transformation in I5.0*

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

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

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

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

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

232 *Relationship between I5.0 transformation factors*

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

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

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

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

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

257 *Relationship between I5.0 transformation and ESG performance*

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

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

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

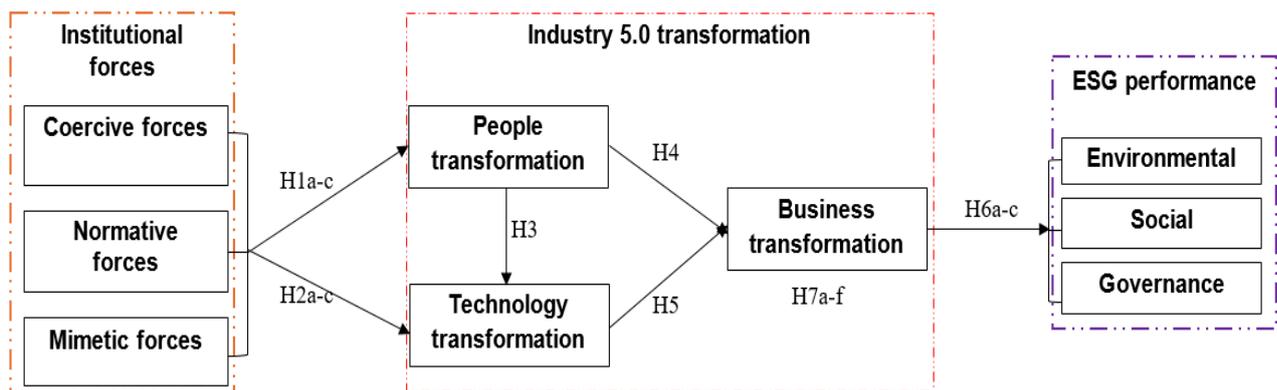
287 H6a-c: Business transformation in I5.0 positively and significantly affects ESG performance
288 (environment, social, and governance).

289 *The mediating role of I5.0 transformation*

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

296 Prior literature supports the notion that DT mediates between exogenous and endogenous
297 variables. For instance, Rawashdeh et al. (2024) affirmed that DT partially mediates between
298 strategic agility and environmental sustainability. Tuyen et al. (2023) affirmed that DT
299 mediates between corporate social responsibility and firm innovation. Moreover, Wu et al.
300 (2023) highlight the mediating role of DT as a strategic response to cope with the social crises
301 during the COVID-19 pandemic. Finally, Chen et al. (2024) claimed the mediating role of DT
302 between fintech and Chinese firm green innovation. Conclusively, past studies support the
303 mediating role of DT between various exogenous and endogenous constructs. However, there
304 is a lack of evidence relating to the mediating role of I5.0 transformation between external
305 forces and ESG performance. To fill this void, the following hypotheses have been proposed.
306 Moreover, Figure 1 highlights the research framework.

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



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

309 **Methodology**

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

313 collection was predetermined and structured. In the 2nd and 3rd layers, this research employed
314 a deductive approach through a mono-quantitative method. According to Saunders et al.
315 (2019), there is a link between positivist philosophy, the deductive approach, and quantitative
316 research design. In the 4th and 5th layers, a cross-sectional survey strategy was adopted. The
317 final layer highlights the data collection and analysis. In this regard, the research primarily
318 focused on the manufacturing and services firms located in the western Corridor of the CPEC
319 (China-Pakistan Economic Corridor). Similar to the prior literature, this research focuses on
320 the manufacturing and services firms located in three industrial estates (Hayatabad, Hattar &
321 Gadon) of Khyber Pakhtunkhwa (KP) in Pakistan (Rahman et al., 2023). The western CPEC
322 corridor passes through KP province to justify the context. Moreover, CPEC is a transformative
323 initiative to strengthen the Pakistani economy and infrastructure. Furthermore, it serves as a
324 catalyst for industrial modernisation. According to Rahman et al. (2023), the sample frame of
325 firms located in these industrial estates is missing. Thus, this research employed G*Power
326 software to calculate the sample size. Based on the input parameters of effect size = 0.15, alpha
327 0.05, power = 0.95 and predictors =6, the minimum sample size is 146. Due to the absence of
328 a reliable and complete sampling frame; a convenience sampling technique was adopted. In the
329 current study context, firms are dispersed across industrial estates, and no publicly accessible
330 database or registry provides an extensive list of potential respondents (Hassan et al. 2022).
331 Therefore, probability sampling techniques like simple random sampling are not feasible; they
332 require a well-defined population list (Saunders et al. 2019).

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

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

348 **Measures**

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

362 **Result & analysis**

363 **Demographic analysis and CMB**

364 This section presents the demographic and common method biases (CMB) analysis. First,
365 Table 1 highlights the demographic analysis of the sample firms in terms of age, type, and
366 number of employees. Table 1 reveals that 52 (19%) firms are in the young age category, 73
367 (26%) firms are in the 6-10 year age category, 86 (32%) firms are in the 11-15 years age
368 category, and 63 (23%) are in the more than 16 years age category. Moreover, most sample
369 firms fall in the manufacturing category (154, 56%), followed by the services category (123,
370 44%). Finally, the sample data indicate that 115 (42%) firms have 5-100 employees, 98 (35%)
371 firms have 101-200 employees, and only 64 (23%) firms have more than 200 employees.

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

377 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%

378 **Structural equation modelling (SEM)**

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

382 *Measurement model analysis*

383 Reliability and convergent validity

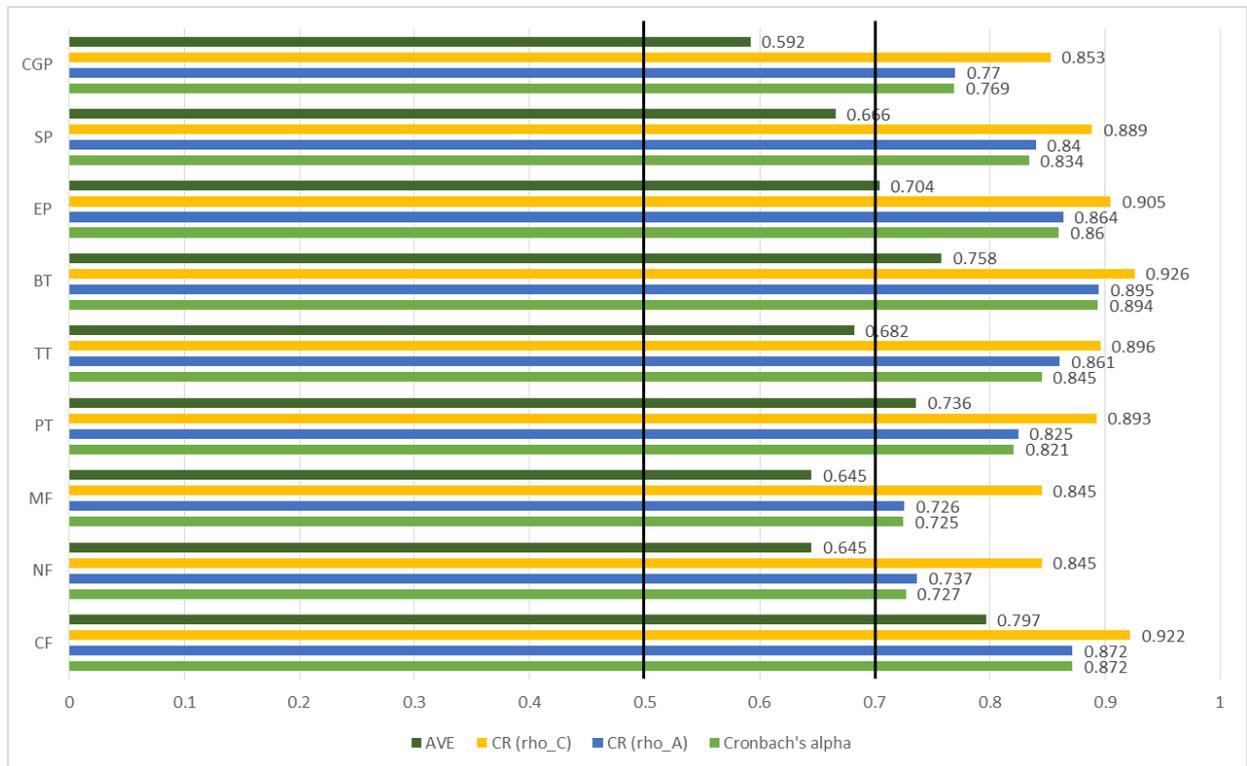
384 Reliability and convergent validity tests were performed in the PLS-SEM measurement
385 analysis. Hair et al. (2023) suggested that Cronbach’s alpha, CR, and rho_A analyses were
386 performed to measure the construct's reliability. Hair et al. (2019) affirmed that the threshold
387 value of all reliability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

393 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				

394



395

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

396 Discriminant validity

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

402 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	

403 *Structural model analysis*

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

406 Direct analysis

407 Henseler et al. (2015) recommended using the bootstrapping technique with 5000 resamples to
 408 evaluate the direct hypotheses, as shown in Table 4. Based on the direct structural analysis,
 409 institutional forces (CF, NF & MF) positively transform the people (PT) in I5.0. The
 410 association between CF→PT ($\beta=0.238$, $t\text{-value}=3.870$, $p=0.001$), NF→PT ($\beta=0.168$, $t\text{-}$
 411 $\text{value}=2.046$, $p=0.040$), and MF→PT ($\beta=0.328$, $t\text{-value}=3.836$, $p=0.001$) are support the
 412 hypotheses. Therefore, H1a-c has been supported. Surprisingly, institutional forces have an
 413 insignificant relationship with technology transformation in I5.0, except for coercive force. The
 414 direct analysis indicates that the relationship between CFTT ($\beta=0.387$, $t\text{-value}=5.878$, $p=0.001$)
 415 is supported, and H2a was accepted. On the other hand, the relationship between NF→TT
 416 ($\beta=0.137$, $t\text{-value}=1.642$, $p=0.100$) and MFPT ($\beta=0.080$, $t\text{-value}=0.870$, $p=0.380$) is not
 417 supported. Thus, H2b-c was rejected. Unexpectedly, the association between PT and TT was
 418 negative and insignificant ($\beta=-0.119$, $t\text{-value}=1.817$, $p=0.069$). Therefore, H3 was not
 419 supported. Furthermore, the analysis indicates that the relationship between PT→ BT ($\beta=0.347$,
 420 $t\text{-value}=6.048$, $p=0.001$) and TT→ BT ($\beta=0.270$, $t\text{-value}=4.364$, $p=0.001$) is positive and

421 significant. Thus, H4 and H5 were accepted. Finally, the direct analysis exhibits that BT has a
 422 positive and significant association with ESG. The SEM results depicted that the relationship
 423 between BT→EP ($\beta=0.483$, $t\text{-value}=9.980$, $p=0.001$), BT→SP ($\beta=0.470$, $t\text{-value}=8.950$,
 424 $p=0.001$) and BT→ CGP ($\beta=0.315$, $t\text{-value}=5.545$, $p=0.001$) are positive and significant.
 425 Therefore, the H6a-c were supported.

426 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

427 Mediation analysis

428 Apart from the direct analysis, Table 5 exhibits the mediation role of BT between exogenous
 429 and endogenous (ESG) variables. The analysis depicted that the relationship between PT→
 430 BT→CGP (H7a: $\beta=0.109$, $t\text{-value}=3.658$, $p=0.001$), PT→ BT→EP (H7b: $\beta=0.168$, $t\text{-value}=4.701$,
 431 $p=0.001$), and PT→ BT→SP (H7c: $\beta=0.163$, $t\text{-value}=4.405$, $p=0.001$) are
 432 positive and significant. Thus, H7a-c were accepted and supported relationships. The analysis
 433 highlights that the relationships between TT→ BT→EP (H7d: $\beta=0.130$, $t\text{-value}=3.843$,
 434 $p=0.001$), TT→ BT→SP (H7e: $\beta=0.127$, $t\text{-value}=3.573$, $p=0.001$), and TT→ BT→CGP (H7f:
 435 $\beta=0.085$, $t\text{-value}=3.104$, $p=0.002$) are positive and supported. Thus, H7d-f was accepted.
 436 Finally, Figure 3 shows the PLS structural model.

437 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

438

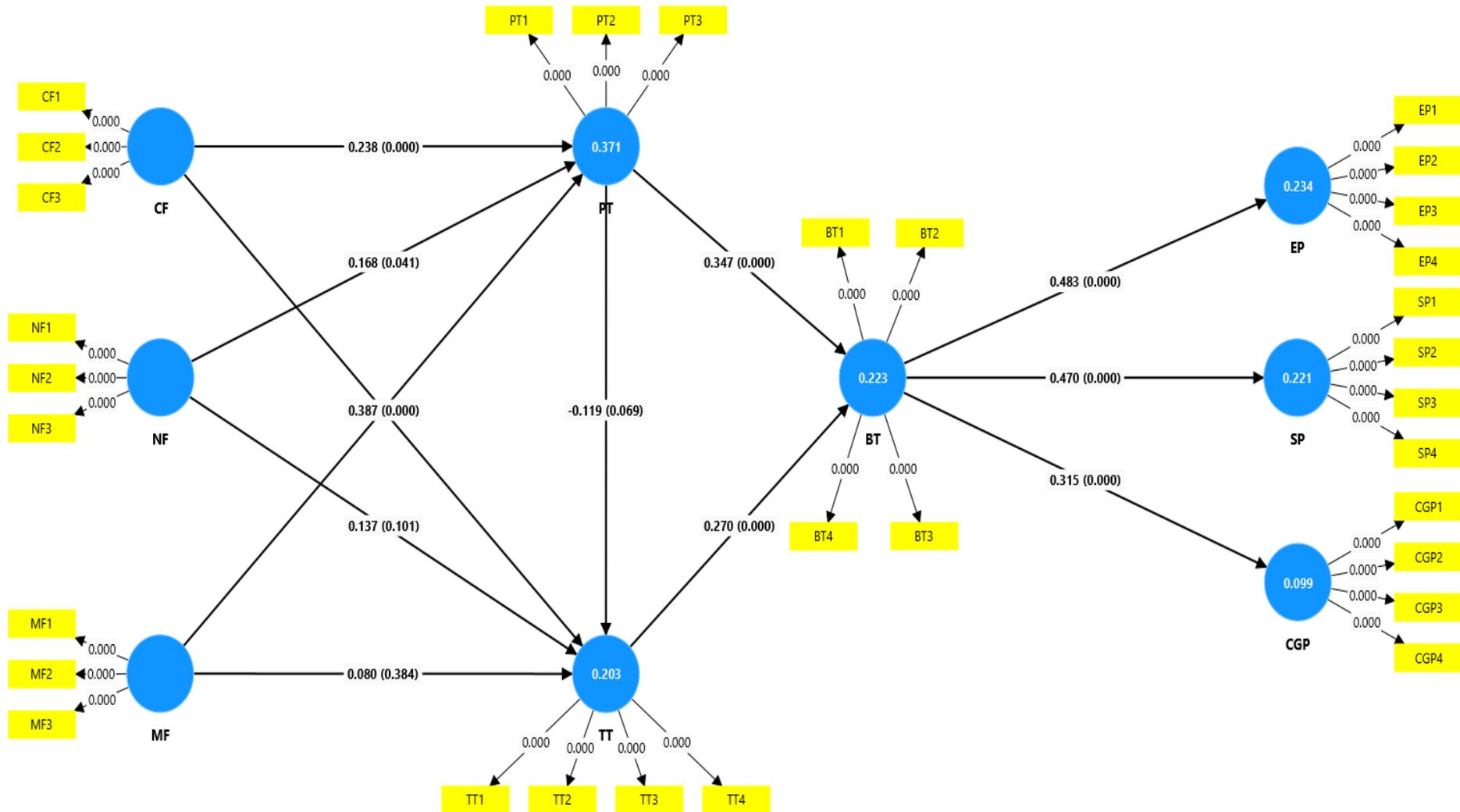


Figure 3. PLS structural model ((Source: Authors own work through SmartPLS))

1 **Findings and discussion**

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

9 The first research objective indicates a direct relationship between institutional forces,
10 I5.0 transformation, and ESG performance. To achieve this, six hypotheses have been proposed
11 (H1-6). The first hypothesis affirmed that institutional forces (CF, NF & MF) positively and
12 significantly impact I5.0 people transformation (PT) and formulated three hypotheses: H1a,
13 H1b, and H1c. Based on the statistical analysis, CF, NF, and MF positively and significantly
14 affect the I5.0 people's transformation. The study findings are supported by past studies (Ali &
15 Johl, 2023; Bag et al., 2020; Dubey et al., 2019). To justify the outcomes, Ali and Johl (2023)
16 argued that firms operating in developing economies lack the financial resources to transform
17 their technical and technological capabilities. Thus, firms emphasise people/social resources
18 (Abayomi et al., 2020; Lin et al., 2020). Moreover, Dubey et al. (2019) argued the importance
19 of human resources, which can effectively orchestrate different technologies. Therefore, H1a-
20 c was accepted. Furthermore, the findings highlight that institutional forces (CF, NF & MF)
21 have a positive impact on I5.0 technology transformation and develop three hypotheses, H2a,
22 H2b, and H3b. The empirical findings indicate that CF has a positive and significant impact on
23 I5.0 technology transformation and is supported by past studies (Dubey et al., 2019; Bennich,
24 2024; Chen and Zuo, 2024). Thus, H2a was accepted. Unexpectedly, the statistical findings
25 highlight that NF and MF have an insignificant effect on I5.0 technology transformation. The
26 study outcomes are supported by past literature (Ali and Johl, 2023; Hsia et al., 2019). This
27 indicates that regulatory pressures or CF dominate the technology adoption in the CPEC. A
28 possible justification for this inconsistency is that limited technological readiness and
29 heterogeneous peer practices may deteriorate the influence of normative expectations and
30 imitation. Additionally, these outcomes may be explained by the fact that only regulatory and
31 government bodies can effectively enforce the digital transformation, especially operating in
32 emerging regions. Thus, H2b & H2c were rejected.

33 Surprisingly, the statistical analysis indicates that the association between people and
34 technology in I5.0 was insignificant. To justify the results, Ghobakhloo et al. (2023) argued
35 that the implementation of I5.0 might be hindered by limited technology access, especially for
36 firms operating in developing regions. Consequently, it may create a disconnected relationship
37 between people and technology factors (Slavic et al., 2024). However, the human-technology
38 interaction is the core of I5.0. However, the implementation of I5.0 principles may face
39 challenges due to existing social and economic inequalities. As a result, it could further obscure
40 the relationship between people and technology (Gamberini and Pluchino, 2024). Thus, H3
41 was rejected. On the other hand, the findings indicate that both people and technological
42 aspects positively and significantly promote the business transformation in I5.0. The outcomes
43 are supported by past studies (Ali and Johl, 2023; Dubey et al., 2019; Nitlarp and Mayakul,
44 2023). Thus, H4 and H5 were accepted.

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

56 Finally, the second objective indicates that the I5.0 business transformation has a
57 mediating role between institutional forces (CF, NF & MF) and ESG performance (H7a-f). The
58 study outcomes are supported by past literature (Al-Omoush et al., 2025; Chen et al., 2024;
59 Lee et al., 2024; Tuyen et al., 2023; Wu et al., 2023). Chen et al. (2024) argued that digital
60 transformation is a vital link between fintech and firm green innovation. Moreover, Lee et al.
61 (2024) contended that digitalisation capability strengthens the association between institutional
62 pressure on sustainability and ESG strategy. Furthermore, Rawashdeh et al. (2024) argued that
63 digital transformation has a mediating role between organisational strategic agility and
64 environmental sustainability. Tuyen et al. (2023) affirmed the mediating role of digital
65 transformation between corporate engagement and firm innovation. Finally, Wu et al. (2023)
66 affirmed the mediating role of digital transformation as a strategic response in the social crisis

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

70 **Research contributions**

71 *Theoretical contributions*

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

90 *Practical contributions*

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

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

106 **Limitations and Future Research Avenues**

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

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