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Bhatia, M. S. & Kumar, S.

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RESEARCH ARTICLE

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Linking stakeholder and competitive pressure to Industry 4.0 and performance: Mediating effect of environmental commitment and green process innovation

Manjot Singh Bhatia[1] | Saurabh Kumar[2]

[1]School of Strategy and Leadership, Coventry University, Coventry, UK

[2]Information Systems Area, Indian Institute of Management Indore, Indore, India

Correspondence
Manjot Singh Bhatia, School of Strategy and Leadership, Coventry University, Coventry, UK.
Email: manjotbht@iiml.ac.in

Abstract

In the recent few years, with an increase in focus on sustainability, firms have been actively pursuing different strategies to contribute towards sustainability. Industry 4.0 (I4) technologies can help organizations to achieve superior environmental as well as economic performance. Through the lens of stakeholder theory (ST) and Schumpeterian view of competition (SCV), this paper examines whether stakeholder and competitive pressures towards sustainability stimulate organizations to implement I4 technologies and commensurate performance outcomes. The study further tests the mediating role of environmental commitment and green process innovation (GPI) on these relationships. The proposed hypotheses are examined using the survey data from 173 manufacturing firms in India by partial least squares (PLS) approach. Findings show that environmental commitment mediates the effect of stakeholder and competitive pressures on I4 technologies. Further, results also show that GPI mediates between I4 technologies and performance. The findings provide insights for managers on how they can best respond to stakeholder and competitive pressures on sustainability and contribute towards sustainable development.

KEYWORDS

competitive pressure, environmental commitment, environmental performance, Industry 4.0, stakeholder pressure, sustainability

1 | INTRODUCTION

Today, the manufacturing environment has become very complex and dynamic (Genovese et al., 2014). There are several aspects such as agility, responsiveness, product quality, and compliance with regulations, which are crucial for firms for their survival in the market (Brousell et al., 2014). Further, the ever-changing requirements of customers have posed significant challenges for organizations. To overcome these challenges and satisfy the customer requirements, firms need to ensure better flexibility to offer customized products with better quality and at competitive prices in the market (Leitão et al., 2016; Shamsuzzoha et al., 2016). This necessitates digitization, automation, connectivity, and integration of manufacturing systems and enterprises (Fatorachian & Kazemi, 2018). At the same time, with an increased focus on sustainable development, firms have also been facing pressures from several stakeholders, such as the government, customers, and so forth, regarding the implementation of environment management practices (Luo et al., 2020). Besides pressure from stakeholders, firms also face significant competitive pressure for implementing environment management practices (Dai et al., 2015).

Industry 4.0 (I4) technologies can ensure digitization, connectivity, and integration of production systems (Naqvi et al., 2015) and help in better managing the systems and satisfy the demands of the customers. "Industry 4.0," as defined by Kohler and Weisz (2016), is "a new approach for controlling production processes by providing real-time synchronization of flows and by enabling the unitary and customized fabrication of products." I4 comprises several advanced technologies such as cloud computing, cyber-physical systems (CPS), Internet of things (IoT), additive manufacturing, big data analytics (BDA), and so forth (Kamble et al., 2020; Lu, 2017). I4 technologies can create an environment in which processes can self-organize and self-optimize based on specific criteria such as customers' demand, availability of resources, costs, and so forth (Leitão et al., 2016). Overall, I4 technologies aim to integrate the processes such that the production is efficient and flexible, and products are of higher quality and lower costs are incurred (Wang et al., 2016). The improved decision-making resulting from I4 technologies leads to better productivity and enables firms to achieve competitive advantage in the market (Bechtold et al., 2014).

Besides the above mentioned benefits, I4 technologies can also help organizations to achieve sustainable performance objectives (Machado et al., 2020; Stock & Seliger, 2016). As firms face pressures from stakeholders and competitive pressures towards sustainability, they can consider I4 technologies for ensuring sustainability outcomes and survive and excel in the market. Earlier studies in literature have examined the influence of stakeholder and competitive pressures towards green supply chain management (GSCM) practices (Dai et al., 2014; Yu & Ramanathan, 2015). Due to the potential benefits of I4 technologies with respect to sustainability, many firms have invested in these technologies in the recent few years (Chung, 2015). However, the impact of stakeholder and competitive pressures towards sustainability on I4 remains unexplored. We fill this gap in the literature and examine stakeholder and competitive pressures as antecedents of I4 technologies. Specifically, based on the stakeholder theory (ST) and Schumpeterian view of competition (SVC), the first objective is to analyze whether stakeholders and competitive pressures towards sustainability influence firms to implement I4 technologies.

The environmental management literature has also emphasized the importance of environmental commitment to respond to environmental issues (Jansson et al., 2017). Environmental commitment can be regarded as a key internal factor, which can impact the actual response of firms towards handling the increasing pressures towards sustainability (Wang et al., 2018). Firms which commit themselves towards environment protection in response to increased pressures on sustainability are likely to implement environment management practices (Chen et al., 2015), including I4 technologies. In this regard, we consider environmental commitment as an important mediator between pressures towards sustainability and I4 technologies. Thus, the second objective is to examine whether environmental commitment mediates the effect of stakeholders and competitive pressures on I4.

Several researchers have discussed how I4 technologies can contribute towards sustainable development (Jabbour et al., 2018; Kamble et al., 2018; Machado et al., 2020; Rosa et al., 2020). The recent studies by Li et al. (2020) and Kumar and Bhatia (2021) have tested this relationship empirically and found that I4 positively affects economic and environmental performance. However, few researchers have also pointed out the negative effects of I4 with respect to product performance (Dalenogare et al., 2018) and economic/environmental performance (Kiel et al., 2017). Therefore, more studies are required for reaching a conclusive agreement with regard to the potential outcomes of I4 technologies. Further, to achieve sustainability outcomes, firms also need to leverage digital technologies to promote green process innovation (GPI). GPI involves modifications and re-design of the production processes and aims to reduce any potential negative effects on environment and reduce overall costs (Guo et al., 2021; Wong et al., 2020). GPI practices can serve as a channel through which firms can leverage I4 technologies for achieving the outcomes with regard to sustainability (Wei & Sun, 2021). Specifically, I4 technologies can address several challenges related to collecting and processing data, thereby promoting GPI and achieving sustainability outcomes. However, the role of GPI between digital technologies and performance remains unexplored in the literature. Therefore, we fill this gap and analyze the effect of GPI between I4 and performance.

This paper has the following three objectives:

1. Analyze the influence of stakeholder and competitive pressures on I4 technologies
2. Examine the mediating role of environment commitment between the effect of stakeholder and competitive pressures on I4 technologies
3. Examine the mediating effect of GPI between I4 technologies and performance

Section 2 provides theoretical support for the framework and subsequently proposes the hypotheses. In Section 3, methodology is discussed, while Section 4 presents findings. Managerial implications are provided in Section 5, and Section 6 presents conclusions and future directions for research.

2 | LITERATURE REVIEW

2.1 | Theoretical underpinnings

ST has received increased attention in literature on sustainability (Dai et al., 2014; Sarkis et al., 2010). According to Freeman (1984), a stakeholder is "any group or individual who can affect or is affected by the achievement of an organization's objectives." Donaldson and Preston (1995) defined stakeholders as "persons or groups with legitimate interests in procedural and/or substantive aspects of corporate activity." Stakeholders include external as well as internal stakeholders. Several researchers consider business to be "a coalition" of stakeholders, including government, employees, customers, shareholders, and so forth (Donaldson & Preston, 1995).

The pressure exerted by stakeholders can significantly motivate firms to implement environment management practices to perform better in the market (Delmas & Toffel, 2008; Sarkis et al., 2010). During the past few years, stakeholders have become more concerned about the issues related to environment, and therefore, firms are under constant pressure from different stakeholders to implement practices that can contribute towards better environmental performance (Geng et al., 2017; Hofer et al., 2012; Klassen, 1993). When firms heed to demands of stakeholders and cooperate with them, it can result in a win-win situation (King, 2007). Many studies have empirically tested the effect of stakeholder pressure on environment management practices (Dai et al., 2014; Darnall et al., 2010). In line with these studies, our proposed model is grounded on ST, which postulates that firms should understand and respond to pressures exerted by stakeholders in developing the strategies related to environment protection and gain competitive advantage. Specifically, we expect that stakeholders' pressures can influence the implementation of I4 technologies, which can lead to sustainability outcomes.

Furthermore, we integrate the SVC as a theoretical grounding to examine how competitive pressure can influence firms to implement I4 technologies. SVC is built on the argument that specific actions of competitors' prompt competitive responses from the focal firm (Schumpeter, 1942). SVC has been used in earlier studies to clarify how and why organizations respond to rival firms or competitors (Young et al., 1996). Although SVC is suitable for examining the engagement of a firm towards adopting I4 technologies in achieving superior environmental performance, it has received minimal consideration in sustainability literature. Earlier, SVC has been used in the context of sustainability by Hofer et al. (2012) and Dai et al. (2014). Using Schumpeterian economics insights, we argue that competitive pressure towards sustainability can influence organizations towards the adoption of I4 technologies. Thus, our proposed framework combines both ST and SVC and argues that stakeholder and competitive pressures influence firms to consider adopting I4 technologies to achieve superior outcomes with regard to sustainability.

2.2 | Hypotheses development

2.2.1 | Stakeholder pressure and I4

According to the ST, the pressure from stakeholders can influence organizations to consider issues related to the environment and implement environment management (Sarkis et al., 2011). Firstly, stakeholders in a supply chain can influence a firm's decision towards environment management practices (Sarkis et al., 2010). Another stakeholder who can influence firms in this direction is Government, which can exert pressure through regulations (Zhu & Sarkis, 2007). Firms that do not conform to these regulations may even face fines or penalties (Sarkis et al., 2010). Pressures may also emerge from non-governmental organizations such as environmental societies like NGOs, influencing firms' decision towards environmental practices (Hoffman, 2000). These societies can influence the public's beliefs against or in favor of a firm's approach to environment management (Benn et al., 2009). Therefore, firms should legitimize the performance so that the stakeholders are satisfied (Deegan, 2002). For instance, three NGOs filed petitions against Kudankulam nuclear plant in Tamil Nadu, India, regarding environmental issues related to the plant, and the power plant has to comply with various environment management practices.[i]

Several empirical studies have also examined the effect of stakeholder pressure on environment practices (Delmas & Toffel, 2008; Wu & Ramanathan, 2015). Recently, few studies have also found that I4 technologies can improve environmental performance (Kumar & Bhatia, 2021; Li et al., 2020). Therefore, to contribute towards sustainability and satisfy the various stakeholders' expectations, firms can implement I4 technologies. In the recent few years, several firms have made considerable investments and adopted I4 technologies. Through the implementation of I4 technologies, they can contribute to the protection of environment and satisfy stakeholders pressure towards sustainability. For instance, United Nations Industrial Development Organization (UNIDO) in its report of 2017 has examined the role of stakeholders in implementing I4 technologies.[ii] Thus, we postulate:

Hypothesis H1. Stakeholder pressure positively affects adoption of I4 technologies.

2.2.2 | Competitive pressure and I4

A key element for a firm to survive and excel in the market is to closely observe the activities and strategies adopted by its competitors (Narver & Slater, 1990). In accordance with the SCV, organizations can improve their place in market through appropriate internal and external activities (Jacobson, 1992). Firms are generally inclined to emulate the behavior or actions of other firms in their social network (Henisz & Delios, 2001). Organizations generally follow their competitors in the market, who could achieve success by following certain specific actions. Over the time, it has been observed that taking appropriate actions at a suitable time can help firms to gain competitive advantage (Jacobson, 1992). As sustainability has gained increased attention during the last few years, activities related to environmental management can certainly help firms to achieve competitive advantage (Hart, 1995). According to Bergh (2002), firms are strongly influenced by their competitors regarding their response related to environmental practices. In these lines, UNIDO promotes Inclusive and Sustainable Industrial Development through three programmatic fields of activity, namely, advancing competitiveness among organizations, creating shared prosperity, and safeguarding the environment (see footnote ii).

Several studies have found evidence that firms pay heed to their competitors' environmental activities (Dai et al., 2014;

[i] https://www.business-standard.com/article/companies/ngo-files-petition-against-kudankulam-project-113071500903_1.html, accessed on 28-April-2021

[ii] https://www.unido.org/sites/default/files/2017-08/REPORT_Accelerating_clean_energy_through_Industry_4.0.Final_0.pdf, accessed on May 03, 2021

Dai et al., 2015; Ye et al., 2013). On similar lines, due to the potential of I4 technologies towards sustainability (Machado et al., 2020), several firms have adopted I4 technologies in their operations. If a firm does not adopt I4 technologies, but its competitors do adopt, it may not be able to achieve a competitive advantage and desired performance with respect to sustainability outcomes. Therefore, firms may implement I4 technologies in response to competitive pressure and ultimately contribute to sustainable development. In this regard, we posit:

Hypothesis H2. Competitive pressure positively affects adoption of I4 technologies.

2.2.3 | Mediating effect of environmental commitment

The responsiveness of the firms towards sustainability practices is affected by their commitment towards the environment. Environmental commitment is the extent to which the top managers in an organization show their commitment to protecting the environment and subsequently implementing the relevant practices (Jansson et al., 2017). The actions taken by organizations that are related to environmental protection generally emanate from internal and external pressures in the organizations (Roy et al., 2001). The organizations wish to retain their good relationship with their stakeholders by heeding to their demands related to environment protection since such practices and activities comply with the social norms and behaviors (Wang et al., 2018).

The pressures towards adopting sustainable practices can also influence management's commitment to implement sustainability initiatives (Jiao et al., 2020). Firms with less commitment to protecting the environment are less likely to implement relevant sustainability initiatives. On the other hand, the environmental commitment can create a conducive atmosphere in the firm for implementing the practices which support the environmental strategies (Lee & Ball, 2003). Therefore, the pressure towards sustainability and environmental commitment can work together and influence the firms' orientation towards environment management initiatives (Wang et al., 2018). On these lines, we argue that in response to pressure towards sustainability, environmental commitment will be a key mediating factor influencing firms to adopt I4 technologies. Thus, we postulate:

Hypothesis H3. Stakeholder pressure positively affects environmental commitment.

Hypothesis H4. Competitive pressure positively affects environmental commitment.

Hypothesis H5. Environmental commitment positively affects adoption of I4 technologies.

2.2.4 | I4, GPI, and performance

The digitization enabled by I4 technologies can create opportunities for GPI by identification of sources of pollution (Wei & Sun, 2021). This can subsequently help firms to re-design their manufacturing processes for reducing pollution. For instance, digitization in manufacturing settings can be achieved by installing and using different types of sensors. These sensors can provide useful information such as those of machine usage, performance indicators, failure models, and exact emission details. These data and information can prove to be helpful for developing better processes. I4 technologies such as CPS and IoT result in effective integration of the manufacturing systems and machinery through access to information on a real-time basis (Lopez research, 2014). This enhanced integration and sharing of information can help streamline the manufacturing processes and help in making optimal decisions (Yan & Xue, 2007). BDA and IoT can build tools for managing performance and systems for measurement, which can help energy and resource management processes (Helo & Hao, 2017; Li et al., 2016). Based on this discussion, we propose:

Hypothesis H6. I4 is positively related to GPI.

I4 technologies can play a significant role towards achieving superior environmental as well as economic performance. I4 technologies allow for higher integration between decision support systems and manufacturing operations (Jung et al., 2017). This enhanced integration and sharing of information can help to streamline the operations and processes on the shop floor and make optimal decisions (Yan & Xue, 2007). The effective exchange of information can be used as a strategic tool for enhancing the performance of manufacturing processes (Guo et al., 2014). This can impact the quality of products (Chen & Deng, 2015) and develop products through integration and improved decisions (Lang et al., 2014). The digitization provided by I4 technologies can support production, planning, and control of operations, which can reduce overall costs and enhance the overall efficiency of the operations. I4 technologies can also provide firms with several advantages on the environmental outcomes. The real-time information collected from other supply chain entities can help organizations to efficiently allocate the resources such as water, energy, materials, and so forth (Chiarini, 2021; Jabbour et al., 2018; Stock & Seliger, 2016). The information gathered through the use of digital technologies can be processed to gain relevant insights and control pollution, water quality, and energy efficiency by optimizing the production processes (Junior et al., 2018).

Hypothesis H7. I4 positively affects economic performance.

Hypothesis H8. I4 positively affects environmental performance.

GPI includes modifications and re-designing of the manufacturing process to enhance the overall environmental performance and

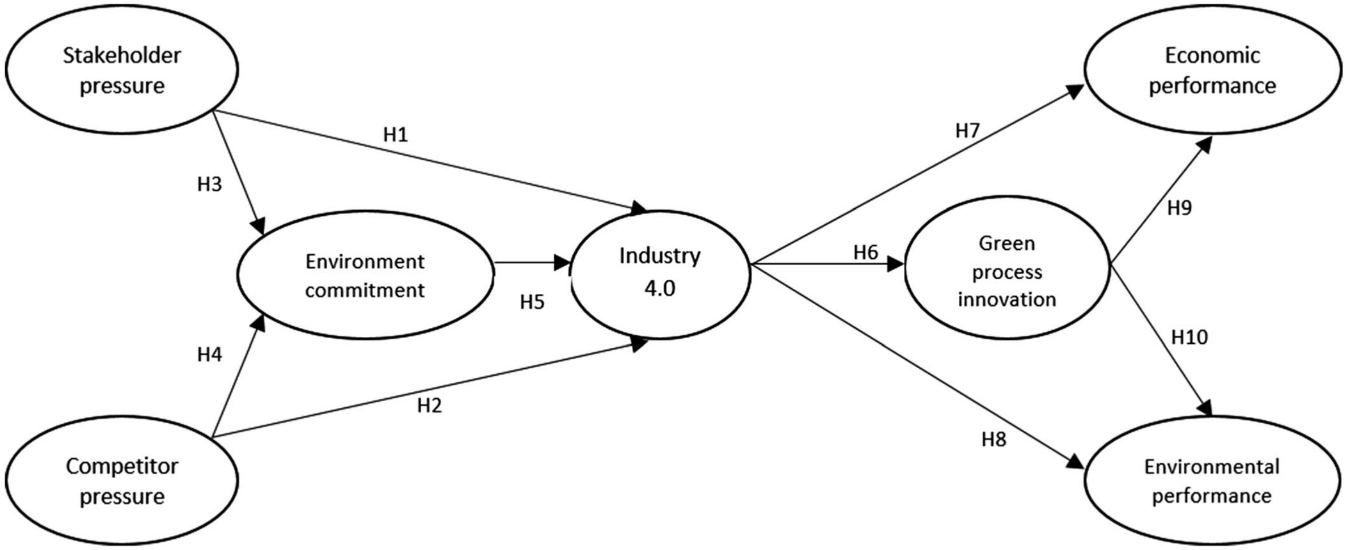

FIGURE 1 Proposed model

savings in costs (Chen et al., 2006; Huang & Li, 2017). GPI can help organizations in improving economic performance through savings in compliance costs and resource savings through reduction in usage of energy and environmental damage (Wong et al., 2020). Through GPI, firms can also reduce on the emissions and minimize waste generated through the manufacturing processes and improve overall productivity and resource efficiency (Chang, 2011; Chiou et al., 2011; Huang & Wu, 2010). Further, GPI also allows firms to reduce waste disposal costs and costs of material inputs (Wong et al., 2020). Based on this, we hypothesize:

Hypothesis H9. GPI positively impacts economic performance.

Hypothesis H10. GPI positively impacts environmental performance.

3 | METHODOLOGY

3.1 | Questionnaire

We prepared a survey questionnaire for collecting the data. The theoretical framework (Figure 1) includes the following constructs: stakeholder pressure, competitive pressure, environmental commitment, I4, GPI, economic performance, and environmental performance. The items of each construct are adapted from the published literature. We used five items to measure stakeholder pressure (Jiao et al., 2020; Sarkis et al., 2010; Yu & Ramanathan, 2015), four items for competitive pressure (Liu et al., 2010), four items for environmental commitment (Wang et al., 2018), and four items for GPI (Dai et al., 2017; El-Kassar & Singh, 2019). These scales are captured using the 5-point Likert scale (1: *Strongly disagree*; 5: *Strongly agree*). We used five items for economic performance (Kamble et al., 2020; Zhu et al., 2011) and four items for environmental performance (Kamble et al., 2020; Li et al., 2020). The items for performance factors are also captured on 5-point scale (1: *Not at all*; 5: *Very significant*).

The items for "Industry 4.0" aim to capture the implementation level and represent the maturity level regarding adequate preparation for implementing the I4 technologies (Kamble et al., 2020). Due to the complex nature of I4 technologies, many firms are uncertain regarding the outcomes of I4 technologies (Bibby & Dehe, 2018). Therefore, these items capture the "degree of implementation" rather than the success level of I4 technologies. The items are adapted from Kamble et al. (2020) and Kumar and Bhatia (2021) and measured using 5-point scale (1: *not considering it*; 5: *implemented successfully*). The content validity is assured through pre-testing with academic and industry experts. The final version also includes demographic information of the potential respondents. The items of latent variables are given in Appendix A.

3.2 | Data collection

The data are collected from Indian manufacturing industries, which include automotive, electrical, electronics, textiles, plastics, and so forth. The collection of data from multiple industries allows in collection of more samples and broad application of results (Kumar et al., 2018). The Indian manufacturing industry is growing at a fast pace, and it is expected that its contribution to gross domestic product (GDP) by 2022 will be 25%.[iii] The production of automobiles grew at a rate 2.36% between 2016 and 2020, with exports growing at 6.94% during the same period.[iv] The electronics industry has

[iii]https://www.ibef.org/download/Manufacturing-February-2021.pdf, accessed on May 07, 2021

[iv]https://www.ibef.org/industry/india-automobiles.aspx, accessed on May 07, 2021

witnessed a growth rate of 14% between 2016 and 2019. By 2025, appliances and consumer electronics industry is expected to be fifth largest around the globe. Besides, India has also attracted investments from several manufacturing companies recently.[v] Therefore, it is important that manufacturing firms actively move towards digitization, which would help to improve efficiency and fulfill customer demands. In fact, the manufacturing industry in India has already made a leap towards the adoption of I4 technologies (see footnote iii). Thus, given the importance of Indian manufacturing industry, this study pertains to the same.

The authors gave a brief about sustainability and I4 at the beginning of the survey instrument. The authors took the assistance of "NexGen Market Research" (a data collection firm) to collect data. Overall, the firm contacted 464 potential firms for filling the survey. Finally, 173 professionals filled the completed questionnaire, resulting in an overall response rate is 37.28%, considered as satisfactory (Malhotra & Grover, 1998). The sample consists of 79% of the responses from the top and middle-level industry professionals. Regarding the experience, 67% of the responses are from professionals who have more than 10 years of experience. With respect to industry, the distribution of responses is as follows: automotive (28.9%), electrical (15.6%), electronics (28.9%), and plastics (13.3%). The remaining responses are from other sectors such as appliances and textiles. We considered firm size as a control variable as it can potentially affect the findings (Gupta et al., 2020). Generally, large firms possess more resources than small firms; hence, they might be more actively involved in implementing I4 technologies (Bhatia & Kumar, 2021).

3.3 | Common method variance (CMV)

We took care of CMV through several measures. First, we kept the items of dependent constructs after the items of independent constructs in the survey instrument (Yadlapalli et al., 2018). We advised the respondents that the questions in the survey have no specific correct answer, and they should answer based on the actual situation in their firm, rather than the feelings and conforming to social norms (Carter & Jennings, 2004). We examined the correlations among the latent variables and found that the highest correlation equals 0.577, which is less than 0.9 (Hazen et al., 2015). Using Harman's single factor test, we found that first factor explains 24.32% of the variance, signifying the absence of CMV (Podsakoff et al., 2003). Additionally, we tested for CMV using the method proposed by Widaman (1985). We tested two models—first model with only traits and second model with inclusion of method factor in addition to traits (Paulraj et al., 2008; Zacharia et al., 2011). The analysis shows that the method factor accounted for only 4.9% of the variance, which is less than 25% (Williams et al., 1989). Further, all items of the first model retained their significance in the second model (Cao & Zhang, 2011). Thus, we can conclude that CMV does not affects the results.

[v]https://www.ibef.org/industry/manufacturing-sector-india.aspx, accessed on May 07, 2021

3.4 | Data analysis approach

The partial least squares (PLS) approach is used to test the conjectures. First, PLS does not require data to follow a normal distribution (Chin, 1998). PLS is also preferred when the primary objective of a study is development of the theory (Sreedevi & Saranga, 2017), and the study is exploratory (Hair et al., 2014; Sodhi et al., 2012). As our study is of exploratory nature (since it uses ST and SCV in the context of I4), PLS is an appropriate method for testing the conjectures.

4 | RESULTS

4.1 | Measurement model

We assessed convergent validity through loadings and average variance extracted (AVE). The AVE depicts the percentage of variation that can be explained by the items of the construct. For instance, an AVE of 0.683 states that the items of the construct used in the study can measure 68.3% of the construct. The earlier literature suggests that AVE should be greater than 0.5 for convergent validity. In this regard, we have found that the AVE for all the latent variables or constructs, except stakeholder pressure, are greater than 0.5. Though AVE for stakeholder pressure is marginally less than 0.5, we have kept all the items in the model due to their importance. Many studies in the past have used AVE value lesser than 0.5 for establishing convergent validity (Wang et al., 2021; Yu & Ramanathan, 2015; Zhao et al., 2011). We have used other measures of convergent validity like loadings of the item and composite reliability. The loadings for most of the items are more than 0.6; however, few items have loading values less than 0.6 (ECP3 and ENP4) (Beka Be Nguema et al., 2022). Therefore, they were removed from the model. The loading of IND1 is 0.59, but as it is very close to 0.6 and more than 0.5 (Tenenhaus et al., 2005), we have kept it in the model. The composite reliability (CR) of all the latent variables is above 0.7, indicating adequate reliability of constructs (Nunnally & Bernstein, 1994). Table 1 shows loadings, CR, and AVE.

Discriminant validity depicts that constructs that should have no relationship among themselves do not have any relationship in actuality. Discriminant validity is validated by a comparison of AVE and inter-construct correlations. We found that AVE of each latent variable is more than the inter-construct correlations (Fornell & Larcker, 1981) (Table 2). We further validated the discriminant validity through heterotrait-monotrait (HTMT) ratios. The HTMT is a measure of similarity between latent variables. All the HTMT values are less than 0.9 (Table 3), which further confirms discriminant validity (Henseler et al., 2015).

4.2 | Structural model

We evaluated the path coefficient of each hypothesis and the corresponding statistical significance. First, we found all the variance

TABLE 1 Reliability and validity

Construct	Item	Loading	CR	AVE	Cronbach's alpha
Stakeholder pressure	STP1	0.64	0.82	0.48	0.72
	STP2	0.61			
	STP3	0.75			
	STP4	0.65			
	STP5	0.77			
Competitive pressure	COP1	0.76	0.82	0.54	0.72
	COP2	0.65			
	COP3	0.76			
	COP4	0.77			
Environmental commitment	EC1	0.75	0.83	0.55	0.73
	EC2	0.69			
	EC3	0.75			
	EC4	0.78			
Industry 4.0	I41	0.59	0.84	0.51	0.76
	I42	0.65			
	I43	0.77			
	I44	0.73			
	I45	0.79			
Green process innovation	GPI1	0.67	0.80	0.50	0.66
	GPI2	0.70			
	GPI3	0.78			
	GPI4	0.67			
Economic performance	ECOP1	0.79	0.80	0.50	0.67
	ECOP2	0.69			
	ECOP3	-			
	ECOP4	0.63			
	ECOP5	0.69			
Environmental performance	ENV1	0.66	0.78	0.54	0.58
	ENV2	0.77			
	ENV3	0.76			
	ENV4	-			

Note: All loadings are statistically significant.

TABLE 2 Discriminant validity—Fornell and Larcker criteria

	STP	COP	EC	I4	GPI	ECOP	ENV
STP	0.688						
COP	0.577	0.736					
EC	0.439	0.419	0.741				
I4	0.329	0.314	0.450	0.711			
GPI	0.403	0.446	0.398	0.424	0.704		
ECOP	0.377	0.383	0.334	0.283	0.344	0.703	
ENV	0.372	0.348	0.275	0.320	0.401	0.537	0.732

inflation factors (VIFs) to be less than the recommended cut-off value of 5 (Hair et al., 2011). The following hypotheses are found to be significant at $p < 0.01$: H3 (Stakeholder pressure and environmental commitment, $\beta = 0.297$), H4 (Competitor pressure and environmental commitment, $\beta = 0.247$), H5 (Environmental commitment and I4, $\beta = 0.349$), H6 (I4 and GPI, $\beta = 0.424$), H9 (GPI and

TABLE 3 Discriminant validity—HTMT ratios

	STP	COP	EC	I4	GPI	ECOP	ENV
STP							
COP	0.802						
EC	0.600	0.575					
I4	0.426	0.422	0.592				
GPI	0.572	0.641	0.577	0.590			
ECOP	0.521	0.565	0.455	0.382	0.478		
ENV	0.560	0.545	0.425	0.464	0.635	0.892	

TABLE 4 Structural model

Hypothesis	Coefficient	*t* value	*p* value	Supported?
H1: STP → I4	0.115	1.184	0.237	No
H2: COP → I4	0.076	0.818	0.414	No
H3: STP → EC	0.297	3.734	0.000	Yes
H4: COP → EC	0.247	3.652	0.000	Yes
H5: EC → I4	0.349	3.474	0.001	Yes
H6: I4 → GPI	0.424	5.408	0.000	Yes
H7: I4 → ECOP	0.167	1.408	0.160	No
H8: I4 → ENV	0.183	2.148	0.032	Yes
H9: GPI → ECOP	0.273	2.819	0.005	Yes
H10: GPI → ENV	0.323	4.116	0.000	Yes

economic performance, $\beta = 0.273$), and H10 (GPI and environmental performance, $\beta = 0.323$). Hypothesis H8 (I4 and environmental performance) is also significant at $p < 0.05$ ($\beta = 0.182$).

The direct relationship between stakeholder and I4 (H1) is not found to be significant. Similarly, the direct relationship between competitive pressure and I4 (H2) is also not found to be significant. Further, Hypothesis H7 (I4 and economic performance) is also found to be insignificant. Rather, I4 indirectly affects economic performance through GPI (explained in detail in Section 4.3). Finally, firm size did not have any significant effect on I4 ($\beta = 0.083$; $p > 0.10$). The hypotheses testing results are given in Table 4. The model explains 23.6%, 14.1%, and 18.8% of the variance (R^2) for I4, economic, and environmental performance, respectively. Stone-Geisser's (Q^2) values for endogenous latent variables are greater than zero, which confirms adequate predictive power (Peng & Lai, 2012).

4.3 | Mediation analysis

The mediation effects of two proposed mediators are tested using the Baron and Kenny (1986) approach. First, to analyze the mediating effect of GPI, we examined two models. Model M1 does not include GPI and includes only the direct relationships between I4 and performance factors. Model M2 includes direct as well as indirect relationships between I4 and performance through GPI. In M1, I4 has a significant effect on both the performance factors. In M2, I4 has significant effect on GPI, and GPI has significant effect on performance factors. Further, the direct effect of I4 on both the performance factors is dropped and significant only for the relationship between I4 and environmental performance. Thus, findings support the mediation of GPI between I4 and performance outcomes.

Similarly, to test the mediation of environmental commitment, we analyzed two models. Model M3 does not include the construct "environmental commitment" and includes only the direct relationships of stakeholder and competitive pressure on I4. Model M4 includes the construct "environmental commitment"; thus, M4 includes indirect and direct effects of competitive and stakeholder pressure on I4. In M3, stakeholder and competitive pressures have significant effect on I4. In M4, the indirect effect of stakeholder and competitive pressure on I4 through the mediator is significant. Further, the direct effect of stakeholder and competitive pressures on I4 is insignificant. Thus, environmental commitment mediates the relationships of stakeholder and competitive pressure on I4.

We also conducted Sobel's test to confirm the mediation effects of both the proposed mediators (Sobel, 1982). The highly significant values from Sobel's test provide support for both the proposed mediators. Finally, we evaluated the size of both the mediating effects by variance accounted for (VAF) (ratio of indirect effect to the total effect) (Nitzl et al., 2016). The VAF of all the effects is more than 20%, which confirms the mediation effect. The mediation analysis is provided in Table 5.

5 | DISCUSSION AND MANAGERIAL IMPLICATIONS

Industry 4.0 provides significant technological advancements to organizations. While technological advances allow the development of products and processes, digital technology must be integrated with sustainability to ensure sustainable development. The three pillars of sustainable development include environment, society, and economy, which are often referred as triple bottom line (TBL). Here, environment plays a very dominant role, and hence, we have considered environmental commitment as an important construct in the study. The current study draws upon the ST and SCV to study the influence of stakeholder and competitive pressure towards sustainability, on I4

TABLE 5 Results—mediation analysis

Hypothesis	Model M1	Model M2	Standard error	VAF	Sobel test
STP → I4	0.220*	0.115	0.097	47.40%	2.51
COP → I4	0.164*	0.076	0.093	53.14%	2.53
STP → EC		0.297**	0.081		
COP → EC		0.247**	0.066		
EC → I4		0.349**	0.101		
Path	**Model M3**	**Model M4**	**Standard error**	**VAF**	**Sobel test**
I4 → ECOP	0.285**	0.167	0.119	55.08%	2.49
I4 → ENV	0.322**	0.183*	0.085	42.80%	3.29
I4 → GPI		0.424**	0.078		
GPI → ECOP		0.273**	0.097		
GPI → ENVP		0.323**	0.078		

*$p < 0.05$.
**$p < 0.01$.

technologies. Further, the study also analyzes the role of GPI between I4 and performance outcomes. The results support the mediating effect of both environmental commitment and green process innovation for adopting I4 technologies. Researchers and industry professionals are utilizing I4 to address issues and challenges related to the triple bottom line of sustainable manufacturing. For example, environmental challenges like those of resource depletion, climate change, and environmental protection can be addressed with I4. This brings a new dimension to I4, which was traditionally thought of as the way of digitizing the operations and getting advantages out of it. However, for this to be realized, there should be complete coherence and convergence of all I4 technologies, including those of AI, data analytics, IoT, machine vision, big data analytics, and machine learning. The coherence and convergence can be achieved by vertical and horizontal integration wherein all the production areas and distributors, and customers are integrated within the system. By vertical integration, we meant integrating various information technology systems at different hierarchical levels ranging from the lowest level of actuators and sensors to the highest level of systems. On the contrary, horizontal integration refers to the integration of various information technology systems which are used in different stages of manufacturing that involve an exchange of energy, materials, and information. The seamless integration increases not only the transparency of the production processes but also optimizes the supply chain activities. These types of connected systems produce a massive amount of data that can play a pivotal role in developing strategies from societal, environmental, and economic perspectives. In a nutshell, the study aims extends the knowledge on relationships among stakeholder and competitive pressures, environmental commitment, I4, GPI, and economic and environmental performance. Identifying these relationships will help managers decide on dedicating the effort and resources towards I4 technologies to respond towards competitive and stakeholder pressures and contribute to sustainability. The implications of these findings are discussed below.

First, the findings show that stakeholders and competitive pressure do not directly influence I4 technologies, but environmental commitment acts as an important mediator between these relationships. Thus, stakeholders and competitive pressure indirectly influence the adoption of I4 technologies by firms through environmental commitment. We leverage ST and SCV to recognize that firms perceive pressure from stakeholders and competitors towards sustainability and implement I4 technologies to achieve the desired outcomes. Using the multi-theoretic approach, this study provides an understanding of how organizations respond to pressure towards sustainability from stakeholders and competitors.

Earlier studies in the literature have used ST to examine the effect of stakeholder pressure towards GSCM and other environmental management practices (Dai et al., 2014; Jiao et al., 2020). These studies have found stakeholder pressure to be a crucial antecedent for GSCM practices. Our study extends this knowledge in the context of I4 technologies. However, in contrast to the other studies, our results show that firms' commitment towards the environment is an important mediator in this relationship. This indicates that in response to stakeholders and competitive pressure, firms will implement I4 technologies only if they understand about sustainability and environment management practices, and are commitment towards environment protection.

Environmental commitment can help organizations to build sensitivity towards environmental challenges. Environment commitment thus encourages organizations to respond to concerns and pressures towards sustainability and implement environmental practices (Chen et al., 2015; Muller & Kolk, 2010). The indirect effect shows that firms do consider the adoption of I4 technologies for responding to pressures. In this respect, the role of top management becomes crucial (Dai et al., 2014), and studies have emphasized it as an important "internal organizational resource" for environment management (Carter & Jennings, 2004; Gavronski et al., 2011). An implication of this result is that top management in an organization needs to evaluate how stakeholders and competitors recognize the significance of I4 technologies and respond accordingly. This finding also indicates that organizations will not respond to competitive and stakeholder pressures unless they perceive and recognize the potential benefits of I4.

Several studies in literature have emphasized that I4 technologies can aid firms in achieving sustainability. However, most of the literature is conceptual in nature and based only on theoretical or qualitative reasoning. Recent studies have analyzed the direct effect of I4 on performance (Kumar & Bhatia, 2021; Li et al., 2020). This paper extends the literature, and examines the mediating role of GPI between I4 and performance. Specifically, we propose that digital technologies can aid in GPI practices and influence performance. The findings show that GPI mediates between I4 and performance outcomes. This shows that digitization of manufacturing processes can help in building green capabilities. GPI practices require large amount of data on the manufacturing processes (Barbieri et al., 2020). One of the key challenges to GPI is that firms are not able to get detailed data about each manufacturing process (Wei & Sun, 2021). Therefore, they are unable to generate novel ideas on making the processes environmentally friendly. I4 technologies can help organizations to develop relevant capabilities which can support GPI through a collection of accurate, diverse, and timely data (Björkdahl, 2020). The organizations can analyze this real time data to achieve economic and environmental performance.

GPI serves as an underlying mechanism, which can help explain the influence of I4 on sustainable performance. The outcomes of digital technologies need to be realized through GPI. Therefore, managers should use digital technologies for GPI and enhance performance. Specifically, organizations should use digital technologies in each part of the manufacturing process and reinforce “machine-to-machine” integration to acquire integrated and holistic data.

6 | CONCLUSIONS

The study examines the effect of stakeholder and competitive pressures on I4 technologies and the role of environmental commitment as a mediator on these relationships. The paper further analyzes the meditating effect of GPI between I4 and performance (environmental and economic performance). In this regard, we proposed a model grounded in ST and SCV, which is subsequently tested using the PLS technique. The findings show that environmental commitment fully mediates the effect of stakeholder and competitive pressure on I4. The result of the study also confirms the effect of GPI as a mediator between I4 and performance. The findings provide insights for managers in the manufacturing firms on the implementation of I4 technologies to respond effectively to competitive and stakeholder pressures and improve economic and environmental performance.

Our study has few limitations. First, the study is based on firms in an emerging market, India; therefore, future studies can test this model in firms in developed countries. Second, studies can test the moderating effect of resource commitment between I4 and performance. Future researchers can also use longitudinal data to examine this model. The case based studies can also be useful to reinforce the findings of this study.

ORCID

Manjot Singh Bhatia https://orcid.org/0000-0002-8930-5059

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APPENDIX A: CONSTRUCTS AND MEASUREMENT ITEMS

Stakeholder pressure (STP)

We feel pressure from customers to contribute towards sustainability (STP1)

We feel pressure from government to contribute towards sustainability (STP2)

We feel pressure from environmental organizations/societies/NGOs to contribute towards sustainability (STP3)

We feel pressure from supply chain partners to contribute towards sustainability (STP4)

We feel pressure from employees of our organization to contribute towards sustainability (STP5)

Competitor pressure (COP)

Sustainability initiatives have been widely implemented by our competitors (COP1)

Our competitors who have implemented sustainability initiatives benefitted greatly (COP2)

Our competitors who have implemented sustainability initiatives are perceived favorably by their customers (COP3)

Our competitors who have implemented sustainability initiatives became more competitive (COP4)

Environmental commitment (EC)

Support from top management and staff (EC1)

Commitment to reduce harmful emissions resulting from operations (EC2)

Consistently assesses the effect of business activities on environment (EC3)

Values the natural environment as much as profits (EC4)

Industry 4.0 (I4)

Internet of Things (I41)

Cloud Computing (I42)

Cyber Physical systems (I43)

Big Data Analytics (I44)

Additive manufacturing (AM) (I45)

Green process innovation (GPI)

We improve existing processes to make them more environmental friendly (GPI1)

We use existing technologies to their maximum to make processes more environmental friendly (GPI2)

We re-design production processes to improve environmental efficiency (GPI3)

We re-design and improve processes to meet environmental criteria and directives (GPI4)

Economic performance (ECO)

Reduced waste treatment costs (ECO1)

Reduced inventory management costs (ECO2)

Reduced material purchasing costs (ECO3)

Reduced waste disposal costs (ECO4)

Reduced rejection and rework costs (ECO5)

Environmental performance (ENV)

Reduced solid waste (ENV1)

Reduced liquid waste (ENV2)

Reduced air emissions (ENV3)

Reduced consumption of hazardous/toxic materials (ENV4)