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Institutional pressure and low carbon innovation policy: the role of EMS, environmental interpretations and governance heterogeneity

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As the global community deals with the urgent need for sustainable development, the formulation and implementation of effective low carbon innovation policies have emerged as a critical challenge. However, the extant literature is unclear in examining low carbon innovation policy. Underpinned by institutional theory, the current study addresses the role of institutional pressure in the development of low carbon innovation policies. Additionally, the study examines the role of environmental management systems as a mediation and environmental interpretations and governance heterogeneity as moderators. Methodologically, the data were collected from the manufacturing sector of Pakistan. The findings suggest that institutional pressure greatly influences low carbon innovation policies. Furthermore, the findings from environmental management systems strongly suggest that they significantly encourage institutional pressure on low carbon innovation. Additionally, the roles of environmental interpretations and governance heterogeneity have a significant effect on the relationship. We use a non-profitability sampling technique. In October 2023, a total of 432 questionnaires were disseminated to manufacturing firms, yielding 299 valid responses for Time-1 and Time-2, respectively.

KEYWORDS

institutional pressure, environmental management system, low carbon innovation policy, environmental interpretations, governance heterogeneity

1 Introduction

In the 21st century, the world is struggling with severe challenges related to sustainability (i.e., particularly concerning climate change and environmental degradation) which have prompted a global shift towards sustainable development practices (Nguyen et al., 2023). Organizations are now focusing on both external and internal pressures that influence or affect their strategic responses (Gunarathne et al., 2021). The contemporary global agenda highlights the urgent need for sustainable development to mitigate the impacts of climate change. While there is a growing recognition of the importance of low carbon innovation policies in achieving sustainability goals (Sovacool et al., 2022). Institutions face significant pressure that effects the effective implementation of such policies. Institutional frameworks often struggle to adapt to the dynamic demands of a

low carbon economy that leading to a gap between policy intentions and practical outcomes. In this regard, the establishment of low carbon innovation policies (LCIP) within the dynamic environment are vitally important for an organization (Yang et al., 2022).

In previous research, the relationship between institutional pressure (IP) and low carbon innovation policy (LCIP) has provided valuable insights (Qi et al., 2021), yet certain gaps persist within the existing literature. Several studies have acknowledged the significance of institutional factors, such as regulatory frameworks and policy support, in shaping the settings for low carbon innovation (Hoicka et al., 2021). However, there remains a need for more rigorous research into the specific mechanisms through which different types of institutional pressure influence firms' innovation behavior. Additionally, the majority of previous research has focused on developed economies (Jiao et al., 2022). However, there is a notable gap in our understanding of how institutional pressures impact low carbon innovation in emerging markets such as Pakistan (Ullah et al., 2022). Furthermore, while some studies have explored the role of organizational characteristics, such as size and industry type, in mediating the relationship between institutional pressure and innovation (Imran et al., 2021). Addressing these gaps will contribute to a more robust and holistic understanding of the relationship between institutional pressure and low carbon innovation, offering valuable insights for policymakers, businesses, and researchers alike. Ultimately, we fully recognize the importance of having energy policy and regulation that strike a balance between predictability and flexibility (Arjoon, 2006). Hence, such framework is essential for fostering confidence among both individuals and businesses, enabling them to make informed investment decisions while also adapting to the dynamic impacts of technological advancements, societal shifts, economic fluctuations, environmental considerations, and evolving national policies.

The existing body of literature on the nexus between institutional pressure and low carbon innovation often lacks comprehensive exploration of the mediating role played by environmental management systems. In previous studies, the primarily focused was given to understand the direct impact of institutional pressures, such as regulations and policies, on firms' low carbon innovation activities (Ngo, 2022). However, the mediating role of an environmental management systems (EMS) in translating these pressures into tangible innovation outcomes has been overlooked. Environmental management systems, including practices like ISO 14001 certification, could serve as a crucial link in understanding how firms navigate and respond to institutional pressures to foster sustainable innovation (Valero-Gil et al., 2023). Addressing this gap will provide a more nuanced perspective on the dynamics between institutional pressure, environmental management systems (EMS), and low carbon innovation (Qi et al., 2021). While studies have recognized the importance of EMS in influencing firms' environmental performance and innovation outcomes, there is a notable absence of research that delves into the nuanced ways in which environmental interpretations and governance structures may shape or alter this relationship. Therefore, strategic alignment is key. Governments must prioritize policy coherence across sectors to drive low-carbon transitions effectively. This includes integrating sustainable finance, taxation, innovation incentives, and international trade for comprehensive climate action (Addy et al., 2024). By embracing these measures, we can pave the way for a resilient and sustainable future. The extent to which varying interpretations of environmental issues within an organization or differences in governance structures across industries may affect the effectiveness of EMS in driving low carbon innovation remains largely unexplored (Valero-Gil, et al., 2023). Understanding the moderating influence of EI and GH could provide valuable insights into the contingencies and contextual factors that impact the relationship between EMS and low carbon innovation (Yue et al., 2022), thereby contributing to a more nuanced understanding of the complex dynamics involved in sustainable innovation within organizational contexts. Consequently, the present study fills research gaps by addressing the role of institutional pressure on low carbon innovation policy. In addition, the mediating role of environmental management systems and environmental intervention and governance heterogeneity (GH) is employed as moderators. Hence, the research questions below arise, which are addressed in this present study:

1. How do institutional pressures influence the low-carbon innovation policies?
2. What is the mediating role played by environmental management systems?
3. How do environmental interpretations and governance heterogeneity moderate the relationship between institutional pressure and effective low-carbon innovation policies?

The current study makes several noteworthy contributions to the existing body of research in the following three major aspects. Firstly, this study brings a novel perspective by examining the relationship between institutional pressure and low carbon innovation policy within the context of a developing country (i.e., manufacturing sector in Pakistan) (Ali et al., 2021). With focusing on a developing economy, the research provides insights into the unique challenges and opportunities faced by firms in such contexts, thereby contributing to a more comprehensive understanding of low carbon innovation practices beyond the typical scope of developed economies (Moshood et al., 2021; Du et al., 2024). Secondly, the study employing both institutional theories to understand the dynamics of the relationship between institutional pressure and low carbon innovation policy (Ebrahimi and Koh, 2021). The integration of these theoretical frameworks enriches the analysis, offering a more nuanced and multifaceted perspective on the factors influencing firms' decisions regarding low carbon innovation. This theoretical contribution enhances the broader understanding of the complex interplay between institutional pressures and stakeholder influences in shaping sustainable innovation policies (Bhuiyan et al., 2023). Thirdly, the study stands out by collecting primary data directly from higher level executives within the manufacturing sector. This approach ensures a more accurate and insightful exploration of the experiences, perceptions, and decision making processes of key decision makers in organizations (Kozioł-Nadolna and Beyer, 2021). This novel data collection method adds depth to the study, providing a rich and firsthand perspective on the strategic considerations and

challenges faced by executives in implementing low carbon innovation policies in the manufacturing sector (Huang et al., 2022). Hence, the remaining portion was followed, in section 2 which is presented about the hypothesis development and literature review. Section 3 discusses the research methodology and data collection. Data analysis results from SPSS software which are provided in Section 4. Lastly, Section 5 presents the discussion, and Section 6 describes the conclusion, and implications for managers and practitioners.

2 Literature review and theoretical development

2.1 Low carbon innovation practices in Pakistan

In Pakistan, low-carbon innovation practices are receiving significant attention from scholars as they seek sustainable solutions. Therefore, combating climate change while fostering economic growth by minimizing carbon emissions is useful for implementing low-carbon innovation policies (Rehman et al., 2021; Khurshid et al., 2023). Nevertheless, renewable energy initiatives are efficiently transforming Pakistan's manufacturing sectors and embracing innovative approaches to reduce carbon emissions (Asghar et al., 2023; Mehmood et al., 2024). The adoption of renewable energy helps the government to increase investment for rapid growth. Therefore, in promoting low-carbon innovation practices, the government drives the transition towards cleaner energy sources (Aized et al., 2018; Asghar et al., 2023). Additionally, initiatives such as green building standards and waste management strategies are promoting eco-friendly practices across various sectors (Khan et al., 2021). Hence, collaboration between government, academia, and the private sector is crucial for the success of low-carbon innovation initiatives in Pakistan (Mehmood et al., 2024). Ultimately, public-private partnerships, technology transfer agreements, and research collaborations are facilitating the development and deployment of innovative solutions in Pakistan (Hussain et al., 2012; Akram et al., 2023). By harnessing the power of innovation, Pakistan is focusing on achieving its sustainable development goals. Thus, the impacts of climate change and ensuring a greener future are being mitigated by utilizing low-carbon innovation policies.

2.2 Institutional theory

Institutional theory is an organizational framework that seeks to understand how institutions shape behavior, norms, and practices within social systems. Institutions, in this context, refer to formal and informal structures, rules, and conventions that guide and regulate human interactions in various domains such as organizations, economies, and societies (Routh, 2022). Institutional theory explores how formal and informal rules, norms, and practices within institutions influence behavior. Regarding the present study, institutional theory helps elucidate how external pressures from governmental bodies, regulatory agencies, and societal expectations impact the adoption and implementation of sustainable practices (Dai et al., 2021). Institutions act as powerful forces that shape the behavior of organizations and policymakers. Institutional pressures, such as coercive, normative, and mimetic influences, are significant drivers in the formulation and execution of low carbon innovation policies (Zhu et al., 2023). Coercive pressures emanate from regulations and policies that mandate the reduction of carbon emissions, creating a legal imperative for organizations to adopt ecofriendly practices (El-Garaihy et al., 2022). Normative pressures arise from social expectations and values that encourage environmentally responsible behavior, while mimetic pressures lead organizations to imitate successful low carbon initiatives to gain legitimacy (Acquah et al., 2021). Underpinned by the institutional theory, policymakers and organizations gain insights into the mechanisms through which external pressures influence decision making processes. This understanding facilitates the development of more effective low carbon innovation policies by aligning them with prevailing institutional norms and expectations, fostering a sustainable and resilient future.

2.3 Institutional pressure

Institutional pressure is defined as the pressure exerted by established social structures, norms, and organizations on individuals, groups, or entities within a society (Rigolini and Huse, 2021). These pressures can shape behaviors, decisions, and practices by creating expectations and standards that individuals or organizations are encouraged or obligated to follow (Cho and Yoo, 2021). Institutional pressure can manifest through formal regulations, informal norms, cultural expectations, and the actions of authoritative bodies, such as governments, regulatory agencies, or influential institutions. It plays a significant role in guiding and constraining the behavior of entities within a given social, economic, or political context. Institutional pressure offers insight into the conduct of decisions making in organizations to accomplish the aspects such as their energy consumption patterns, ecological initiatives, and environmental management practices (Imran et al., 2021). The Institution pressure pointed out that external factors, including legal and regulatory frameworks, societal values and norms, as well as cultural expectations, significantly influence the company's aspects. Hence, the effect external environment changes the organizations must adapt to ensure their sustainability. Therefore, these changes can have adverse effects on companies, highlighting the importance of acknowledging and addressing external shifts, especially in environmental matters (Leipold, 2021).

2.4 Low carbon innovation policy

Low carbon innovation policy refers to a set of strategies, measures, and initiatives implemented by governments or other governing bodies to promote and support the development, adoption, and diffusion of technologies and practices that contribute to a reduction in carbon emissions (Udeagha and Muchapondwa, 2023). The primary goal of low carbon innovation policies is to drive the transition towards a more

sustainable and environmentally friendly economy. These policies often focus on fostering innovation across various sectors, including energy, transportation, industry, and agriculture, by providing incentives, funding, and regulatory frameworks that encourage the research, development, and deployment of low-carbon technologies. Such policies aim to address the challenges associated with climate change, enhance energy efficiency, and promote the use of clean and renewable energy sources, contributing to the overall mitigation of greenhouse gas emissions (Chien et al., 2022). Therefore, the key components of low carbon innovation policies include financial support mechanisms, such as grants, subsidies, and tax incentives, to promote businesses and researchers to invest in the adoption of low carbon technologies. Additionally, these policies may involve the establishment of research and development programs. So, on, partnerships between public and private sectors, and the implementation of supportive regulatory frameworks that facilitate the integration of innovative solutions into the broader economy by fostering a conducive environment for low carbon innovation (Stokke et al., 2022). Hence, these policies play a crucial role in driving the transition towards a more sustainable and resilient society, addressing climate change challenges and promoting long term environmental stewardship.

2.5 Hypothesis development

2.5.1 Institutional pressure and low carbon innovation policy

Institutional pressure suggests that organizations, including government bodies and regulatory agencies, are influenced by external factors such as societal norms, values, and expectations. Coercive pressures from governmental and non-governmental entities, as well as societal expectations for sustainable practices, can drive the formulation and adoption of policies that promote innovation in technologies and practices with reduced carbon footprints (Jain et al., 2020; Xie et al., 2022). In addition, institutional pressures, including regulatory requirements and public demands for environmental responsibility, create an environment in which governments are compelled to design and implement policies that incentivize and facilitate the transition towards a low carbon innovation policy (Li et al., 2023; Dong et al., 2024). In this study, we examined coercive pressure and low carbon innovation policy significantly shape the formulation and execution of policies aimed at fostering innovation with reduced carbon footprints. Coercive pressure, as proposed by institutional pressure, involves the imposition of mandatory regulations and standards on organizations, compelling them to comply with environmental mandates. Regarding low carbon innovation policy perspective, coercive pressures exerted by government authorities and regulatory bodies can drive the establishment of policies that incentivize the development and adoption of technologies and practices contributing to lower carbon emissions (Raghoo and Shah, 2022). Based on institutional theory, the impact of coercive pressure is instrumental in influencing the direction and effectiveness of low carbon innovation policies. According to institutional theory, coercive pressures act as a catalyst for policymakers to design and implement initiatives that encourage the research, development, and integration of innovative solutions aimed at mitigating climate change (Mehedi et al., 2023). However, the current study implies that coercive pressures act as a crucial role in shaping the trajectory of low carbon innovation policies and acting as a driving force for governments to prioritize and implement measures that contribute to a more sustainable and environmentally friendly future.

Hypothesis. (H1a): Coercive pressure influence positively LCIP

The correlation between normative influence and policies promoting low carbon innovation may contribute to aligning societal values, cultural norms, and expectations in shaping initiatives aimed at fostering innovation with a diminished carbon footprint. According to institutional theory, normative pressure emanates from internal cultural values, and in the context of low carbon innovation policy, it can serve as a compelling force driving governments to adopt measures aligned with sustainability goals (Cervantes, 2023). Normative pressures are reflected in the expectations of citizens and stakeholders for environmentally responsible practices, creating an environment where policymakers feel compelled to enact regulations that encourage the development and adoption of low carbon technologies (Singhania and Saini, 2023). This hypothesis suggests that societal norms and cultural values act as influential factors, prompting governments to prioritize policies that support the transition to a more sustainable and ecofriendly economy. Moreover, the current study proposed that normative pressure influences the perception of environmental responsibility, pushing governments to align their policy agendas with broader societal expectations. In regions where there is a strong normative inclination towards sustainability, policymakers may be more likely to adopt and implement low carbon innovation policies that resonate with the prevailing cultural values. By recognizing and responding to normative pressures, governments can contribute to the widespread acceptance and adoption of low carbon technologies, fostering a culture of environmental consciousness and responsibility (Liao et al., 2023). Overall, the current study highlights the role of normative pressure in shaping the direction and effectiveness of policies aimed at promoting low-carbon innovation.

Hypothesis. (H1b): Normative pressure influence positively LCIP

The hypothesis regarding mimetic pressure and low carbon innovation policy posits that uncertainties and challenges in the internal and external environments can lead governments to emulate successful policies implemented by other regions or nations. Mimetic pressure, as outlined in institutional theory, arises when governments imitate the actions and strategies of their peers or leading entities to address complex and uncertain situations (Zhu, et al., 2023). In the context of low carbon innovation policy, this hypothesis suggests that governments may be prompted to adopt similar policies and practices that have proven successful in other jurisdictions facing comparable environmental challenges. As countries witness the effectiveness of low carbon innovation strategies elsewhere, mimetic pressures come into play, influencing policymakers to replicate those strategies to naivete uncertainties and accelerate the transition towards a more sustainable and low carbon economy (Butler and Hackney, 2021).

Furthermore, the hypothesis implies that mimetic pressure can lead to the convergence of policy approaches among different regions, contributing to a global alignment in the pursuit of low carbon innovation. Policymakers, observing successful low carbon initiatives in other parts of the world, may feel compelled to replicate these models to enhance their own environmental performance and foster innovation within their domestic industries (Sovacool et al., 2022). As mimetic pressures drive governments to adopt similar policies, there is potential for a collective and harmonized effort in addressing climate change challenges through innovative solutions. Ultimately, the hypothesis emphasizes the role of mimetic pressure in influencing the cross border diffusion of effective low carbon innovation policies and the potential for collaborative global efforts in combating environmental issues.

Hypothesis. (H1c): Mimetic pressure influence positively LCIP

2.5.2 Mediating role of environmental management system

The presence and effectiveness of EMS within organizations act as a facilitator in navigating and responding to institutional pressures that ultimately fostering the development and implementation of policies geared towards low carbon innovation. According to institutional theory, organizations are subject to various external pressures, including coercive, normative, and mimetic pressures. EMS, comprising structured frameworks and processes for environmental stewardship, can serve as a facilitator mechanism by helping organizations adapt to these pressures (Hamzah et al., 2021). When faced with coercive pressures, EMS provides a structured approach for companies to comply with environmental regulations, ensuring that they meet mandatory standards. Additionally, in the face of normative pressures, EMS can guide organizations in aligning their internal practices with societal expectations and cultural values, creating a foundation for the adoption of low carbon innovation policies that resonate with broader environmental concerns (Peck and Parker, 2016). Underpinned by the stakeholder theory, EMS can contribute to the positive mediation by providing companies with a systematic and adaptable approach to address uncertainties and challenges presented by institutional pressures. Moreover, EMS can serve as a model for best practices, enabling organizations to learn from the successful environmental management strategies of their peers and competitors (Tourais and Videira, 2016). As organizations implement effective EMS, they can demonstrate a commitment to environmental responsibility, building a foundation for the adoption of low carbon innovation policies (Du et al., 2024). Overall, our study highlights the role of EMS as a mediating factor that positively influences the relationship between institutional pressures and the formulation of policies aimed at advancing low carbon innovation.

Hypothesis. (H2): EMS mediate between institutional pressure and LCIP

2.5.3 Moderating role of environmental interpretations

The hypothesis proposing that environmental interpretations strengthen the link between environmental management systems (EMS) and low carbon innovation policy suggests that organizations' perceptions and interpretations of environmental issues play a crucial role in enhancing the connection between the structured environmental management approaches and the formulation of policies promoting low carbon innovation (Peng and Bai, 2018). Environmental interpretations encompass how organizations understand, prioritize, and respond to environmental challenges. When organizations develop a nuanced and proactive understanding of the environmental landscape, it enhances their ability to leverage EMS effectively. In this context, a well embedded environmental interpretation within the organizational culture can reinforce the value of EMS as a strategic tool for identifying opportunities and challenges related to low carbon innovation (Lee et al., 2018). Organizations that view environmental sustainability as a core strategic priority are more likely to integrate EMS seamlessly with the formulation and execution of policies geared towards reducing carbon footprints and fostering innovation in sustainable practices.

Furthermore, the hypothesis posits that a strong environmental interpretation can foster a proactive organizational stance, encouraging the use of EMS not only for compliance but as a catalyst for continuous improvement and innovation. Organizations that perceive environmental issues as critical drivers for long term success are more inclined to explore and invest in innovative solutions (Murphy and Gouldson, 2000). EMS, in this context, serves as a dynamic framework that enables organizations to identify, assess, and act upon opportunities for low carbon innovation. The hypothesis suggests that a deep understanding and interpretation of environmental concerns within the organizational context strengthen the alignment between EMS and the development of robust policies that drive low carbon innovation, creating a synergy that goes beyond mere compliance to proactive environmental leadership.

Hypothesis. (H3). Environmental interpretation strengthens the link between EMS and LCIP

2.5.4 Moderating role of governance heterogeneity

The current study proposing that governance heterogeneity weakens the relationship between environmental management systems and low carbon innovation policy. This relationship posits that variations in governance structures across organizations may hinder the effective integration of environmental management practices with the development and implementation of policies aimed at fostering low carbon innovation. Governance heterogeneity refers to the diversity in decision-making structures, policies, and leadership approaches among different organizations (Su et al., 2022). In instances where organizations have disparate governance frameworks or lack alignment in environmental objectives, the translation of EMS effectiveness into the formulation of coherent low carbon innovation policies may face challenges. Heterogeneous governance structures can result in a lack of standardized practices and strategic direction, making it difficult for organizations to seamlessly embed EMS into their overall sustainability goals and policies (Ma et al., 2022)

Moreover, the study suggests that governance heterogeneity may lead to inconsistencies in the interpretation and prioritization of environmental issues within organizations. Divergent governance

frameworks can create silos and conflicting priorities, diminishing the synergy between EMS and low carbon innovation policy development (Xu, et al., 2023). For instance, if various departments within an organization operate with distinct governance principles, it may impede a cohesive and coordinated effort to integrate EMS effectively into the strategic decision-making process related to low carbon innovation (Lee et al., 2018). Ultimately, the hypothesis underscores the importance of governance coherence and alignment in facilitating a robust relationship between EMS and policies promoting low carbon innovation within organizational contexts.

Hypothesis. (H4). Governance heterogeneity weakens the relationship between EMS and LCIP

2.6 Research Framework

3 Methodology

3.1 Sample and questionnaire

This study concentrated on manufacturing firms in Pakistan, acknowledging the significant role of the manufacturing sector in the country's economy, displaying promising growth prospects (Javeed and Lefen, 2019). Pakistan places considerable emphasis on value creation, deeming the manufacturing sector pivotal for its national economy (Ram et al., 2011). The choice of the manufacturing sector is primarily influenced by the contribution of Pakistani SMEs. Pakistani manufacturing firms prioritize CSR initiatives, implementing measures to diminish their carbon footprint, conserve energy and water, and minimize waste generation. Additionally, Pakistani SMEs invest in green technologies, such as renewable energy sources and energy efficient machinery, to address environmental impacts. The sample for the current study encompasses small and medium-sized enterprises (SMEs) from two major business regions: Punjab and Sindh, recognized as significant contributors to the national GDP with 6.8% and 6.7%, respectively (Bibi and Ahsan, 2022). The Pakistan SMEs Annual Report 2022 indicates that there are 179,271 SMEs in Punjab, constituting 19.8% of all SMEs in Pakistan. According to the report, Sindh accounts for 14.7% (133,703) of the total operating SMEs in Pakistan, with a substantial contribution from Punjab reported as PKR 321,069 million (23.5%) and Sindh as PKR 217,818 million (15.95%). To select the sample, a non-probability convenience sampling technique was utilized. This approach proves beneficial in exploratory research, where the primary objective is to gather preliminary insights, formulate hypotheses, or evaluate research instruments. Convenience sampling facilitates the rapid collection of initial data, enabling researchers to gauge the feasibility of conducting a more extensive study. Prior to proceeding with the definitive data collection phase, a pilot test was conducted. The present study adopted questionnaires from previous studies. Hence, we draw a hypotheses and conceptual model of the study are shown in Figure 1.

Therefore, the present study utilized a seven-point Likert scale questionnaire to assess all items and constructs. The use of a seven-point scale offers greater granularity and precision compared to scales with fewer response options, allowing respondents to convey a broader range of opinions and furnishing researchers with more nuanced data for analysis. Following Cohen's recommendations, G*Power Software 3.1.9.2, endorsed by Cohen for determining appropriate sample sizes, was employed. G*Power software is utilized for its efficacy in sample size determination. According to the G*Power parameters outlined by (Faul et al., 2009), the designated effect size conventions are small (g = 0.05), medium (g = 0.15), and large (g = 0.25). Opting for a medium effect size (g = 0.15), which is also considered as f2 (f2 = 0.15, $\alpha = 0.05$, $\beta = 0.20$), the study necessitated a minimum sample size of 148 participants.

3.2 Two-wave research design

This research employed a two-way research design, employing distinct time intervals for data collection. A two way research design, synonymous with a cross-sectional study, is a widely recognized approach in scientific inquiry (Smyth et al., 2021). This design involves gathering data from the same set of participants at two distinct time points. The interval between these time points enables a thorough exploration of variations and connections over time. By collecting data at two different junctures, the two way research design allows researchers to establish temporal precedence, facilitating the inference of causality. This design is particularly instrumental in discerning whether a specific variable precedes and influences another variable or outcome (Podsakoff et al., 2003). Therefore, in the present investigation, Time-1 (T1) encompasses the examination of the independent variable (institutional pressure) and dependent variable (low carbon innovation policy), while Time-2 (T2) delves into the exploration of moderating variables (environmental interpretations and governance heterogeneity), with the mediating variable being the (environmental management system). The time interval gap between T1 and T2 spans approximately 2 weeks, strategically implemented to diminish potential biases linked to self-reporting or single source data (Liu et al., 2010). The assignment of unique codes to participants during data collection within this two wave research design stands as a crucial measure, ensuring precise tracking and identification of individuals across successive waves. During this study, each participant is allocated a distinctive code or identifier, potentially comprising a numerical combination. The assignment of these codes may follow a random, sequential, or other systematic approach. These codes are subsequently linked to participants' data, which facilitating the correlation of their responses across various waves. In October 2023, a total of 432 questionnaires were disseminated to manufacturing firms, yielding 299 valid responses for Time-1 and Time-2, respectively. Individuals who took part in the Time-1 phase were extended invitations for participation in the Time-2 phase, utilizing their unique codes. The overall response rate stood at 53%. For detailed demographic information on the respondents and their respective manufacturing firms, refer to Table 1.

3.3 Measures

All items were rated on a seven point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). These scales were adapted from previous research by (Latif et al., 2020) in which institutional pressure variables were measured by twelve questions that were on

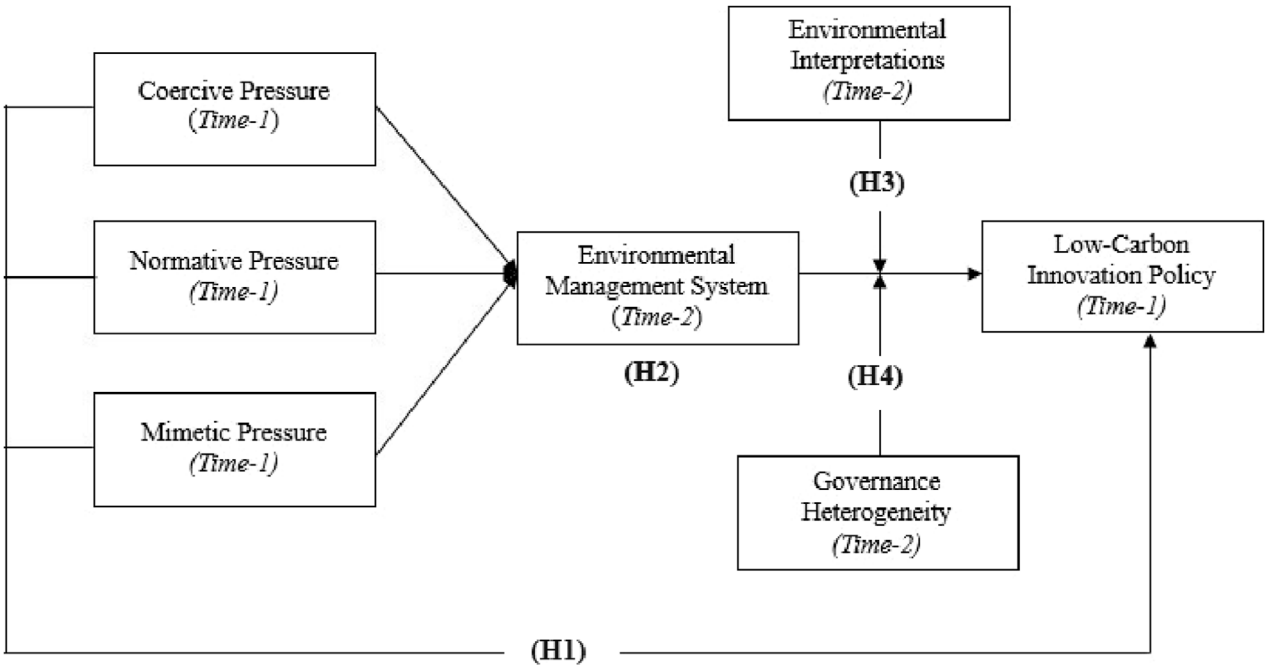

FIGURE 1
Research framework.

TABLE 1 Demographic profile.

	Frequency	Percentage (%)
Gender		
Male	260	87
Female	39	13
Age		
16–20	20	6.7
21–25	56	18.7
26–30	84	28.1
31–35	139	46.5
Level of Education		
Undergraduate	49	16.4
Postgraduate	250	83.6
Working Experience		
1–3 Years	11	3.7
4–6 Years	102	34.1
7–9 Years	44	14.7
More than 9 Years	142	47.5

three factors coercive pressure, normative pressure and mimetic pressure. Additionally, four items measuring environmental interpretations were adapted from Wang et al. (2018), and five items assessing governance heterogeneity were adapted from (Tsai, 2023). Finally, low-carbon innovation policy was measured using the six scale which are adopted from (Hu and Li, 2023).

3.4 Common method bias (CMB)

In order to utilize the potential impact of common method bias (CMB) on data quality, a two stage approach was adopted in this study. First and foremost, the researchers considered the influence of different endogenous and exogenous variables (Podsakoff et al., 2003), as well as temporal asynchrony factors known to contribute to CMB (Doty and Glick, 1998). Additionally, Harman's method, a well-established technique for assessing CMB issues, was applied. The outcomes of this method revealed that the single factor value accounted for only 47.31% of the variance, falling below the critical threshold of 50% suggested by (MacKenzie and Podsakoff, 2012). Consequently, it was reasonably concluded that CMB had unlikely exerted a significant influence on the study.

4 Analyses and results

4.1 Descriptive analysis

The demographic profile of the surveyed population highlights key figures. In terms of gender, 260 participants were male, constituting 87%, while 39 participants were female, making up 13%. Age distributi1on showed a varied range, with the highest number in the 31–35 age group at 139, accounting for 46.5%. When it came to educational background, 250 respondents were postgraduates, comprising 83.6%, while 49 were undergraduates, making up 16.4%. The survey also delved into working

TABLE 2 Measurement model results.

Constructs	Items	FL	(α)	CR	AVE
Coercive Pressure	CP1	0.829***	0.853	0.907	0.710
	CP2	0.843***			
	CP3	0.857***			
	CP4	0.841***			
Normative Pressure	NP1	0.897***	0.878	0.941	0.800
	NP2	0.907***			
	NP3	0.911***			
	NP4	0.863***			
Mimetic Pressure	MP1	0.911***	0.931	0.953	0.835
	MP2	0.921***			
	MP3	0.919***			
	MP4	0.903***			
Environmental Management System	EMS1	0.861***	0.847	0.918	0.651
	EMS2	0.821***			
	EMS3	0.817***			
	EMS4	0.787***			
	EMS5	0.761***			
	EMS6	0.789***			
Environmental Interpretations	EI1	0.873***	0.867	0.898	0.687
	EI2	0.831***			
	EI3	0.819***			
	EI4	0.791***			
Governance Heterogeneity	GH1	0.903***	0.921	0.935	0.742
	GH2	0.843***			
	GH3	0.849***			
	GH4	0.897***			
	GH5	0.813***			
Low Carbon Innovation Strategy	LCIS1	0.903***	0.917	0.947	0.750
	LCIS2	0.861***			
	LCIS3	0.873***			
	LCIS4	0.911***			
	LCIS5	0.843***			
	LCIS6	0.801***			

Note: N = 299; *$p < 0.05$; **$p < 0.01$, FL , Factor Loadings. α = Cronbach's alpha. CR, Composite Reliability; AVE, average variance extracted.

experience, showcasing a diverse workforce. Individuals with more than 9 years of experience dominated with 142 participants, representing 47.5%, followed by 4–6 years at 102 participants, constituting 34.1%, 7–9 years at 44 participants, making up 14.7%, and 1–3 years at 11 participants, accounting for 3.7%. This comprehensive demographic profile provides an adverse understanding of the respondents and sets the stage for a more targeted analysis (See Table 1).

4.2 Construct reliability and validation

In our analysis, we employed several statistical measures to assess the robustness of our research constructs. In Table 2, Factor loading, a crucial indicator of the strength and relevance of items in a latent variable, which ranged from 0.716 to 0.921, with higher values signifying a more significant contribution to the construct.

TABLE 3 Mean, standard deviation, and correlation (N = 229).

Constructs	Mean (SD)	1	2	3	4	5	6	7	8	9	10	11
1.Gender	1.12 (0.331)	1										
2.Age	3.12 (0.943)	0.053	1									
3.Level of education	1.81 (0.362)	−0.012	−0.026	1								
4.Working Experience	3.01 (0.973)	0.041	−0.021	0.018	1							
5.CP	3.897 (0.931)	−0.023	−0.017	−0.023	−0.017	**0.843**						
6.NP	4.231 (0.867)	−0.019	−0.013	−0.017	−0.13	0.821	**0.894**					
7.MP	4.467 (0.813)	−0.16	−0.011	−0.013	−0.011	0.813**	0.877**	**0.914**				
8.EMS	4.951 (0.737)	−0.013	−0.009	−0.009	−0.007	0.807**	0.853**	0.903**	**0.807**			
9.EI	4.909 (0.791)	−0.009	−0.074	0.041	0.005	0.801**	0.821**	0.897**	0.801**	**0.829**		
10.GH	4.761 (0.747)	−0.006	−0.038	0.037	0.031	0.797**	0.811**	0.867**	0.796**	0.821**	**0.861**	
11.LCIP	4.932 (0.721)	−0.004	−0.042	0.002	−0.019	0.791**	0.803**	0.837**	0.763**	0.813**	0.828**	**0.866**

Abbreviation: CP: Coercive Pressure NP: Normative Pressure MP: Mimetic Pressure EMS: Environmental Management System EI: Environmental Interpretations GH: Governance Heterogeneity LCIP: low carbon innovation policy, **Note:** N = 299; *$p < 0.05$; **$p < 0.01$. SD, standard deviation. Average Variance Extracted (AVE) square roots are shown in bold on the correlation matrix diagonal.

Furthermore, cronbach's alpha, a measure of internal consistency, ranged from 0.847 to 0.931, exceeding the widely accepted threshold of 0.7 according to (Tavakol and Dennick, 2011), indicating high reliability. Composite reliability, reflecting the consistency of the construct, exhibited values between 0.898 and 0.953, surpassing the recommended threshold of 0.7 according to (Bacon et al., 1995). Additionally, average variance extracted (AVE), ranged from 0.651 to 0.835, surpassing the threshold of 0.5 of (Henseler et al., 2015), indicating satisfactory convergent validity. Therefore, the results demonstrated that all of the constructs in the current study have greater reliability than the indicated threshold values. (Perreault et al., 1989; Shevlin and Miles, 1998). Finally, as illustrated in Table 3, it is essential to highlight that the square root of the average variance extracted (AVE) on the diagonal surpasses the correlation coefficients with other variables. This finding underscores the legitimacy of discrimination, as emphasized by (Henseler et al., 2015).

4.3 Hypothesis testing

To evaluate the hypothesis the hierarchical regression analysis was performed. Before analysis, to minimize multicollinearity all continuous variables in this research were meant centered. The results of the regression analysis were displayed in Table 4. In hypothesis 1, we argued that coercive pressure, normative pressure and mimetic pressure positively linked between low carbon innovation policies. Therefore, we found that the coercive pressure ($\beta = 0.209$, $p < 0.01$), normative pressure ($\beta = 0.203$, $p < 0.01$) and mimetic pressure ($\beta = 0.191$, $p < 0.01$) significant and have a positive relationship in model 5. Hence, in hypothesis 2 we analyzed the relationship between environmental management system ($\beta = 0.267$, $p < 0.01$) significantly and positively affect low carbon innovation policy, as shown in Table 4, Model 4. The hypothesis three proposed that the environmental interpretations strengthen the relationship between environmental management system and low carbon innovation policy ($\beta = 0.283$, $p < 0.001$) so on, the hypothesis three was supported and significant in model 7. In hypothesis four proposed that the governance heterogeneity weakens the relationship between environmental management system and low carbon innovation policy ($\beta = -0.153$, $p < 0.001$) so on, the hypothesis four was supported and significant in model 7.

5 Discussion

The current study, grounded in the theoretical framework of institutional theory, seeks to investigate how institutional pressure influences low carbon innovation policy. This influence is examined through the mediating role of environmental management systems and the moderating roles of environmental intervention and governance heterogeneity. Recent trends indicate that institutional pressure plays a crucial role in reinforcing low carbon innovation policy, with organizations utilizing it to enhance their strategies (Chen et al., 2018). The first research question focuses on the impact of institutional pressure on low carbon innovation policy, contributing to value creation for stakeholders (Wesseling et al., 2022). The study's findings align with previous research (Tian et al., 2023). The second research question explores the mediating role of environmental management systems in the relationship between institutional pressure and low carbon innovation policy, with results consistent with earlier studies (Gunarathne et al., 2021). Lastly, the third research question delves into the moderating role of environmental intervention and governance heterogeneity in the link between environmental management systems and low carbon innovation policy. The results are in line with existing literature, suggesting that governance diversity can either bolster or weaken this relationship based on effective management (Yang et al., 2023).

TABLE 4 Results of regression analysis.

Variables	EMS		LCIP				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Controls							
Gender	−0.086	−0.101	0.077	0.107	0.069	0.107	0.073
Age	−0.127	−0.087	−0.049	−0.017	−0.037	−0.023	0.001
Level of education	−0.263	−0.237	0.127	0.203	0.143	0.209	0.163
Working Experience	−0.239	−0.229	0.011	0.081	0.019	0.083	0.141
Predictor							
CP		0.433***			0.209***	0.113***	0.057***
NP		0.417***			0.203***	0.107***	0.049***
MP		0.391***			0.191***	0.101***	0.037***
Mediator							
MCS				0.267***		0.214***	0.169***
Moderation							
EI							0.393***
GH							−0.217**
Interaction effect							
MCSXEI							0.283***
MCSXGH							−0.153**
Model Statistics							
F Value	1.381	7.522***	1.581	3.463**	2.651*	3.323***	7.057***
R2	0.033	0.220	0.042	0.117	0.87	0.127	0.283
Change R2		0.181		0.060	0.037	0.069	0.151

Abbreviation: CP: Coercive Pressure NP: Normative Pressure MP: Mimetic Pressure EMS: Environmental Management System EI: Environmental Interpretations GH: Governance Heterogeneity LCIP: low carbon innovation policy, **Note**. N = 299. Standardized coefficients are reported $p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

6 Managerial and regulatory implication

The current study offers several insights to implications to managers and policymakers. In current study, low carbon innovation policy in Pakistan's manufacturing sector carries significant managerial implications. Managers must spearhead a strategic shift towards adopting ecofriendly technologies, necessitating investment in employee training to ensure seamless integration. In manufacturing sector, supply chain management becomes crucial, requiring evaluation and collaboration with environmentally conscious suppliers to align with the policy's objectives. Staying abreast of evolving environmental regulations is imperative, prompting the establishment of dedicated teams for compliance monitoring and reporting. Positioning the company as a leader in sustainable practices becomes a key marketing strategy, appealing to environmentally conscious consumers. Managers must allocate resources for continuous research and development in low carbon technologies, fostering a culture of innovation within the organization. Collaborating with industry peers, research institutions, and government agencies becomes essential to share best practices and stay ahead in sustainable innovation. Risk management takes center stage, necessitating the identification and assessment of potential challenges associated with the adoption of low carbon technologies. Employee engagement becomes a focal point through awareness programs, encouraging a sense of environmental responsibility among the workforce. Financial planning must incorporate the costs and benefits of sustainable initiatives, exploring available incentives to offset initial investments. Continuous monitoring and evaluation systems ensure ongoing improvement, allowing businesses to not only comply with low carbon policies but also thrive as environmentally responsible entities in the dynamic setting of Pakistan's manufacturing sector.

7 Conclusion

The significance of a low carbon innovation policy in the contemporary landscape cannot be overstated. Institutional pressure highlights the pivotal role to shaping the sustainable

practices within industries. As businesses navigate the complex web of environmental challenges, the implementation of a robust low carbon innovation policy emerges as a guiding framework. The study highlights the substantial impact of EMS and emphasizing their role as catalysts for change. Their integration into organizational structures fosters a culture of environmental responsibility with the broader objectives of low carbon innovation policies. Furthermore, the findings highlight the importance of environmental intervention and governance heterogeneity as a key driver that emphasizing its capacity to shape and enhance the effectiveness of low carbon initiatives. The limitation of our study is explore through the determinants of energy policy failure in relation to societal goals, particularly examining aspects like energy justice, fairness, and social equity in decision-making processes to enhance sustainability efforts. Firstly, future research can be conducted to see how stakeholders influence administrative rules in the industry to inform public policies for improving society's social inclusion. Secondly, further deeper insight can be achieved by incorporating internal and external environmental factors to see how low carbon innovation practices work in industrialization approach in future research and also use different control variable to measure the institution pressure in low carbon innovation policy. Thirdly, this study analyzed the manufacturing sectors of Pakistan to explore how institutional pressure influences low-carbon innovation policies. For future endeavours, insight could be enhanced by incorporating a comparative future study in microfinance banks that are focusing on green credit policies. Fifth, our study aims to analyse the relationship between Institutional Pressure and Low Carbon Innovation Policy. Future research can be recognize the significant role that policy-induced financial constraints play in incentivizing green innovation within businesses. Ultimately, the study reinforces the importance of a comprehensive low carbon innovation policy, acting as a linchpin for sustainable development in the face of evolving environmental challenges.

Data availability statement

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

Author contributions

MY: Conceptualization, Project administration, Supervision, Writing–review and editing. HT: Methodology, Resources, Supervision, Writing–original draft. NS: Software, Visualization, Writing–review and editing, Resources. AH: Data curation, Formal Analysis, Methodology, Software, Visualization, Writing–review and editing.

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Conflict of interest

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

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