

RESEARCH ARTICLE

Impact of Top Management team Diversification on Green Innovation Performance in the Presence of Top Management Behavioral Integration and CEO Attributes

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Abstract: The study aims to investigate the effect of top management team (TMT) diversity on green innovation performance (GIP) specifically in Pakistan's manufacturing sector, in which TMT Behavioral Integration (TMTBI) plays a mediating role and CEO attributes act as moderators in the form of duality, gender, and tenure. Using upper echelons theory as a foundation, the argument is made that TMTs with greater diversity create an enabling environment for group decision-making and knowledge exchange, while the aforementioned CEO attributes act as antecedents of this relationship by enabling or constraining strategic focus. The authors administered a survey to 294 non-financial firms listed on the Pakistan Stock Exchange (PSX), and structural equation modeling (SEM) was utilized to analyze the relationships. The study found that TMT Diversity (TMTD) negatively impacts GIP, while TMTBI positively mediates this link, thus emphasizing the need for teamwork, which seldom translates diverse viewpoints into sustainable innovation. While CEO duality and tenure seem to strengthen the relationship between TMTD and TMTBI, gender does not have a significant moderating effect. The study further emphasizes the important role of product/process innovations as intervening variables between TMTD and GIP. By stressing the interplay between environmental performance and several internal governance structures, the present study will majorly contribute to the literature on green innovation. For practical implications, this stresses that firms should build an environment of behavioral integration in TMT members in relation to CEO on-sight leadership to help realize sustainability initiatives. Future research could be done to validate this by applying cross-industry or longitudinal studies to generalize these findings.

Keywords: Green Innovation (GI), Behavioral Integration (BI), CEO Duality, Gender, Tenure, Upper Echelons Theory Framework, Corporate Governance, Leadership

Introduction

The issue of sustainability has become one of the major concerns due to increased global warming and environmental degradation (Zhang et al., 2019). Green innovation can be defined as the creation of new or improved technologies, processes or products that contribute to the reduction of environmental degradation and the attainment of sustainable development goals (Bataineh et al., 2024). It not only ensures that enterprises are abiding by environmental laws but also creates a positive outcome for all parties involved (Schatzenstaller, et al., 2017). Hence, enterprises should adopt green innovation to realize the environment and the economy (Lin et al., 2019). Thus, there has been more discussion about green innovation. Numerous articles have presented different prior conditions of green innovation, like policies, institutions, and public

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pressure (Wu et al., 2020). A majority of these studies are based on corporate external factors, as opposed to a few that have been researching corporate internal factors (Yu et al., 2022). The upper-echelon theory postulates that a firm's strategic decision-making and resource distribution decisions are largely shaped by the discretion of the TMT and their work experience (Wang et al., 2022). Leadership by CEOs also plays a crucial role in decision-making since they need to apply certain leadership behaviors to help TMT members perform their functions, coordinate their work, and cooperate (Friedman et al., 2022). There has been a growing body of upper echelons studies that have examined the CEO-TMT interface, which refers to the connection and relationship between a CEO and other members of the top management team with a particular emphasis on the impact of this relationship on organizational outcomes such as firm performance, strategic decisions and decision outcomes (Pham et al., 2023). Companies, especially in industrial settings, have made process innovation one of their top strategic priorities to address the opportunities and threats presented by process innovation (Savastano et al., 2022). As a result of these challenges, conceptual and case-based literature indicates the importance of the top management team (TMT) (Firk et al., 2022). Specifically, the TMT is crucial to establish the basis for process and product innovation because of its duties in relation to the identification of potential strategic relevance of innovation, the communication of these potentials, and the allocation of resources (Firk et al., 2022). Education can be an indicator of a person's knowledge, skills, and potential (Yu et al., 2020). CEOs are key drivers of process innovation because they are the main decision-makers who determine the inputs, processes and output of technological innovation (Wang et al., 2017). However, there needs to be more research that examines the influence of CEOs on strategic orientation and the type of process innovation (Kurzahls et al., 2020).

The green innovation is becoming a core strategic focus for TMT for the following reasons. The growing concerns about the global environment have forced organizations to play a role in addressing environmental problems. Therefore, there needs to be an environment of collaboration and communication to increase the positive impact of TMT diversity. (Li et al., 2019). CEO behavior, the relationship between TMT Diversity (TMTD) and green innovation will be positive; this is a process in which TMT members have good relationships that will support information sharing and collaborative decision-making (Garcia –Granero et al., 2018).

Previous studies have emphasized the role of other factors when investigating the determinants of green innovation (Baeshen et al., 2021). However, little attention has been paid to the internal conditions of new companies, especially those related to TMTs. Factors such as strategy and structure are considered internal organizations that influence a company's innovation (Huang et al., 2016). To further explain the relationship between TMTD and green innovation, we hypothesized that TMTD is a mediator between TMTD and green innovation (Xie et al., 2022).

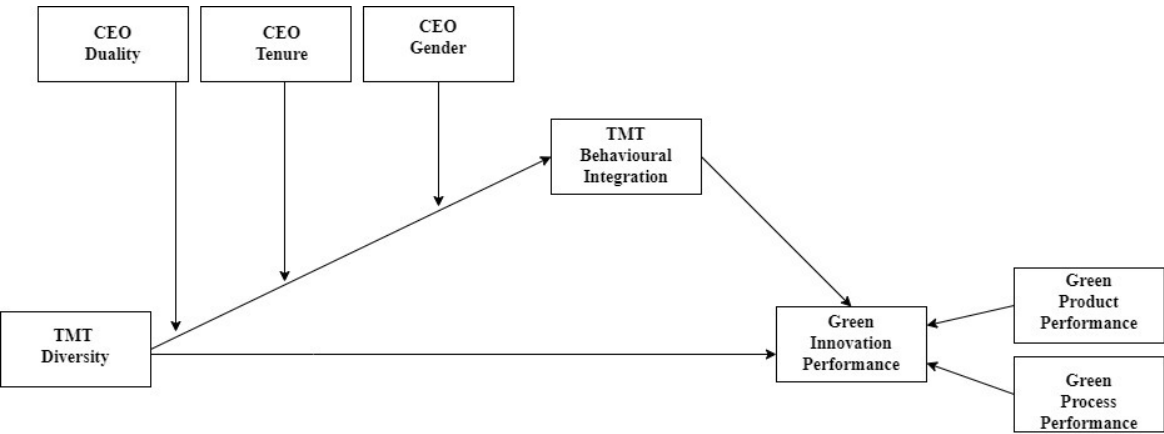
Considering the above, there is a need to conduct a study aimed at filling the existing gaps in the prior studies. Therefore, the main objective of this study is to investigate the impact of TMTD and TMT Behavioral Integration (TMTBI) on green innovation performance in the presence of CEO attributes, process and product innovation. Overall, this study will help investors, auditors, and regulators for the enhancement of firm performance.

This research demonstrates a better understanding of the impact of TMTD and green innovation performance. The founding research questions in this research are:

- ▶ Does TMTD affect Green Innovation Performance?
- ▶ Does TMTD affect CEO attributes?
- ▶ Do CEO attributes mediate the relationship between TMTD and process innovation?
- ▶ Do CEO attributes mediate the relationship between TMTD and product innovation?
- ▶ Do CEO attributes significantly and positively link with green innovation performance?
- ▶ CEO attributes and process innovation mediate the association between TMTD and green innovation performance.

- ▶ Do CEO attributes and product innovation mediate the association between TMTD and green innovation performance?

Figure 1
Theoretical Framework



Literature Review

TMT diversity (TMTD) and Green Innovation Performance

UE theory believes that TMT organizational behavior will influence business strategy because the knowledge structure of decision-makers and the different ideas or views they conceive of for certain situations can lead to different choices (Liu et al., 2017). The tactics of senior leaders are based on understanding and interpreting situations (Bendig et al., 2018). For this, they rely on the application of general rules (such as beliefs, emotions, values, and knowledge) in organizational context to facilitate the interpretation of the process (Hobfoll et al., 2018) Therefore, business strategy and performance should be based on the characteristics of top management because decisions are made according to the worldview of the leadership (Aboramadan, 2021). The relationship between the diversity of business leaders and innovation also applies to the green design context. Green innovation is one of the most important concepts of the environment, which means saving resources, controlling pollution, incorporating environmental management into business processes, and making changes in production and services. Companies need to adapt their strategies to meet new trends and integrate environmental sustainability into their business models and organizational goals (Asadi et al., 2020). TMT diversification is an important factor in the strategic decision-making process of green innovation performance (Huang et al., 2019). Therefore, TMT diversification increases its ability to solve problems and identify new relationships, which will help businesses better understand and respond to environmental problems, thus directing them to green innovation (Lettl et al., 2009). Thus, we hypothesize that.

H1: There is a significant association between TMTD and Green Innovation Performance.

TMTD and TMT behavioral integration (TMTBI)

TMTD and TMTBI is a multifaceted relationship (Attah-Boakye et al.,2023). Hence it is believed that there are probably some contextual factors at the firm level that affect the former relationship. In our study, it is hypothesized that the effect of TMTD will be stronger on innovation when there is some form of coordination or integration between the TMT members. It can also be appreciated and realized that diversity in terms of background characteristics of TMT in ecological or green challenges can be acknowledged and fostered through positive and cooperative communication among the team members. Furthermore, in the context of the working team, the members value other team members and are sensitive to the impact of the actions they make on others (Imam et al., 2021). Hence, it can be argued that different TMTs may be more involved in the strategic challenge and thus we hypothesized as

H2: TMTD significantly linked with TMT behavioral integration.

TMT Behavioral Integration (TMTBI) Mediator

The relationship between TMTD and green innovation is mediated by TMT behavioral integration, implying that it usually indicates how often TMT members communicate in reciprocal and cooperative terms with each other (Zaman et al., 2022). Behavioral integration such TMTs will communicate, cooperate, and value the inputs of other members and group decisions (Carmeli & Schaubroeck, 2006). Hence, integration among members enables TMTs to share expertise, knowledge, and information for the generation of innovative ideas. Such integration will also help TMT members develop an all-encompassing awareness of societal and environmental concerns. Boone and Hendriks (2009) also state that TMT diversities are rich sources of environmental and social information. This kind of information could be obtained by TMT members through information sharing and ongoing communication with the other members of the TMT (Hambrick, 1994). Therefore, behaviorally integrated TMTs would be able to make and implement decisions with regard to the incorporation of environmental and social information. Consequently, we hypothesized that

H3: TMTBI mediates the relationship between TMTD and green innovation performance.

CEO Attributes as Moderator

The CEO's age, tenure, and education may contribute to collaborative behaviour in the TMT because they influence team relationships and performance. People with high self-esteem are sensitive to social and interpersonal relationships and always pay attention to managing their emotions to meet needs and expectations, among others (Zhou et al., 2020). They can also encourage people to be involved, empathize with people with different needs, and help them resolve conflicts through cooperation or negotiation (Rahim et al., 2023). On the other hand, people with low self-esteem focus on internal behaviors rather than social cues and are not good at solving problems (Emine et al., 2020). Therefore, it is not surprising that CEOs with high self-esteem gain respect by establishing strong personal relationships with TMT members, thereby improving cooperation and collaboration harmony.

Additionally, CEO self-monitoring may encourage knowledge sharing within the TMT. People with high self-esteem are motivated to cognitively interpret the behavior and emotions of others (Reisenzein, 2020). Therefore, a self-aware CEO must know other TMT members very well and know how to manage them. The same applies if members can share their thoughts and feelings with the CEO personally. Broader knowledge contributes to the diversity of TMT (Ma et al., 2021). Thus, we hypothesize that.

H4: CEO attributes (CEO duality, CEO tenure, and CEO gender) significantly moderate the association between TMTD and TMT Behavioural Integration

CEO Attributes and the Relationship between TMTD and Process Innovation

Organizational leadership also has a significant impact on organizational innovation through the type of leadership behavior that is demonstrated by the CEOs. More specifically, CEO attributes are important in shaping TMT behavior and innovation processes. TMTD improves the quality of effective decision-making by improving team communication and collaboration. This combination is necessary to create a constructive environment for innovation. Recent research shows that TMTs with collaborative behaviors are more likely to participate in new projects due to sharing, trust, and collaborative problem-solving (Xie et al., 2022). TMTD is positively associated with innovation, where certain individual characteristics such as leadership, risk-taking behaviour, and innovativeness are instrumental in this relationship. For instance, transformational leadership can facilitate and enhance TMTs to accomplish innovation as suggested by Jansen et al. (2009). TMTD and process innovation are two aspects that should be carefully examined, and the involvement or participation of CEO attributes is significant in understanding this connection. Thus, it is hypothesized that

H5: CEO attributes mediate the relationship between TMTD and process innovation.

CEO Attributes and the Relationship between TMTD and Product Innovation

CEO characteristics mediate the relationship between the diversity of TMT and product innovation. According to ARAUJO et al., (2023) visionary and innovation-oriented CEOs serve to develop a culture of product innovation through the TMT. Several studies confirmed that CEO innovation orientation relationship has a positive impact on product innovation through fostering innovation and development (Sun et al., 2023). Green innovation performance is defined as the capacity of firms developing products and services to produce minimal adverse effects on the environment. It is argued that positive and significant factors belong to those CEOs who are high in environmental orientation and who are committed to the issue of sustainability will then seek to embark on green initiatives (Unal et al., 2019). Such CEOs are likely to support green innovations to enhance sustainable performance and adopt eco-friendly investments such as green innovation related technologies. Thus, it is hypothesized that

H6: CEO attributes mediate the relationship between TMTD and product innovation.

CEO Attributes and Green Innovation Performance

This study also reveals that there is a positive and significant relationship between CEO characteristics and green innovation performance. Studies also show that green-oriented CEOs encourage companies to engage in green practices and technologies and, hence, achieve better green innovation performance (Mady et al., 2022).

The mediating roles of process and product innovation. Product innovation refers to the creation of new or improved products or services that can improve green performance through the elimination of waste and the optimization of efficiency (Luan et al., 2022).

H7: CEO attributes significantly and positively linked with green innovation performance.

CEO Attributes, Process Innovation, TMTD and Green Innovation Performance

CEOs' characteristics and green innovation process are the mechanisms through which TMTD influences green innovation performance. If CEOs focus their attention on developing the process of innovation, then collaboration with TMT can be used to implement green processes and improve green innovation performance (Ciasullo et al., 2022). In other words, if managers understand the importance of the innovation process, they can direct the TMT to organize the processes of forming and establishing environmental processes. It has been noted that the business environment can be observed from the process of innovation, and this can lead to improvement of green innovation performance through reduction of resource consumption and output in the environment (Ciasullo et al., 2022). TMT compensation structures may be positively related to an organization's green performance through the intermediaries of green leadership that commit to enhancing the organization's green performance by motivating employees to employ new technologies and waste management techniques. This mediation explains that CEO behaviour and innovation processes are the elements that mediate between TMTD and the direct effects of green outcomes (Gao et al., 2023).

H8: CEO attributes and process innovation mediate the association between TMTD and green innovation performance.

CEO Attributes, Product Innovation and the Relationship between TMTD and Green Innovation Performance

The mediation between CEO attributes and product innovation reveals that the diversified TMTs can influence CEOs whose sustainability orientation is more efficient in defining the role of cooperation in the creation of environmentally friendly products (Dhir et al., 2023). They enhance the new green activities of organizations by minimizing the exploitation of environmental resources and expanding into the growing market of sustainable products (Albort-Morant et al., 2016). Their potential to emphasize the significance of innovation

can make TMT concentrate on producing products using recycled materials aimed at saving energy and having a longer lifespan. Contrary to the previous strategies of TMT diversification activities, holding firms to new green product innovation will enhance the organization's green innovation performance (Li et al.,2020).

H9: CEO attributes and product innovation mediate the association between TMTD and green innovation performance.

Methodology

We collect the data from manufacturing sector firms listed on Pakistan stock exchange (PSX hereafter). The large-scale manufacturing firms of Pakistan contribute 12.01 percent in GDP while 16.1 percent in labour force (Economy Survey of Pakistan, 2022/23). Since last decade approximately 3 percent decline in global market share has been witnessed by the manufacturing sector of Pakistan. The recent reports of IPCC claims that manufacturing sector of Pakistan face various issues including environmental pollution and claims that manufacturing sector of Pakistan significantly contribute to global warming (Fahad & Wang, 2020). In addition to that large scale manufacturing firms in Pakistan lack in compliance with regulations, effective waste management and monitoring of pollution and adoption of green innovation methods (Shahzad et al., 2022). There are two major sectors current listed on PSX financial and non-financial. Approximately 369 companies listed on PSX are categorized as non-financial sector while 180 companies listed under financial sector. Using the probability sampling technique the present study considered 369 firms as sample listed as non-financial firms. We distribute the questionnaire to CEO(s) with first, second, and third reminders and a total of 294 questionnaires were returned with the response rate of 80 percent. The final version of questionnaire consists of 19 items to measure the TMT diversity, TMT behavioral integration, and green innovation performance including the demographic including CEO tenure, gender, and duality. Respondents were informed about the use of data is only for academic purposes and privacy will ensure and post-analysis responses will be discarded.

Table 1
Sample Description

Total Listed Companies on PSX		549
Less:	Companies Categorized under Financial Sector	180
	Companies Categorized under Non-Financial Sector	369
Less:	Companies with Missing Information	75
	Final Sample of the Study (Companies)	294

Measures
TMTD and TMTBI

The measuring scale of TMTD and behavioral integration were derived from the study of Bengtsson et al., (2020) which is related to the extent to which TMT members participate in sharing knowledge, authority and resources. Nine item scale is used to inquire about TMTD and behavioral integration.

Green Innovation

The measurement of green innovation performance is based on previous studies (Wang, 2019) and consists of 8 items. Chen et al. (2006) defined green innovation performance as the effectiveness of innovation by companies in the context of green processes and products, including energy-saving technology, new green products, pollution prevention and environmental management.

Process Innovation

Every business can benefit from innovation in terms of revenue. Therefore, an organization's success in the market depends on innovation. Six questions based on the Likert scale (1 strongly disagree to 5 Strongly Agree) were used to evaluate the process innovation (Terziovski et al.,2014).

Product Innovation (PRI)

Product innovation is the best way to reduce costs and improve product value and performance to meet customer needs (Paladino et al., 2007). In this study, a five-point Likert scale was used to examine Product innovation. The four innovation indicators used to evaluate product innovation are higher specifications, customer satisfaction, providing quality products and customer service, and supporting the creation of quality products to meet customer needs.

Operationalization

Table 2

Operationalization and Measurement of Variables

Variables	Measures	Sources
CEO Tenure	The number of years the CEO maintains the title in the firm	Chandran et al. 2021
CEO Duality	1 if a same person is chairman and CEO otherwise 0	(Alqatan et al.,2019)
CEO Gender	1 if the CEO is female otherwise 0	(Mukherjee & Sen,2022)

Descriptive Statistics

The results of descriptive statistics are reported in table 3. The results of descriptive statistics were based on the mean, standard deviation, maximum and minimum values of latent constructs used in regression analysis. The results of gender indicate a mean value of 0.986 with the deviation of 0.118 which indicate that most of CEO are male in firms listed on PSX during the sample period.

The present study considered the considered the CEO education as master’s in finance as 1 (maximum) otherwise 0 (minimum). The mean value of education is 0.137 which indicate that most of the CEO specialization is not in finance as the mean value is near to 0 while the deviation from mean is 0.344.

The mean value of experience indicate that mean value is 51.584 which sample of selected companies indicate an experience of CEO is 51.5 years while the 25 is minimum years of experience and 60 is maximum years of experience. Moreover, the CCC indicate the mean value is -3.015 with the minimum -19.60 and maximum is 16.59 with deviation from mean is 1.50. The mean value of family-ownership is 0.793 with the minimum value is 0 while the maximum value is 1 with the deviation from mean value is 0.405. The results indicate that most of the sample companies are family-owned firms.

Furthermore, the results indicate that the mean value of firm age is 40.95 while the minimum value is 5 and maximum value is 77 years. Moreover, the mean value of firm size is 3.63 while the minimum value is 0.839 and maximum value is 6.45 with the standard deviation is 0.866. The results of descriptive statistics indicate that mean value of firm leverage is 0.758 and minimum value is -55.87 and maximum value is 18.17 with the standard deviation of 4.43.

Table 3

Descriptive Statistics

	CEO Experience	CEO Duality	CEO Tenure	CEO Gender	CEO Age	CEO Education	GIP	BBI	BD
Mean	1.81	0.44	1.64	0.13	2.37	0.63	3.64	3.09	3.56
Standard Deviation	0.46	0.50	0.80	0.34	0.50	0.48	0.64	0.49	0.65

	CEO Experience	CEO Duality	CEO Tenure	CEO Gender	CEO Age	CEO Education	GIP	BBI	BD
Sample Variance	0.21	0.25	0.64	0.11	0.25	0.23	0.41	0.24	0.43
Minimum	1.00	0.00	1.00	0.00	1.00	0.00	2.13	2.17	1.40
Maximum	3.00	1.00	3.00	1.00	3.00	1.00	4.75	4.33	5.00

Correlation Analysis

The results of correlation analysis indicate that family-ownership positively linked with CEO education, CCC and indicate negative relationship with the CEO gender and CEO experience. Furthermore, firm size and leverage significantly and positively linked with the CCC while firm age negatively and significantly linked with the CCC.

Table 4
Correlation Analysis

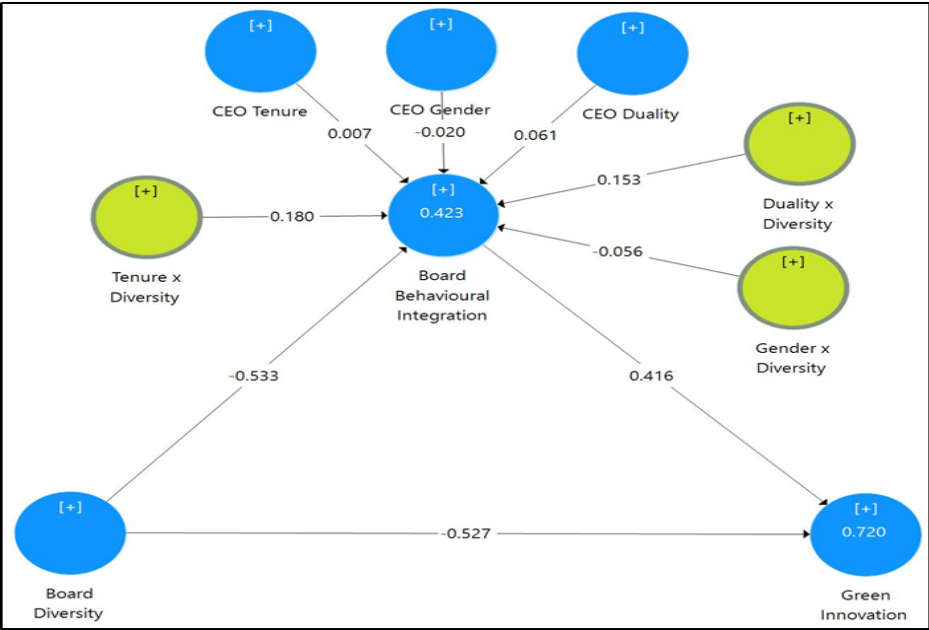
	Board Behavioural Integration	Board Diversity	CEO Duality	CEO Gender	CEO Tenure	Green Innovation
Board Behavioural Integration	1.000					
Board Diversity	0.614	1.000				
CEO Duality	0.060	0.077	1.000			
CEO Gender	0.126	0.192	0.047	1.000		
CEO Tenure	0.037	0.089	0.173	0.142	1.000	
Green Innovation	0.740	0.783	0.109	0.205	0.165	1.000

*p < 0.10. **p < 0.05. ***p < 0.01.

Results and Discussion

To assess the measurement model, it is necessary to carry out three statistical tests, namely factor analysis, convergent validity and reliability and discriminant validity (Cheung et al., 2023). In the current study, the minimum threshold for each item that was deemed to measure the relevant construct was set at 0. 50 (Hsu et al., 2007). Before testing validity and reliability of the model, testing of structural model can lead to theoretical framework (Hair et al., 2012). The higher-order presence can be measured by the most appropriate method known as CFA as postulated by Schwarz et al., (2014). Before proceeding to the factor analysis, the descriptive statistics and correlations help in understanding the nature of the data.

Figure 2



Discriminant validity was assessed by comparing the square root values of AVE and the correlations among constructs. The values of factor loading > 0.707, CR > 0.7, rho > 0.7 (Dijkstra and Henseler, 2015), and AVE > 0.5 (Vinzi et al, 2010) We found the greater AVE square root value of all constructs in contrast to the measurements of correlation among the constructs (Fornell and Larcker, 1981)

Table 4
Reliability and Measurement Model

	Loadings	Cronbach's Alpha	CR	AVE
BBI1	0.740	0.862	0.897	0.593
BBI2	0.693			
BBI3	0.765			
BBI4	0.844			
BBI5	0.761			
BBI6	0.808			
BODD1	0.768	0.743	0.838	0.571
BODD2	0.870			
BODD3	0.815			
BODD4	0.523			
GPRD1	0.899	0.918	0.935	0.676
GPRD2	0.811			
GPRD3	0.880			
GPRD4	0.872			
GPRO1	0.814			
GPRO2	0.655			
GPRO3	0.799			
GPRO4	0.899			

Table 4 presents the testing of hypothesis and this table shows that TMTBI($\beta = 0.416$, $t=7.839$, $p=0.000$) is positively associated with Green innovation performance at 1% level of significance .It means that Hypothesis is supported in such a way that if the Board has Integrated behavior then green innovation performance will also be enhanced and this finding is supported by prior literature(Xie et al.,2022).Board Diversity ($\beta = -0.533$, $t=8.588$, $p=0.000$) is negatively and significantly associated with TMTBI. It means that If Board in not diversified then board behavioral integration increases and this finding is supported by the previous studies (Al-Jaifi et al., 2023).Board diversity ($\beta = -0.527$, $t = 10.529$, $p=0.000$) is negatively and significantly associated with Green innovation It means that if Board is not diversified then Green innovation is enhanced and this finding is supported by prior literature (de Abreu et al.,2023).Duality ($\beta = 0.153$, $t=2.139$, $p=0.033$) and Tenure ($\beta =0.10$, $t=2,739$ $p=0.000$) are positively moderate the relationship of diversity and TMTBI and this finding is supported by the prior literature (Yao et al.,2023;Ma et al.,2024).

Table 5
Testing of Hypotheses

	Coeff.	S. D	T-Value	P-Values
Board Behavioural Integration -> Green Innovation	0.416	0.053	7.839	0.000
Board Diversity -> Board Behavioral Integration	-0.533	0.062	8.588	0.000
Board Diversity -> Green Innovation	-0.527	0.050	10.529	0.000
CEO Duality -> Board Behavioural Integration	0.061	0.060	1.012	0.312
CEO Gender -> Board Behavioural Integration	-0.020	0.048	0.411	0.681

	Coeff.	S. D	T-Value	P-Values
CEO Tenure -> Board Behavioural Integration	0.007	0.056	0.126	0.899
Duality x Diversity -> Board Behavioural Integration	0.153	0.072	2.139	0.033
Gender x Diversity -> Board Behavioural Integration	-0.056	0.045	1.224	0.221
Tenure x Diversity -> Board Behavioural Integration	0.180	0.066	2.739	0.006

Table 5 present the results of indirect hypotheses and this table shows that Board diversity ($\beta = -0.222, t=5.159$ and $P=0.000$) negatively but significantly moderates the relationship of Board Behavioral integration and green innovation and this finding is supported by (Sierra-Moran et al.,2024).The moderation between Duality and Diversity has a significant and positive indirect effect ($\beta =0.064, t=2.101, p=0.036$) on green innovation through Board behavioral integration and this finding is associated with the findings of Novitasari et al.,(2023).The moderation between Tenure and Diversity has a significant and positive indirect effect ($\beta =0.075, t=2.611, p=0.009$) on green innovation through Board behavioral integration and this finding is associated with the findings of Cahyono et al.,(2023).

Table 3
Testing of Indirect Hypotheses

	Coeff.	S. D	T-value	P-Values
Board Diversity -> Board Behavioural Integration -> Green Innovation	-0.222	0.043	5.159	0.000
Duality x Diversity -> Board Behavioural Integration -> Green Innovation	0.064	0.030	2.101	0.036
Gender x Diversity -> Board Behavioural Integration -> Green Innovation	-0.023	0.019	1.216	0.224
Tenure x Diversity -> Board Behavioural Integration -> Green Innovation	0.075	0.029	2.611	0.009

Conclusion

The findings of this study suggest a positive influence of these factors on green innovation, but CEO attributes show an insignificant relationship with green innovation However, our study has limitations, as it reflects the perspectives of current TMTs of manufacturing industries, and results may differ among TMTs of other companies or industries.

This study contributes to the exploration of variables within the manufacturing industries, an area less explored in Pakistan and globally. We found significant positive effects across all variables, highlighting the need for further research to identify the impact of CEO attributes on green innovation performance The surge in demand of green innovation in the manufacturing industries leads towards the focus on TMT diversity, behavioral integration and CEO attributes Therefore, our research aims to uncover the internal factors contributing to the manufacturing industry's growth, emphasizing the role of TMTD and behavioral integration in enhancing green innovation performance , thus contributing to the sector's success.

References

- Aboramadan, M., Alolayyan, M. N., Turkmenoglu, M. A., Cicek, B., & Farao, C. (2021). Linking authentic leadership and management capability to public hospital performance: the role of work engagement. *International Journal of Organizational Analysis*, 29(5), 1350-1370. <https://doi.org/10.1108/ijoa-10-2020-2436>
- Agustia, D. (2023). Does green innovation play an important role in the effect board gender diversity has on firm performance?. *Intangible Capital*, 19(2), 146-164. <https://doi.org/10.3926/ic.2020>
- Al-Jaifi, H. A., Al-Qadasi, A. A., & Al-Rassas, A. H. (2023). Board diversity effects on environmental performance and the moderating effect of board independence: evidence from the Asia-Pacific region. *Cogent Business & Management*, 10(2). <https://doi.org/10.1080/23311975.2023.2210349>
- Alqatan, A. (2019). The association between board diversity, earnings management and firm performance in Kuwait: A research agenda. *Corporate governance: Search for the advanced practices*, 254-274. <https://doi.org/10.22495/cpr19p14>
- Asadi, S., OmSalameh Pourhashemi, S., Nilashi, M., Abdullah, R., Samad, S., Yadegaridehkordi, E., Aljojo, N., & Razali, N. S. (2020). Investigating influence of green innovation on sustainability performance: A case on Malaysian hotel industry. *Journal of Cleaner Production*, 258(120860), 120860. <https://doi.org/10.1016/j.jclepro.2020.120860>
- Attah-Boakye, R., Costanzo, L. A., Guney, Y., & Rodgers, W. (2021). The effects of top management team strategic cognition on corporate financial health and value: an interactive multi-dimensional approach. *European Journal of Finance*, 1–32. <https://doi.org/10.1080/1351847x.2021.1977360>
- Baeshen, Y., Soomro, Y. A., & Bhutto, M. Y. (2021). Determinants of green innovation to achieve sustainable business performance: Evidence from SMEs. *Frontiers in Psychology*, 12, 767968. <https://doi.org/10.3389/fpsyg.2021.767968>
- Bataineh, M. J., Sánchez-Sellero, P., & Ayad, F. (2024). Green is the new black: How research and development and green innovation provide businesses a competitive edge. *Business Strategy and the Environment*, 33(2), 1004–1023. <https://doi.org/10.1002/bse.3533>
- Bendig, D., Strese, S., Flatten, T. C., da Costa, M. E. S., & Brettel, M. (2018). On micro-foundations of dynamic capabilities: A multi-level perspective based on CEO personality and knowledge-based capital. *Long Range Planning*, 51(6), 797–814. <https://doi.org/10.1016/j.lrp.2017.08.002>
- Bengtsson, M., Raza-Ullah, T., & Srivastava, M. K. (2020). Looking different vs thinking differently: Impact of TMTDon coopetition capability. *Long Range Planning*, 53(1), 101857. <https://doi.org/10.1016/j.lrp.2018.11.001>
- Boone, C., & Hendriks, W. (2009). Top management team diversity and firm performance: Moderators of functional-background and locus-of-Control diversity. *Management Science*, 55(2), 165-180. <https://doi.org/10.1287/mnsc.1080.0899>
- Cahyono, S., Harymawan, I., & Kamarudin, K. A. (2023). The impacts of tenure diversity on boardroom and corporate carbon emission performance: Exploring from the moderating role of corporate innovation. *Corporate Social Responsibility and Environmental Management*, 30(5), 2507-2535. <https://doi.org/10.1002/csr.2500>
- Carmeli, A., & Schaubroeck, J. (2006). Top management team behavioral integration, decision quality, and organizational decline. *The Leadership Quarterly*, 17(5), 441-453. <https://doi.org/10.1016/j.leaqua.2006.06.001>
- Cennamo, C., Dagnino, G. B., Di Minin, A., & Lanzolla, G. (2020). Managing digital transformation: Scope of transformation and modalities of value Co-generation and delivery. *California Management Review*, 62(4), 5-16. <https://doi.org/10.1177/0008125620942136>

- Chandra, S., Ghosh, P., & Sinha, S. (2023). Addressing employee turnover in retail through CSR and transformational leadership. *International Journal of Retail & Distribution Management*, 51(5), 690-710. <https://doi.org/10.1108/ijrdm-07-2022-0237>
- Cheung, G. W., Cooper-Thomas, H. D., Lau, R. S., & Wang, L. C. (2023). Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations. *Asia Pacific Journal of Management*, 41(2), 745-783. <https://doi.org/10.1007/s10490-023-09871-y>
- Ciasullo, M. V., Montera, R., & Douglas, A. (2022). Environmental sustainability orientation and ambidextrous green innovation: Do the roles of women on corporate boards matter? *Sinergie Italian Journal of Management*, 40(2), 209-231. <https://doi.org/10.7433/s118.2022.10>
- De Abreu, M. C., Soares, R. A., Daniel-Vasconcelos, V., & Crisóstomo, V. L. (2022). Does board diversity encourage an environmental policy focused on resource use, emission reduction and innovation? The case of companies in Latin America. *Corporate Social Responsibility and Environmental Management*, 30(3), 1161-1176. <https://doi.org/10.1002/csr.2411>
- de Andrade Araújo, N. (2023). How Will Leadership Agility be Affected By the Organization-S Work Digitalization and Dynamic Workforce Engagement in the Future of Work? Case Applied in the Insurance Sector (Master's thesis, Universidade NOVA de Lisboa (Portugal)).
- Dhir, A., Khan, S. J., Islam, N., Ractham, P., & Meenakshi, N. (2023). Drivers of sustainable business model innovations. An upper Echelon theory perspective. *Technological Forecasting and Social Change*, 191, 122409. <https://doi.org/10.1016/j.techfore.2023.122409>
- Dijkstra, T. K., & Henseler, J. (2015). Consistent partial least squares path modeling. *MIS Quarterly*, 39(2), 297-316. <https://doi.org/10.25300/misq/2015/39.2.02>
- Emine, K. A. L. E. (2020). Self-monitoring and contextual performance: the mediating role of self esteem. *Ankara Hacı Bayram Veli Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 22(1), 98-119.
- Fahad, S., & Wang, J. (2020). Climate change, vulnerability, and its impacts in rural Pakistan: a review. *Environmental Science and Pollution Research International*, 27(2), 1334-1338. <https://doi.org/10.1007/s11356-019-06878-1>
- Firk, S., Gehrke, Y., Hanelt, A., & Wolff, M. (2022). Top management team characteristics and digital innovation: Exploring digital knowledge and TMT interfaces. *Long Range Planning*, 55(3), 102166. <https://doi.org/10.1016/j.lrp.2021.102166>
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *JMR, Journal of Marketing Research*, 18(1), 39. <https://doi.org/10.2307/3151312>
- Friedman, Y., & Carmeli, A. (2022). CEOs driving decision making toward higher performance: Strategic micro-foundations of small-sized family firms. *The Journal of Applied Behavioral Science*, 58(2), 256-280. <https://doi.org/10.1177/00218863211023279>
- Gao, D., Li, S., & Guo, C. (2023). Top management team career experience heterogeneity, digital transformation, and the corporate green innovation: a moderated mediation analysis. *Frontiers in Psychology*, 14, 1276812. <https://doi.org/10.3389/fpsyg.2023.1276812>
- García-Granero, A., Fernández-Mesa, A., Jansen, J. J. P., & Vega-Jurado, J. (2018). Top management team diversity and ambidexterity: The contingent role of shared responsibility and CEO cognitive trust. *Long Range Planning*, 51(6), 881-893. <https://doi.org/10.1016/j.lrp.2017.11.001>
- Ghonim, M. A., Khashaba, N. M., Al-Najaar, H. M., & Khashan, M. A. (2022). Strategic alignment and its impact on decision effectiveness: a comprehensive model. *International Journal of Emerging Markets*, 17(1), 198-218. <https://doi.org/10.1108/ijoem-04-2020-0364>
- Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, 40(3), 414-433. <https://doi.org/10.1007/s11747-011-0261-6>

- Hambrick, D. C. (1994). Top management groups: A conceptual integration and reconsideration of the "team" label. *Research in Organizational Behavior*, 16, 171–171.
- Hashmi, H. B. A., Voinea, C. L., Caniëls, M. C. J., Ooms, W., & Abbass, K. (2023). Do top management team diversity and chief sustainability officer make firms greener? Moderating role of top management team behavioral integration. *Sustainable Development*. <https://doi.org/10.1002/sd.2529>
- Hsu, S.-H., Wang, Y.-C., & Tzeng, S.-F. (2007). The source of innovation: Boundary spanner. *Total Quality Management & Business Excellence*, 18(10), 1133–1145. <https://doi.org/10.1080/14783360701596274>
- Huang, Y.-C., Yang, M.-L., & Wong, Y.-J. (2016). The effect of internal factors and family influence on firms' adoption of green product innovation. *Management Research Review*, 39(10), 1167–1198. <https://doi.org/10.1108/mrr-02-2015-0031>
- Imam, H., & Zaheer, M. K. (2021). Shared leadership and project success: The roles of knowledge sharing, cohesion and trust in the team. *International Journal of Project Management*, 39(5), 463–473.
- Jansen, J. J. P., Tempelaar, M. P., van den Bosch, F. A. J., & Volberda, H. W. (2009). Structural differentiation and ambidexterity: The mediating role of integration mechanisms. *Organization Science*, 20(4), 797–811. <https://doi.org/10.1287/orsc.1080.0415>
- Kurzahls, C., Graf-Vlachy, L., & König, A. (2020). Strategic leadership and technological innovation: A comprehensive review and research agenda. *Corporate Governance An International Review*, 28(6), 437–464. <https://doi.org/10.1111/corg.12351>
- Li, M., & Jones, C. D. (2019). The effects of TMT faultlines and CEO-TMT power disparity on competitive behavior and firm performance. *Group & Organization Management*, 44(5), 874–914. <https://doi.org/10.1177/1059601118813790>
- Li, P.-Y., & Huang, K.-F. (2019). The antecedents of innovation performance: the moderating role of top management team diversity. *Baltic Journal of Management*, 14(2), 291–311. <https://doi.org/10.1108/bjm-07-2017-0202>
- Lin, W.-L., Cheah, J.-H., Azali, M., Ho, J. A., & Yip, N. (2019). Does firm size matter? Evidence on the impact of the green innovation strategy on corporate financial performance in the automotive sector. *Journal of Cleaner Production*, 229, 974–988. <https://doi.org/10.1016/j.jclepro.2019.04.214>
- Liu, Y. (2017). A review of the relationship between TMT shared cognition and strategic decision making. *American Journal of Industrial and Business Management*, 07(10), 1101–1110. <https://doi.org/10.4236/ajibm.2017.710078>
- Luan, N. T., Hau, D. N. D., & Thu, N. T. A. (2022). The influence of green product development performance to enhance enterprise effectiveness and innovation. *Economies*, 10(5), 113. <https://doi.org/10.3390/economies10050113>
- Ma, C., Ge, Y., & Zhao, H. (2024). Top management team diversity and adaptive firm performance: the moderating roles of overlapping team tenure and severity of threat. *Journal of Organizational Change Management*, 37(1), 1–23. <https://doi.org/10.1108/jocm-11-2022-0321>
- Mady, K., Abdul Halim, M. A. S., Omar, K., Abdelkareem, R. S., & Battour, M. (2022). Institutional pressure and eco-innovation: The mediating role of green absorptive capacity and strategically environmental orientation among manufacturing SMEs in Egypt. *Cogent Business & Management*, 9(1). <https://doi.org/10.1080/23311975.2022.2064259>
- Mukherjee, T., & Sen, S. S. (2022). Impact of CEO attributes on corporate reputation, financial performance, and corporate sustainable growth: evidence from India. *Financial Innovation*, 8(1). <https://doi.org/10.1186/s40854-022-00344-7>
- Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital innovation management. *MIS quarterly*, 41(1), 223–238. <https://www.jstor.org/stable/26629644>

- Novitasari, M., & Agustia, D. (2023). Competitive advantage as a mediating effect in the impact of green innovation and firm performance. *Business: Theory and Practice*, 24(1), 216–226.
- Paladino, A. (2007). Investigating the drivers of innovation and new product success: A comparison of strategic orientations. *The Journal of Product Innovation Management*, 24(6), 534–553. <https://doi.org/10.1111/j.1540-5885.2007.00270.x>
- Pham, T.-D. T., & Lo, F.-Y. (2023). How does top management team diversity influence firm performance? A causal complexity analysis. *Technological Forecasting and Social Change*, 186(122162), 122162. <https://doi.org/10.1016/j.techfore.2022.122162>
- Reisenzein, R. (2020). Cognitive theory of emotion. *Encyclopedia of personality and individual differences*, 723–733.
- Savastano, M., Zentner, H., Spremić, M., & Cucari, N. (2022). Assessing the relationship between digital transformation and sustainable business excellence in a turbulent scenario. *Total Quality Management & Business Excellence*, 1–22.
- Schratzenstaller, M., Krenek, A., Nerudová, D., & Dobranschi, M. (2017). EU Taxes for the EU Budget in the Light of Sustainability Orientation-a Survey. *Jahrbücher Für Nationalökonomie Und Statistik*, 237(3), 163–189.
- Shahzad, M., Qu, Y., Rehman, S. U., & Zafar, A. U. (2022). Adoption of green innovation technology to accelerate sustainable development among manufacturing industry. *Journal of Innovation & Knowledge*, 7(4), 100231. <https://doi.org/10.1016/j.jik.2022.100231>
- Sierra-Morán, J., Cabeza-García, L., & González-Álvarez, N. (2024). Independent directors and firm innovation: the moderating role of gender and nationality diversity. *European Journal of Innovation Management*, 27(2), 373–402. <https://doi.org/10.1108/EJIM-12-2021-0621>
- Sierra-Morán, J., Cabeza-García, L., González-Álvarez, N., & Botella, J. (2024). The board of directors and firm innovation: A meta-analytical review. *BRQ Business Research Quarterly*, 27(2), 182–207. <https://doi.org/10.1177/23409444211039856>
- Sun, W., Huang, C., & Su, Z. (2023). How do non-family CEOs influence family firm innovation performance? *Management Decision*, 61(10), 2945–2972. <https://doi.org/10.1108/md-05-2022-0705>
- Svahn, F., Mathiassen, L., & Lindgren, R. (2017). Embracing digital innovation in incumbent firms. *MIS quarterly*, 41(1), 239–254. <https://www.jstor.org/stable/26629645>
- Terziovski, M., & Guerrero, J.-L. (2014). ISO 9000 quality system certification and its impact on product and process innovation performance. *International Journal of Production Economics*, 158, 197–207. <https://doi.org/10.1016/j.ijpe.2014.08.011>
- Ünal, E., Urbinati, A., & Chiaroni, D. (2019). Managerial practices for designing circular economy business models: The case of an Italian SME in the office supply industry. *Journal of Manufacturing Technology Management*, 30(3), 561–589.
- Vinzi, V. E., Chin, W. W., Henseler, J., & Wang, H. (2010). *Handbook of partial least squares* (Vol. 201, No. 0). Berlin: Springer.
- Wang, J., & Cao, H. (2022). Improving competitive strategic decisions of Chinese coal companies toward green transformation: A hybrid multi-criteria decision-making model. *Resources Policy*, 75(102483), 102483. <https://doi.org/10.1016/j.resourpol.2021.102483>
- Xie, X., Han, Y., & Hoang, T. T. (2022). Can green process innovation improve both financial and environmental performance? The roles of TMT heterogeneity and ownership. *Technological Forecasting and Social Change*, 184(122018), 122018. <https://doi.org/10.1016/j.techfore.2022.122018>
- Yao, T. (2023). Antecedents of top management team and board gender diversity: A review and an agenda for research. *Corporate Governance An International Review*, 31(1), 227–248. <https://doi.org/10.1111/corg.12495>
- Yu, H., Wang, J., Hou, J., Yu, B., & Pan, Y. (2023). The effect of economic growth pressure on green technology innovation: Do environmental regulation, government support, and financial development

- matter? *Journal of Environmental Management*, 330(117172), 117172.
<https://doi.org/10.1016/j.jenvman.2022.117172>
- Zaman, R., Jain, T., Samara, G., & Jamali, D. (2022). Corporate governance meets corporate social responsibility: Mapping the interface. *Business and Society*, 61(3), 690–752.
<https://doi.org/10.1177/0007650320973415>
- Zhang, D., Rong, Z., & Ji, Q. (2019). Green innovation and firm performance: Evidence from listed companies in China. *Resources, Conservation, and Recycling*, 144, 48–55.
<https://doi.org/10.1016/j.resconrec.2019.01.023>
- Zhou, J., Li, X., Tian, L., & Huebner, E. S. (2020). Longitudinal association between low self-esteem and depression in early adolescents: The role of rejection sensitivity and loneliness. *Psychology and Psychotherapy*, 93(1), 54–71. <https://doi.org/10.1111/papt.12207>