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Green Transformational Leadership, Environmental Strategy, and Green Innovation: Mediated Moderation of Knowledge Sharing and Green Absorptive Capacity

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Abstract

This study explores the impact of green transformational leadership and environmental strategies on promoting green innovation in manufacturing firms in Pakistan. It examines how such leadership and its strategies encourage employees to foster green innovation through effective knowledge-sharing and enhanced green absorptive capacity. The current study was conducted with a sample of 413 respondents collected via survey forms, and the hypotheses were tested using structural equation modeling in AMOS. The findings indicate that green transformational leadership significantly impacts green innovation by supporting subordinates in generating new ideas, products, and policies. Furthermore, environmental strategies strongly influence green innovation, as green vision and strategies

are essential for incorporating green innovation. The mediating role of knowledge sharing strengthens the relationship between green transformational leadership and green innovation and between environmental strategy and green innovation. The moderating impact of green absorptive capacity also proved significant. The study concludes that these constructs are vital antecedents of green innovation and provide a solid foundation for sustainable practices. This research contributes to the literature on the natural resource-based view (NRBV) theory and green innovation by highlighting the roles of green transformational leadership, knowledge sharing, and environmental strategy. It offers valuable insights for executives and managers in promoting green innovation within firms and implementing eco-friendly strategies and policies through structured knowledge-sharing.

Keywords: Green transformational leadership, environmental strategy, green innovation, knowledge sharing, green absorptive capacity, manufacturing sector, Pakistan.

1. Introduction

Industrial activities have increased over the past few decades owing to rapid economic development, which has negatively affected the environment and depleted resources (Adomako & Tran, 2022; Ma et al., 2024). This has raised an alarming global situation, requiring us to tackle this issue as soon as possible and contribute to the body of literature, as stated by Awan, Nauman, and Sroufe (2021). Studies have highlighted the importance of green innovation (GI). GI is a modern solution encouraging firms to produce less harmful products and services. GI involves adopting new practices to prevent pollution, reduce waste, and save energy (Zhang et al., 2020). Business operations, policies, strategies, and productivity are managed by considering all the environmental impacts. GI is a multidimensional solution that generates goodwill for the firm, reduces cost, and effectively reduces environmental glitches (Chen, Lai, & Wen, 2006; Ahakwa et al., 2024). It also creates ample opportunities for sustainable growth and reduces environmental issues, which is why achieving an environmental sustainability agenda is unavoidable. Thus, GI is regarded as a successor to sustainability, but this is not yet the final statement (Awan et al., 2021).

This study addresses these concerns by investigating the role of green transformational leadership (GTL) in promoting GI in firms. The GTL is a strategic source for incorporating GI. Transformational leaders motivate followers to achieve environmental objectives and goals (Begum et al., 2022). They have proven to be the source of individual consideration, intellectual stimulation, inspiration, and charisma for their followers (Avolio & Bass, 1995). They support communication networks and an environment of trust, which ultimately help develop strategies and knowledge sharing (KS) and encourage GI within a firm (Howell & Avolio, 1993; Begum et al., 2022). Various studies have shown that GTL plays a crucial role in reducing the harmful impacts of pollution on the environment (Li et al., 2020; Al Doghan et al., 2022; Alketbi & Ahmad, 2023; Ullah, Mehmood, & Ahmad, 2023). Despite the known benefits of GTL, limited research has been conducted on the

association between GTL and GI. The first objective of this study was to fill this gap by evaluating the role of GTL in inducing GI in firms.

Developing a robust environmental strategy (ES) is integral to implementing GI. ES refers to the plans and actions taken by firms to manage their environmental impact (Chaudhry, Asad, & Hussain, 2020; Adomako, Ning, & Adu-Ameyaw, 2021). This includes developing and implementing policies and practices to reduce environmental harm and promote sustainability (Appannan et al., 2023). An effective ES is essential to integrate GI into business operations (Li et al., 2023). This helps firms align their activities with environmental regulations, reduce waste, and improve energy efficiency. By adopting comprehensive environmental strategies, firms can proactively address environmental challenges, enhance their competitive advantage, and gain an innovative edge. However, previous studies have predominantly focused on performance indicators, highlighting the need for GI and making the second objective of our study (Albort-Morant, Leal-Millán, & Cepeda-Carrión, 2016; Huang & Li, 2017b; Afshan et al., 2023).

Knowledge sharing (KS) within firms is crucial to complementing these strategies. KS is an exchange of information, skills, and expertise among employees. It is vital to foster innovation and enhance a firm's competitive advantage (Mushtaq & Bokhari, 2011; Al-Husseini, El Beltagi, & Moizer, 2021). An imbalance in natural resources is partially caused by firms' business operations and activities (Hall & Wagner, 2012). In the absence of KS, scarce resources and abilities of firm network members are of no value. Thus, KS is crucial for any firm's relative competitiveness (Mushtaq & Bokhari, 2011). Many managers do not favor the diffusion of knowledge and practices, even if they are devising ES in the firm. The global practices in the firms of developing countries, including some Asian ones, reveal that managers need to consider that globalization essentials are based on peculiar environmental issues and preventing the workforce from gaining excessive knowledge (Aragón-Correa, Martín-Tapia, & Hurtado-Torres, 2013). However, we suggest that KS should be the basis for firms' devising different policies and strategies, including environmental policies, to preserve the natural environment effectively. In the GI context, KS enables firms to integrate environmental considerations into their business strategies and operations. It supports developing and implementing green practices by ensuring that valuable information is disseminated throughout a firm. Owing to fluctuating evidence, we checked the role of KS in bridging the GTL and ES, which constituted the third objective of our study.

Firms must develop strong green absorptive capacity (GAC) to utilize shared knowledge effectively. GAC refers to a firm's ability to recognize the value of new external information, assimilate it, and apply it to commercial ends, specifically in the context of green and sustainable practices. GAC is vital for a firm's innovation and adaptation to environmental challenges. Firms with high GAC are better equipped to absorb and utilize green knowledge, which enhances their ability to implement GI effectively (Albort-Morant

et al., 2016; Albort-Morant et al., 2018; Fatima, Ahmed, & Mahnoor, 2023). The rightfulness of a firm depends on its capability to absorb knowledge, align it, and implement it to achieve its economic goals (Leblebici et al., 1991). Firms with more GAC have more flexibility and adaptation to external pressures. GAC is a critical component of KS activities that are crucial for GI and enhance their survival and financial performance (Albort-Morant et al., 2016). Therefore, we propose that GAC moderates the influence of GTL and ES on KS, which is the fourth objective of our study.

This study proposes a model that connects with past literature by linking GTL and ES with GI and individually analyzes GAC and KS in the mediation moderation model. This research was conducted in Pakistan's manufacturing sector to achieve the objectives of our study. Firms in developing countries play a proactive role in developing green, innovative products and processes. Pakistani manufacturing firms comprise players in the global market, and the emerging importance of GTL has a substantial impact on GI as it advances toward developing green and innovative products and processes. Our model primarily unveils the contribution of the Natural Resource-Based View (NRBV), as it is essential for promoting new initiatives for developing green products and services that proficiently use resources. Moreover, this study examined the mediating role of KS between GTL, ES, and GI. The strong influence of ES on GI underscores the importance of these strategies for fostering GI within firms. Finally, this study highlights the moderating role of GAC, directing managers to focus on enhancing GAC for influential KS.

This section presents the study's background, significance, and problem statements. The subsequent section comprehensively reviews the relevant literature and develops the hypotheses. The third section details the methodology used in this study. The fourth section presents the empirical analysis, and the fifth section discusses the results, implications, and concluding remarks.

2. Theoretical Framework and Hypotheses Development

GTL is a strategic source for introducing GI and increasing firm productivity after the final score. This versatile nature of leadership epitomizes creativity and changes in the workplace (Jiang & Yang, 2015). This versatile leadership style fosters creativity and adaptability in the workplace, emphasizing the achievement of environmental goals (Singh et al., 2020). GI focuses on developing green products, processes, policies, and procedures to mitigate environmental impacts (Xie, Huo, & Zou, 2019). GTL represents a combination of intangible resources, such as motivation, skill development, and the potential to incorporate new thoughts that help achieve environmental objectives and goals (Singh et al., 2020). The current study is based on a natural resource-based view that observes the environmental effects of firms' resources, products, and processes obtained from them. The NRBV structure describes the triangular link between a firm's capabilities, resources, and environment. NRBV highlights a firm's proficiency in polishing capabilities to use natural resources efficiently to control environmental problems (Hart, 1995). New environmental strategies have been devised based on these bases under the supervision of the GTL

through KS and promoting GI. NRBV focuses on three dimensions: product stewardship, pollution reduction, and sustainable development (Begum et al., 2022; Özgül & Zehir, 2023). Primarily, product stewardship lessens the lifetime environmental impacts of products, which start from their formation until they become final products or maybe at their disposal. Second, reducing pollution is the primary goal of every innovative firm, which requires minimal wastage, emissions, and contamination. Lastly, sustainable development focuses on developing eco-friendly strategies and low-impact technologies and products (De Stefano, Montes-Sancho, & Busch, 2016; Begum et al., 2022). The field of strategic management is based on NRBV to evaluate GI and address environmental glitches. The NRBV encourages line managers to introduce innovative ideas for reducing emissions and waste in production lines to achieve superior GI (Begum et al., 2022). Through KS, firms integrate GTL principles with ES and facilitate GI by fostering a knowledge exchange and innovation culture.

2.1 Green Transformational Leadership and Green Innovation

A sudden shift in the marketplace demands that leaders be transformational, as they encourage the self-growth of personnel by paying more profound attention to their developmental needs and concerns. They motivate their followers to devise new policies and strategies to tackle old situations and issues to bring change (García-Morales, Jiménez-Barrionuevo, & Gutiérrez-Gutiérrez, 2012). They set examples for their subordinates to achieve firm goals through commitments and values that benefit the firm, society, and the environment. They promote creativity by empowering followers and delivering unique knowledge to introduce GI (Carreiro & Oliveira, 2019; Janjua, SHI, & Sahibzada, 2024). GI functions as a connector in the amalgamation of environmental and business goals. Chen et al. (2006) stated that GI encompasses new adaptations in processes, products, and technologies to prevent pollution, conserve energy, recycle waste, design green products, and enhance environmental management practices. GI fosters economic development by facilitating optimal changes in policies, products, processes, services, and technologies, all geared toward mitigating environmental challenges (Akhtar et al., 2024). GTL encourages employees to ingrain creativity, create novel linkages, and devise green policies and practices to promote GI (Li et al., 2020). GTL helps to bring GI by introducing new trends and current knowledge from the market, building financial resources, training staff, and advancing green technologies to execute GI (Xie et al., 2019; Begum et al., 2022; Özgül & Zehir, 2023; Janjua et al., 2024). GTL can encourage the workforce to create rare, new, novel, and creative ideas, which are the building blocks of GI. Based on the arguments above, the following hypothesis is proposed:

- *H1. GTL has a significant and positive impact on GI.*

2.2 Environmental Strategy and Green Innovation

Nowadays, firms are gaining a competitive advantage by understanding and implementing environmental strategies, and this trend is quite visible. GI is also considered a sustainable development with new and improved processes, technologies, products, and practices for reducing environmental issues (Rehman et al., 2021). Sustainable performance is drastically improved by incorporating environmental strategies into firms. This sudden shift towards ES has highlighted that the sustainable performance of firms with ES is comparatively improved compared to others (Solovida & Latan, 2017; Akhtar et al., 2024). GI promotes environmentally friendly products, policies, technologies, and processes. Likewise, ES focuses on utilizing green raw materials, reducing pollution, promoting recycling, and reducing waste. Thus, we can create environmentally friendly products, services, and policies (Singh et al., 2020). GI has a direct effect on the performance of any firm as it is helpful in cost-cutting and improving productivity. ES can earn a competitive edge for firms by ingraining GI because the strength of these strategies is based on GI (Mulaessa & Lin, 2021; Khan et al., 2023). GI is a new tool for introducing eco-friendly products and processes and clearing all the negative impacts. Previously, an association between ES and competitive advantage was identified in GI. Liu, Guo, and Chi (2015) have also proposed the relationship between ES and performance (Özgül & Zehir, 2023). Similarly, Chen et al. (2016) declared that ES promotes green creativity, the first step in incorporating GI in firms. Based on the above arguments, the following hypothesis is proposed.

- *H2. ES has a significant and positive impact on GI.*

2.3 Green Transformational Leadership and Knowledge Sharing

Transformational Leaders motivate their employees in various ways and encourage them to increase their efficiency. KS is a grapevine of information that starts from individuals to groups within a firm, which helps its workforce perform better (Mushtaq & Bokhari, 2011). In this way, working experience and technologies are exchanged between staff members. Xiong and Deng (2008) stated that one primary way to promote KS in firms is through the opted leadership style. These leaders create a culture that promotes KS, focuses on personnel development, and creates loyalty for the firm (Bollinger & Smith, 2001). They maintain a culture of promoting KS by enforcing a collection of beliefs, values, customs, and expectations related to KS. This supportive atmosphere is focused on maintaining a vision and mission as well as trust and justice (Masa'deh, Obeidat, & Tarhini, 2016). Knowledge is collected and shared among employees for the sake of GI. Xiao, Zhang, and Ordóñez de Pablos (2017) clarified that the workforce performs more innovatively and is willing to engage in KS with colleagues under the supervision of Transformational Leaders. GTL develops feasible working conditions and provides resources to promote KS activities within firms. Le and Lei (2018) highlight that GTL positively affects contributing knowledge and KS by maintaining a climate of confidence among employees. The association between GTL and the peculiar components of KS activity remains unexplored

and insufficient. This study explored this relationship and proposed the following hypotheses:

- *H3. GTL has a significant and positive impact on KS.*

2.4 Environmental Strategy and Knowledge Sharing

KS is the extent to which a firm distributes knowledge about itself and its links with the environment and task-related problems to its workforce, which strongly impacts its performance (Pfeffer, 1995). Different studies have highlighted the importance of delivering and sharing knowledge for the sake of employees' contributions toward devising policies and strategies for firms. Similarly, Rothenberg (2003) raised the significance of sharing knowledge with staff and allowing them to play their roles in reducing environmental impacts. It was also revealed that when an ES is appropriately communicated, it encourages the workforce to promote eco-initiatives (Ramus & Steger, 2000; Adomako et al., 2021; Begum et al., 2022). People's environmental knowledge will obtain the data, process it, and use it to devise policies and strategies to overcome environmental problems. It also helps to understand the positive outcomes of responsible actions taken for environmental well-being (Frick, Kaiser, & Wilson, 2004). KS is a crucial step in knowledge management to address environmental issues (Yeboah, 2023) effectively. Sekino and Nakamura (2006) found that knowledge collected from environmental management projects can be organized and utilized to solve environmental distress by devising new policies and strategies to handle the situation well (Bresciani et al., 2023). Based on these arguments, the following hypothesis is proposed.

- *H4. ES has a significant and positive impact on KS.*

2.5 Knowledge Sharing and Green Innovation

KS is identified as a pivotal factor in fostering green innovation across various studies, and it is posited as a critical component in achieving green innovation within sustainable practices (Wang & Wang, 2012; Al-Husseini et al., 2021). KS activities are designed in a channelized manner of extracting, donating, collecting, assimilating, exchanging, and transferring knowledge within a firm, which helps generate new ideas and strategies that are eco-friendly (Wang & Wang, 2012). GTL enforces the flow of knowledge and the exchange of skills and experiences linked with different staff members. Contradictions or interesting facts emerge when considering the direct influence of knowledge sharing. While some studies find a direct positive association between KS and GI (Wang & Wang, 2012; Yeboah, 2023), others suggest that knowledge sharing does not mediate the relationship between specific antecedents and green innovation outcomes (Shafait & Huang, 2024). Prior studies consistently underscore the importance of KS in enhancing GI. It acts as a mediator and moderator in various contexts, influencing the success of green products, processes, and behaviors. However, the direct effects of KS on GI are complex and may vary depending on the specific antecedents and outcomes considered (Al-Husseini

et al., 2021; Shafait & Huang, 2024). The relationship between KS and GI is multifaceted and significant, with implications for both theory and practice in pursuing sustainable development and environmental performance. Consequently, KS is encouraged and promoted through the strong influence of transformational leaders by ingraining respect and admiration (Al-Husseini et al., 2021; Yeboah, 2023). Employees are motivated to introduce new ideas in the GI process and encourage them to propose different policies and strategies that are environmentally friendly. Less knowledge and attention are given to this linkage, and limited data are available (Sahoo, Kumar, & Upadhyay, 2023). Therefore, on these grounds, we propose the following hypothesis:

- *H5. KS has a significant and positive impact on GI.*

2.6 The Moderating Role of Green Absorptive Capacity

The Absorptive Capacity of any firm is categorized as its ability to fetch new knowledge and value it, compile it, and later implement it at commercial ends (Lane, Salk, & Lyles, 2001). In recent studies, GAC is regarded as the highlighter of environmental issues and has also proposed different mechanisms for overcoming green inertia (Pacheco, Alves, & Liboni, 2018). Similarly, GAC also acts like a magnet that captures knowledge from the market at total capacity, which is helpful for firms in every context (Najafi-Tavani, Sharifi, & Najafi-Tavani, 2016). Firms identify and utilize more knowledge inflows depending on the capacity of their knowledge absorption while considering the rules and regulations. GTL is a building block connecting firms' knowledge-sharing and learning processes (Flatten, Adams, & Brettel, 2015). GTL can gather and infuse external knowledge into firms in comparison with market leaders as they strive to increase the KS capacity of firms. They clearly envision the best knowledge extraction, exploitation, absorption, and implementation to increase the firm's knowledge base (Ferreras Méndez, Sanz Valle, & Alegre, 2018). Studies related to this relationship are scarce, but environmental strategies are effective in this way, as they focus on obtaining information and knowledge in the most channelized way. Firms with more knowledge absorption capacity have more chances of executing environmental issues such as ES (Albort-Morant et al., 2018). Delmas, Hoffmann, and Kuss (2011) argued that in developing an ES, GAC is the most fundamental factor that facilitates gaining, gathering, changing, sharing, and exploiting knowledge.

- *H6a. GAC strengthens the relationship between GTL and KS.*
- *H6b. GAC strengthens the relationship between ES and KS.*

Following is the conceptual model of the study:

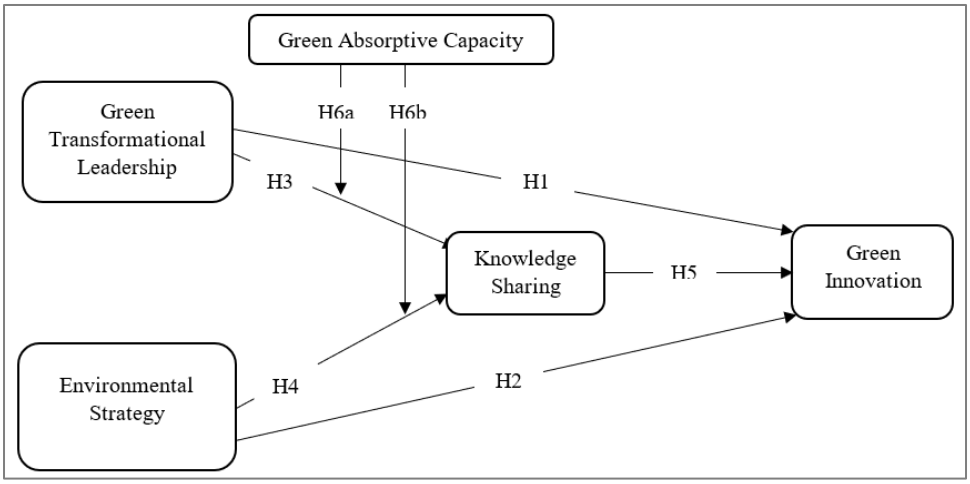

Figure 1. Conceptual Model

3. Methodology

The data for the current study were collected from Pakistani manufacturing firms established in multiple geographic regions, including Karachi, Lahore, Faisalabad, and Sialkot. They display diverse cultures and varying extents of economic development. Pakistani manufacturing firms are critically managing administrative control, especially in the environmental sector, to overcome environmental problems such as pollution, desertification, and waste control. Considering these environmental regulations in the Pakistani context is helpful for KS and extension in this research area. Our sample included only firms in the local bodies' directory, such as the Chamber of Commerce. We randomly selected 900 firms and collected the contact information of the focal persons of these firms, primarily senior managers or CEOs from the directories. The survey forms were mailed to the focal persons, from where they were dispersed to the intended respondents. A cover letter enclosing all details of the research purpose was attached to the survey forms. The anonymity of all respondents was assured as they mailed us directly that confidentiality was guaranteed to increase the response rate. Incomplete questionnaires were discarded, and only 413 were selected for final consideration, representing a response rate of 45.8%. Sultan, Wong, and Azam (2021) argued that at least 200 readings are required to execute a co-variance-based SEM. Data were collected from June 2023 to October 2023 via convenience sampling. The rationale was to collect the maximum responses shortly, and there were very few complications. The survey form was based on multiple closed-ended questions relevant to the constructs of the study. A total of 34 items were posted in the questionnaire; their measurement details are in the upcoming section.

3.1 Measurements

This study focused on the constructs examined in preceding studies to evaluate all items. The feedback against each item of all the variables was measured on a classical 5-point Likert Scale, where the scale began with one as 'Strongly disagree' and up to 5 as 'Strongly agree.' The survey began with questions based on GTL in Pakistani manufacturing industries, which were adapted from Singh et al. (2020) and had six items to be evaluated. ES was measured using eight items concerning environmental business and corporate strategies. The items of this construct were adapted from Kraus, Rehman, and García (2020) and were also used by Solovida and Latan (2017). The eight GAC items were borrowed from Wang and Juo (2021), and the same items were adapted from Zhang et al. (2020). KS was evaluated using four items, which were extracted from Zhang et al. (2020), and the same items were also previously used by Perols, Zimmermann, and Kortmann (2013). Lastly, GI was evaluated based on green product innovation and green process innovation with the help of eight items adapted from Wang and Juo (2021). Table 1 below demonstrates the construct items and supporting evidence from the literature.

Table 1: Constructs and Items

Constructs	Items	Adapted Sources
GTL	6	García-Morales et al. (2012); Singh et al. (2020); Bhat et al. (2024)
ES	8	Sharma (2000); Solovida and Latan (2017); Kraus et al. (2020)
GAC	8	Zhang et al. (2020); Wang and Juo (2021),
KS	4	Jang et al. (2002); (Mushtaq & Bokhari, 2011)
GI	8	Huang and Li (2017a); Zhang et al. (2020); (Wang & Juo, 2021)

4. Data Analysis and Results

The characteristics of the firms are listed in Table 2, in which the industry type, size, and ownership structure are disclosed. Based on industry, 126 of 413 belonged to communication and computer-related equipment, 30.7% of the total sample. Of these, 115 (28%) were from Electrical Machinery and Equipment, 20 (4.9%) were from chemical and related products, 15 (3.6%) were from pharmaceutical and medical products, 17 (4.1%) were from Machinery and engineering, and 11 (2.7%) were from instruments and related products. The number of Transport Equipment was 25 (6.1%), 24 (5.8%) were for Smelting and Pressing, 20 (4.9%) belonged to Metal Products, 11 (2.7%) to Nonmetallic mineral Products, 8 (1.9%) were from Rubber and Plastics, 9 (2.2%) belonged to Textile and Apparel and yet 10 (2.4%) were left which are categorized as 'Others.' According to firm size, 144 (35%) firms had fewer than 100 employees. A total of 155 (37.7%) firms had employees in the range of 100-500, 83 (20.2%) had employees in the range of 500-1000, and 20 (4.9%) had a workforce of more than 2000 employees. Considering

ownership structure, 127 (30.9%) out of 413 were private firms, 169 (41.1%) were state-owned, and 115 (28%) were foreign-invested firms.

Table 2: Sample Profile

Items	Characteristics of the firm	Frequency	Percentage
Industry	Communication & Computer related equipment	126	30.7
	Electrical Machinery and Equipment	115	28
	Chemical and Related Products	20	4.9
	Pharmaceutical and medical	15	3.6
	Machinery and engineering	17	4.1
	Instrument and Related Products	11	2.7
	Transport Equipment	25	6.1
	Smelting and Pressing	24	5.8
	Metal Products	20	4.9
	Nonmetallic mineral Products	11	2.7
	Rubber and Plastics	8	1.9
	Textile and Apparel	9	2.2
	Others	10	2.4
No. of Employees	<100	144	35
	100-500	155	37.7
	500-1000	83	20.2
	1000-2000	20	4.9
	>2000	9	2.2
Ownership Structure	Private firms	127	30.9
	State Owned firms	169	41.1
	Foreign Invested	115	28

4.1 Model Reliability and Validity

We used the SEM model in IBM SPSS v28 and IBM AMOS v26 to analyze our collected data sheets. Wang et al. (2020) have convinced that the SEM method is the most appropriate and efficient process to examine the complex models having diverse determinants. SEM was repeatedly used to measure the structural association between the constructs while calculating the CFA and regression. Likewise, Cronbach's alpha and composite reliability were calculated to ensure the model's reliability by examining internal consistency. The normality of the data was confirmed as the mean value was in the range, and the skewness of the data was also in the range of -1 to +1.

Table 3: Descriptive Statistics

Constructs	Min	Max	Mean	SD	Skewness
KS	1.00	5.00	3.2094	.99178	-.223
ES	1.00	5.00	3.4013	.91828	-.526
GAC	1.00	5.00	3.2212	1.23063	-.251
GI	1.00	5.00	3.5366	1.11422	-.442
GTL	1.00	5.00	3.3781	1.15672	-.460

The reliability of all variables was checked by calculating Cronbach's alpha. The threshold value of reliability is above 0.6, and that of Cronbach's alpha is above 0.7 (Abbasi et al., 2021). In our study, all values were above 0.8, which confirms reliability. The composite reliability values of the GTL, ES, GAC, GI, and KS were 0.979, 0.9, 0.986, 0.984, and 0.888, respectively. The values of Cronbach's alpha for the GTL, ES, GAC, GI, and KS were 0.979, 0.925, 0.985, 0.962, and 0.888, respectively. The factor loading of all the variables was also above 0.7, which confirms convergent validity.

Table 4: CFA Analysis

Constructs	Items	Factor Loading	AVE	Cronbach's Alpha	Composite Reliability
GTL	GTL1	0.803	0.886	0.979	0.979
	GTL2	0.830			
	GTL3	0.999			
	GTL4	0.996			
	GTL5	0.998			
	GTL6	0.997			
ES	ES1	0.757	0.545	0.925	0.900
	ES2	0.715			
	ES3	0.738			
	ES4	0.992			
	ES5	0.983			
	ES6	0.526			
	ES7	0.502			
	ES8	0.499			
GAC	GAC1	0.770	0.897	0.985	0.986
	GAC2	0.797			
	GAC3	0.994			
	GAC4	0.995			
	GAC5	0.998			
	GAC6	0.999			
	GAC7	0.990			
	GAC8	0.996			
GI	GI1	0.727	0.691	0.962	0.946
	GI2	0.788			
	GI3	0.993			
	GI4	0.806			
	GI5	0.790			
	GI6	0.994			
	GI7	0.786			
	GI8	0.714			
KS	KS1	0.859	0.665	0.888	0.888
	KS2	0.793			
	KS3	0.812			
	KS4	0.795			

The threshold value of CMIN/DF should be less than 3.0; however, in our case, it was 2.8. The value of the GFI should be greater than 0.8; in our case, it was 0.841. The values of CFI and IFI should be more than 0.9, and the observed values in our case are 0.97.

Similarly, the value of RMSEA should be less than 0.08; in our case, it is 0.066, which means that all the values are in the range and ensure the fitness of the proposed model.

Table 5: Model Fitness

Indications	Observed Values	Threshold Values
CMIN/DF	2.80	<3.0
GFI	0.841	>0.8
CFI	0.97	>0.9
IFI	0.97	>0.9
RMSEA	0.066	<0.08

On the same pattern, we also confirmed discriminant validity, as the relationship of an individual construct is stronger with itself than with the rest. For example, GAC has the highest value with itself, i.e., 0.947, whereas, with constructs, it is lower than 0.947. GTL has a value of 0.941, ES has 0.738, GI has 0.831, and KS has 0.815 with their selves, and with other constructs, the values are comparatively low, confirming the discriminant validity.

Table 6: Validity Concerns

Constructs	GAC	GTL	ES	GI	KS
GAC	**0.947**				
GTL	0.558	**0.941**			
ES	0.271	0.391	**0.738**		
GI	0.253	0.360	0.432	**0.831**	
KS	0.320	0.353	0.508	0.421	**0.815**

4.2 Common Method Bias

When conducting survey-based studies, it's essential to address the issue of common method bias (CMB) to ensure the validity of the results. One common approach to detect CMB is Harman's one-factor test Harman (1976 and, we used this test to check for CMB in our study. According to our results, the total variance explained by one factor is 27.69%, well below the 50% threshold suggested by {Podsakoff et al. 2003). This indicates that CMB is not a significant concern in our study. Therefore, based on the test, we can assume that our study has no substantial CMB issue. This enhances the credibility and reliability of our research findings.

4.3 Hypotheses Testing

Table 7 shows that GTL positively influences GI, as indicated by a significant optimistic estimate of 0.139 with a p-value of 0.00. This suggests that leaders focusing on green initiatives can foster innovation within their organization. Similarly, ES significantly promotes GI, with a positive estimate of 0.497 and a p-value of 0.00, highlighting that robust environmental strategies support and drive innovative green practices. GTL also

positively affects KS, with a significant estimate of 0.240 and a p-value of 0.00, indicating that leaders who emphasize green values encourage sharing knowledge and ideas among employees. ES has a similar positive effect on KS, as shown by the significant positive estimate of 0.320 and a p-value of 0.00. This suggests that effective environmental strategies facilitate the organization's exchange of knowledge and information. KS positively influences GI, with a significant positive estimate of 0.201 and a p-value of 0.00. This indicates that sharing knowledge and ideas within the firms promotes the development and implementation of innovative green solutions.

Table 7: Hypotheses Testing

Hypothetical Relationship	Estimate	S.E.	P-value	Decision
GTL → GI	0.139	0.044	0.000	Significant
ES → GI	0.497	0.058	0.000	Significant
GTL → KS	0.240	0.052	0.000	Significant
ES → KS	0.320	0.055	0.000	Significant
KS → GI	0.201	0.046	0.000	Significant
GAC*GTL → KS	0.290	0.022	0.000	Significant
GAC*ES → KS	0.803	0.020	0.000	Significant

Additionally, GAC moderates the relationships between GTL and KS, as well as between ES and KS. The interaction term for GAC and GTL is significant, with a positive estimate of 0.290 and a p-value of 0.00, suggesting that firms with a high capacity to absorb and apply new green knowledge can better leverage leadership initiatives to improve knowledge sharing. Similarly, the interaction term for GAC and ES is significant, with a positive estimate of 0.803 and a p-value of 0.00, indicating that firms with higher absorptive capacity can more effectively utilize environmental strategies to foster knowledge sharing.

5. Discussion on Results

This study explores new perceptions of GI in relation to GTL, KS, and ES, with the moderating effect of GAC. The first hypothesis of our study is based on GTL and GI, which is proven to be significant and consistent with past studies (Begum et al., 2022), which proves that GTL is a unique and effective source of introducing GI in firms (Carreiro & Oliveira, 2019; Özgül & Zehir, 2023). In the presence of effective GTL, firms are exposed more to GI as they have more urge to be ecologically innovative. The study's second hypothesis is the influence of ES on GI, which has been proven to be significantly positive and supported by previous studies (Mulaessa & Lin, 2021). Similar results were also proven by Chen et al. (2016), who state that environmental strategies are more effective and are backed by GI. The third hypothesis is the strong influence of GTL on KS, which has also been proven to be enormously significant and shows that GTL plays a significant

role in promoting KS in firms (Begum et al., 2022). In the presence of a GTL, the flow of knowledge is streamlined and provided to the right person at the right time. These results align with Mushtaq and Bokhari's (2011) and Le and Lei (2018) findings. The fourth hypothesis of the study is the strong impact of ES on KS, which is proven to be significant and is also in line with previous studies conducted by Rothenberg (2003), Ramus and Steger (2000), and (Begum et al., 2022). KS plays a crucial role in devising ES, which benefits both firms and the environment (Khan et al., 2023). To develop unique and green environmental strategies, an exemplary source of information must be channeled through influential KS (Janjua et al., 2024). The fifth hypothesis claims that KS has a significant impact on GI, which reveals that KS is the critical source of incorporating GI in firms under the strong influence of GTL, which helps implement ES under the strong influence of GTL; the mediums of knowledge and information are in a channelized flow with GI support. Similar findings of Al-Husseini et al. (2021) stated. Hypotheses 6a and 6b are consistent with previous studies because GAC has a strong moderation effect in both cases (Zhang et al., 2020; Sarmad, Pirzada, & Iqbal, 2023; Akhtar et al., 2024). Ferreras Méndez et al. (2018) have also argued the strong impact of GAC on this association of GTL and KS. From the ES view, our study is inconsistent with the previous findings of Setiawan and Hartanto (2020) where the hypothesis was rejected but, in our case, it is accepted (Akhtar et al., 2024). GAC strengthened the relationship between GTL and ES with KS, as it provides a magnetic effect on the coherence of these constructs.

6 Study Contribution and Implications

6.1 Theoretical Contribution

This study contributes to the body of literature in several ways, primarily by advancing the NRBV theory concerning GI, GTL, ES, GAC, and KS. Our research demonstrates that GI is essential for conserving resources and ensuring cost-effectiveness. GTL is crucial in integrating green ES through KS and sustaining it via GAC. We reveal how GTL utilizes firm resources and capabilities through KS to promote GI within the firm, emphasizing the need for GTL to encourage GI in Pakistani firms. By motivating followers to develop green products and processes, GTL articulates a clear green vision, addressing individual needs and promoting KS. This study explores the unique relationships between KS and GI, ES and KS, and the moderating role of GAC in these interactions. We identify how KS mediates the relationship between GTL and ES with GI, defining KS as the flow of knowledge used to devise firm policies and strategies. Highlighting the moderating effect of GAC, we show its role in absorbing relevant green information and knowledge within a firm. This makes KS a vital connector in the proposed relationships and a novel addition to the literature.

6.2 Practical Implications

Our findings have practical implications for executives and managers. The strong relationship between GTL and GI indicates that GTL's unique leadership style compels followers to work smartly and innovatively. Managers should promote KS among

employees to generate green ideas, products, processes, policies, and strategies that enhance the firm's reputation. Understanding the importance of GTL and ES as critical determinants of GI is crucial for managers. GTL motivates subordinates to identify environmental issues, devise innovative solutions, and generate novel ideas for green products and processes facilitated by GAC. This capability is essential for addressing environmental challenges, reducing greenhouse gases, sustaining economic growth, and developing innovative business models. Thus, green development is crucial for environmental sustainability, and GTL is essential at all levels. Firms should integrate GTL, ES, and KS to embed GI for optimal results.

From an institutional perspective, GI is gaining attention due to environmental challenges and their adverse effects on human health. Governments should introduce green market-based instruments, such as green taxes, to promote GI. Policymakers should develop and enforce policies that encourage green initiatives and promote GI in all firms, including manufacturing ones. Legal bodies should facilitate dialogue with all stakeholders, including firms and academic personnel, to integrate GTL, KS, ES, and GI realistically. Governments should also recognize and reward individuals and institutions that promote GI and green initiatives, offering citizenship points or awards in various ceremonies and events.

7. Conclusion

GI is a novel tool for tackling environmental problems and increasing firms' productivity. This study explored the robust relationships of GTL and ES with GI, in addition to the mediation of KS and moderation of GAC. It has been revealed that GTL, directly and indirectly, affects GI through KS. Similarly, ES has a substantial direct impact on GI and KS. This study also confirms that KS is synergized when connecting GTL and ES with GI, which is the mediation—the GTL-KS and ES-KS linkages strongly moderate GAC, which is positive and significant. Therefore, manufacturing firms must use GTL and effective ES to promote GI in their green processes and policies. These policies and strategies should be devised through KS through ideas, experiences, and skills, and GAC channels this flow. This study proposes a unique model for managers and CEOs to opt for GTL to increase productivity and focus more on KS to promote GI.

7.1 Limitations and Future Indications

This study has certain limitations that provide guidelines for future studies. First, data collection was based on a cross-sectional approach, while future studies could incorporate a longitudinal approach to conduct a more in-depth study. Second, the researchers could check our conceptual model by changing the leadership style and its subsequent effects on GI, i.e., Responsible or ethical leadership, and evaluate whether the relationship remains the same. Third, we used a quantitative approach, but future scholars could use qualitative (i.e., interviews with managers can provide more phenomenal indicators) approaches to

elaborate the scope of methodologies. Fourth, we randomly selected the manufacturing sector, but future researchers could focus on a different sector.

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