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Does green human capital act as an effective antecedent to improve three dimensions of green supply chain learning and environmental performance? Astudy of Pakistan's manufacturing sector

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Abstract:

Academics have paid less consideration to how inter-firm learning in the literature of green supply chain and human factors facilitate the environmental performance of the manufacturing sector in emerging markets. Portraying upon the intellectual capital-based view, the study explores the impact of green human capital on green supply chain learning and environmental performance. This study has used the SEM approach to test the theoretical framework grounded on the data collected from the 291 supply chain professionals of manufacturing firms in Pakistan. This study found that green supplier learning and green customer learning progress green internal learning. Our study indicated that green human capital enhances all tri- dimensions of green supply chain learning, which directly improves the environmental performance of supply chain department manufacturing firms and also helps HR professionals make policies to improve environmentally conscious behavior by utilizing their human capital as a competitive edge. The findings of this study add in to the literature and extend a new body of knowledge by investigating GHC as an indicator to improve GSC learning by assessing intellectual capital-based views. The findings also encourage managers to seek a competitive edge by using green human capital and green supply chain learning to achieve firm environmental performance.

Keywords: Green human capital, Green supplier learning, Green internal learning, Green customer learning, Environmental performance, Manufacturing sector, Pakistan

Introduction:

The rapid growth of environmental apprehensions and the necessity for sustainable practices has led to a significant shift towards green supply chain management (Novitasari & Agustia, 2021).

Green supply chain learning plays a crucial role in enhancing environmental sustainability, efficiency, and competitive advantage for organizations. Over the past few decades, there has been an increasing stress over addressing the negative environmental impacts of human activities (Agyabeng-Mensah et al., 2024). This has led to the development of various studies and approaches in the field of green business, including green HRM, green supply chain management, green behaviors, green purchasing, and low-carbon discharge (Chishti & Ahmed, 2023)The focus has shifted towards investing in Green human capital, which offers competitive benefits while also managing the environment. While process and technological advancements are essential for creating sustainable supply chains, the human element cannot be overlooked (L. Li et al., 2022). Organizations understand that the knowledge, abilities, and attitudes of their workforce towards environmental sustainability have a significant impact on the success of green initiatives. This insight has given rise to the idea of "green human capital," which describes the environmental knowledge, skills, and behaviors that people within an organization possess (L. Li et al., 2022; Zhang et al., 2016).

However, the success of green supply chain learning initiatives heavily relies on the presence of a skilled workforce that possesses the necessary knowledge and capabilities to implement and manage sustainable practices (Lisi et al., 2020). This is where the concept of green human capital becomes relevant. "Green human capital" denotes the essential knowledge, abilities, and competencies individuals possess to facilitate the adoption and successful execution of eco-friendly supply chain practices. It encompasses behavioral aspects such as environmental consciousness and dedication to sustainability, alongside technical proficiencies like familiarity with green technologies and procedures (Asiaei et al., 2023). The advancement and utilization of green human capital can significantly influence the efficacy of green supply chain education initiatives. Understanding the influence of green human capital on green supply chain education is increasingly vital for several reasons. Firstly, as sustainability emerges as a pivotal factor in organizational prosperity, companies are acknowledging the necessity of cultivating a workforce equipped with the expertise and capabilities needed to implement green practices effectively (Yusoff et al., 2019). Second, the complexity of sustainable supply chain management necessitates continuous learning and adaptation. Organizations that foster a culture of learning and development to ensure their workforce remains up to date with the latest sustainable practices and technologies (Verma et al., 2023). By uncovering the relationship between green human capital and green supply chain learning, this research aims to provide practical insights for organizations seeking to improve their sustainability performance. The findings will inform strategies for identifying, nurturing, and leveraging green human capital, thereby contributing to the overall advancement of sustainable supply chain management practices. Ultimately, this research will contribute to building a more environmentally responsible and resilient business ecosystem.

Literature Review:

Green Human Capital:

Green human capital refers to the knowledge, skills, and abilities of individuals that contribute to sustainable and environmentally friendly practices and solutions (Agyabeng-Mensah & Tang, 2021). It encompasses the understanding and expertise in areas such as renewable energy, energy efficiency, waste management, sustainable agriculture, climate change mitigation, and environmental conservation. Green human capital is crucial for addressing environmental challenges and promoting sustainable development. It involves a workforce that is equipped with the necessary knowledge and skills to innovate, implement, and advocate for environmentally friendly practices in numerous segments of the economy (Tjahjadi et al., 2023). This includes professionals in fields such as engineering, science, policy-making, education, and business. Investing in green human capital is essential for transitioning to a more sustainable and low-carbon economy (Yong et al., 2019). It involves education and training programs that enhance individuals' understanding of environmental issues and equip them with the skills to develop and implement sustainable solutions. This can include formal education programs, vocational training, professional development courses, and capacity-building initiatives. Green human capital development can occur at various levels, from individual training programs to national policies and international cooperation (Mansoor et al., 2021). Governments, businesses, and organizations play a crucial role in fostering green human capital by supporting educational institutions, creating job opportunities in the green economy, and promoting research and innovation in sustainable technologies (Aman-Ullah et al., 2022; Boon et al., 2018). By developing and harnessing green human capital, societies can benefit from increased job creation, economic growth, improved environmental stewardship, and enhanced resilience to climate change. It also helps foster a culture of sustainability, where individuals are empowered to make informed decisions and take actions that contribute to a greener and more sustainable future.

Green supply chain learning:

Green supply chain learning refers to the process of acquiring knowledge and understanding about sustainable practices and strategies in supply chain management (Lisi et al., 2020). It involves learning about environmentally friendly initiatives, renewable resources, waste reduction, energy efficiency, and other sustainable principles within the context of supply chain operations. Green supply chain learning starts with developing an understanding of environmental challenges and their impact on supply chain operations (Agyabeng-Mensah et al., 2024). This includes studying climate change, pollution, resource depletion, and other ecological issues. Learning about sustainable sourcing involves understanding how to identify and select suppliers that adhere to environmentally friendly practices. This includes evaluating suppliers' environmental certifications, ethical sourcing policies, and their commitment to reducing carbon emissions and waste. Green supply chain learning focuses on identifying opportunities to reduce energy consumption and increase efficiency throughout the supply chain (Guo et al., 2020). This includes learning about energy-efficient transportation, warehouse management, and optimizing

manufacturing processes. Green supply chain learning also emphasizes the importance of collaboration and partnerships with suppliers, customers, and other stakeholders. This involves learning about developing sustainable supplier relationships, engaging customers in sustainable practices, and working with regulatory bodies and industry associations to promote green initiatives (J. Wang et al., 2020). Organizations can promote green supply chain learning through various means, including employee training programs, workshops, seminars, online courses, and collaboration with academic institutions and industry experts. By investing in green supply chain learning, businesses can enhance their environmental performance, reduce costs, and gain a competitive edge in a world increasingly focused on sustainability. Green supply chain learning involves three dimensions i.e. green supplier learning, Green internal learning and green customer learning.

Green supplier learning refers to the process of acquiring knowledge and understanding about environmentally responsible suppliers. It involves researching, evaluating, and selecting suppliers that prioritize sustainability and have environmentally friendly practices throughout their supply chain. According to some research, learning from suppliers can help businesses develop new products (Lisi et al., 2020). As suppliers are involved early in the design process in order to identify potential issues with the new product's green attributes, learning from suppliers from the perspective of the supply chain improves firms' ability to solve problems (N. Wang et al., 2022). Based on their expert knowledge, businesses can work with suppliers to develop new products or processes and obtain crucial information from them regarding material selection, energy efficiency, and waste. Green supplier learning increases a company's ability to reuse materials and elements, reduce resource consumption, and generate less waste by encouraging mutually beneficial knowledge acquisition and integrating (Agyabeng-Mensah et al., 2024). Additionally, green supplier learning might enhance the environmentally friendly features of current goods or services. For instance, according Bartos et al., (2022) when suppliers take steps to provide eco-friendly materials to reduce the impact of their products on the environment or reusable components, it makes it easier for the manufacturer to change or adapt the design of already-existing products by means of an environmental management system to meet the necessities of new materials/components. Green internal learning: internal learning" as a process of acquiring knowledge within an organization, "green internal learning" refer to a sustainable approach to education and training within a company or institution. This concept would emphasize environmentally conscious practices in the design, implementation, and delivery of learning programs. By adopting "green internal learning" practices, organizations can enhance their commitment to sustainability while simultaneously equipping their workforce with relevant knowledge and skills (Albort-Morant et al., 2018).

Green customer learning refers to the process by which customers become more informed and educated about sustainable and environmentally friendly products and practices (Lisi et al., 2020). It involves increasing awareness and knowledge about the impact of consumer choices on the environment and encouraging the adoption of more sustainable behaviors. This can involve labeling, eco-certifications, and product information that highlights sustainability features and benefits. Offering training programs and workshops to educate customers about sustainable living, energy efficiency, waste reduction, and other eco-friendly practices (Juniati et al., 2019).

These initiatives empower customers with the knowledge and skills to make greener choices. According to Pham & Pham, (2023) green customer learning encompasses the ideas of information gathering, capability development, and cooperative problem solving. According to Agyabeng-Mensah et al., (2023) it can provide insights into customers' desires and preferences of environmentally friendly products and reduce waste disposal. It may also encourage exchange of knowledge and mutual comprehension between the company and its customers. The company is likely to devote more time and resources to developing environmentally friendly goods or product components that consume less material, emit fewer toxic chemicals, and benefit the environment through the reuse and recovery of material and component parts in order to satisfy customers' demands for reducing environmental risks (Shah, 2020). The goal of green customer learning is to empower individuals to make more informed choices that align with their environmental values, leading to a collective positive impact on the planet. By promoting education and awareness, businesses can contribute to shaping a more sustainable future.

Environmental performance:

Environmental performance is becoming increasingly important as organizations and individuals recognize the need to address environmental challenges, mitigate climate change, and contribute to a more sustainable future (Nguyen et al., 2021). Governments, regulatory bodies, and consumers are placing greater emphasis on environmental performance when making decisions and evaluating the credibility and reputation of entities. Environmental performance refers to the measurement and evaluation of an entity's impact on the environment (Dzikriansyah et al., 2023). It assesses how an organization, process, product, or individual performs in terms of resource consumption, waste generation, emissions, and other activities that can affect the environment. Measuring environmental performance involves collecting and analyzing data on various environmental indicators. Some commonly used indicators include: Energy consumption, Greenhouse gases (GHGs), such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), contribute to weather variation (Kraus et al., 2020). Measuring and managing GHG emissions helps organizations understand their carbon footprint and develop strategies to reduce emissions, monitoring water consumption helps identify water conservation opportunities and minimize water-related impacts, such as depletion of local water sources or pollution of water bodies, tacking the amount and type of waste generated by an organization, as well as the methods used for waste management (recycling, composting, landfilling, etc.) (Lu & Taylor, 2018), monitoring and reducing emissions of pollutants, such as air pollutants (particulate matter, sulfur dioxide, nitrogen oxides) and water pollutants (heavy metals, chemicals, nutrients), impact on biodiversity by evaluating land use practices, habitat preservation efforts, and the potential effects of their activities on ecosystems and wildlife and ensuring compliance with applicable environmental laws and regulations is an essential aspect of environmental performance. These strategies may include adopting cleaner technologies, implementing energy-efficient practices, promoting recycling and waste reduction, investing in renewable energy, and integrating sustainability into their procedures and supply chains (Ghaderi et al., 2023). Many researchers in the field of environmental studies agreed that environmental performance can be achieved directly through efficient environmental management and tends to be viewed as an all-encompassing organizational performance. For instance, Linn & Maenhout, (2019) demonstrated

how linked environmental management practices are favorably related to environmental performance. In their study, environmental performance was distinct as "a firm's effectiveness in meeting and exceeding society's expectations with respect to pertains for the natural environment".

Hypothesis development:

Green Human capital and green supply chain learning:

With the changing climate, human factors are becoming more crucial to oversee problems with the environment and promoting sustainability in supply chains of firm as a cost edge (Agyabeng-Mensah & Tang, 2021). According to intellectual capital view the human capital can act as competitive edge in fostering learning among supply chains of firms. The term "green human capital" refers to the knowledge, abilities, skills, and expertise that people have in relation to environmental awareness, sustainability, and eco-friendly practices. It includes knowledge of waste reduction, sustainable business practices, clean energy, environmental preservation, and other environmentally friendly endeavors (Bag & Gupta, 2020) . Green human capital, including expertise in sustainable practices, environmental regulations, and technological advancements, can be transferred to suppliers through various channels such as training programs, workshops, and collaborative partnerships. Previously studies have operationalized green supply chain learning as unidimensional concept and multidimensional concept. As per Can Saglam,(2023) supply chain learning is a three dimensional concept therefore taking from their concepts this study has employed green supply chain learning as three dimensional concept (green supplier, green internal and green customer learning). When suppliers possess a workforce with green human capital (green skills and knowledge), they are more likely to explore and implement innovative solutions to reduce their environmental impact (Cheng et al., 2023).

Companies with a strong focus on sustainability often prefer working with suppliers who share their environmental values. Zhan et al., (2022) study argues that investing in green human capital, suppliers can attract such buyers and establish long-term relationships based on mutual sustainability goals. This collaboration allows for shared learning and the exchange of best practices. Buyers and consumers are increasingly demanding environmentally friendly products and services, and suppliers that can meet these demands are well-positioned for success (Murad & Zou, 2023) . Green human capital can also enhance green internal learning by inculcating green knowledge, skills and abilities among employees and when these employees will interact with customer then they will be able to collect information from customer in taking green initiatives. The impact of green human capital on green supply chain learning is significant (Muafi & Sulistio, 2022). By integrating and expanding the green knowledge that the focus company has already acquired from its green suppliers and clients internally, we anticipate that learning from external SC partners will help it gain new knowledge, update its knowledge base, and renew its current knowledge. The implementation of other practices within a firm and the supply chain is made easier by the use of human capital, which collaborates with other organizational resources and capabilities (Yong et al., 2020). Despite the role of green human capital in the success influence of green supply chain practices, the influence of green human capital on green supply chain learning remains an unexplored research gap. In addition, little

research has been done on the impact of green human capital on learning in green supply chains (Agyabeng-Mensah & Tang, 2021). Therefore, we argued that;

H1a: There is a positive relationship between green human capital and green supplier learning.

H1b: There is a positive relationship between green human capital and green internal learning.

H1c: There is a positive relationship between green human capital and green customer learning.

Green supply chain learning and environmental performance

The evolving dynamics of the business landscape, coupled with the growing environmental awareness among stakeholders, necessitate collaborative learning with supply chain partners to foster innovation in environmental sustainability. This learning process involves engaging supply chain members to enhance a corporation's environmental sustainability strategies and actions (Lisi, Zhu, & Yuan 2020), thereby boosting their comprehension of environmental issues and their enthusiasm for engaging in green initiatives. Learning from supply chain partners can elevate employees' environmental consciousness (Su et al., 2020), motivating them to actively contribute to environmental sustainability efforts (N. M. Nguyen et al., 2023). Previous research has emphasized the significance of supply chain learning in improving various performance aspects, including operational, financial, flexibility, innovation, and service performance (Huo et al., 2020; Guo et al., 2020; Sun et al., 2023). However, the contribution of Global Supply Chain Learning (GSCL) to environmental performance remains relatively unexplored in existing studies (Agyabeng-Mensah et al.,2024). To establish an environmentally friendly supply chain, suppliers and customers can collaborate through the GSCL process to exchange vital information on waste reduction and energy conservation. For businesses to implement environmental performance, it is contended that processes that lead to the sharing of knowledge, resources, and processes are essential (Zhao et al., 2022). In order to ensure product reuse, recovery, repair, and recycling and to reduce the use of non-renewable resources, GSCL supplies knowledge regarding the raw materials in green manner (Terrada et al., 2022).

Green supply chain learning promotes the adoption of environmentally friendly behaviors like efficient transportation, the use of renewable energy sources, and improved logistics (Lisi et al., 2020). As a result, the overall carbon footprint and greenhouse gas emissions are decreased, which helps to slow down climate change. Companies can find opportunities to reduce waste generation and enhance recycling efforts by using a green supply chain learning process that fosters cooperation and sharing of information along the supply chain (Agyabeng-Mensah et al., 2023). As a result, less waste is sent to landfills, and a circular economy strategy is encouraged. Firms that invest in learning about the green supply chain are better able to communicate with their suppliers about sustainability-related issues. They might motivate suppliers to implement their own green initiatives, ensure suppliers follow environmental regulations, and promote environmentally friendly practices. GrainCorp, a major Australian agriculture company, disclosed that drought reduced grain shipments by 23%, resulting in a 64%

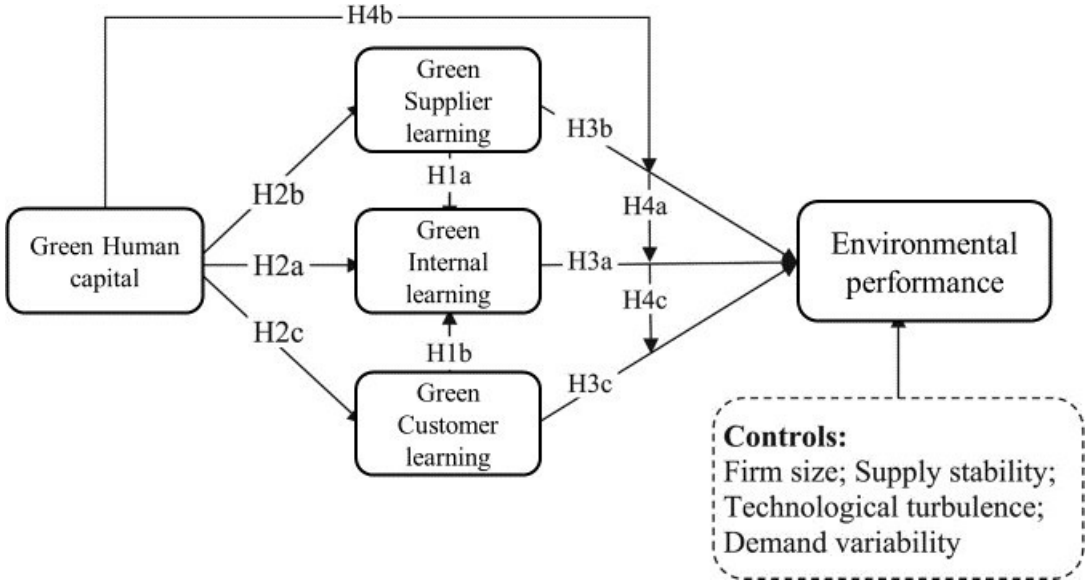
drop in revenue in 2014. Unilever anticipates that it forfeits around €300 million annually as lack of water and declining productivity in agriculture drive up food prices. Despite the environmental risks inherent in supply chains, few companies collaborate with suppliers in order to manage those hazards (Agyabeng-Mensah et al., 2024). Think about, for instance, how companies are addressing the effects of their supply chains on the environment. Only 25% of the businesses that disclose their emission of greenhouse gases to CDP, a charitable organization that encourages the disclosure of negative environmental data, claim to work with their suppliers to reduce emissions. Green supply chain learning can increase collaborating and integrating among supply chain employees or partners (Terrada et al., 2022). Businesses that use green supply chain learning as either a preventative or a reactive strategy to meet customer environmental requirements are likely to retain their current share of the market in today's market, where concerns about the environment matter most. Learning creates awareness among employees regarding environmental preservice as agenda of UNSESCO Agenda 21 also emphasize on providing learning regarding environment therefore it's important to focus over this area. A supply chain's reputation can be protected and improved through environmentally conscious behaviors. Through learning, it gets faster, which improves the performance of the environment among employees. According to Wu & Zuo, (2023) study, supply chain learning helps employees become more environmentally conscious and knowledgeable. It also increases their awareness of environmental issues and their interest in participating in environmental initiatives. Employees' concern for the environment can be raised by learning from supplier relationships, which can also encourage them to take an active role in promoting environmental performance (Merneedi & Palisetty, 2023). In the contemporary marketplace, increasing awareness of environmental issues among customers has also prompted the adoption environmentally friendly practices by firms in order to diminish the damaging impact of their operations on the environment and meet the changing environmental demands of the firm's customers Firms must understand their customers' environmental needs for the purpose to establish processes and products that exceed their expectations (Marchi et al., 2018). Customer knowledge assists businesses to develop goods and services that provide businesses with green value. Firms that learn from their customers' expectations gain an edge over others (Xia et al., 2020). Green customer learning is the process of assembling data, expertise, and evidence from customers in order to promote environmentally friendly initiatives. According to Agyabeng-Mensah et al., (2022) acquiring insight from customers and suppliers can progress a company's environmental performance. Therefore, based on the literature and reports, we hypothesized that:

H2a: There is a positive relationship between green supplier learning and environmental performance.

H2b: There is a positive relationship between green internal learning and environmental performance.

H2c: There is a positive relationship between green customer learning and environmental performance

Theoretical Framework:



Research Approach:

Sample size and data collection:

To test the hypothesis cross sectional survey was conducted in Pakistan. The sample was purposively selected from the employees of supply chain department of manufacturing firms working in Pakistan. With the sample of 1200 firms we selected 451 firms on the basis of well-established supply chain department and adoption of environmental conscious business practices. We contacted them by using networks and phone calls to participate in the research study. Out of 451 manufacturing firms 287 agreed and allowed their supply chain departments to provide us with the information via survey questionnaire. The questionnaire was sent to them online using google form link and 300 responses were taken from them. Among 300 responses 9 were invalid and afterward omitted from the questionnaire to create accuracy in responses for analysis.

Measures*:*

The questionnaire items were adopted by using previous studies. A five-point likert scale i.e. 1 signifies as strongly disagree while 5 indicates as strongly agree was used to measure the data collected from the respondents. We contacted eight prominent professors and five business professionals to check and confirm the rating items' validity in terms of content and, with their input, enhance the contents of the survey. With 20 respondents who shared the same qualifications as our respondents, an updated form of the survey was pilot-tested. The pilot test suggestions indicated that the final, complete survey was appropriate for the purpose of the research. The variables used in this study are ‘’ green human capital, green supply chain learning

and environmental performance. Green human capital is measured using five items adapted from Chang (2016) and while environmental performance was measured by using scale of Yong et al. (2019). Scale of green supply chain learning was adopted from the study of Lisi et al., (2020) and (Agyabeng-Mensah et al., (2024).

Results:

We mitigated potential biases in our research by addressing non-response and typical method biases. The researchers compared the disparity between the initial and subsequent responses to the metrics of theoretical constructs, as outlined by Handfield & Bechtel, (2002) and Stank et al. (2001). The t-test findings were observed to be negligible, indicating there was no evidence of bias in nonresponse in the study we performed. We employed two methodologies to investigate the potential presence of common method bias. Initially, the assertion was validated using a one-factor test proposed by Harman (Podsakoff et al., 2003). However, the study revealed eleven factors with eigenvalues surpassing 1.0, clearing up 74.85% of the total of variance, with the first component clearing up only 12.62% of it. Subsequently, confirmatory factor analysis (CFA) was conducted to evaluate the proposed one-factor analysis (Hu & Bentler, 1998; B. Li & Guo, 2012). The model's fit indices were as follows: chi-square (χ^2) = 5,724.69 with 902 degrees of freedom, root mean square error of estimate (RMSEA) = 0.20, standardized root mean square residual (SRMR) = 0.14, non-normed fit index (NNFI) = 0.66, and comparative fit index (CFI) = 0.68.

The fit indices indicated unsatisfactory results, notably inferior of the measurement model, suggesting that a single-factor model is not adequate. Consequently, we believe this study does not suffer from the common issue of common technique bias. To evaluate construct reliability, a two-stage approach was employed (Narasimhan & Jayaram 1998). Initially, one-dimensionality was assessed using exploratory factor analysis (EFA), which demonstrated strong loadings for each item on its intended construct and lower loadings on other constructs, indicating construct one-dimensionality. Secondly, reliability was assessed using Cronbach's alpha and composite reliability (CR) (Lloria & Moreno-Luzon 2014), with all values exceeding 0.75, surpassing Nunnally's recommended cutoff point.

The convergent validity of the model was assessed using Confirmatory Factor Analysis (CFA) as described by O'Leary-Kelly & Vokurka, (1998). The adequacy of the model was confirmed by satisfactory fit indices: $\chi 2$ = 1431.33 with degrees of freedom (d.f.) = 704, RMSEA = 0.074, NNFI = 0.94, CFI = 0.95, and SRMR = 0.055 (Hu & Bentler, 1998). Our analysis revealed that all t-values exceeded 2.0, and factor loadings surpassed 0.50, indicating robustness. Moreover, examination of Table 6 showcased that the average variance extracted (AVE) values exceeded 0.50, affirming convergent validity. To test discriminant validity, a controlled CFA model was created for each variable of constructs, with a correlation set at 1.0. The contrast between the initial unconstrained model, where correlations were dynamically estimated, and the constrained model revealed substantial discrepancies in $\chi 2$ statistics (Table 2), indicating discriminant validity (Bagozzi, Yi, & Phillips, 1991). Furthermore, by comparing correlation co-efficient

within the central construct and with other constructs against the square root of the AVE, discriminant validity was further confirmed, with the square roots of the AVE consistently surpassing correlations (Table 3) (Fornell & Larcker, 1981).

Table 1

Variables	1	2	3	4	5	6	7	8	9
1. Firm -Size									
2. Technological Turbulence	17.67								
3. Demand Variability	20.44	15.16							
4. Supply Stability	37.02	15.89	45.72						
5. Green Human Capital	15.65	12.03	22.12	26.30					
6. Green Internal Learning	39.87	12.65	36.90	15.47	8.45				
7. Green Supplier Learning	34.73	15.22	34.69	16.07	18.92	16.05			
8. Green Customer Learning	38.77	17.72	38.8	28.85	24.98	16.55	17.43		
9. Environmental Performance	48.45	13.99	42.37	47.65	22.65	18.88	43.07	37.43	

Note: All χ^2 differences are significant at 0.01 level

Hypothesis testing:

Proposed model

In Figure 1, we applied structural equation modeling (SEM) with maximum likelihood estimation to examine the assumptions. The outcomes were produced utilizing the LISREL 8.80 software, resulting in fit indices of $\chi 2 = 1583.91$, d.f. = 718, RMSEA = 0.079, NNFI = 0.92, CFI = 0.92, and SRMR = 0.12, indicating a suitable model fit (Hu & Bentler, 1998). Pathways with noteworthy standardized coefficients at the 0.05 significance level are depicted in Figures 2 and 3. These results validate H1a and H1b, revealing a positive correlation between green supplier and green customer learning, as well as green internal learning. Green human capital is associated with the three GSC learning dimensions, supporting H2a, H2b, and H2c. Environmental performance exhibits favorable correlations with both internal and external learning, supporting H3a and H3c. However, H3b is refuted due to the absence of a statistically significant positive relationship between green supplier learning and environmental performance. Furthermore, green human capital strengthens the impact of green supplier learning on environmental performance, supporting H4b. Nevertheless, H4a and H4c are dismissed as green human capital does not enhance the effect of green internal and green customer learning on

environmental performance, respectively (Table 2 & 3).

Table 2. Outcomes of effects of Green Human capital and green supply chain learning

Dependent variable: Environmental performance				
Independent variable	***Model 1***	***Model 2***	***Model 3***	***Model 4***
Constant	**3.75*****(.399)	**3.18*****(.396)	**3.04*****(.399)	**2.75*****(.398)
Firm- Size	−.02 (.035)	−.02 (.033)	−.04 (.033)	−.03 (.033)
Technological Turbulence	**.27*****(0.052)	**.15*** (.053)	**.16**** (.053)	**.18**** (.056)
Demand Variability	.06 (.049)	.05 (.048)	.02 (.048)	.00 (.048)
Supply Stability	.08 (.067)	−.05 (.073)	−.06 (.073)	−.07 (.072)

Table 3. Outcomes of effects of Green Human capital and green supply chain learning

Dependent variable: Environmental performance				
Independent variable	***Model 1***	***Model 2***	***Model 3***	***Model 4***
Green Internal Learning(GIL)		**.26***** (.059)	**.21**** (.062)	**.22***** (.061)
Green CustomerLearning (GCL)		**.14*** (.067)	**.12*** (.067)	**.11*** (.067)
Green Supplier Learning(GSL)		−.01 (.068)	−.03 (.067)	−.01 (.067)
Green Human Capital(GHC)			**.12*** (.051)	**.14**** (.051)
GHC*GIL				−.01 (.040)
GHC*GCL				−.07 (.054)
GHC*GSL				**.13**** (.050)
R^2	.154	.264	.284	.313
Change in R^2	–	.110	.021	.028
F	9.431	10.488	10.129	8.315
Change in F	–	10.255	5.869	2.774
p-value (change)	.000	.000	.017	.044

Note: The typical errors for each unstandardized limit approximation are exposed in additions.

*Significant parameter approximations are set in bold. *p < 0.05, **p < 0.01, ***p < 0.001.*

The secondary connection between GSC learning and environmental performance was tested using a tri-phase regression and the Sobel-test (Baron & Kenny,1986). Table 4's findings demonstrate how green supplier learning enhance environmental performance when green

internal learning is fully mediated. Additionally, we find that by means of partial mediation of green internal learning, green customer learning can also enhance environmental performance.

Table 4

GSL → GIL → EP			***GCL → GIL → EP***		
	GSL	***GIL***		***GCL***	***GIL***
M1: EP	0.14 (.075)		M1: EP	0.22**(.065)	
M2: GIL	0.32***(.073)		M2: GIL	0.28***(.074)	
M3: EP	0.04 (.064)	0.28***(.059)	M3: EP	0.13* (.058)	0.25***(.058)
Sobel z = 3.18			Sobel z = 2.86		

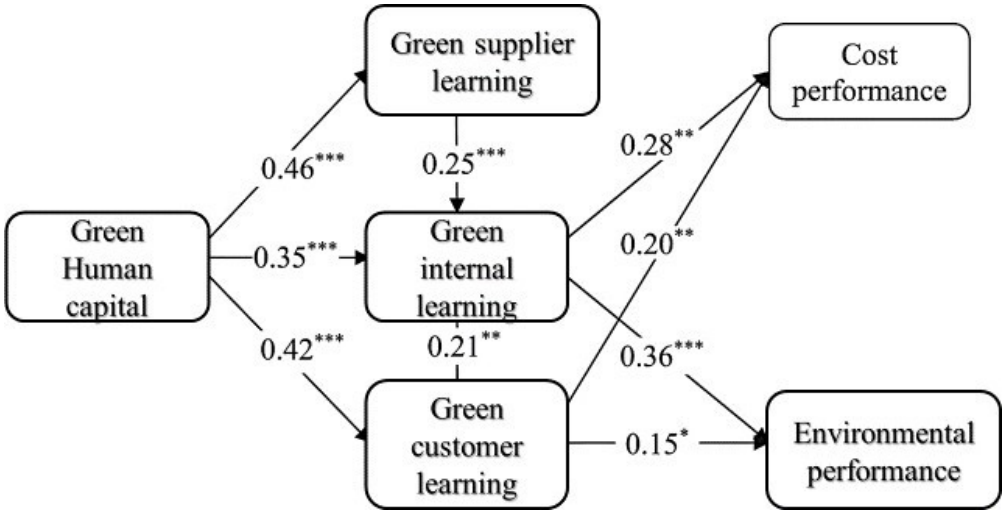
*Note: *p < .05; **p < .01; ***p < .001.*

GSL: Green Supplier learning; GIL: Green Internal learning; GCL: Green Customer learning; EP: Environmental performance.

Alternative models:

Figures 4 and 5 display the outcomes of the testing of two additional models. Table 5 displays the fit indices. In alternative model 1, the path from external to green internal learning was eliminated. In line with Lewin, Massini, and Peeters' suggestions, this model represents theory of intellectual capital view. It does, however, miss a crucial component of the intellectual capital view hypothesis, which holds that the process of creating green internal knowledge also makes use of green external knowledge (Lewin et. al, 2011). The second alternative model included cost performance. For Pakistani's producers' environmental performance is crucial, but it also requires a lot of assets and a variety of sources of human capital. Good fit indices were produced by the two models. The results were robust, as evidenced by the direct correlations between information exchange, GSC learning, and environmental performance in the alternative models and those in the suggested model. We initially compared the parsimony fit indices, such as the parsimony normed fit index (PNFI), parsimony goodness-of-fit index (PGFI), and Akaike information criterion (AIC), in order to assess the quality of the model. The PGFI and PNFI of the three models were essentially the same, but the AIC of the suggested model was significantly lower than that of the alternative models 1 and 2. This shows that the model that has been suggested is superior to the alternative models.

Alternative - model 1



Alternative - model 2

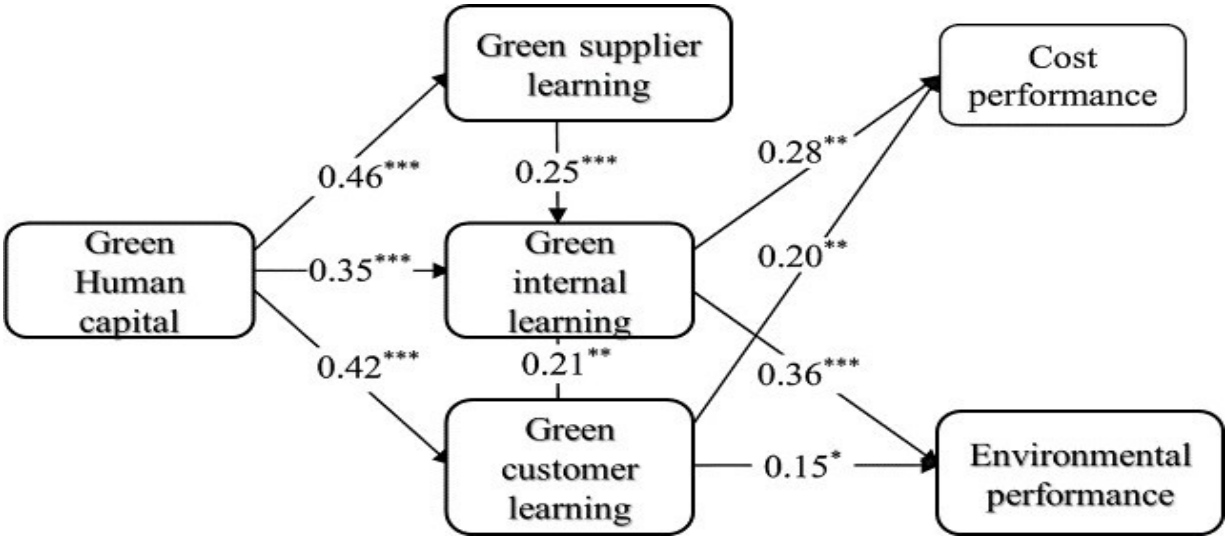


Table 5. Model fit Indices

Fit indices	Proposed model	Alternative model 1	Alternative model 2
χ^2	1773.91	1613.29	2159.74
d.f.	719	722	1006
RMSEA	0.079	0.082	0.076
SRMR	0.12	0.11	0.073
CFI	0.97	0.96	0.93
NNFI	0.92	0.95	0.94
AIC	1859.97	1915.06	2457.47
PGFI	0.63	0.63	0.62
PNFI	0.82	0.82	0.83

Discussion:

This study closes a noteworthy slit in the literature on production and operations research by providing an empirically comprehensive picture of the relationships between Green Human capital, GSC learning, and Environmental performance. Our findings indicate that Green Human capital is associated with all three dimensions of GSC learning, and that while GSC learning generally improves environmental performance, green supplier, green internal and green customer learning have unique effects. The effect of green supplier learning on environmental performance is further amplified by environmental performance. First, the relationship between external and internal learning is supported by our research. This result is consistent with the intellectual capital-based view, which holds that businesses can improve green internal learning by incorporating green external learning obsessed by internal systems and structures by utilizing their human capital (knowledge, skills and abilities) of the supply chain employees to make them learn environmentally conscious to gain competitive edge in long term. Since this investigation explains how businesses incorporate exterior facts from suppliers and customers into internal green operations, and use it to improve internal learning, it directly contributes to intellectual capital-based view. The findings also support the claim from the (Haq,2020) that the process of creating internal knowledge is positively impacted by having possession of external knowledge. As a result, our research supports the notion that external learning is crucial for enhancing internal learning. This is a significant discovery because the majority of the literature currently available on GSC learning fails to demonstrate connections between the different facets of GSC learning (Lisi et al., 2020). The result clarifies the intricate and multifaceted function of GSCL. The logical explanation for this result is that suppliers and customers are distributed, primarily in areas that are distant from the main firm, and there is a deficient learning infrastructure in a developing nation such as Pakistan. These conditions can foster a learning cycle that is irregular, repetitive learning, and information misunderstandings, all of which can be detrimental to the operation of GSC learning. While other research has highlighted the role of GSCL in maintaining organizational sustainability our study indicates that GSCL has a relatively major role in helping manufacturing industries to achieve environmental performance. Finally, the study confirms the role of green human capital in initiating GSC learning to achieve firm environmental

performance under intellectual capital-based review. This further demonstrates how organizations can meet supply chain environmental performance targets by giving equal weight to social and technical aspects.

Theoretical contributions:

The outcomes of this investigation provide some important theoretical advances. Firstly, this study has empirically investigated the relationship between GHC (Green human capital) and GSCL (Green supply chain learning). Then by employing SEM approach this study empirically tested the relationship between GSC learning and Environmental performance in manufacturing companies of Pakistan. This study has also contributed in theory by employing intellectual capital-based view. Previous studies have used to emphasized on technical and social factors drive the environmentally conscious activities but this study confirms that human capital specifically green human capital of the firm can play an active role in driving GSC learning among the employees of the firm. As a result, manufacturing organizations use supply chain learning to gather environmental knowledge from customers and suppliers in order to improve employee environmental behaviors.

Finally, this study extends the applications of the Intellectual capital-based view (Galbrith,1969) and (Martín-de-castro et al., 2016) which focuses on intangible resources that directly impact a firm to gain competitive advantage and highest performance. Several important practitioners (e.g., Brooking, 1996; Edvinsson, 1997; Sveiby, 1997) initially developed proposals linked to this theory. Reed et al. (2006) suggested "An Intellectual Capital-Based View of the Firm". Drawing on ICV, this investigation recommends that GHC helps firms advance their green agendas. Employee competence and performance are crucial for achieving long-term competitive advantage, according to empirical research. A suitable climate and strategic focus are necessary for an organization to gain advantages of its intellectual capital.

Managerial implications:

This study enhances the knowledge of supply chain and HR leaders by suggesting several implications to improve suppliers, internal and customer green learning in promoting environmental performance. This study analyzes the green supplier, customer, and internal learning elements of GSC learning, supporting operation and production managers in meeting green targets by emphasizing the distinct utility of each. Our findings show that external learning promotes internal learning. This means that manufacturing managers should develop a GSC learning process that involves both internal and external components. Managers, for example, could take initiatives to encourage suppliers and customers to share information with internal operations. To improve environmental performance, managers should organize keen learning teams and hold assemblage deliberations with suppliers as well as customers along internal organization on a regular basis. Second, this study demonstrates that green human capital can act as a cost-effective asset for managers to use to achieve targeted objectives and increase learning. Managers should use green internal and external learning to address environmental issues. The

findings indicate that when suppliers learn, it enhances environmental performance by fostering internal learning. Therefore, to harness the advantages of green supplier learning, managers need to translate supplier knowledge into opportunities for internal learning. The findings also suggest that green supplier learning has an influence on environmental performance when green human capital is deployed as a competitive asset. Furthermore, the study can help industrial organizations make informed decisions about policies and strategies that address climate risk and environmental concerns. In terms of social implications, the study's findings can help reduce raw material consumption and maximize resource usage in order to manage natural resources responsibly and conserve the environment for future generations. Organizations should prioritize enhancing their workforce's environmental expertise. All HR procedures should match the environmental management system. The HR director must initiate communication with top management to develop organizational-level policies regarding environmental protection activities. An HR department's hiring and selection policy should focus on finding applicants' environmental interests and knowledge. Environmental protection education and training must begin. These will assist employees in adopting green production processes, thereby meeting the needs of environmentally concerned clients. Employees' commitment to exhibiting green habits in the workplace must also be considered when determining promotion criteria. Employees who have a strong environmental enthusiasm should be discovered and exploited as environmental catalysts. Consequently, policymakers must recognize the relevance of green HC, Green supply chain education and environmental responsibility. Due to increased pressure from stakeholders and environmentally sensitive clients, industrial businesses must comply with environmental legislation in order to achieve corporate environmentalism.

Conclusion, Limitations and Future Recommendations:

The link between Green Human Capital, Green Supply Chain Learning, and Environmental Performance is critical for production and operations management studies. Consequently, this study undertakes a practical examination of how green human capital influences the three facets of green supply chain learning, thereby enhancing the environmental performance of manufacturing enterprises. The outcomes of our research offer valuable insights for both scholars and industry professionals, particularly in terms of intellectual capital analysis. We explore the interconnections among various aspects of green supply chain (GSC) learning, revealing that the adoption of environmentally conscious practices by suppliers and customers enhances internal green learning. Furthermore, we observe a positive correlation between human capital investment and the advancement of all GSC learning dimensions. Additionally, we delve into how these learning components relate to environmental performance, finding that both consumer and internal learning directly impact environmental outcomes, whereas supplier learning does not exhibit a significant influence. Despite enriching the current understanding of GSC learning dynamics, our study encounters certain limitations. Firstly, our empirical investigation relies heavily on data from industrial firms in Pakistan, thus potentially limiting the generalizability of our findings. Future research could address this by incorporating data from a broader range of businesses and geographic locations. Secondly, our study's reliance on cross-sectional data means that the findings are static and fail to capture the evolving nature of the relationship

between GSC learning and performance metrics. Utilizing longitudinal data in future studies could offer a more nuanced understanding of these dynamics. Lastly, while we highlight the importance of GSC learning as a crucial corporate activity, we acknowledge the need for future research to delve deeper into the intricacies of GSC learning, particularly at the network level, recognizing its dynamic and multifaceted nature.

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