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CHALLENGES OF SUSTAINABLE DEVELOPMENT: ANALYZING THE IMPACT OF GREEN TECHNOLOGY CAPABILITY ON SUSTAINABLE PERFORMANCE

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ABSTRACT

This study explores the factors influencing green innovation (GRIN) in small and medium-sized enterprises (SMEs) and the role of green technology capability (GTC) as a moderating variable. Green innovation, which includes technologies and practices aimed at reducing environmental impact, is crucial for sustainable development but is challenging for SMEs due to resource constraints. This research focuses on three main drivers: green absorptive capacity (GAC), sustainable human capital (SHC), and organizational support (OS). GAC enables firms to assimilate and apply external environmental knowledge, while SHC emphasizes environmentally oriented skills and values among employees. OS, including policies and resource provision, fosters a supportive environment for GRIN. The study reveals that each of these factors positively influences GRIN and that GTC strengthens these relationships by allowing firms to integrate green technologies more effectively. Empirical data from Pakistani SMEs highlights GTC's significant role in enhancing the environmental, economic, and social benefits of GRIN. This research contributes to the literature on sustainable business practices and suggests that SME leaders invest in green technologies to support GRIN. It also encourages further exploration of GTC's impact across different industry sectors.

Keywords: *Green Absorptive Capacity, Sustainable Human Capital, Organizational Support, Green Technology Capability, Green innovation and Sustainable performance*

INTRODUCTION

Increasing environmental pressures and the need to address sustainability issues are exerting pressure on firms to implement green measures, especially SMEs, as key players in green innovation (GRIN). Green innovation specifically refers to the innovation of technology aimed at decreasing the negative effect on the environment, reducing resource waste, and enhancing ecological efficiency (Chen, 2008; Zhang et al., 2019). SMEs enjoy the benefits of high flexibility and adaptability (Pilar et al., 2018). Nonetheless, the accomplishment of green practices in SMEs is

hardly possible because of resource constraints and a lack of adequate knowledge. As GRIN emerges as an important prerequisite for sustainable development, the factors that influence green innovation in SMEs and the ways by which additional organizational capabilities can improve their outcomes should be well illustrated.

The findings of this research provide an understanding of the constructs that influence GRIN, including absorptive capacity, sustainable human capital, and organizational support. Innovative capability refers to the absorptive capacity, which is the ability to recognize, acquire, and exploit knowledge from outside the company's boundaries (Cohen & Levinthal, 1990). As the absorptive capacity of organizations is higher, they are in a better position to absorb and translate environmental information into green innovation (Albort-Morant et al., 2018). A fourth key driver is sustainable human capital, which would entail the integration of human resources with environmental objectives. Sustainable practices and values within employees help support green innovation as people start to incorporate sustainability into their work activities (Renwick et al., 2016). Leadership backing and resource availability for supporting green practices also helped in having an organizational environment encouraging green practices as the supportive organizational environment comes up with necessary resources and achievable goals and objectives for sustainable development (González-Benito & González-Benito, 2006).

However, these determinants may not fully explain the scope of green innovation in SMEs alone, mainly because innovation in small firms is more complex. In this regard, green technology capability, as a moderating factor, enhances the links between these determinants and GRIN. Green technology capability deals with the ability of an organization to integrate, manage, and leverage green technologies, improving absorptive capacity, human capital, and organizational support for green innovation performance. Green technology capability further enhances opportunities that allow SMEs to overcome knowledge and resource deficiencies in embracing sophisticated technology for environmental agenda and improved performance (Chen et al., 2015). Moderation by green technology capability increases absorptive capacity in so far as the organization's ability to acquire and apply green technology knowledge is concerned. Furthermore, it can enhance the impact of sustainable human capital by enabling employees to utilize their environmental competence as planned (Qu et al., 2021).

The objectives of this current research are to gain a better understanding of the factors that determine GRIN in the context of SMEs and also to test the moderating role of green technology capability. Thus, the current study offers a complex look at green innovation in SMEs by combining absorptive capacity, sustainable human capital, and organizational support and deepening how green technology capability strengthens these connections. This research makes a significant theoretical and practical contribution to the understanding of green innovation for sustainable business, including its managerial implications for European SMEs that are competing for competitive advantage and the environment.

2.0 Literature review:

2.1 Theory: The Natural Resource-Based View is an extension of the traditional resource-based theoretical framework outlined by Wernerfelt (1984) and Barney (1991) but put forward by Hart (1995), which explores the effector source of competitive advantage entailed by the natural environment. NRBV argues that a firm can create firm-specific assets which can create sustainable competitive advantages in environmentally supportive resources and capabilities relevant to enhanced environmental quality (Hart, 1995). Components of the NRBV include pollution control, product care, and sustainable development, all of which are directed towards the reduction of environmental effects on firm performance (Chen et al., 2014; Wang, 2019). Pollution prevention encompasses elements of operational cost reduction by helping to obtain optimum efficiency in order to minimize pollution and its effect in equal measures on costs (Hart, 1995; Qu et al., 2021). Product stewardship builds on this view, including life stream perspectives to enhance product sustainability from conception to accumulation (Hart, 1995). Sustainable development is the most elaborate type of

innovation because it requires interrelated strategies for sustaining the economy as well as the environment, such as the invention of environmentally sustainable products like green technology and procurement (Teece, 2009). Research evidence demonstrates that organizations implementing NRBV practices, like green innovation, report both environmental and financial gains due to efficiency savings and increased popularity (Aboelmaged & Hashem, 2019; Shahzad et al., 2020). That is why the NRBV framework encompasses environmental responsibility with strategic management and offers a simple solution for increasing environmental demands to achieve sustainable growth for firms.

2.2 Hypotheses development:

2.2.1 Green Absorptive Capacity and Green Innovation

Extending more broadly from the idea of absorptive capacity, which defined the ability of a firm to identify, acquire, and exploit extrinsic information (Cohen & Levinthal, 1990), GAC directly relates to the firm's capability for knowledge acquisition and use in support of green operations. Research undertaken previously shows that GAC is positively related to a firm's capability to put effective practices regarding environmental knowledge into practice, which will work to facilitate the uptake of eco-innovation. Through the framework of GAC, a firm is able to effectively prevent and mitigate threats emanating from the environment by integrating green knowledge and developing green innovation on new products, processes and business models, as highlighted by Tseng and Hung (2011).

Operation flexibility can also be posited to interact with green technology capability because the latter helps to bolster a firm's practical implementation of green knowledge to make the adoption of green innovation meaningful and significant (Chen et al., 2015). Large firms that have advancement in green technology are better placed to acquire and utilize green knowledge, given that they have the technological systems to support greens (Qu et al., 2021). This capability also enhances the GAC and green innovation link because it translates and implements the green technology into the firms' strategic and operational processes to achieve a sustainable agenda.

Hypothesis 1: Green absorptive capacity has a positive impact on green innovation within firms.
Hypothesis 1a: Green technology capability positively moderates the relationship between green absorptive capacity and green innovation.

2.2.2 Sustainable Human Capital and Green Innovation

The present sustainable human capital (SHC) means the extent to which the relevant skills, values and knowledge of the workforce are congruent with the environmental objectives of an organization to foster a workforce that is equipped for and supports the advancement of green business solutions (Renwick et al., 2016). SHC empowers employees with knowledge and interest in embracing environmentally sustainable working procedures that boost an organization's capacity for the improvement of green products, processes and practices (Wagner, 2013). Based on the literature review, there is evidence that firms that have a strong SHC enable the organization to integrate sustainability into the day-to-day operations, as Green human capital brings out positive initiatives that promote the environmental sustainability of the organization Pava & Cho (2012).

Green technology capability can be seen to offer a moderating influence through bridging the relationship between SHC and green innovation by allowing employees to disclose their environmental skills by relying on modern state-of-the-art green technologies." This capability enhances the quality of SHC because it gives the employees the right tools and systems to apply all the green knowledge they have to practical, creative solutions (Chen et al., 2015). The green technology capability of the firms also plays an important role in enhancing the positive impact of SHC on green innovation because the firms with high green technology capability provide facilities to their employees to implement their green skills in a better way.

Hypothesis 2: Sustainable human capital has a positive impact on green innovation within firms.

Hypothesis 2a: Green technology capability positively moderates the relationship between sustainable human capital and green innovation.

2.2.3 Organizational Support and Green Innovation

OS is the extent of the available resources, structural environment and cultural support that an organization makes available for innovation, in this case, green innovation. Culturally supportive organizational environments are instrumental in encouraging employees to carry out green activities in the organization mainly because they are provided with the needed resources and commitment from the leadership towards sustainability practices (García-Machado & Martínez-Ávila, 2019). In emphasizing that the engagement of the employees in innovation for producing environmentally sustainable solutions is critical for enhancing green responsibilities within the organization, the OS relies on dedicated resources, involving the cooperation of departments and heads, and strong leadership.

Green technology capability makes the relationship between OS and green innovation more indirect and reflects the level of required resources and infrastructure for green innovation. OS can be more beneficial to organizations that are advanced in green technology capability because such organizations can provide up-to-date green tools and technologies in support of related programs (Chen et al., 2015). In particular, when firms have expressed high levels of green technology capability, sources of organizational support were found to provide a considerably stronger and more direct input into green innovation, as green tech-savvy employees possess the technological means through which green initiatives could be realized.

Hypothesis 3: Organizational support has a positive impact on green innovation within firms.

Hypothesis 3a: Green technology capability positively moderates the relationship between organizational support and green innovation.

2.2.4 Green Innovation and Sustainable Business Performance

Green innovation (GRIN) is defined as a sustainable innovation that focuses on resolving ecological issues and generating new valuable assets for companies (Chen, 2008). GRIN actively promotes waste minimization, better resource utilization as well as low impact on the environment, making it consistent with the principles of SBP, which is a concept that gauges organizational performance in environmental, economic as well as social insets (Elkington, 1998). In this context, it can be explained that GRIN helps organizations improve their environmental impact through the exploitation of cleaner technologies and more sustainable procedures that affect environmental factors (Kammerer, 2009). In addition to this, it is agreed that GRIN promotes economic performance by decreasing costs, increasing efficiency, and brand reputation, thereby creating market competitiveness since many green users are conservation-conscious (Dangelico, 2013).

The social disposition of SBP is also affected by GRIN since firms that go green enhance the lives of their workers, create happy customers, and operate well with the community (Freeling & Mabey, 2017). Organizational benefits are realized when operational activities conform to stakeholders' demands for corporate responsibility, hence improving the image and goodwill (Mehta & Chugan, 2015). Reviewing the consequences of GRIN in relation to the environment, the economy, and society shows that the triple bottom line perspective underpins the concept, which reasons sustainable performance along these dimensions.

Hypothesis 4: Green innovation positively impacts sustainable business performance across its environmental, economic, and social dimensions.

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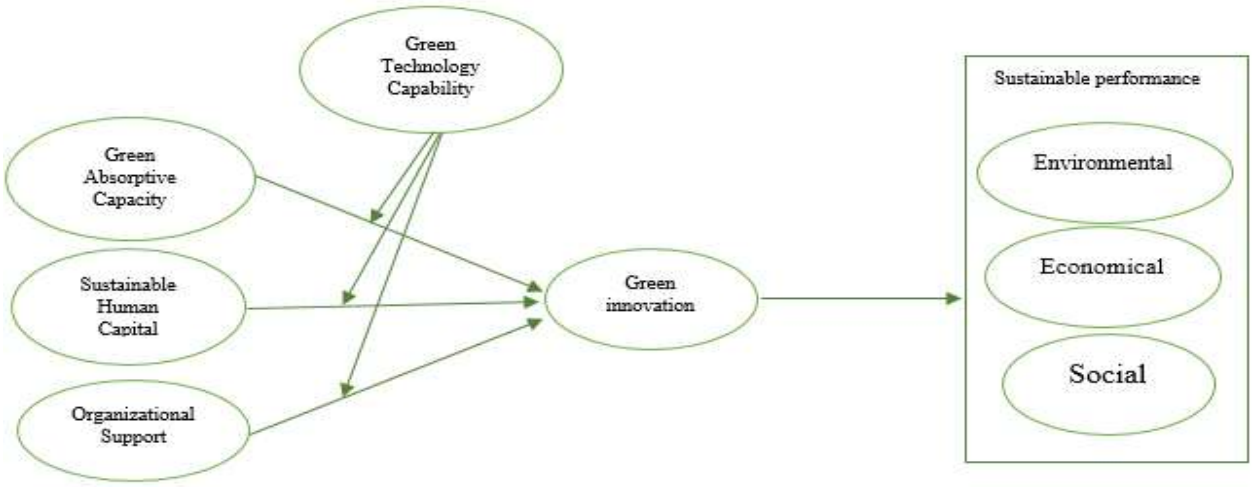

Figure 1: Research Model

3.0 Methodology:

In the current study, a quantitative research approach was used to test the proposed conceptual model in the SMES sector of Pakistan. The collection of data was done in two phases. First, five managerial participants who worked in SME manufacturing concerns of Pakistan located in Karachi and Lahore were selected for the semi-structured interview. Such interviews were important in finding out key drivers of change for green innovation (GRIN) and sustainability performance at the business level in Pakistan. From these interviews, a research questionnaire was established, which included the construct items identified in the prior studies of GRIN and sustainable performance adopted for the Pakistan market context.

In the second phase, data were collected through sampling using a random probability technique, which gave every firm participating an equal likelihood of being selected. This approach made it easier to recruit diverse and balanced respondents across the construction, energy/logistics, manufacturing/IT and service industries. This survey aimed at the SMEs of Pakistan; the criterion used for the classification of firms was consistent with Pakistan's SME definition set by SMEDA, which categorizes firms with an employee strength below 250 and an annual turnover of less than PKR 1 billion. A total of 300 useful responses were collected from managers of SMEs based in Pakistan through the survey. Among these respondents, 40 per cent are from small enterprises, which were further classified as having 6-49 employees. The remaining 60 per cent are from medium enterprises, which are classified as having 50-249 employees. Some of the respondents' roles were business owners, managers, and executives. In contrast, 68 per cent of the respondents were male participants because male employees generally occupy managerial positions in most Pakistani SMEs. This sample offered a bird's eye view of GRIN practices and sustainability performance in the SME sector of Pakistan.

3.1 Measurements:

This paper focused on several constructs that captured the levels of green innovation and other factors to examine the effects of green innovation on the sustainable business performance of SMEs in Pakistan. Every construct has also been measured by a set of items with a 5-Likert response scale in which one stands for strongly disagree and 5 for strongly agree. The measurement items for each construct were developed from existing literature on Pakistani SMEs and are, hence, reliable and valid. In the research, the various constructs were captured on a 5-point Likert scale borrowed from the previous literature. According to Chen et al. (2014), Green Absorptive Capacity (GAC) consists of five items that reflect an organization's capacity to identify and utilize knowledge of the external environment.

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Sustainable Human Capital (SHC) developed by Chang & Chen, 2012 and Aboelmaged & Hashem, 2019 used four items to measure the investments in employee skills and sustainable development. OS, as defined in Jun et al. (2019), measures the green innovation supportive human resources and reimbursement structures and is assessed with three items. Green Technology Capability (GTC) of six items measured the firm's capability to adopt and deploy green technologies. The item sample included 'We deploy technologies to minimize emissions'. Other dimensions, also classified into Green Innovation (GRIN) adopted from Kusi-Sarpong et al. (2015) and Aboelmaged and Hashem (2019), had four items related to environmental consciousness. Sustainable Business Performance (SBP) was measured in three dimensions: Environmental, Economic, and Social Performance questionnaire based on Bansal (2005) and Wang (2019), measuring the environmental load, financial effectiveness and social value-added.

4.0 Results:

4.1 Reliability statistics

Table 1: Reliability Statistics

Construct	Items	Loadings	Cronbach's Alpha (α)	(CR)	(AVE)
Green Absorptive Capacity	5	0.89, 0.91, 0.88, 0.92, 0.90	0.958	0.961	0.823
Sustainable Human Capital	4	0.88, 0.90, 0.86, 0.84	0.936	0.938	0.775
Organizational Support	3	0.87, 0.88, 0.91	0.918	0.921	0.783
Green Technology Capability	6	0.85, 0.89, 0.87, 0.86, 0.88, 0.90	0.943	0.946	0.812
Green Innovation	4	0.86, 0.88, 0.85, 0.87	0.934	0.937	0.778
Environmental Performance	3	0.84, 0.91, 0.85	0.893	0.896	0.731
Economic Performance	3	0.86, 0.88, 0.87	0.910	0.912	0.758
Social Performance	4	0.83, 0.85, 0.84, 0.82	0.902	0.906	0.712

Table 1 displays information regarding various constructs being tested for their reliability and validity, green absorptive capacity, sustainable human capital, and organizational support, to name but a few. The data shows that each of the constructs has several items, whereas factor loadings show the extent to which each item loads on a particular construct. Both sets of loadings are above 0.80, which confirms high levels of −relation. Cronbach's Alpha (α) and Composite Reliability (CR) are used to verify reliability, in which values get from 0.893 to 0.961 against all of the constructs. Cronbach's Alpha values are above 0.70, indicating the model has good internal reliability for each of the constructs. Validity is assessed in line with the constructs' Average Variance Extracted (AVE), of which all possess scores over the recommended 0.50 such that 0.81>0.70. This suggests that each of the constructs accounts for a relatively great amount of the variability in its items, hence the convergent validity. Taken together, the constructs show high stability and consistency, which indicates the reliability of the measures used for evaluating organizational capabilities in green practices, human capital, innovation, and performance indicators with regard to environmental, economic, and social impacts.

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4.2 Discriminant Validity:

Table 2: Validity Statistics

	GAC	SHC	OS	GTC	GI	EP	ECP	SP
GAC	**0.907**							
SHC	0.78	**0.882**						
OS	0.74	0.77	**0.886**					
GTC	0.76	0.75	0.78	**0.901**				
GI	0.75	0.76	0.76	0.79	**0.878**			
EP	0.73	0.74	0.75	0.78	0.77	**0.854**		
ECP	0.72	0.73	0.74	0.76	0.76	0.79	**0.874**	
SP	0.71	0.72	0.73	0.74	0.75	0.76	0.78	**0.840**

The table 2 shows the discriminant validity of several organizational constructs, namely Green Absorptive Capacity (GAC), Sustainable Human Capital (SHC), Organizational Support (OS), Green Technology Capability (GTC), Green Innovation (GI), Environmental Performance (EP), Economic Performance (ECP), and Social Performance (SP). These correlations are then compared with the diagonal values (indicated by the bold numbers) that are the square root of each construct's average variance extracted (AVE). All diagonal values are more than 0.84, which shows that each construct is more similar with its items than with other constructs and thus satisfies the discriminant validity test. This is more evident through the self-correlation of the GAC construct, which stands at 0.907 and was higher when compared to SHC (0.78) and OS (0.74). Likewise, for other constructs, GTC and GI have a high self-correlation coefficient of 0.901 and 0.878, respectively, while their correlation with the other constructs is less.

4.3 Hypothesis relationship:

Table 3: Results

Hypothesis	**Structural Path**	**Path Coefficient**	**t-value**	**(p < 0.05)**	**Findings**
H1	GAC → GRIN	0.325	1.415	0.048	Supported
H1a	GAC x GTC → GRIN	0.290	2.500	0.013	Supported
H2	SHC → GRIN	0.672	3.290	0.003	Supported
H2a	SHC x GTC → GRIN	0.310	2.300	0.021	Supported
H3	OS → GRIN	0.601	5.600	0.000	Supported
H3a	OS x GTC → GRIN	0.350	3.000	0.005	Supported
H4a	GRIN → ENP	0.930	46.800	0.000	Supported
H4b	GRIN → ECP	0.955	35.500	0.000	Supported
H4c	GRIN → SOCP	0.950	34.000	0.000	Supported

Green Absorptive Capacity (GAC) is significantly related to Green Innovation (GRIN) with a path coefficient of 0.325, t = 1.415, p < 0.05, hence supporting the hypothesis 9 (see Table 3). When interacting with GAC, we also find a positive effect of Green Technology Capability (GTC) on GRIN with a path coefficient of 0.290 and t-value of 2.500 (p = 0.013), indicating that the combined influence of the two on GRIN is stronger. SHC has a positive correlation with GRIN, with a coefficient value of 0.672 and a highly significant 't' value of 3.290 (p < 0.00). The moderating role of SHC × GTC on GRIN is also significant with path coefficient = 0.310; p = 0.021. Organizational Support (OS) has a significant direct impact on GRIN with a path coefficient of 0.601 at t= 5.600 (p < 0.001). The relationship between OS and GTC influences GRIN, where the coefficient is 0.350, t-value 3.000, s, and p = 0.005. GRIN has very high and significant path coefficients (0.930, 0.955,

0.950) with ENP, ECP, and SOCP and extremely high t-values confirming the hypothesis that green innovation has a strong positive influence on environmental, economic and social performance.

5.0 Discussion:

The purpose of this current research was to examine the factors that determine green innovation within the context of SMEs and assess how GTC influences the relationship between GAC, SHC, and OS and the GRIN outcomes. The results not only support all the primary relationships specified in prior research but also extend this work's contribution by extending an understanding of how and why GTC enhances these factors and how SMEs can better implement sustainability initiatives through effective investment in technology.

The favorable impact of GAC on GRIN supports previous literature that established its importance for firms to identify and internalize environment-related information. SMEs, in particular, require such capabilities as flexibility and the ability to adapt rapidly, which are important competitive strengths but are limited by the resources available. Thus, there are some limitations to SMEs' traditional approach to GRIN by extending the moderating role of GTC. Our research hypotheses imply that SMEs with strong GTC are able to put more effort into the proper use of environmental knowledge. This means that GTC not only supports absorptive capacity but also facilitates the conversion of green knowledge into further effective and valuable actions by SMEs, which supports the suggestions of the dynamic capabilities perspective (Chen et al., 2015). Likewise, SHC has made a significant contribution to GRIN by showing that having environmentally conscious employees helps a firm embrace green advancements. The findings show that environmental skills and values are important for organizations as they help to foster sustainable practices among employees. GTC also strengthens this relationship by offering employees the best techniques and systems they can use to apply for green technology skills. SMEs use SHC and GTC together to enhance human resources implementation and provide a better foundation for GRIN. In this respect, this research adds to the human capital theory by showing that if the necessary technologies are put in place and aligned to the skills of the employee, innovation becomes possible.

Another significant predictor was organizational support (OS), which indicates that firms that actively support their green practices through the provision of policies, resources, and green leadership are likely to innovate. The existence of GTC strengthens this association, which implies that when an organization promotes environmental responsibility and combines it with improved technology profiling, there is substantial support for GRIN. This is in line with previous studies on the relationship between organizational culture and support and green innovation (González-Benito & González-Benito, 2006) and reveals the fact that investment in green technology can improve the impact of OS. To understand the effects of GRIN on SBP, our research highlighted environmental, economic, and social dimensions, all of which are impacted by GRIN. This dovetails with the writing of the TBL (Triple et al.), which posits a business strategy where companies aim to be financially, environmentally and socially sustainable (Elkington, 1998). Notably, GTC enlarges the economic performance consequences of GRIN because superior green technologies increase expenditures' cost-effectiveness and organizational efficiency, as well as companies' competitiveness. The environmental performance of GRIN is also enhanced in the overall context of firms with high GTC and could actually stretch pollution control mechanisms, means of waste management, and resource efficacy. On a social aspect, GTC-equipped firms can more easily attain and maintain skilled personnel with environmental awareness, thus improving work morale and meaningful stakeholders' confidence.

5.1 Implications and Future Directions

The findings have several theoretical and practical significances. First, this study contributes to the literature by applying the NRBV in light of the established structural equation modelling framework and by employing GTC as a second-order moderator for improving the extant theoretical suggestion of a firm's innovation capability. In practical terms, it stresses that green

technology is not only important as an operational improvement for SMEs but also as a strategic asset for achieving superior GRIN and sustainable performance. Regarding the emergence of GTC as an area of focus to change SMEs' green practices, policymakers and leaders of SMEs should build special incentives to support the extensive use of such tools.

Subsequent studies should conduct cross-sectional comparisons to replicate the results and assess how industry characteristics in different sectors affect the applicability of GTC to managing GRIN results. Furthermore, longitudinal research may unveil more detailed trends of GTC on the SME sustainability journey, especially in emerging regions.

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