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Digital Innovation & Knowledge Integration as Drivers of Sustainable Operational Performance: The Mediating Role of Green Process Innovation in Pakistan's Construction Sector

[1]Muhammad Arshad, [2]Muhammad Nasir Chaudhry & [3]Hafiz Ahmed Ullah
[1]Assistant Professor, Federal Chartered Degree Awarding Institute for Art and Culture, Pakistan.
[2]Assistant Professor, Federal Chartered Degree Awarding Institute for Art and Culture, Pakistan
[3]Federal Chartered Degree Awarding Institute for Art and Culture, Pakistan

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ABSTRACT

This study examines how digital innovation capability and knowledge integration influence sustainable operational performance in Pakistan's construction sector, with a focus on the mediating role of green process innovation. The objective is to understand how technological advancement and organizational knowledge practices jointly enhance sustainability outcomes in construction projects, which are critical for environmental compliance and resource efficiency. A quantitative, cross-sectional research design was adopted. Data were collected from project managers, site engineers, and operations supervisors working in large and medium-scale construction firms across Lahore, Karachi, and Islamabad. The findings indicate that both digital innovation capability and knowledge integration have a significant positive impact on sustainable operational performance. Green process innovation partially mediated these relationships, demonstrating that construction firms leveraging digital tools and integrated knowledge systems adopt greener processes, reduce environmental impact, and enhance overall sustainability. It contributes empirical evidence from a developing economy by highlighting how construction firms in Pakistan can achieve sustainable operational performance through coordinated technological and knowledge-driven strategies.

Corresponding Author's Email: ahmed.awan757@gmail.com
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1.0 Introduction

The modern construction industry is becoming dynamic and multidimensional as the pace of technological advancements accelerates, as the degree of environmental concerns and the demands of the society to sustainable development increase. Construction is one of the most resource-consuming and environmentally negative spheres in the world, and the contribution to energy consumption, waste production, and greenhouse emissions contribute to the fact that it gains more and more attention of policy-makers, researchers, and experts. The construction industry is a two-fold ethical dilemma in developing world economies such as Pakistan, who must juggle between the issue of creating infrastructure systems and on the other hand, must be forced to follow the environmental policies and sustainable development standards (Sattar, 2022). The intensive urbanization process, the population growth, and the building of the industrial areas have raised the requirements on the construction companies to guarantee the most effective use of the resources, lessen the wastes, and follow the practices that could be environmentally friendly.. The changing environment requires a revolutionary strategy whereby technological innovation and knowledge management are used to ensure sustainable performance of the operations, which is the capacity of firms to undertake operations in a way that maximizes use of resources, reduces environmental effects, and provides organizational sustainability (Sahoo, Kumar, & Upadhyay, 2023).

In this regard, the capability of digital innovation has been identified as an important aspect of sustainable performance, which is the capacity of firms to embrace, implement, and utilise digital technologies to enhance the process. The tools and systems included in the digital innovation include Building Information Modeling (BIM), project management software, Internet of Things (IoT) sensors, and automated monitoring platforms that can help firms to obtain real-time data, optimize the distribution of resources, and introduce more efficient construction methods. Digital innovations improve operational performance as well as environmental performance as they allow to plan processes, minimize mistakes, and perform predictive maintenance (Patrício, Varela, & Silveira, 2025). In equal measure, parallel is the aspect of knowledge integration, which is the ability of an organization to obtain, assimilate, and effectively apply knowledge both interdepartmentally and inter-project-wise. It entails knowledge sharing mechanisms, cross- functional cooperation and systematic codification of best practice, which, together, enable the construction companies to apply accumulated experience into viable, sustainable solutions. Digital innovation provides firms with technological instruments; however, knowledge integration also makes sure that these instruments are implemented efficiently within projects, which create synergies that make sustainable operational performance (Al-Husain et al., 2025).

Interrelation among these variables and the effects they have on the sustainability is further mediated by the green process innovation that concerns the implementation of the ecologically friendly processes, techniques and practices that have minimal ecology footprints and also that do not compromise the effectiveness of operations. Green process innovation can consist of using sustainable building materials, energy efficient processes, waste minimizing processes, and

processes that meet international environmental standards. The hypothetical connection between digital innovation, knowledge integration, and green process innovation is based on the resource-based view (RBV) and dynamic capabilities theory (Mondal, Singh, & Gupta, 2025). According to the RBV, competitive advantage and high level of performance is attained when firms utilize the use of unique resources and capabilities including technological competencies and organizational knowledge that are of value, rare, and they are difficult to duplicate. The dynamic capabilities theory takes this view a step further by focusing on the ability of a firm to combine, develop and re-develop both internal and external capabilities in response to the volatile environments. In the construction industry, digital innovation and the integration of knowledge are strategic resources and capabilities that, on the one hand, when combined with the green process innovation, allow companies to respond dynamically to the pressures of the environment, regulatory requirements, and market demands related to sustainable practices, and therefore, improve the performance of operations (Zhu, Zhang, Siddik, Zheng, & Sobhani, 2023).

Although the interest of scholars in the field of digital technologies, knowledge management, and sustainability is increasing, the literature still demonstrates considerable gaps in conducting research, especially in the context of developing economies. The majority of empirical researches were majorly addressing the developed economies where digital tools or sustainability practices are more common, and the impact of the same on construction companies in such nations as Pakistan is not well studied. In addition, other studies that have been conducted in the past have tended to focus on digital innovation, knowledge management or green process innovation individually, and have not considered it in relation to its combined impacts on sustainable operations outcome. This piece meal methodology restrains the comprehension of the interaction between technological capabilities and knowledge practices to create an environmentally friendly operation (Hu, Itani, Kim, Landers, & Liu, 2025). Moreover, although the role of green innovation has been identified as an essential operation sustainability mechanism, there is a dearth of empirical information on the mediating role of green innovation between digital innovation, knowledge integration, and performance. The combination of these constructs is especially applicable, though not adequately examined in the context of Pakistan construction sector, where limited adoption of technology, irregular knowledge management and inadequate environmental compliance policies are prevalent (Hussain, Huaping, Waqas, & Iqbal, 2025).

The research issue, thus, revolves around the problem of how Pakistani construction companies can use digital technologies and knowledge base to ensure sustainable operational performance without breaking the environment and regulatory rules. The low levels of technological adoption, poor practices in terms of knowledge sharing, and traditional practices commonly face the construction organizations in Pakistan as they struggle to adopt sustainable operations. Meanwhile, the worsening of the environment, rising energy costs, and stricter compliance regulations make firms rethink the functioning processes and invest in the new and environmentally-friendly solutions (Attah, Ogunsola, and Garba, 2023). The role played by digital innovation and knowledge assimilation in sustainable operational performance and to what extent the green process innovation mediate that association is essential in creating strategies that would

serve in enhancing the efficacy, ecological footprint, and long run competitiveness in the construction industry. The urgency of this question to the work of organizations and the significance of the issue in the broader framework of the society, especially, environmental responsibility, resource sustainability, and sustainable urban growth explain its importance (Pera, 2020).

The significance of the study is that it brings a contribution to theory and practice in the area of the sustainable construction management. Ideally, it offers a collaborative model between digital innovation ability, knowledge integration, and green operation innovation and sustainable operational performance, and hence closing the gap on the literature. With the analysis in the framework of a developing country with institutional, technological, and environmental specifics, Pakistan, the study can apply the sustainability theories, such as the RBV and dynamic capabilities, to the context that has been underserved in the, so far, empirical literature. Practically, the study has operational implications in the construction managers, policymakers and the industry stakeholders. It emphasizes the need to invest in digital tools, commit to knowledge-sharing processes in organizations, and use green process innovations in a systematic way to make operations more sustainable. Such insights can be used to make strategic decisions, to inform the allocation of resources and to enable the formulation of policies and interventions to enable the advancement of environmentally responsible practices within the construction industry.

Moreover, the research highlights the importance of a comprehensive approach in the development of sustainable operational performance and it is found that digital innovation and knowledge integration are reinforcing in the context of mediating by green process innovation. With the isolated technological solutions that the construction companies apply, the lack of connection between these solutions and the knowledge practices and the correspondence between the operations and the green innovations, the isolated construction companies in question run the risk of the suboptimal sustainability effects. On the other hand, a greater efficiency, less waste and functioning within the environmental and regulatory standards can be attained in organizations that develop both technological and knowledge base and in which the environmentally conscious processes are implemented. The importance of human capital, managerial decision making and organizational culture are also subject to this integrated approach in terms of sustainability of operations. The combination of knowledge is a guarantee that knowledge is transferred between teams, thereby increasing the level of innovation and problem-solving, where digital technologies can also be used to guarantee accuracy, tracking, and efficacy in construction processes. Green process innovations translate these capacities into environmental sustainability practices and fill the gap between strategy and practice.

Moreover, the paper is also added to the expanding body of knowledge on sustainability in emerging markets, where there are resource-based limitations, gaps in regulations, and poor technological infrastructure. Exploring how the construction companies in Pakistan are leveraging on digital and knowledge capabilities to adopt the green practices, the study provides empirical evidence that can be applied to enlighten other developing countries who are limited by the same factors. Green process innovation mediating role is an exploration area particularly because it

illuminates on how technological and knowledge resources could be converted into the actual deliverables of sustainability. The managers who are interested in concentrating on interventions, efficiently investing and developing performance measures that indicate at once both efficiency of operation and impact on the environment are interested in this knowledge. Also, the knowledge which the research will produce can be applied in training programs, network, and policies which will encompass the construction sector so that practices which are sustainable are also implemented quickly in the industry.

Lastly, the investigation addresses the research gaps, thereby addressing an immediate evidence-based approach to address the issue of operational sustainability in the construction sector in Pakistan. It shows that sustainable operational performance is not unconditionally dependent on the technological adoption but synergistic combination of knowledge management and process-level environmental innovation. The study also forms a basis to future researches on other mediating or moderating variables, including organizational culture, regulatory support, or financial constraints, which could be involved in the relationship (innovation, knowledge integration, and sustainability). On the whole, this paper provides an inclusive outlook on the motivational factors of sustainable operational performance that should be highlighted by the fact that construction companies could reach significant environmental and operational results through the careful coordination of digital innovation, knowledge integration, and green process innovations in their operation model. This alignment will not only lead to improvement of the performance of the firms but also aids in the greater goals of the society such as sustainable development, environment and resource efficiency, which will create a strong base of sustainable construction industry in Pakistan and similar developing economies.

2.0 Literature Review

The theoretical perspective that the current paper is based on is the Resource-Based View (RBV) and the Dynamic Capabilities Theory (DCT), thus providing a solid background on the analysis of how organizations can convert resources and capabilities to long-term operational success. According to RBV, the resources that help firms achieve sustainable competitive advantage are those that are valuable, rare, inimitable, and non-substitutable - such as technological capabilities and well-integrated knowledge systems (e.g., big data and digital infrastructure). Literature on the topic is focused on the idea that digital and IT capabilities are strategic assets that, when properly utilised, can pursue both business efficiency and environmental sustainability (Al-Husain et al., 2025; Sharma et al., 2024).

In the construction industry, the ability to introduce and utilize innovative digital technologies, which are Building Information Modeling (BIM), Internet of Things (IoT)-supported monitoring tools, analytics, and modeling, is considered a strategic asset, and it is referred to as digital innovation capability. Such technologies make it possible to optimize planning of a project, its real-time monitoring and distribution of resources, which leads to the reduction of wastes, minimization of errors, and optimization of environmental performance (Mahajan and Narkhede, 2024; Bamigboye and Kirgiz, 2025). According to the recent empirical study, companies with strong digital infrastructure and operational capabilities demonstrated significantly greater degrees

of so-called green process collaborative innovation, highlighting the importance of digitalization in the process of sustainable process redesign (Alsofiani, 2024; Al-Husain et al., 2025).

To supplement digital innovation, knowledge integration, or the ability to acquire, assimilate, share, and use knowledge within teams, projects, functional units, etc. is necessary. By engaging in systematic knowledge management (sharing of best practices, codifying lesson learned, cross-functional work) the firms can convert unstructured digital information and technical expertise into practical and sustainable practices. This is consistent with the literature on the topic of green knowledge management that proves that intellectual capital that is generated internally when well managed encourages green innovation and sustainable performance in the construction and related industries (Khan, Mehmood and Kwan, 2024; Shahzad et al., 2020).

Whereas the RBV focuses on the resources that a firm holds, DCT focuses on the ability of the firm to adapt, reconfigure and put the resources to use in reaction to the changing environmental conditions. Green process innovation in this perspective is a dynamic capability, a process-level capability that enables firms to re-engineer processes, embrace energy-saving or waste-reduction procedures and integrate sustainability into operations. It has been empirically proven that firms that integrate digital capabilities and green knowledge management have much better sustainable performance (Al-Husain et al., 2025; Discover Sustainability, 2025). In turn, a combined RBV and DCT model warrants the analysis of the interactive influence of digital innovation competence, knowledge integration, and green process innovation on sustainable performance of operations. Digital innovation and knowledge integration constitute digital strategic resources of the RBV, and green process innovation aided by dynamic capabilities enables its reorganization and eventual transformation into sustainable results.

The implementation of digital technologies (BIM, IoT, digital twins, analytics) along with extensive knowledge management has been found to minimize waste, enhance resource efficiency, and enhance environmental performance in construction projects, which is supported by empirical studies (Zahedi, Alavi and Sardroud, 2024; Mahajan and Narkhede, 2024). Considering the interplay of digital transformation and sustainability challenges across the globe, and especially in the emerging economies, this combined strategy yields explanatory value as well as practical applicability to the construction companies which desire to attain sustainable operational excellence.

3.0 Methodology

This study adopts a quantitative research approach to examine the impact of digital innovation capability and knowledge integration on sustainable operational performance, with green process innovation as a mediating variable, in the construction sector of Pakistan. The study is based on positivistic philosophical paradigm that assumes that reality is objective and measurable, and the relationship between the variables can be quantified and analyzed with the help of the statistical methods. Positivism justifies the utilization of structured data gathering tools and underlines hypothesis testing, which was compatible with the aim of the study to empirically prove the associations between the suggested constructs. The quantitative and cross-sectional design will ensure that the study captures the perceptions and experiences of construction

professionals in one point in-time such that causal and mediating relationship can be examined between the variables. The strategy will make sure that the study can give generalizable findings on the operational and sustainability practice of construction companies within the setting of Pakistan.

The study population is divided into project managers, site engineers, and operations supervisors who are employed in mid-size and large-scale construction companies in Pakistan, and especially in the major cities of the country, including Lahore, Karachi, and Islamabad, where construction processes are the most centralized and high-technological. These professionals have been chosen owing to the fact that they are the ones who have direct involvement in the process of operational planning, project implementation, and decision making that directly affect the outcome of technology adoption and sustainability. Since there is no national database of construction professionals, the population will be found using firm-level directories, professional associations, and industry networks. The estimated target population includes some thousands of professionals working in managerial and technical positions in the construction organizations, which is going to constitute a solid framework of including variable views on digital innovation, knowledge integration, and green process innovation.

The sampling approach used was stratified random sampling in order to make sure that various subgroups in the population are sufficiently represented in the study. The stratification attempted was by the size of the firm and geographical location and the participants were selected proportionally out of the medium and large construction firms in the chosen urban centers. This sampling method will reduce the chances of biasness as well as increase the representativeness of the sample because the insights will not be skewed by a type of firm or region. Through this approach, a sample of 500 construction professionals was first of all targeted, where 450 valid responses were received and this gave a high response rate, sufficient statistical power to perform structural equation modeling analysis. The proposed sample is believed to be sufficient to the proposed model as it satisfies some of the frequently recommended minimum sample sizes in Partial Least Squares Structural Equation Modeling (PLS-SEM) which dictates that larger sample sizes are needed to achieve stability, reliability, and validity of the models especially in the mediation effects testing.

The survey questionnaire was a structured questionnaire, which was used to collect the data by capturing the perception and experience on the digital innovation capability, knowledge integration, green process innovation, and sustainable operational performance. To evaluate the adoption, integration, and effectiveness of the constructs of the study, the questionnaire had questions based on a five-point Likert scale, which can be strongly disagree to strongly agree. The questionnaire was first tested on academic and industry experts to make sure that the questionnaire had validity in terms of content and would be understood within the context of the construction sector in Pakistan. The questionnaire was sent both electronically and physically, through use of professional networks, organizational contacts and industry associations as a way of maximizing its reach and response rate. The objectives of the study, the voluntary participation, and confidentiality assured the respondents and prompted the respondent to provide honest answers

and reduced the likelihood of biasing responses. The period of data collection was two months, which enabled the researcher to follow up effectively with the respondents to increase the dataset completeness and accuracy.

To perform the data analysis, Partial Least Squares Structural Equation Modeling (PLS-SEM) was used with SmartPLS 4.0, as it would be appropriate to test the complex modeling with a mediating effect and be effective in small to medium sample sizes without distributional assumptions. The analysis entailed a two-step process, which commenced with the determination of the measurement model to determine the reliability, convergent and discriminant validity of the constructs and the structural model, which tested the hypothesized relationships, and mediation effects. PLS-SEM proved to be especially suitable in this study as it has the ability to estimate more than one relationship at a time, gives information on the predictability nature of the model, and can be used to analyze the direct and indirect impacts which is imperative in testing the mediating factor of green process innovation. Significance of path coefficients, t-values and effects sizes were assessed by bootstrapping procedures with 5000 resamples and provided robust and reliable inferential conclusions on hypothesized relationships.

4.0 Findings and Results

4.1 Reliability Analysis

Table 4.1 Reliability Analysis

Construct	Indicator	Loading	Cronbach's Alpha	Composite Reliability (CR)	Decision
DIC	DIC1	0.812	0.876	0.912	Acceptable
	DIC2	0.845			
	DIC3	0.821			
KI	KI1	0.803	0.862	0.903	Acceptable
	KI2	0.826			
	KI3	0.812			
GPI	GPI1	0.798	0.854	0.895	Acceptable
	GPI2	0.819			
	GPI3	0.811			
SOP	SOP1	0.832	0.881	0.917	Acceptable
	SOP2	0.849			
	SOP3	0.838			

The measure of reliability demonstrates that all the constructs, such as Digital Innovation Capability (DIC), Knowledge Integration (KI), Green Process Innovation (GPI), and Sustainable Operational Performance, possess high level of internal consistency and measurement quality making it understandable how they are organized in a structural analysis. The loading of all the

indicators is more than the recommended minimum of 0.70 which means that there exists strong item-to-construct correlation and that all items reliably measure their underlying latent variable. Value of Alpha of all constructs is found to be between 0.854 to 0.881 which is well above the acceptable value of 0.70 and this is a good sign of a high reliability of the measurement model. In the same vein, the Composite Reliability (CR) values stand between 0.895 and 0.917, which also confirms the stability and internal consistency of the constructs not mentioning the fact that they are also above the desirable 0.70 mark. All these findings confirm the construct validity of digital innovation capability, knowledge integration, green process innovation and sustainable operational performance in that the constructs are strong, accurate and highly reliable to offer a thorough measure of the structural relations in the PLS- SEM model.

4.2 Discriminant Validity (HTMT)

Table 4.2 Discriminant Validity

Construct	DIC	KI	GPI	SOP
DIC	1	0.632	0.584	0.591
KI	0.632	1	0.618	0.637
GPI	0.584	0.618	1	0.664
SOP	0.591	0.637	0.664	1

The findings of the discriminant validity of the HTMT confirm that all the constructs in the model, which include the Digital Innovation Capability (DIC), Knowledge Integration (KI), Green Process Innovation (GPI), and Sustainable Operational Performance (SOP), are empirically differentiated and they measure dissimilar conceptual areas. The values of all the HTMT values are much lower than the conservative level of 0.85, with inter-construct correlations varying between 0.584 and 0.664 that suggest that the constructs are related to each other in a theoretically meaningful manner, but are not overlapping excessively. As an example, a reasonable association can be seen in the HTMT value between DIC and KI (0.632) which conforms to the idea that digitally advanced companies tend to be more knowledge integration practices but the value is not too high to demonstrate discriminant validity. Equally, the correlation between GPI and SOP (0.664) shows that the process innovations that are greener are a natural contributor to sustainability outcome, but it does not prejudice the uniqueness of each construct. All in all, these findings are good indicators that the measurement model is aligned to the discriminant validity criteria such that each construct is unique in its contribution to the explanation of the structural relations of the study.

4.3 Collinearity Assessment (VIF)

Table 4.3 Collinearity Assessment

Construct	VIF Value	Interpretation
DIC	2.102	Acceptable
KI	2.256	Acceptable
GPI	1.978	Acceptable

The VIF scores show that there is no multicollinearity in the structural model because all constructs have a VIF value that is significantly lower than the 5 threshold of acceptable levels of collinearity. All the Digital Innovation Capability (VIF = 2.102), Knowledge Integration (VIF = 2.256) and Green Process Innovation (VIF = 1.978) have a range of values that can be recommended as not overly strong linear effects on other predictors. These values give a balanced and independent contribution of each variable to the model so that the estimates of path coefficients are not inflated and biased by multicollinearity. Acceptable VIF scores reinforce the validity of the structural model since they assert that the predictors of digital innovation capability, knowledge integration, and green process innovation are independent but complementary constructs in their explanations of sustainable operational performance.

4.4 Model Fit

Table 4.4 Model Fit Table

Fit Index	Value	Threshold	Interpretation
SRMR	0.058	< 0.08	Good Fit
NFI	0.912	> 0.90	Acceptable Fit
RMS_theta	0.075	< 0.12	Acceptable Fit

The indices of the model fit clearly show that the structural model has an overall satisfactory and acceptable fit to its ability to explain the relationships between the constructs of the study. The SRMR value of 0.058 is way below the acceptable value of 0.08 which gives a perfect match between the measured and predicted correlation and there exists little misspecification of the model. On the same note, the NFI value of 0.912 is greater than the

acceptable level of 0.90 indicating that the proposed model is much better than the null model and it is able to represent the data structure behind the data. Also, the value of RMS theta, 0.075, is well under the mark of 0.12, which means that the reflective model of measurement is sound and has a small amount of residual variance. All these signs indicate that the model is appropriate to the data and it offers a solid basis to the interpretation of the assumed structural relationships.

4.5 Structural Model Results

Table 4.5 Structural Model Results

Hypothesis	Path	β (Beta)	t-value	p-value	f^2	Decision
H1	DIC → SOP	0.422	7.134	<0.001	0.086	Supported
H2	KI → SOP	0.356	6.012	<0.001	0.071	Supported
H3	DIC → GPI	0.489	8.152	<0.001	0.123	Supported
H4	KI → GPI	0.437	7.689	<0.001	0.098	Supported
H5	GPI → SOP	0.305	5.478	<0.001	0.065	Supported

The empirical evidence presented by the structural model leads to a high level of support that all the hypothesized relationships are correct and that digital innovation capability, knowledge integration and green process innovation are the key drivers to the improvement of sustainable operational performance in the construction industry in Pakistan. Digital Innovation Capability ($b = 0.422$, $p < 0.001$) is also a significant enhancer of sustainable operations, which proves that companies using digital tools and technologies are more environmentally efficient and sustainable in their operations. Knowledge Integration ($b = 0.356$, $p < 0.001$) is also found to be positively significant at a significant level, indicating that the construction companies that do successfully synthesize and transmit knowledge between teams are better placed to introduce sustainable practices. Moreover, DIC ($b = 0.489$, $p < 0.001$) and KI ($b = 0.437$, $p < 0.001$) significantly positively contribute to the Green Process Innovation, which is why technology adoption and knowledge-based ability is crucial to enhance the environmental friendliness of the processes. Green Process Innovation, in its turn, has a very substantial effect on Sustainable Operational Performance ($b = 0.305$, $p < 0.001$), which proves the mediating role of the former where it allows firms to transform technological and knowledge resources into real sustainability results. The effect sizes (f2 between 0.065 and 0.123) reveal the small to the medium effects, all of which proves the sound and consistent model, which is expected and proves the interconnection between digital transformation, knowledge practices, and green innovation in sustaining sustainable performance.

4.6 Mediation Analysis (Indirect Effects)

Table 4.6 Mediation Analysis

Mediation Path	Indirect β	t-value	p-value	Effect Size	Type of Mediation
DIC → GPI → SOP	0.149	4.826	<0.001	Medium	Partial
KI → GPI → SOP	0.133	4.412	<0.001	Medium	Partial

Through the mediation analysis, it is apparent that Green Process Innovation is a meaningful and vital mediating variable in the association between the two Digital Innovation Capability and Sustainable Operational Performance and between Knowledge Integration and Sustainable Operational Performance. That indirect influence of DIC on SOP via GPI ($b = 0.149$, $p = 0.001$) indicates that the companies with a greater ability of digital innovation do not only enhance the sustainability but also receive more benefits through the enhancement of the environmentally friendly processes that simplify the utilization of the resources and minimize the environmental impact. Likewise, the mediation effect of KI and SOP via GPI ($b = 0.133$, $p < 0.001$) implies that integration and active dissemination of knowledge within the construction companies lead to the adoption of environmentally friendly advancement in the process, which in turn improves positive operational results. The two mediation effects are statistically significant and medium effect sizes, which prove that GPI is an important process whereby technological and knowledge-based capabilities are converted into sustainability performance. The partiality of the mediation indicates that although GPI is a significant means, DIC and KI also have direct beneficial links with SOP, which means that digital transformation, knowledge integration, and green innovation work together to ensure sustainable performance of the construction industry.

5.0 Discussion and Conclusion

The outcomes of the study provide a lot of empirical support to the assumption that the capacity to innovate digitally and combine knowledge are the pillars of sustainable operational performance in the Pakistani construction business. The importance and positive contribution of the digital innovation capability to the sustainable operational performance indicates the contribution levels of technological development in improving the efficiency of environmental operations, resource efficiency and overall operational sustainability. This observation is consistent with the contemporary considerations that suggest the construction firms, which adopt digital tools, i.e., BIM systems, automation tools, and data-driven monitoring systems are more likely to eradicate wastes, attain greater precision, and reduce the environmental impact of their operation. The fact that there is a high relationship between digital innovation capacity and green process innovation continues to provide support to the thesis statement that technological preparedness not only enhances efficiency, but also the impetus to greener building development, thereby driving companies to embrace more sustainable processes that would eventually result to the ultimate environmental goals.

Similarly, knowledge integration has such significance to the green process innovation and

sustainable operational performance to the point that collaborative learning, organizational knowledge sharing, and cross-functional communication matter. Construction projects are complex and are to be synchronized at all time between the engineers, project managers and on field personnel. The findings show that the capability of the companies to integrate both the internal and external knowledge bases like environmental laws to the ideal practices of green building render them more inclined to incorporate novel procedures that are ecologically friendly. This reflects on theoretical positions that are grounded in the Knowledge-Based View (KBV) which believes that the organizational knowledge is a strategic asset that enhances the innovation capability and general performance. The results of these findings suggest that the very idea of knowledge integration not only improves the inner competencies but also enables the companies to anticipate the concerns of sustainability and change the operational models accordingly.

The mediating ability of green process innovation adds a little more light to the alteration of digital innovation capacity and knowledge combination to the sustainable outcome. The partial mediation indicates that both DIC and KI have direct impacts on the sustainability performance though the impact is significantly enhanced when they are mediated by process innovations that are environmentally oriented. This adds to the thesis that green process innovation is an intermediary, which transforms the technological and knowledge-based resources into feasible, environmentally-friendly solutions. The given observations can be attributed to the ideas of the Natural Resource-Based View (NRBV) that presupposes that, to guarantee long-term sustainability and competitive advantage, any firm must run environmentally oriented innovations. Results of the mediation prove that an investment in digital tools or knowledge systems alone will not be able to create a sustainability benefit, firms should also invest in these resources to create and implement green processes to achieve all benefits of sustainability.

The general results can be said to be representative of a holistic and consistent framework in which digital innovation, integration of knowledge and green process innovation can have a positive role to play in enhancing sustainable operation performance. This balanced model demonstrates that building sector does not find an environment that will provide sustainability through individual efforts but a set of technological readiness and culture of knowledge and innovation orientation is a synergistic one. The model fit indicators and the reliability indicators are added to the reinforcement of the framework even further, as the framework makes sure that the relationships are based on theory and even backed. The results also apply to the available literature of the unbalanced sustainability implementation due to cost factors, lack of technological capability, and lack of effective institutional forces in a developing economy.

Summing up, the study concludes that the digital innovation ability and integration of knowledge have a significant role in sustainable performance of operations both directly and indirectly through green process innovation. The results confirm that construction firms that invest in the solutions of digitalization, improve their knowledge base, and are active in searching green innovations have a significantly higher chance of meeting the sustainability objectives and increasing the efficiency of the operations. The findings show the extent to which the need to integrate technological change and environmental environments is strategic and demonstrate that

sustainable performance is a multidimensional phenomenon that is constituted by interdependent organizational resources. The study is well grounded in the theory and empirical data in explaining how the Pakistani construction firms can transition faster into sustainable operations.

These results lead to several recommendations which can be made by practitioners and policymakers. The construction companies should prioritize the use of the digital technologies that enhance real time monitoring, automation and predictive planning because these resources are key to sustainability of operations in the companies. The companies should also be in a position to instill the cultures of knowledge sharing through the implementation of collaborative platforms, cross-functional training programs, and partnerships with academic and regulatory institutions. The organizational levels must also be well incorporated into the green innovation objectives in the strategic planning of the organization to ensure that the technological and knowledge-based projects are geared towards the environmental goals. The policymakers can also enhance change in the industry level, through incentives to digital and green innovations, updating the building codes in accordance with the sustainability requirements, as well as encourage inter-industry collaboration to exchange knowledge.

The implications of this study include a lot of implications on theory, practice, and policy. Theoretically, the study will help to bring together the NRBV, KBV, and innovation capability models within the context of the concept of sustainability in the construction industry, demonstrating the way of their combination to interpret the performance findings. The results indicate to the practitioners that it is necessary to invest in digital and knowledge capabilities as strategic instruments to improve competitiveness and sustainability. To policymakers, the study is an evidence-based study that would assist them in developing interventions that can foster sustainable modernization of the construction sector. On the whole, the study can make a significant contribution to the current discussion on the topic of sustainable construction because it presents an all-encompassing, empirically supported framework of improving the environmental and functional performance of developing countries setting.

Hafiz Ahmed Ullah: Problem Identification and Theoretical Framework
Muhammad Arshad: Data Analysis, Supervision and Drafting
Muhammad Nasir Chaudhry: Methodology and Revision

Conflict of Interests/Disclosures

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