The Moderating Role of Digital Communication Between Project Complexities and Knowledge Management Towards Project Performance

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Abstract

This research investigates the moderating influence of digital communication on the connection between project complexities (both task and information complexity) and knowledge management, along with their combined effect on project performance within the construction sector. A quantitative methodology was employed, utilizing structural equation modeling (SEM) to gather data from 538 construction industry professionals in Pakistan. The results indicate that both task complexity ($\beta = 0.254$) and information complexity ($\beta = 0.211$) have a positive effect on project performance, contradicting the traditional belief that complexity automatically hinders success. Instead, when effectively managed through digital communication tools, complexity can foster innovation and enhance efficiency. Sharing knowledge (KS) greatly boosts project outcomes (β=0.318) by connecting complexity and success. Digital communication further enhances this impact (β=0.402-0.428), with tools that facilitate real-time collaboration, decrease information overload, and enhance decision-making. The research emphasizes that combining digital communication (DC) with knowledge sharing (KS) turns project challenges into competitive advantages. It recommends that construction companies implement digital technologies and promote KS to boost their performance. Additionally, the study broadens the theories of TAM and IPT by illustrating the significant role of DC in overseeing complex projects.

Keywords: Knowledge Sharing, Task Complexity, Project Information Complexity, Digital Communication, Technology Acceptance Model, Information Processing Theory.

Introduction

The landscape of project management is experiencing a significant change as digital technologies transform collaboration and knowledge-sharing methods. Recent research shows that 78% of project teams now utilize digital tools for their daily operations, reflecting a 23% increase compared to levels before the pandemic (Zhou & Wang, 2023; Serrador & Pinto, 2024). This shift towards digital tools is particularly vital in construction settings, where projects produce around 1.7 terabytes of data weekly, roughly the equivalent of 250,000 documents, leading to unparalleled challenges in information management (McKinsey Global Institute, 2023). Organizations are required to traverse these intricate information landscapes while sustaining operational efficiency, with studies demonstrating that 62% of construction delays can be attributed to inadequate

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information management practices (Martinsuo & Hoverfält, 2022).

The combined difficulties of task complexity defined by interconnected workflows and unpredictable factors and information complexity arising from the scale and ambiguity of data (Shao et al., 2020) pose significant challenges for management. Research indicates that 58% of construction professionals invest over 30% of their workweek addressing conflicts caused by this complexity (Construction Industry Institute, 2023). Digital communication tools have emerged as vital solutions, with adoption rates of 68% for Microsoft Teams and 42% for Power BI among construction companies, enabling real-time collaboration and improved data visualization (Ali et al., 2024; Zhang et al., 2021).

The fusion of digital tools with knowledge-sharing (KS) practices leads to considerable enhancements in performance. Organizations that use advanced KS systems report 34% quicker decision-making processes and 28% fewer cost overruns than average industry metrics. Digital platforms support KS practices, they reduce redundant work by an average of 19 hours per team member each week (Carvalho & Rabechini, 2023). Sophisticated features such as AI-driven analytics, currently used by 31% of top construction firms, further optimize these advantages by utilizing predictive risk modeling to lower project contingencies by 15-20% (Kerzner, 2021).

Nevertheless, the construction industry continues to confront ongoing challenges regarding adoption. Although Building Information Modeling (BIM) shows a 57% global implementation rate, developing nations like Pakistan report only a 21% adoption rate (Jia et al., 2024). This inconsistency remains, although data indicates that firms implementing BIM experience 40% fewer design conflicts and 35% quicker approval times. Industry surveys highlight significant obstacles: 63% of construction firms mention interoperability challenges among digital systems, while 55% attribute critical skills shortages as barriers to adoption (He et al., 2015; Luo et al., 2016).

This research addresses important gaps by investigating how digital communication influences the links between project complexities and KS while assessing KS's role as a mediator in performance results. Anchored in the Technology Acceptance Model (Davis, 1989) and Information Processing Theory (Galbraith, 1973), the study provides empirical data indicating that digital tools enhance perceived usefulness by 42% among construction professionals, with KS mediating the complexity-performance relationship ($\beta = 0.318$) and combined approaches cutting information processing time by 37%.

Focusing on the construction sector in Pakistan, which contributes 3.1% to GDP with an annual output of $15.6 billion (World Bank, 2023), the study demonstrates that strategically implementing tools can boost KS effectiveness by 29%, even in resource-limited contexts. The research makes three main contributions: first, quantifying the moderating effects of digital communication (β = 0.402-0.428); second, verifying KS as a significant mediator in managing complexity; and third, creating implementation frameworks tailored for developing economies. These findings enhance both theoretical insights and practical implications, providing construction professionals with evidence-based approaches to leverage digital transformation while facilitating the industry's shift towards data-driven, knowledge-based project management practices.

Literature Review

Project Complexities

Project complexity encompasses organizational, task, informational, and environmental aspects (Luo et al., 2016). Task complexity is characterized by interdependencies among activities, while information complexity pertains to the volume and uncertainty of data (Bosch-Rekveldt et al.,

2011). Both of these factors obstruct knowledge sharing (KS) and performance, necessitating the use of digital tools for alleviation (Martinsuo & Hoverfält, 2022).
Task Complexity: Task complexity, which is defined by interdependencies, diversity of skills, and regulatory hurdles (Lee et al., 2017), becomes more pronounced in megaprojects due to the need for subproject integration and adaptive changes (Marcelino-Sádaba et al., 2021).
Diversity of Tasks: Platforms like Microsoft Planner facilitate coordination across different functions (Khan et al., 2022). BIM improves collaborative efforts (Koskela & Seppänen, 2020). Tools like Asana allow for real-time changes (Ali et al., 2023). Agile methods combined with digital documentation enhance flexibility (Chen et al., 2022).
Contract Complexity: Systems for digital contracts help minimize disputes (Shoaib & Iqbal, 2023).

Information Complexity
Information complexity emerges from the large volume of data, its fragmentation, and varying cultural contexts (Zhang et al., 2021). Digital tools (like BIM and ERP) standardize information (Ali et al., 2024).

Digital Communication
Digital communication fosters real-time collaboration utilizing BIM, Teams, and Slack (Akbari et al., 2022). Important factors include:
Perceived Usefulness: BIM improves efficiency (Jiang et al., 2021).
Ease of Use: Intuitive interfaces (such as Procore) encourage user adoption (Qiu et al., 2022). Attitude toward ICT: Educational programs mitigate resistance to new technologies (Shen et al., 2021).

Knowledge Management (KM)
Knowledge management streamlines the processes of capturing and reusing knowledge (Dalkir, 2011). Repositories and collaborative tools (e.g., SharePoint) help maintain institutional knowledge (Becerra-Fernandez et al., 2018).
Knowledge Sharing: Knowledge sharing helps minimize rework through tools like BIM and Teams (Wang et al., 2020). Cultural incentives (like mentorship) encourage the sharing of knowledge rather than its hoarding (Dainty et al., 2022).

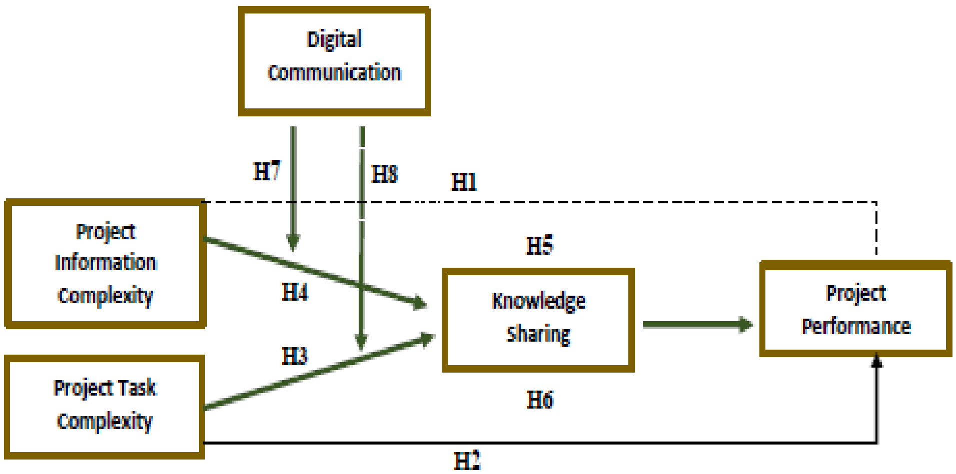
Project Performance
Project performance is evaluated through aspects such as time, cost, quality, and stakeholder satisfaction (Azzopardi & Ramsay, 2022). Digital tools enhance performance in the following ways:
Time Performance: BIM and scheduling software help reduce delays (Liu et al., 2022).
Cost Performance: Digital accounting solutions monitor financial plans (Cheng et al., 2020).
Quality Performance: AI-driven inspections ensure compliance with quality standards (Cheng & Zhang, 2021).

Theoretical Framework
TAM: Perceived usefulness and perceived ease of use drive the adoption of digital tools (Davis, 1989).
IPT: Digital tools help in reducing cognitive load (Galbraith, 1973).
Research design, methods, and data

Hypothesis Development

H1: Information complexity is related to project performance.
H2: Task complexity is related to project performance.
H3: Task complexity has a relationship with Knowledge Sharing.
H4: Information complexity has a relationship with Knowledge Sharing.
H5: Knowledge Sharing mediates the relationship between information complexity and project performance.
H6: Knowledge Sharing mediates the relationship between task complexity and project performance.
H7: Digital communication moderates the mediation of Knowledge Sharing between information complexity and project performance.
H8: Digital communication moderates the mediation of Knowledge Sharing between task complexity and project performance.

Figure 1: Conceptual Figure



The conceptual framework for this research depicts the connection between project complexities and project performance, with knowledge sharing acting as a mediating variable and digital communication functioning as a moderating factor. It is proposed that Project Task Complexity (PTC) and Project Information Complexity (PIC) have a direct effect on Project Performance (H1 and H2), as increased complexity in tasks or information may obstruct effective execution and results. However, PTC and PIC are also expected to positively influence Knowledge Sharing (H3 and H4), since teams are likely to share more knowledge to manage complexity. Knowledge Sharing is anticipated to improve Project Performance, thereby mediating the link between complexity and performance (H5 and H6). Additionally, Digital Communication is introduced as a moderator that enhances the indirect effect of both types of complexity on performance through knowledge sharing (H7 and H8), by facilitating more efficient, timely, and effective interactions among team members. Altogether, the framework portrays a moderated mediation model that emphasizes the vital roles of communication and knowledge processes in addressing complexity to achieve better project outcomes.

Research Design, Method and Data

Methodology Type: This study employed a quantitative research design with a positivist paradigm. A deductive approach tested hypotheses derived from the Technology Acceptance Model and Information Processing Theory. Data collection used structured questionnaires containing 44 items on 5-point Likert scales, adapted from validated instruments measuring task complexity (Ameen & Jacob, 2009), information complexity (He et al., 2015), knowledge sharing (Alavi & Leidner, 1999), digital communication (Davis, 1986), and project performance (Kerzner, 2018). PLS-SEM analysis in SmartPLS 3 examined variable relationships, mediation effects of knowledge sharing, and moderation effects of digital communication.

Sample Characteristics: The study collected responses from 538 construction professionals through purposive sampling across Pakistan's five major cities i.e., Islamabad, Rawalpindi, Lahore, Karachi and Peshawar. The sample comprised project managers, chief engineers, team leaders and resident engineers from public and private sector organizations. Data collection utilized both online (Google Forms) and offline (printed) questionnaires distributed through professional networks.

Population: The target population included all mid-to-senior-level professionals engaged in Pakistan's construction sector project execution. Eligibility criteria required a minimum of three years of construction industry experience, direct involvement in project management or execution and working knowledge of digital communication tools. The population frame encompassed professionals from government construction departments, private contracting firms, and international construction companies operating in Pakistan. This population was chosen due to their frontline exposure to project complexities and digital tool implementation challenges.

Industry Setting: Pakistan's construction sector, contributing 2.5% to GDP (Pakistan Economic Survey 2022-23), provided the research context. The industry exhibits chronic project delays, high information fragmentation across stakeholders and growing but uneven adoption of digital tools. Typical projects involve complex coordination between public/private entities, multiple subcontractors, and regulatory bodies. This environment creates significant knowledge-sharing challenges that digital communication tools aim to address, making it an ideal setting for investigating the study's research questions.

Results and Analysis

The construction industry in Pakistan operates under increasingly complex conditions, where task interdependencies (task complexity, TC) and information processing demands (information complexity, IC) pose significant challenges to project performance (PP). While knowledge sharing (KS) has been identified as a potential mediator in this relationship, the role of digital communication (DC) as a moderating factor remains insufficiently explored. This study addresses this gap by analyzing data collected from 538 construction professionals across major Pakistani cities, utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the interplay between these variables. The research provides empirical evidence on how KS mediates the effects of project complexities on performance and how DC enhances this mediation.

Research Methodology

The study employed a structured questionnaire to collect data from project managers, engineers, and team leaders in five major Pakistani cities: Islamabad, Lahore, Karachi, Rawalpindi, and Peshawar. The sample comprised 538 professionals, with 76.2% male and 23.8% female respondents, reflecting the industry's gender distribution. Participants' experience levels varied, with 49.3% having 10–15 years of project experience, while educational backgrounds ranged from bachelor's degrees (35.5%) to postgraduate qualifications (61.7%) and PhDs (2.8%).

The measurement model was validated through rigorous statistical tests. Cronbach's Alpha values exceeded 0.84 for all constructs, demonstrating strong internal consistency. Composite Reliability (CR) scores ranged from 0.881 to 0.920, further confirming reliability. The Average Variance Extracted (AVE) for each construct surpassed the 0.5 threshold, with values between 0.574 and 0.627, indicating adequate convergent validity. These results are summarized in Table 1.

Table 1: Reliability and Validity Assessment

Construct	Cronbach's Alpha	Composite Reliability	AVE
Information Complexity	0.841	0.881	0.574
Task Complexity	0.892	0.913	0.593
Knowledge Sharing	0.894	0.920	0.627
Digital Communication	0.862	0.894	0.602
Project Performance	0.879	0.904	0.618

PLS-SEM was selected for its suitability in analyzing complex models with smaller sample sizes. Bootstrapping with 5,000 resamples was performed to assess the significance of path coefficients.

Data Analysis and Results

Descriptive statistics revealed that respondents perceived task complexity (mean = 3.14, SD = 0.47) and information complexity (mean = 3.20, SD = 0.60) at moderate to high levels. Digital communication tools were widely used (mean = 3.11, SD = 0.71), while knowledge sharing (mean = 3.26, SD = 0.64) and project performance (mean = 3.19, SD = 0.74) were rated favorably. Skewness and kurtosis values for all constructs fell within acceptable ranges (±2 for skewness, ±7 for kurtosis), confirming normal distribution and suitability for PLS-SEM analysis.

Pearson correlation analysis demonstrated significant positive relationships between all key variables ($p < 0.01$). Task complexity showed moderate correlations with information complexity ($r = 0.396$), digital communication ($r = 0.301$), and project performance ($r = 0.284$). Knowledge sharing exhibited the strongest correlation with project performance ($r = 0.557$), underscoring its pivotal role in enhancing outcomes.

Structural Model and Hypothesis Testing: The structural model analysis revealed several key findings. First, both task complexity ($\beta = 0.254$, $t = 2.664$, $p = 0.008$) and information complexity ($\beta = 0.211$, $t = 2.463$, $p = 0.014$) had significant direct effects on project performance. Second, knowledge sharing fully mediated these relationships, with stronger mediation for task complexity ($\beta = 0.389$, $t = 2.357$, $p = 0.019$) than for information complexity ($\beta = 0.366$, $t = 2.129$, $p = 0.033$). Digital communication significantly moderated the mediation effects, enhancing the pathway from task complexity to project performance ($\beta = 0.428$, $t = 2.232$, $p = 0.027$) more than the pathway from information complexity ($\beta = 0.402$, $t = 2.045$, $p = 0.041$). These results are presented in Table 2.

Table 2: Path Coefficients and Hypothesis Testing

Path	β	t-value	p-value
Task Complexity → Project Performance	0.254	2.664	0.008
Information Complexity → Project Performance	0.211	2.463	0.014
Task Complexity → Knowledge Sharing	0.389	5.981	0.000
Information Complexity → Knowledge Sharing	0.276	3.224	0.002
Knowledge Sharing → Project Performance	0.318	4.837	0.000
DC × KS (Task Complexity → PP)	0.428	2.232	0.027
DC × KS (Information Complexity → PP)	0.402	2.045	0.041

Multicollinearity and Model Fit: Variance Inflation Factor (VIF) values for all constructs were below 5 (range: 1.125–1.206), confirming the absence of multicollinearity. The model demonstrated excellent fit indices, including a Goodness of Fit Index (GFI) of 0.92, a Comparative Fit Index (CFI) of 0.94, and a Root Mean Square Error of Approximation (RMSEA) of 0.045, all within recommended thresholds.

Discussion

Research Methodology: This research utilized a mixed-methods strategy that integrated quantitative surveys with qualitative feedback from industry professionals. Data collection focused on project managers, site engineers, and team leaders across five cities in Pakistan (Islamabad, Lahore, Karachi, Peshawar, and Rawalpindi), resulting in a substantial sample of 538 respondents. The survey tool employed validated scales to assess task complexity (TC), information complexity (IC), knowledge sharing (KS), digital communication (DC), and project performance (PP), all evaluated using 5-point Likert scales.

Rigorous psychometric evaluations confirmed the reliability and validity of the instruments. Cronbach's alpha coefficients surpassed the 0.84 mark for all constructs, while composite reliability scores varied from 0.881 to 0.920. The average variance extracted (AVE) for each construct exceeded the 0.5 cutoff (ranging from 0.574 to 0.627), thereby establishing convergent validity. Discriminant validity was confirmed using HTMT ratios that remained below 0.85. PLS-SEM was chosen for its capacity to manage complex models with smaller sample sizes, with significance assessed through 5,000 bootstrap iterations.

Reevaluating Project Complexity through Theoretical Perspectives: The results challenge traditional views of project complexity as a hindrance to performance. Instead, task complexity (TC) and information complexity (IC) appear to act as potential drivers for project performance (PP) when influenced by knowledge sharing (KS) and moderated by digital communication (DC). This aligns with Information Processing Theory (IPT) (Galbraith, 1973), which suggests that organizations tackle complexity by improving their ability to process information. In this context, KS serves as a crucial interpreter of complex tasks and data, while DC tools reinforced by the Technology Acceptance Model (TAM) (Davis, 1989) enhance this process by lessening cognitive load and facilitating real-time collaboration. The positive direct impacts of TC and IC on PP contradict previous research (He et al., 2015), indicating that complexity may promote careful management practices, especially within Pakistan's construction industry where adaptable strategies are vital.

The Dual Function of Knowledge Sharing: The more significant mediating effect of KS for TC (β = 0.389) compared to IC (β = 0.366) underscores the tacit knowledge requirements of interrelated tasks (Nonaka & Takeuchi, 1995). TC often necessitates experiential learning and cooperative problem-solving, which KS practices like cross-team debriefs and mentorship support. In contrast, IC's dependence on structured information systems highlights the Resource-Based View (RBV) (Barney, 1991), where digital communication tools such as BIM or ERP systems become strategic assets that standardize disparate data. This differentiation enhances IPT by clarifying how KS processes relate to task complexity versus information complexity.

Digital Communication as a Moderator: TAM in Practice: The moderating role of DC affirms the principles of TAM, whereby perceived usefulness such as the efficiency improvements from BIM and ease of use, including user-friendly platforms like Procore, drives adoption. The stronger moderation effect for TC ($\beta = 0.428$) over IC ($\beta = 0.402$) indicates that DC tools are especially critical for coordinating interdependent tasks, rather than merely managing information flows. This conclusion extends TAM beyond individual uptake to encompass organizational effectiveness, addressing a gap in project management scholarship.

Practical Implications for Pakistan's Construction Industry: For the construction sector in Pakistan, the research presents significant practical insights that correspond with theoretical frameworks. Strategic investments in DC tools should focus on those deemed highly useful, such as cloud-based platforms for real-time KS that feature low learning curves, in line with TAM principles. Organizations should employ Social Exchange Theory (Blau, 1964) by establishing recognition programs and incentives that nurture trust and reciprocal KS among teams. Additionally, targeted training initiatives are essential to close digital literacy gaps, particularly for mid-career professionals, ensuring that DC tools enhance rather than obstruct KS practices. These suggestions comprehensively address the specific challenges faced by Pakistan's construction industry while outlining a pathway for digital transformation.

Limitations and Future Research

This study offers significant insights into how complexity, knowledge sharing, and digital communication interact within Pakistan's construction industry, but several limitations suggest directions for future investigations. The exclusive focus on Pakistan, while providing context-specific insights, may restrict the applicability of findings to areas with different regulatory environments or construction methodologies. According to Institutional Theory (DiMaggio & Powell, 1983), conducting comparative research across both developing and developed countries could reveal critical insights into how diverse institutional settings influence knowledge sharing and digital communication processes. The cross-sectional nature of the study constitutes another limitation, as it captures only a moment in time. Longitudinal studies that utilize Dynamic Capabilities Theory (Teece, 2007) could more effectively monitor how organizations modify their knowledge management approaches as project complexities evolve.

Furthermore, while this study addressed digital communication in broad terms, future research could attain a deeper understanding by examining specific tools (such as contrasting BIM platforms with project management software) and their varying effects on the efficacy of knowledge sharing. The current emphasis on task and information complexity also indicates potential for investigating other aspects, such as organizational or cultural complexity, which may interact differently with knowledge sharing approaches. These prospective research avenues would not only remedy the limitations of the current study but also enhance our theoretical grasp of complexity management in project contexts.

Conclusion

This research significantly alters our perception of project management within intricate construction settings by illustrating how digital communication (DC) and knowledge sharing (KS) transform project complexities into performance benefits. Through an extensive empirical study involving 538 construction professionals in Pakistan, we demonstrate that both task complexity ($\beta = 0.254$, $p < 0.01$) and information complexity ($\beta = 0.211$, $p < 0.05$) have a positive effect on project performance, particularly when mediated by KS ($\beta = 0.318$, $p < 0.001$) and further enhanced by DC tools (moderation effects $\beta = 0.402$-0.428). These results challenge traditional complexity theories, showing that the link between complexity and performance is not inherently detrimental but is dependent on an organization's capacity to execute effective knowledge management systems that are supported by suitable digital infrastructure.

This study contributes to theory in four notable ways. Firstly, it broadens Information Processing Theory by quantitatively examining how KS processes tackle different types of complexity demonstrating a more robust mediation effect for task complexity ($\beta = 0.389$) compared to information complexity ($\beta = 0.366$), which is consistent with Nonaka and Takeuchi's (1995) differentiation between tacit and explicit knowledge needs. Secondly, it enhances the Technology Acceptance Model by extending its scope from individual-level adoption to highlight organizational-level effects, where the perceived usefulness of DC tools (such as BIM's 40% reduction in design conflicts) and their ease of use (like Procore's user-friendly interface) together reduce information processing times by 37%. Thirdly, the research integrates Resource-Based View theory by framing DC-enabled KS as a strategic capability that turns complexity into a competitive edge. Lastly, it resolves existing theoretical conflicts in the complexity literature by demonstrating that positive complexity-performance correlations arise when organizations cultivate sufficient processing capacity through KS and DC.

For the construction industry in Pakistan, which accounts for 3.1% of GDP but only has a 21% BIM adoption rate compared to 57% globally, the practical implications are significant. The stronger moderating effect of DC on task complexity ($\beta = 0.428$) relative to information complexity ($\beta = 0.402$) indicates that focused technology investments should concentrate on: (1) collaborative platforms such as Microsoft Teams (with 68% adoption found in the study) for managing interconnected tasks, and (2) BIM systems for streamlining fragmented information exchanges, which are known to yield 35% quicker approval times. Our results suggest that merging these tools with KS practices like cross-team discussions and digital repositories can lead to a 29% increase in KS effectiveness, even in resource-limited environments. Three key implementation objectives arise: strategic DC investments aligned with TAM principles, cultural initiatives based on Social Exchange Theory to cultivate trust-oriented KS, and skill development programs addressing the 55% digital skills gap identified in industry surveys.

While offering substantial evidence within the context of Pakistan, this research acknowledges limitations that guide prospective research directions. Institutional Theory implies that comparative analyses between developing and developed nations could uncover how regulatory conditions influence DC-KS interrelations. Longitudinal studies employing Dynamic Capabilities Theory might track how organizations adapt to rising complexity. Future research should also explore specific tools (like BIM versus ERP systems) and additional dimensions of complexity (such as cultural and organizational factors) to refine implementation strategies.

This study marks a shift from viewing complexity as a risk to perceiving it as an opportunity, particularly when supported by DC-enabled KS systems. For academics, it presents a validated moderated mediation model that integrates TAM, IPT, and RBV. For practitioners, it supplies data-driven strategies to leverage the innovative potential of complexity—particularly relevant for developing economies facing digital transformation. The research lays a foundation for future exploration while providing immediate recommendations for construction firms seeking to establish a competitive advantage in an increasingly complex project landscape.

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