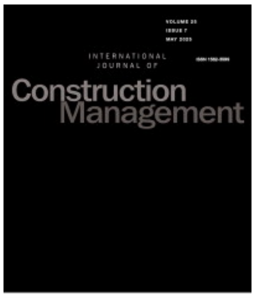

International Journal of Construction Management

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tjcm20

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To cite this article: Francis Kwesi Bondinuba, Noela Bondinuba, Cecilia Modupe Mewomo, Glybet Camynta-Baezie & Haruna Domanamwin Abudu (16 Apr 2025): Building collaborative advantage: exploring innovative stakeholder engagement models for construction project success, International Journal of Construction Management, DOI: 10.1080/15623599.2025.2488922

To link to this article: https://doi.org/10.1080/15623599.2025.2488922

Published online: 16 Apr 2025.

INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT
https://doi.org/10.1080/15623599.2025.2488922

Building collaborative advantage: exploring innovative stakeholder engagement models for construction project success

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ABSTRACT

This research examines the influence of innovative stakeholder engagement models and collaborative advantages on the success of construction projects. The study utilised Structural Equation Modeling *via* Smart PLS on 250 questionnaires distributed to construction industry stakeholders. 213 valid responses were obtained, assessing the relationship between innovative stakeholder engagement models and collaborative advantages in project success. Hypotheses were tested, and the constructs' validity and reliability were evaluated. The study indicates that innovative stakeholder engagement models indirectly affect the success of construction projects through collaborative advantages, with stakeholder engagement facilitating the transformation of these strategies into positive project outcomes. The research concludes that innovative engagement models, supported by collaborative advantages and stakeholder engagement, are vital for project success. It emphasises the importance of prioritising these factors instead of merely depending on innovative practices. Practitioners should employ collaborative tools, advanced technologies, and participatory planning to strengthen stakeholder engagement, trust, and collaboration in construction projects, while future research should examine cross-cultural interactions. The study explores the correlation between innovative practices and stakeholder involvement in construction projects, highlighting collaborative benefits for success. It identifies gaps in existing literature and suggests the need for future research using longitudinal methodologies to evaluate the long-term effects across different cultural and organisational contexts.

ARTICLE HISTORY
Received 1 January 2025
Accepted 29 March 2025

KEYWORDS
Collaborative advantage; construction project success; innovative stakeholder engagement; models

Introduction

The construction sector faces challenges like delays, budget overruns, and stakeholder failures, which hinder project success, reduce efficiency, and compromise sustainable project results, leading to diminished profitability (Ali and Haapasalo 2023). Stakeholder engagement is crucial for overcoming challenges and facilitating effective planning, resource allocation, and conflict resolution (Bahadorestani et al. 2020). Innovative engagement models are gaining attention for their ability to enhance collaboration and project goals by utilizing new tools, technologies, and methodologies to improve communication, trust, and stakeholder satisfaction (Willis and Alves 2019).

Conventional stakeholder engagement methods often lack the necessary innovation to address contemporary construction projects' evolving and intricate demands (Osunsanmi et al. 2020). Consequently, projects often exceed their defined scope, budget, and timeline, and understanding innovative engagement models and collaborative benefits is limited to enhancing construction project outcomes (Maddaloni and Davis 2017). Bridging this gap necessitates comprehensively examining the interactions among stakeholder engagement, innovative models, and collaborative practices. This research explores the impact of stakeholder engagement and innovative engagement models on construction project success, analyzing how collaborative advantages enhance the connection between these models and project outcomes, and identifying key factors affecting stakeholder engagement, innovative models, and collaborative advantages within construction projects (Bryson et al. 2016; Ardhiansyah et al. 2023).

Innovative engagement models in industries like healthcare, technology, and manufacturing improve collaboration, project outcomes, and stakeholder relationships, particularly in the construction industry, overcoming challenges like miscommunication and conflicting goals (Xie et al. 2025). The construction sector is embracing innovative stakeholder engagement models, utilizing digital technologies, data-driven decision-making, and inclusive frameworks like Building Information Modeling (BIM) and Virtual Reality (VR), to enhance project design and collaboration (Shehadeh et al. 2025).

Research in construction management shows that digital tools and collaborative frameworks can enhance stakeholder trust, reduce delays, and increase satisfaction among project owners, contractors, and end users (Dolla et al. 2023). Advancements in

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social media and communication platforms are enhancing stakeholder engagement, promoting diverse voices, and boosting project buy-in throughout the project lifecycle (Ebekozien et al. 2025). The literature emphasizes the need for a more integrated, collaborative strategy in modern construction projects, which not only improves project outcomes but also fosters long-term, sustainable relationships with stakeholders, ultimately enhancing project success (Larsson and Larsson 2020).

The research examines the effectiveness of innovative stakeholder engagement models in successfully executing construction projects, emphasising strategies that promote project goals, budget compliance, stakeholder satisfaction, and long-term sustainability (Xue et al. 2018). The study aims to enhance stakeholder management in the construction sector by recommending innovative engagement techniques such as collaborative contracting and the implementation of Construction 4.0 technologies, which encourage collaboration and improve project outcomes (Willis and Alves 2019). Furthermore, this research offers key policy recommendations for advancing collaborative methods and ensuring that stakeholder interests align with project objectives (Mokoena et al. 2023). Following this introduction, the study is structured into six sections: the concept of innovative engagement models in the construction industry, the research approach, data analysis and results, a discussion of the findings, implications for policy, research, and practice, and the conclusion of the study.

Concept of innovative engagement models in the construction industry

The emergence of innovative engagement models within the construction sector signifies a departure from conventional, hierarchical frameworks of stakeholder participation toward more inclusive and technology-oriented strategies. These models enhance communication, collaboration, and trust among stakeholders in construction projects, bridging gaps between project goals and stakeholder expectations. They incorporate advanced tools and methodologies, ensuring project success (Bryson et al. 2016; Poirier et al. 2016; Osunsanmi et al. 2020). Proactive stakeholder engagement is crucial for successful construction projects, as it addresses interests, expectations, and concerns, mitigates risks, and enhances decision-making quality. Projects with strong stakeholder involvement show improved performance, increased trust, and higher satisfaction levels (Maddaloni and Davis 2017; Ali and Haapasalo 2023). Stakeholders' active participation in planning stages is crucial for aligning project objectives with expectations, providing valuable insights, anticipating challenges, and formulating effective solutions. This strategy fosters a sense of ownership and commitment among stakeholders, ensuring the project's success (Poirier et al. 2016; Bahadorestani et al. 2020).

According to Misnan et al. (2024), innovative engagement strategies in the construction industry are designed to address the inefficiencies and conflicts of traditional project management and promote a more integrated, collaborative environment where all stakeholders can actively participate in decision-making and project success. The transition from linear management to participatory methods marked the beginning of stakeholder engagement in the construction industry. Formal communication between contractors and stakeholders was the main focus of early strategies (Kliem 2021). However, strategies changed to include more collaborative frameworks as the industry realised how crucial collaboration was to lowering risks, enhancing quality, and meeting deadlines. From the very beginning of the project, real-time collaboration between various stakeholders is made possible by tools such as Building Information Modeling (BIM) and Integrated Project Delivery (IPD) (Wagh and Vyas 2024).

Engagement models that emphasize cooperative value creation among all stakeholders have been greatly impacted by the growth of co-creation in the construction industry. Innovative engagement models have been shaped by co-creation research, which shows that early stakeholder involvement in design and decision-making aligns with needs and expectations and improves project outcomes (Alshukri et al. 2024). Co-creating values-in-use in housing development projects and infrastructure development programs has been studied by Liu et al. (2019) and Candel et al. (2021). They discovered that involving stakeholders early on can improve stakeholder collaboration, generate shared value, and avert disputes later on. In addition to improving decision-making and raising satisfaction levels for all stakeholders, this strategy guarantees alignment with project goals. One strategy used in the construction industry to encourage cooperation among stakeholders is exploitative learning. This method enhances knowledge sharing, problem-solving, and the development of new competencies within the project team, according to Liu et al. (2021). Better project results and overall project success follow from this. The study draws attention to how creative engagement models are becoming more and more prevalent in the construction industry, especially in the use of digital tools and teamwork. Successful project outcomes in a rapidly changing environment depend on a shift toward co-creation and learning-based approaches.

Stakeholder engagement relies on clear, consistent, and transparent communication. This minimizes misunderstandings, builds trust, and keeps stakeholders informed about project progress. Customizing communication strategies to meet specific needs, such as regular updates or interactive platforms, enhances collaboration and reduces conflicts (Galli 2020). Integrating advanced technologies, including Building Information Modeling (BIM), project management software, and cloud-based systems, has transformed the landscape of stakeholder engagement (Mostafa et al. 2020; Brahmi et al. 2022). These technologies enable real-time communication, optimise workflows, and enhance coordination among various project teams.

Furthermore, collaborative tools not only boost efficiency but also empower stakeholders to actively participate in achieving project objectives (Chasanidou et al. 2016; Willis and Alves 2019). Trust is crucial for effective collaboration and stakeholder relationships. It reduces resistance to innovative approaches, enhances information sharing, and fosters a culture of mutual respect and accountability, leading to improved coordination and performance in projects (Strahorn et al. 2017).

Innovative engagement strategies, such as co-creation and participatory budgeting, have been proven effective in improving project outcomes by fostering a shared sense of responsibility and alignment with project objectives among stakeholders. Participatory budgeting allows stakeholders to influence resource distribution, ensuring transparency and prioritising essential project components. It fosters consensus, increases stakeholder satisfaction, and improves project performance (Bryson et al. 2016; Osunsanmi et al. 2020).

Stakeholders' willingness to adopt advanced technologies like virtual reality, blockchain, and artificial intelligence is crucial for maximising the potential of these innovative engagement strategies. This enhances stakeholder comprehension and approval during the planning phase. Blockchain technology enhances transaction transparency, while AI streamlines decision-making, but successful integration depends on stakeholders' innovation readiness and adequate training and resources (Maghsoudi et al. 2016; Willis and Alves 2019). Collaborative contracting methods like integrated project delivery (IPD) and public-private partnerships (PPP) align stakeholders' interests, encourage shared accountability, and minimise conflicts. IPD focuses on collective decision-making and transparent risk-sharing. PPP leverages public and private sectors' strengths for innovation and resource allocation, fostering a collaborative atmosphere for successful construction projects (Xue et al. 2018; Willis and Alves 2019).

The involvement of local community stakeholders significantly influences the success of projects. This ensures initiatives are tailored to local needs and expectations, minimising opposition and promoting acceptance. Active participation also enhances social license and strengthens community relationships. Strategies for fostering community involvement include public consultations, surveys, and participatory planning workshops (Maddaloni and Davis 2017; Bahadorestani et al. 2020). Innovative engagement strategies can optimise project timelines by improving coordination and minimising delays. Building Information Modeling (BIM) offers real-time updates and efficient scheduling, while participatory planning addresses stakeholder concerns early. These strategies mitigate delay risks and ensure timely project completion by addressing stakeholder concerns (Chasanidou et al. 2016; Blagovisny et al. 2019; Mostafa et al. 2020).

The success of a construction project is determined by its achievement of objectives such as scope, quality, and functionality, which are crucial for meeting stakeholders' expectations and achieving project goals. Innovative engagement models help clarify project aims, align stakeholder priorities, and address potential issues, resulting in superior outcomes (Maghsoudi et al. 2016; Ali and Haapasalo 2023). Compliance with project timelines is crucial for maintaining stakeholder trust and preventing financial and operational disruptions. Innovative engagement strategies like real-time monitoring systems and collaborative planning can minimise delays and improve team coordination. Active stakeholder involvement promotes efficient decision-making processes, ensuring timely project completion (Blagovisny et al. 2019; Bahadorestani et al. 2020).

Cost overruns in the construction sector pose a significant issue due to inadequate communication, rework, and unforeseen complications. To address these challenges, effective collaboration and stakeholder trust are essential. Advanced methodologies such as integrated project delivery and participatory budgeting enable stakeholders to make informed decisions, optimise resource allocation, mitigate financial risks, and adhere to budgetary constraints (Willis and Alves 2019; Daboun et al. 2023). Stakeholder satisfaction, shaped by their perception of listening, value, and responsiveness, is vital for project success. Engagement strategies that emphasise open communication, inclusive decision-making, and collective accountability enhance stakeholder satisfaction, leading to more effective and improved project execution (Maddaloni and Davis 2017; Galli 2020). Moreover, sustainability extends beyond project completion, encompassing its long-term value, functionality, and role in achieving environmental and social objectives. Engagement practices prioritising sustainability include innovative, environmentally friendly designs, aligning the project with broader societal and regulatory standards, and enhancing its relevance (Bahadorestani et al. 2020; Oke 2022).

Collaborative advantages encompass the benefits derived from effective teamwork and the alignment of goals among participants in construction projects. These benefits are further enhanced by adopting innovative engagement models that cultivate trust, harmonise interests, and establish mutual accountability. By prioritising collaboration, construction firms can streamline operations, mitigate risks, and improve overall project outcomes (Bryson et al. 2016; Willis and Alves 2019). Collaboration strengthens competitive positioning by encouraging a cohesive response to project challenges and opportunities, allowing stakeholders to pool resources, share knowledge, and align objectives, thereby enhancing project results. Such advantages are particularly crucial in complex, large-scale construction ventures, where diverse stakeholder contributions can drive innovation and efficiency (Maddaloni and Davis 2017; Xue et al. 2018). The effectiveness of collaboration hinges on clear communication, mutual respect, and coordinated actions among stakeholders, enabling seamless cooperation to achieve project goals and minimise conflicts and inefficiencies. Tools such as Building Information Modeling (BIM) and collaborative project management software significantly improve stakeholder interactions, fostering transparency and integration in the working environment (Chasanidou et al. 2016; Strahorn et al. 2017; Brahmi et al. 2022).

Long-term stakeholder relationships are crucial for successful collaborative projects. Trust-based approaches (Bondinuba et al. 2016) and ongoing engagement foster strong partnerships beyond individual initiatives. These relationships improve project outcomes by facilitating effective negotiations, expediting conflict resolution, and aligning stakeholder interests (Bahadorestani et al. 2020; Daboun et al. 2023). Collaboration significantly reduces project costs by addressing inefficiencies, delays, and disputes. It reduces resource waste and facilitates timely decision-making. Collaborative contracting approaches like integrated project delivery promote transparency and equitable risk distribution, making them advantageous for cost management (Willis and Alves 2019; Mokoena et al. 2023).

Furthermore, Collaboration in construction projects fosters innovation by leveraging the collective expertise and creativity of diverse stakeholders, fostering open communication and shared learning, and incorporating advanced technologies and sustainable practices into complex project challenges (Maghsoudi et al. 2016; Osunsanmi et al. 2020; Vosman et al. 2023).

Conceptual framework and hypotheses

The research is underpinned by a conceptual framework designed to elucidate the relationships among Stakeholder Engagement, Innovative Engagement Models, Collaborative Advantage, and the success of construction projects. These latent variables are central to the investigation and are defined through specific, quantifiable dimensions. The framework suggests that both stakeholder engagement and innovative engagement models exert direct and indirect effects on collaborative advantage, subsequently influencing the success of construction projects. Stakeholder Engagement is a critical foundation, incorporating elements such as the significance of stakeholder involvement, participation in planning processes, the efficacy of communication strategies, the utilisation of collaborative tools, and the establishment of trust among stakeholders. These components underscore the importance of active stakeholder participation and aligning their interests to foster collaboration and achieve project success.

Furthermore, Innovative Engagement Models enhance stakeholder collaboration by integrating methods and tools. They consider factors like project outcomes, technology readiness, collaborative contracting effectiveness, community stakeholder involvement, and project timeline implications. These dimensions emphasize the importance of innovation in improving stakeholder interactions and promoting operational efficiency.

Collaborative Advantage is a mediating variable that signifies the additional value of effective collaboration among various stakeholders. The concept emphasizes the importance of collaborative advantage, stakeholder interactions, relationship development, project expenditures, and innovation promotion. It links engagement models to project success, highlighting its role in fostering shared objectives and innovation. Ultimately, Construction project success is determined by evaluating factors like goal fulfillment, timeline adherence, budget compliance, stakeholder satisfaction, and long-term effects. It is determined by the combination of stakeholder engagement, innovative approaches, and collaborative advantages.

The research hypotheses are formulated to investigate the interrelations among the primary latent variables: Innovative Engagement Models, Stakeholder Engagement, Collaborative Advantages, and Construction Project Success. These hypotheses embody the theoretical relationships outlined in the conceptual framework and seek to empirically assess the connections among these constructs. Innovative engagement frameworks, which include mechanisms such as participatory budgeting, virtual reality, and collaborative contracting, are suggested to improve the efficacy of stakeholder involvement. Such effective engagement serves as a facilitator, enhancing the beneficial effects of these innovative models on project results by promoting trust, participation, and communication.

H1: *The effectiveness of stakeholder engagement mediates the relationship between innovative engagement models and construction project success.*

Collaborative advantages, including enhanced coordination, reduced costs, and increased innovation, are posited to mediate the connection between innovative engagement models and project success. This implies that although innovative models may trigger transformations, their genuine worth manifests through the bolstered collaboration among involved parties.

H2: *Collaborative advantages mediate the relationship between innovative engagement models and construction project success.*

Innovative engagement models are crucial to the success of construction projects. They enhance the efficiency of planning, execution, and coordination among stakeholders, facilitating more streamlined workflows, minimising delays, and improving the alignment of project objectives.

H3: *Innovative engagement models positively influence construction project success*

The degree of stakeholder engagement is essential in determining the success of construction projects. When stakeholders are actively involved, communication is clear, trust is nurtured, and alignment with project goals is attained. This alignment reduces conflicts and contributes to greater overall satisfaction.

H4: *Stakeholder engagement directly impacts the success of construction projects.*

Collaborative advantages are crucial to the successful execution of construction projects. Elements such as cost efficiency, enhanced innovation, and robust relationships among stakeholders contribute to increased effectiveness and sustainability, positioning collaboration as an essential factor in project delivery.

H5: Collaborative advantages contribute significantly to achieving construction project success.

Research approach

This research utilised a quantitative methodology to investigate the interconnections among Innovative Engagement Models, Stakeholder Engagement, Collaborative Advantages, and the success of construction projects. The selection of a quantitative framework was predicated on its capacity to systematically quantify variables and evaluate hypotheses through statistical methods, thereby offering empirical evidence for the proposed conceptual model. Data were primarily gathered through structured questionnaires administered to individuals within the construction sector. To validate the research instrument's clarity, relevance, and structure, a pilot study used 30 participants from diverse stakeholder categories, such as project managers, contractors, consultants, clients/owners, and other construction personnel. Insights from this preliminary study prompted modifications that improved the survey's effectiveness in capturing data pertinent to Innovative Engagement Models and Construction Project Success. Subsequently, the refined questionnaire was distributed to 250 participants, resulting in 232 completed responses. After thorough screening for completeness and consistency, 213 responses were deemed usable for analysis. The questionnaire employed a Likert scale to assess participants' perceptions of the constructs, facilitating a nuanced understanding of the relationships between innovative engagement models and project success (Emerson 2021).

Convenience sampling was utilised to collect responses from the intended population. This non-probability sampling method was chosen due to its practicality and efficiency in obtaining various viewpoints from stakeholders in the construction sector. While convenience sampling may restrict the generalizability of the findings, it facilitates the acquisition of significant insights that mirror the naturally occurring differences in stakeholder experiences (Emerson 2021). The target population included essential stakeholders such as project managers, contractors, consultants, clients/owners, and various construction workers, encompassing diverse roles within the construction industry.

The data collected were analysed through a dual approach, utilising Structural Equation Modeling (SEM) *via* Smart PLS software alongside descriptive statistical analysis conducted with SPSS. The selection of SEM was predicated on its capacity to assess intricate relationships among latent variables and to evaluate the hypotheses delineated in the conceptual framework. This analytical technique facilitated an in-depth exploration of the relationships among Innovative Engagement Models, Stakeholder Engagement, Collaborative Advantages, and Construction Project Success, yielding substantial empirical support (Schneider and Heath 2020). Concurrently, SPSS was utilised for descriptive statistical analysis to confirm the reliability and validity of the measurement scales. This process was critical in reinforcing the robustness of the findings and the credibility of the constructs integrated into the study. Collectively, these analytical strategies offered a thorough understanding of the dynamics associated with innovative engagement models and their influence on the success of construction projects.

The research utilised a measurement scale ranging from 'strongly disagree' to 'strongly agree,' with numerical values assigned from 1 to 5. The study focused on three latent constructs: Innovative Engagement Models, Stakeholder Engagement, Collaborative Advantages, and Construction Project Success in Ghana, represented by 20 items, as detailed in Table 1. These latent variables are conceptualised as first-order multidimensional constructs, each comprising ten measurement items adapted from previous research to align with the specific context of this study. The chosen items assess various dimensions of the constructs through measurement indicators, thus enabling a comprehensive evaluation that adheres to established methodologies in the academic literature.

Data analysis and results

This section delineates the analysis and outcomes of the study, emphasising critical elements of the data and their correspondence with the research objectives. It commences with a summary of participant demographics, underscoring their roles, experience, and other pertinent characteristics. An evaluation of the structural model's robustness and the sample size sufficiency follows to confirm the findings' validity and reliability.

Structural equation modeling (SEM) is a crucial tool for evaluating the quality of a model, with Partial Least Squares SEM (PLS-SEM) being particularly useful in construction management research. The R^2 value measures the predictive power of a model, with higher values indicating better fit and accuracy. Path coefficients represent the strength and direction of relationships between constructs, and statistical significance is typically tested using bootstrapping (Zeng et al. 2021). The f^2 effect size indicates the contribution of an independent variable to the explanation of the dependent variable. PLS-SEM uses the Q^2 value to measure predictive relevance, SRMR to measure model fit, CR and AVE to assess internal consistency and reliability, and AVE to measure convergent validity (Zeng et al. 2021). These criteria ensure that construction management models are not only statistically significant but also reliable and predictive in real-world settings.

Reliability and validity assessments are conducted for the constructs to verify internal consistency. The subsequent presentation includes the results of the analysis of latent variables as first-order constructs, fit indices of the conceptual model, and the relationships within the structural model. Lastly, a summary of the hypothesis testing results indicates whether each hypothesis has been supported or rejected. This thorough methodology ensures the findings are robust and consistent with the study's theoretical framework and research objectives.

Demography of participants

Table 2 offers a comprehensive overview of the diversity and representativeness of the sample. A substantial portion of the respondents were Project Managers (33.8%) and Consultants (33.3%), highlighting a notable presence of individuals engaged in project planning and execution. Contractors comprised 16.4% of the sample, while Clients/Owners (8.5%) and Others (8%) constituted smaller segments. The participants displayed a broad spectrum of professional experience, with 41.8% possessing between 5 and 10 years of experience and 33.3% with 11–20 years. A lesser segment (16.4%) had under 5 years of experience, while 8.5% had over 20 years. Regarding the annual revenues of the companies represented, half of the participants (50.2%) were affiliated with firms generating less than $1 million, followed by 33.3% from companies with revenues between $1 and $5 million. Smaller percentages were associated with larger firms, with 8% earning between $6 and $10 million and 8.5% exceeding $10 million.

Assessment of the structural model and sample size

The structural model utilised in this research was examined through SPSS and Smart PLS-SEM to investigate the interconnections among the primary constructs of Innovative Engagement Models, Stakeholder Engagement, Collaborative Advantages, and Construction Project Success. Structural Equation Modeling (SEM) was selected for its ability to analyse intricate relationships among various latent variables, thereby facilitating a thorough assessment of the factors that impact construction project results (Hair, Ringle, & Sarstedt 2011). Determining the sample size adhered to the recommendations set forth by Hair, Ringle, and Sarstedt (2011), which stipulate that the sample size should be no less than ten times the highest number of structural paths directed at any latent variable. In this investigation, 250 questionnaires were disseminated, yielding 232 valid responses and 213 after data screening. This figure surpasses the minimum requirement for SEM analysis, ensuring adequate statistical power for evaluating the structural model. The evaluation of the structural model was carried out in two distinct phases. Initially, the measurement model (outer model) was assessed to verify the reliability and validity of the constructs, confirming that the observed indicators accurately reflected the underlying latent variables. This assessment included checks for internal consistency reliability, convergent validity, and discriminant validity. Subsequently, the structural model (inner model) was analysed to scrutinise the relationships among the constructs, with a particular emphasis on the hypothesised pathways connecting Innovative Engagement Models, Stakeholder Engagement, Collaborative Advantages, and Construction Project Success. This analysis yielded insights into the strength and significance of these relationships, thereby providing a comprehensive understanding of how each construct contributes to achieving successful project outcomes.

Measurement of the model reliability and validity

This section examines the evaluation of the reliability and validity of the measurement model to confirm that the constructs employed in the structural model accurately reflect the variables of interest. Essential metrics such as internal consistency reliability, convergent validity, and discriminant validity were analysed. Reliability was assessed through Cronbach's Alpha, rho_A, and Composite Reliability (CR), while convergent validity was evaluated using the Average Variance Extracted (AVE). Discriminant validity was determined by the Heterotrait-Monotrait Ratio (HTMT) and the Fornell-Larcker Criterion, ensuring that each construct is sufficiently distinct from the others. Cronbach's Alpha, Composite Reliability, Average Variance Extracted, and Heterotrait-Monotrait Ratio are used to evaluate the validity and reliability of the suggested model, which yields a measurement model that is both reliable and valid (Cheung et al. 2024). Using Cronbach's Alpha (α) to assess internal consistency, the study found that all constructs were more reliable than acceptable, meaning that each construct's items are consistent and measure the desired dimensions (Izah et al. 2023). The findings from these assessments are detailed in the subsequent tables.

Table 1. Constructs and measurement items.

Construct	Code	Items	Measurement items	Source
Innovative engagement models	IEM1	Impact of innovative models on outcomes	Innovative engagement models positively influence project outcomes by fostering creativity and inclusiveness.	(Ali and Haapasalo 2023)
	IEM2	Willingness to adopt new technologies	Adopting new technologies enhances efficiency and enables stakeholders to contribute innovatively to projects.	(Osunsanmi et al. 2020)
	IEM3	Effectiveness of collaborative contracting	Collaborative contracts ensure the alignment of stakeholder goals, leading to better outcomes.	(Willis and Alves 2019)
	IEM4	Community stakeholder involvement	Active involvement of community stakeholders increases project success by addressing their specific needs and concerns.	(Maddaloni and Davis 2017)
	IEM5	Implications for project timelines	Assesses how innovative stakeholder engagement practices impact project timelines, including delays or acceleration.	(Blagovisny et al. 2019)
Stakeholder engagement	SE1	Importance of stakeholder engagement	Stakeholder engagement is crucial for ensuring project alignment with expectations and fostering collaboration.	(Bahadorestani et al. 2020)
	SE2	Stakeholder involvement in planning	Early stakeholder involvement in planning improves decision-making and reduces conflicts during project execution.	(Ali and Haapasalo 2023)
	SE3	Effectiveness of communication strategies	Clear and effective communication strategies facilitate better understanding and collaboration among stakeholders.	(Galli 2020)
	SE4	Use of collaborative tools	Digital tools improve efficiency and stakeholder interaction in project management.	(Chasanidou et al. 2016)
	SE5	Trust among stakeholders	Building trust among stakeholders ensures smoother collaboration and reduces resistance.	(Bondinuba et al. 2016; Strahorn et al. 2017)
Collaborative advantages	CA1	Importance of collaboration in projects	Collaboration enables shared expertise and resource pooling, which improves project outcomes.	(Xue et al. 2018)
	CA2	Quality of stakeholder collaboration	High-quality collaboration among stakeholders reduces project risks and enhances performance.	(Maddaloni and Davis 2017)
	CA3	Priority on relationship-building	Focusing on relationship-building ensures long-term engagement and project success.	(Daboun et al. 2023)
	CA4	Impact on project costs	Collaborative approaches help manage costs effectively by aligning stakeholder interests.	(Xue et al. 2018)
	CA5	Enhancement of innovation	Collaboration fosters innovation by encouraging knowledge-sharing and joint problem-solving.	(Maghsoudi et al. 2016)
Constructions project success	CPS1	Achievement of project objectives	Successful project management leads to the achievement of predefined goals and objectives.	(Ali and Haapasalo 2023)
	CPS2	Timeliness of project completion	Adherence to project schedules is a critical indicator of success.	(Blagovisny et al. 2019)
	CPS3	Budget adherence	Effective project management ensures that projects stay within budget limits.	(Mokoena et al. 2023)
	CPS4	Stakeholder satisfaction	Meeting stakeholder expectations enhances satisfaction and promotes future collaboration.	(Daboun et al. 2023)
	CPS5	Long-term project impact	Projects that achieve sustainable outcomes create long-term benefits for stakeholders and communities.	(Oke and Aigbavboa 2017)

Source: Authors Construct, 2024.

Table 3 outlines the reliability and convergent validity metrics associated with the examined constructs. The Cronbach's Alpha values range from 0.727 to 0.861, indicating an acceptable level of internal consistency reliability. Furthermore, all Composite Reliability (CR) values surpass the 0.7 benchmark, affirming robust reliability across the various constructs. The Average Variance Extracted (AVE) values also exceed the recommended threshold of 0.5, signifying adequate convergent validity. For example, the construct of Collaborative Advantages recorded an AVE of 0.607. In contrast, Construction Project Success attained the highest AVE of 0.645, confirming that the indicators effectively represent the underlying latent variables.

Table 4 analyses discriminant validity through the Heterotrait-Monotrait Ratio (HTMT). All HTMT values fall below the recommended threshold of 0.85, affirming the constructs' distinctiveness. For instance, the HTMT value between Collaborative Advantages and Construction Project Success is 0.786, suggesting a relationship between the constructs while maintaining their statistical separation. The highest HTMT value recorded is 0.811, observed between Innovative Engagement Models and stakeholder engagement, which still adheres to the acceptable criteria.

Table 5 assesses discriminant validity through the Fornell-Larcker Criterion. Each construct's square root of the Average Variance Extracted (AVE) surpasses its correlations with other constructs, confirming their uniqueness. For example, the square root of AVE for Collaborative Advantages is 0.779, greater than its correlation with Construction Project Success (0.668) and other constructs. Likewise, stakeholder engagement exhibits a square root of AVE of 0.782, which exceeds its correlation with Innovative Engagement Models (0.646), ensuring that the constructs are sufficiently distinct.

Results of the latent variables as first-order constructs

Table 6 provides an overview of the descriptive statistics and factor loadings associated with each measurement item linked to the latent constructs of Collaborative Advantages (CA), Construction Project Success (CPS), Innovative Engagement Models (IEM), and Stakeholders Engagement (SE). Each construct exhibits robust and dependable factor loadings, affirming the validity of their respective measurement items in assessing the underlying variables. For Collaborative Advantages (CA), the factor loadings range from 0.711 for CA1 to 0.833 for CA3, with all items surpassing the recommended threshold of 0.7. CA3 demonstrates the highest loading at 0.833, underscoring its pivotal role in encapsulating collaborative advantages, while CA1, with a loading of 0.711, remains within an acceptable range. The elevated T-statistics, such as 32.14 for CA3, alongside *p*-values of 0, further validate the significance of these loadings, reinforcing the integrity of the CA constructs. In the context of construction project success (CPS), factor loadings vary from 0.7 for CPS1 to 0.853 for CPS3. CPS3 and CPS4 present the most substantial contributions, with loadings of 0.853 and 0.85, respectively, highlighting their critical importance in defining project success. Although CPS1 has the lowest loading at 0.7, it still meets the inclusion threshold, ensuring the construct's reliability. T-statistics, such as 35.112 for CPS3, further substantiate the significance of these associations.

Regarding Innovative Engagement Models (IEM), factor loadings range from 0.66 for IEM4 to 0.799 for IEM2. While most items display acceptable loadings, IEM4's loading of 0.66 is the lowest, indicating a potential weakness in its relationship with the overall construct compared to other items. IEM5 was excluded due to insufficient performance, ensuring that only reliable indicators are retained in the model. For stakeholder engagement (SE), loadings range from 0.621 for SE1 to 0.832 for

Table 2. Respondents demographic characteristics.

Role	Frequency	Percent %
Project manager	72	33.8
Contractor	35	16.4
Consultant	71	33.3
Client/owner	18	8.5
Others	17	8
Total	213	100
Years of experience	Frequency	Percent %
Less than 5 years	35	16.4
5–10 years	89	41.8
11–20 years	71	33.3
More than 20 years	18	8.5
Total	213	100
Company's annual revenue	Frequency	Percent %
Less than $1 million	107	50.2
$1–5 million	71	33.3
$6–10 million	17	8
More than $10 million	18	8.5
Total	213	100

Source: Field data, 2024.

Table 3. Construct reliability and validity.

Construct	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted (AVE)
Collaborative advantages	0.837	0.84	0.885	0.607
Construction project success	0.861	0.868	0.9	0.645
Innovative engagement models	0.727	0.729	0.831	0.552
Stakeholders engagement	0.84	0.86	0.886	0.612

Source: Field data, 2024.

Table 4. Discriminant validity Heterotrait Monotrait—ratio (HTMT) matrix.

Construct	Collaborative advantages	Construction project success	Innovative engagement models	Stakeholders engagement
Collaborative advantages				
Construction project success	0.786			
Innovative engagement models	0.612	0.514		
Stakeholders engagement	0.524	0.534	0.811	

Source: Field data, 2024.

Table 5. Discriminant validity Fornell Larcker criterion.

Construct	Collaborative advantages	Construction project success	Innovative engagement models	Stakeholders engagement
Collaborative advantages	0.779			
Construction project success	0.668	0.803		
Innovative engagement models	0.475	0.411	0.743	
Stakeholders engagement	0.454	0.469	0.646	0.782

Source: Field data, 2024.

Table 6. Descriptive statistics of measurement variables and SEM factor loading.

	Original sample (O)					
	Initial	Final	Sample mean (M)	Standard deviation (STDEV)	T Statistics (|O/STDEV|)	P values
CA1	0.711	0.711	0.712	0.039	18.286	0
CA2	0.806	0.806	0.802	0.029	27.973	0
CA3	0.833	0.833	0.833	0.026	32.14	0
CA4	0.804	0.804	0.802	0.025	32.042	0
CA5	0.733	0.733	0.732	0.038	19.393	0
CPS1	0.7	0.716	0.716	0.043	16.763	0
CPS2	0.818	0.82	0.82	0.028	28.83	0
CPS3	0.853	0.851	0.849	0.024	35.112	0
CPS4	0.85	0.841	0.84	0.022	38.906	0
CPS5	0.785	0.779	0.775	0.037	21.051	0
IEM1	0.737	0.737	0.738	0.033	22.191	0
IEM2	0.799	0.799	0.799	0.03	26.971	0
IEM3	0.769	0.769	0.769	0.036	21.574	0
IEM4	0.66	0.66	0.657	0.043	15.396	0
IEM5	*Dropped*					
SE1	0.621	0.621	0.623	0.054	11.504	0
SE2	0.828	0.828	0.826	0.027	30.818	0
SE3	0.799	0.799	0.799	0.032	24.925	0
SE4	0.832	0.832	0.832	0.023	35.779	0
SE5	0.81	0.81	0.81	0.024	33.577	0

Very significant at $p < 0.001$. Source: Field data, 2024.

Table 7. Fit indices model.

	Saturated model	Estimated model
SRMR	0.073	0.081
d_ULS	1.018	1.236
d_G	0.354	0.36
Chi-Square	422.751	421.615
NFI	0.792	0.792
rms Theta	0.156	

Source: Field data, 2024.

SE4. Although SE1 has the lowest factor loading at 0.621, it remains above the minimum threshold, thereby supporting its inclusion in the analysis.

Results of fit indices

Table 7 illustrates the fit indices for both the saturated and estimated models, providing valuable insights into the overall efficacy of the model in accounting for the data. In Partial Least Squares Structural Equation Modeling (PLS-SEM), the fit assessment diverges from Covariance-Based SEM (CB-SEM) (Sarstedt et al. 2021). While CB-SEM focuses on achieving optimal fit indices, PLS-SEM emphasises predictive accuracy and variance explanation, often at the expense of strict fit criteria. Therefore, the fit indices presented here should be interpreted with care, as they primarily enhance understanding of the model's dynamics rather than as conclusive indicators of its quality.

The Standardized Root Mean Square Residual (SRMR) is crucial for assessing the difference between observed and predicted correlations (Shi et al. 2020). The saturated model yields an SRMR of 0.073, whereas the estimated model presents a slightly elevated SRMR of 0.081. Both Figures 1 and 2 are below the acceptable threshold of 0.10, suggesting a good fit and indicating minimal residual discrepancies within the models. The d_ULS (Unweighted Least Squares discrepancy) and d_G (Geodesic discrepancy) provide further insights into model discrepancies. The saturated model reports a d_ULS of 1.018 and a d_G of 0.354, while the estimated model shows marginally higher values of d_ULS (1.236) and d_G (0.36).

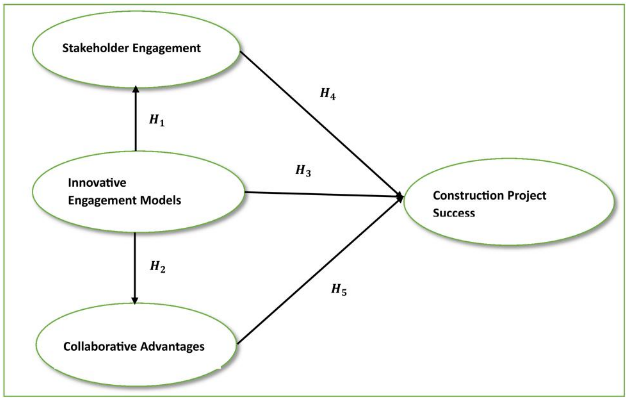

Figure 1. Conceptual framework and hypotheses. Source: Authors construct, 2024.

These findings imply slight differences in fit between the two models, with discrepancies remaining within acceptable limits for PLS-SEM.

The Chi-Square statistics for the saturated model (422.751) and the estimated model (421.615) are closely aligned, suggesting a consistent performance across the models. It is important to note that while χ values can be influenced by sample size and deviations from an ideal fit in covariance-based structural equation modelling (CB-SEM), in partial least squares structural equation modelling (PLS-SEM), these values primarily serve as benchmarks and do not possess the same level of diagnostic significance (Shengeza et al. 2023). The Normed Fit Index (NFI), which assesses the model's fit relative to a null model, is recorded at 0.792 for both models. Although this figure falls short of the recommended 0.9 threshold for CB-SEM, it remains acceptable within the PLS-SEM framework, where the emphasis is placed on predictive performance rather than strict adherence to fit indices. Finally, the RMS Theta, which assesses the residuals of the outer model, is reported at 0.156. While values below 0.12 are preferred for reflective models, in the context of exploratory research or PLS-SEM, slightly elevated values such as this can still be deemed acceptable, provided the model exhibits robust predictive capabilities.

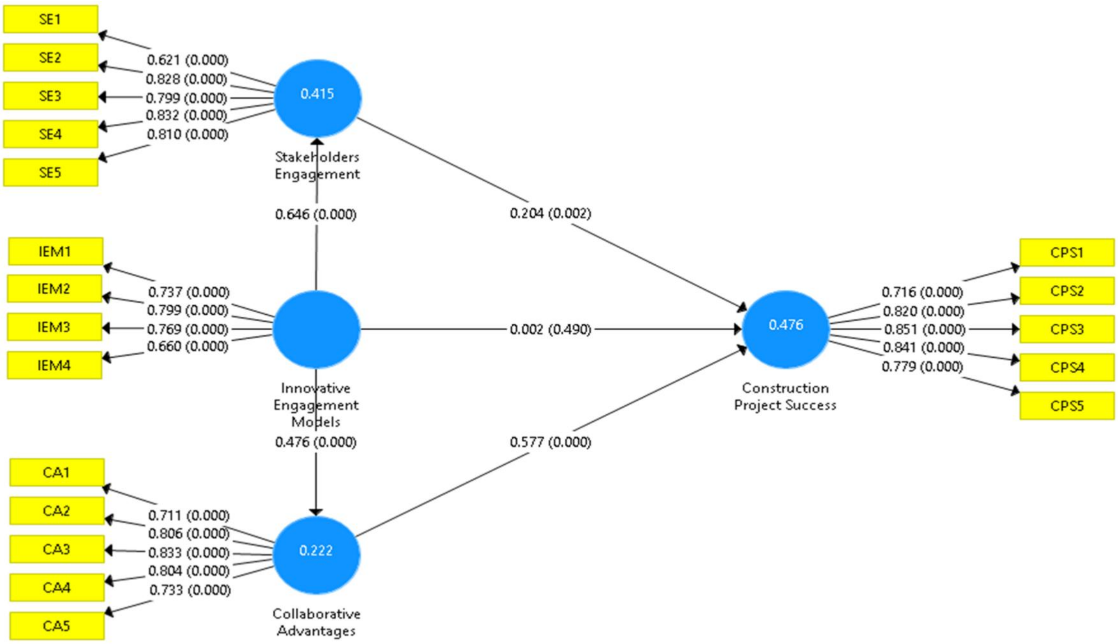

Figure 2. Structural model diagram: Results of hypothesis testing. Source: Field data, 2024.

Table 8. R^2 results.

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Collaborative advantages	0.226	0.234	0.054	4.184	0
Construction project success	0.484	0.494	0.038	12.853	0
Stakeholders engagement	0.417	0.424	0.052	8.03	0

Very significant at $p < 0.001$. Source: Field data, 2024.

Results of the structural model

Table 8 presents the R^2 values, which indicate the extent to which the independent variables account for the variance in the dependent constructs. Construction Project Success has the highest R^2 value, at 0.484, suggesting that 48.4% of its variance can be attributed to the independent constructs. This underlines the model's robust predictive ability. In contrast, Stakeholder Engagement and Collaborative Advantages have R^2 values of 0.417 and 0.226, respectively, reflecting moderate levels of predictive strength. Additionally, the elevated T-statistics and significant p-values further corroborate these results.

Summary of hypothesis testing

The findings indicate that stakeholder engagement (SE) serves as a mediator in the relationship between innovative engagement models (IEM) and construction project success (CPS), as evidenced by a substantial total indirect effect of IEM on CPS (0.406, $p = 0.000$). This suggests that, despite the direct effect of IEM on CPS being negligible (0.002, $p = 0.490$), its impact on CPS is effectively transmitted through SE, which exhibits a significant positive path coefficient towards CPS (0.204, $p = 0.002$). These results emphasise the critical role of SE in converting innovative engagement strategies into measurable project outcomes.

H1: *The effectiveness of stakeholder engagement (SE) mediates the relationship between innovative engagement models (IEM) and construction project success (CPS).*

Collaborative advantages (CA) play a significant mediating role in the relationship between IEM and CPS, as indicated by the robust and significant path coefficient from IEM to CA (0.476, $p = 0.000$) and from CA to CPS (0.577, $p = 0.000$). This mediation effect illustrates that IEM enhances CPS primarily by cultivating collaborative advantages, which emerge as the most potent direct predictor of CPS within the model. This relationship underscores the importance of collaboration-driven benefits in achieving success in construction projects.

H2: *Collaborative advantages (CA) mediate the relationship between innovative engagement models (IEM) and construction project success (CPS).*

Although the direct effect of IEM on CPS is not statistically significant (0.002, $p = 0.490$), the notable total indirect effect (0.406, $p = 0.000$) indicates that IEM positively affects CPS indirectly through its associations with SE and CA. This finding suggests that IEM does not directly contribute to project success but operates through intermediary constructs to influence outcomes. It highlights the interconnected pathways through which innovative engagement practices enhance project performance.

H3: *Innovative engagement models (IEM) positively influence construction project success (CPS).*

The engagement of stakeholders (SE) directly influences the success of construction projects, as demonstrated by a notable path coefficient from SE to CPS (0.204, $p = 0.002$). This finding suggests that the effective involvement of stakeholders in project activities positively affects project success. It emphasises the

Table 9. Summary of hypothesis testing.

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*p* values
CA ≥ CPS	0.577	0.581	0.058	9.923	0
IEM ≥ CA	0.476	0.481	0.056	8.432	0
IEM ≥ CPS	0.002	0.004	0.071	0.025	0.49
IEM ≥ SE	0.646	0.65	0.04	16.003	0
SE ≥ CPS	0.204	0.201	0.07	2.936	0.002
Total indirect effect					
IEM ≥ CPS	0.406	0.41	0.056	7.301	0

Very Significant at $p < 0.001$. Source: Field data, 2024.

importance of stakeholder participation in navigating project complexities and improving overall results in construction endeavours.

H4: Stakeholder engagement (SE) directly impacts the success of construction projects (CPS).

The robust and significant path coefficient from CA to CPS (0.577, $p = 0.000$) indicates that collaboration (CA) is crucial for the success of construction projects. This finding illustrates those collaborative advantages, including shared resources and effective partnerships, serve as the primary drivers of CPS within this framework. It highlights the strategic necessity of promoting collaboration to improve project outcomes, positioning CA as a vital facilitator of success in construction projects. (Table 9)

H5: Collaborative advantages (CA) contribute significantly to achieving construction project success (CPS).

Discussion of results

The findings offer valuable insights into the interconnections among innovative engagement models (IEM), stakeholder engagement (SE), collaborative advantages (CA), and the success of construction projects (CPS). Consistent with the research aims, it was determined that IEM does not directly influence CPS; rather, its impact is mediated by factors such as SE and CA. Stakeholder engagement was identified as a pivotal mediator in the relationship between IEM and CPS, underscoring its role in linking innovative approaches with project results. Furthermore, collaborative advantages were recognised as the most significant predictor of CPS, emphasising the importance of promoting collaboration to succeed in construction endeavours. These results affirm that both SE and CA are critical pathways for harnessing the advantages of innovative engagement strategies to improve project performance.

The variables that assess the impact of innovative models on project outcomes, the willingness to adopt new technologies, the efficacy of collaborative contracting, the engagement of community stakeholders, and the effects on project timelines collectively offer a thorough insight into their significance in construction projects. Osunsanmi et al. (2020) research underscores that integrating technologies such as virtual reality and Building Information Modeling (BIM) can greatly enhance decision-making processes and stakeholder comprehension, reinforcing the notion that a readiness to adopt technology is crucial. Similarly, Willis and Alves (2019) stress the significance of collaborative contracting frameworks, such as Integrated Project Delivery (IPD), which aligns with the findings of this study that effective contractual agreements promote collaboration and enhance project timelines. Nevertheless, the observation that IEM does not directly impact Collaborative Project Success (CPS) contrasts with some existing literature, indicating that the effectiveness of innovative practices is largely contingent upon stakeholder involvement and the benefits of collaboration rather than merely the adoption of new technologies.

The elements of stakeholder engagement (SE), such as the significance of stakeholder involvement, participation in planning processes, the efficacy of communication strategies, the application of collaborative tools, and the establishment of trust among stakeholders, are consistent with the prevailing academic discourse. Bahadorestani et al. (2020) highlight the necessity of early and proactive stakeholder participation in addressing conflicting interests, which aligns with the findings of this study that underscore the critical role of stakeholder engagement in the success of construction projects. Furthermore, Chasanidou et al. (2016) illustrate how using collaborative tools enhances communication and coordination, corroborating this study's conclusions regarding the beneficial impact of SE on construction project success (CPS). Strahorn et al. (2017) also highlight the importance of trust in cultivating robust project relationships, reinforcing that trust is a fundamental factor in achieving favourable outcomes in the construction sector.

The variables that assess Collaborative Advantage (CA), including the significance of collaboration, the quality of stakeholder relationships, the emphasis on relationship-building, the influence on project costs, and the promotion of innovation, highlight its position as the primary driver of Collaborative Project Success (CPS) in this investigation. Bryson et al. (2016) established that collaborative methodologies facilitate resource sharing, lower expenses, and encourage innovative solutions, which is consistent with the outcomes of this study. Likewise, Daboun et al. (2023) associate effective relationship management with project success, further underscoring the necessity of prioritising relationship-building as a fundamental aspect of CA. This research contributes to the existing body of knowledge by illustrating that CA is a mediator between Innovative Engagement Management (IEM) and CPS, thereby elucidating how collaboration transforms innovative practices into concrete project advantages.

The effectiveness of construction projects is evaluated through various metrics, including the attainment of project goals, compliance with schedules, budget adherence, stakeholder contentment, and long-term viability. Research by Ali and Haapasalo (2023) highlights the critical nature of aligning stakeholder expectations with project aims, which resonates with this study's findings that Stakeholder Engagement (SE) positively influences CPS. Oke and Aigbavboa (2017) examine the role of sustainability in enhancing long-term project value, reinforcing this study's assertion that CPS is a multifaceted construct that transcends immediate results. This research enhances the literature by demonstrating that, although multiple factors influence CPS, collaborative advantages remain the most crucial predictor.

Implications for policy, research, and practice

The research emphasises the importance of stakeholder engagement in the success of construction projects. It advocates for stakeholders' early and proactive involvement, promoting collaborative contracting approaches such as Integrated Project Delivery and incorporating advanced technologies, including Building Information Modeling (BIM) and cloud-based collaboration platforms. These practices foster innovation and facilitate sustainable outcomes in project execution, ensuring a harmonious environment for all parties involved. The study recommends future research on innovative stakeholder engagement frameworks within the construction sector. This could involve utilising advanced technologies like AI, blockchain, and virtual reality and exploring cultural and organisational barriers to their adoption. Longitudinal studies and comparative analyses could also yield valuable insights. This research indicates that practitioners in the construction industry can enhance project outcomes by improving stakeholder engagement practices, adopting collaborative tools such as BIM and project management software, building stakeholder trust, and employing innovative contracting methods like public-private partnerships and Integrated Project Delivery. These approaches encourage a more collaborative and innovative project environment.

The research aims to enhance the participation of stakeholders in managing construction projects using novel models and approaches. The research proposes a measurement model integrating stakeholder management, co-creation theory, and principles of project management. It broadens the scope of Liu et al. (2024) study of co-creation in infrastructure projects to commercial developments and residential houses, extending its insights on stakeholder engagement and project performance. The research emphasizes good engagement strategies and cooperative tools in construction projects, such as Building Information Modeling and Virtual Reality, regarding good communication and trust. The research suggests that trust, cooperation, and cooperative strategies should be the priority of project managers over risk management to improve outcomes and conflict avoidance. The research supports co-creation construction project management theories for improving stakeholder satisfaction and outcomes and suggests digital tools for long-term engagement, challenging the traditional behaviour of stakeholders.

The study emphasizes the need for ongoing research on stakeholder participation and coordination in construction, particularly on the use of digital technologies like BIM and VR.

Conclusion

This study investigated the interconnections among innovative stakeholder engagement models, collaborative advantages, and the success of construction projects. The results indicate that although innovative engagement models (IEM) do not have a direct impact on construction project success (CPS), they exert significant indirect influences through stakeholder engagement (SE) and collaborative advantages (CA). Notably, CA was identified as the most robust predictor of CPS, highlighting the essential role of collaboration in achieving favourable project outcomes. Furthermore, SE was recognised as a crucial mechanism for converting the potential of IEM into concrete benefits, emphasising the necessity of active participation, trust, and effective communication among stakeholders. These insights enhance the existing body of knowledge by elucidating the mechanisms through which innovative practices affect project success, enriching the literature and providing practical recommendations for the construction sector.

The practical implications of this research underscore the need to cultivate collaborative advantages and prioritise stakeholder engagement to optimise the effectiveness of innovative engagement strategies. Industry practitioners can enhance project performance and stakeholder satisfaction by implementing collaborative contracting, participatory planning, and leveraging advanced technologies. Additionally, policymakers can utilise the findings to develop guidelines that institutionalise these practices, ensuring compliance with industry standards and fostering sustainability in construction initiatives. Future research should examine the influence of novel technologies, including blockchain and artificial intelligence, on the engagement and collaboration of stakeholders. Furthermore, longitudinal research that evaluates the enduring effects of stakeholder involvement on the sustainability of projects would yield significant insights. Comparative analyses across various cultural and organisational settings could enhance the comprehension of the elements that foster collaborative benefits and project success. By delving into these domains, subsequent studies can expand upon the conclusions of this research, propelling the discipline of construction management forward and fostering more efficient stakeholder practices within the industry.

Acknowledgments

We would like to acknowledge all the respondents within the study areas for their support in this study. All authors have consented to the acknowledgment statement.

Informed consent statement

All participants in the study gave informed consent. Their information was secured with permission, and they were informed of the study's outcome, including the publication of the findings.

Disclosure statement

The authors whose names are listed immediately below certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants, participation in speakers' bureaus, membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript. Author names: The authors listed report affiliation or involvement in an organization or entity with a financial or non-financial interest in the subject matter or materials discussed in this manuscript.

Funding

The authors affirm that any financial or material assistance from any organization or individual did not support the research presented in this paper. This research was undertaken solely with our resources, and we maintain no financial or personal relationships with any entity that could have influenced the findings presented in this paper. We confirm that no conflicts of interest could have impacted the research or the results presented in this paper. This research was conducted with the utmost integrity and objectivity,

and the findings presented are based solely on the data collected and analyzed. We acknowledge the contributions of any individuals who assisted with the research but confirm that they did not receive any financial or material support for their contributions.

Data availability statement

Researchers interested in accessing the data must submit a request outlining their research intentions and how they plan to use the data. Access will be granted at the discretion of the research team, provided that the proposed use aligns with ethical research standards and respects the confidentiality of the participants.

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