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Evaluating procurement strategies for modular construction: a stakeholder-centred approach

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Abstract

Purpose – The construction industry is shifting towards modular construction to enhance efficiency, cost-effectiveness and sustainability. However, procurement strategies play a critical role in determining project success. This study aims to evaluate different procurement strategies suitable for modular construction and examine their influence on project outcomes, addressing existing gaps in stakeholder perspectives.

Design/methodology/approach – Data were gathered through elite virtual interviews with stakeholders across the modular construction sector. The interviewees included professionals with expertise in procurement, construction management and modular building systems. A thematic analysis was conducted to synthesise the insights from the interviews and secondary data sources.

Findings – The study identified various procurement strategies applicable to modular construction, including design and build, construction management, turnkey, cost-plus, public-private partnership (PPP) and joint venture. Findings suggest that procurement strategy selection significantly influences modular projects' cost, time, quality and risk management. Key barriers include fragmented supply chains, regulatory challenges, limited stakeholder collaboration and insufficient procurement standardisation. The study recommends integrated supply chain models, policy reforms, digital procurement tools and enhanced stakeholder engagement to enhance procurement efficiency.

Research limitations/implications – The study is limited to perceived procurement strategies in modular construction and influences on project outcomes based on semi-structured virtual interviews. Future research should further validate the findings through empirical case studies and quantitative assessments of procurement performance in modular construction projects.

Originality/value – This research examines how procurement practices affect stakeholder satisfaction, teamwork and long-term modular construction project success, unlike typical cost and time efficiency studies.

Keywords Procurement strategy, Modular construction, Design-build, turnkey, Reverse auction, Public-private partnership

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1. Introduction

The construction industry has long been criticised for inefficiencies, including cost overruns, delays and quality issues. Modular construction is a revolutionary solution to these problems, which entails producing building components offsite and assembling them on-site (Adekunle *et al.*, 2024a). Modular construction provides advantages, including shorter project schedules, better quality control and less waste by using standardised procedures and cutting-edge manufacturing techniques. However, using efficient procurement techniques that fit its particular needs and features is essential to deploy modular construction successfully (Hussein and Zayed, 2021). Procurement techniques are crucial throughout a construction project's lifecycle in deciding how resources are distributed, stakeholders are involved and risks are controlled. Even though modular construction is becoming increasingly popular, little is known about how procurement tactics affect project results. Van der Ham and Opdenakker (2021) argued that compared to traditional construction processes, procurement in modular construction is intrinsically more difficult. Excellent coordination across various stakeholders, including designers, manufacturers, contractors, suppliers and clients, is necessary to integrate offsite and onsite activities. Due to each stakeholder's different roles, interests and expectations, cooperation and communication are crucial to the project's success.

The collaborative requirements of modular construction may not be well met by traditional procurement methods, which frequently prioritise competitiveness and cost reduction (Wuni and Shen, 2020). As a result, procurement techniques need to be assessed and modified to fit this novel strategy better. This study attempts to bridge this gap by examining the viability of various modular construction procurement procedures and their effects on key project outcomes, such as cost-effectiveness, time savings, quality and stakeholder satisfaction. When assessing procurement techniques in modular construction, a stakeholder-centered approach is essential. Any construction project is propelled by its stakeholders, whose viewpoints, interactions and experiences significantly influence the project's outcome (Vuorinen and Martinsuo, 2019). For instance, contractors might concentrate on reducing onsite complexity, while manufacturers might prioritise early design choices to expedite production. On the other side, clients might value timely delivery and cost predictability. Developing procurement strategies that encourage cooperation, align goals and reduce conflicts requires understanding these various motivations (Otasowie *et al.*, 2024a). This study attempts to find procurement procedures that balance the interests of all parties and improve the overall effectiveness of modular building projects by taking a stakeholder-centred approach. In addition, risk management in modular construction is directly impacted by procurement techniques (Hsu *et al.*, 2019). Separating offsite and onsite activities introduces unique risks, such as delays in module transportation, discrepancies between design and production and coordination challenges during assembly. Effective procurement strategies must address these risks by fostering stakeholder transparency, accountability and flexibility.

This study investigates the effects of several procurement techniques on risk allocation and management in modular construction, including design-build (DB), framework agreements and public-private partnerships (PPPs). This work is crucial because it could help promote modular construction as an effective and sustainable substitute for conventional building techniques. This study will offer practical insights for industry experts and governments looking to maximise modular construction practices by assessing procurement strategies from stakeholders' viewpoints. Ultimately, the findings aim to bridge the gap between theoretical knowledge and practical application, paving the way for more effective

and collaborative procurement approaches in the modular construction sector. This will be achieved through the following:

(1) To evaluate the different procurement strategies suitable for modular construction.

(2) To evaluate the influence of the different procurement strategies on project outcomes.

2. Literature review

Procurement strategies are fundamental to achieving project success in the construction industry (Windapo *et al.*, 2022). These strategies provide the framework for acquiring goods, services and works from external sources, ensuring the seamless execution and delivery of projects. Traditionally, models like design-bid-build (DBB) and DB have been widely used. DBB separates the design and construction phases, allowing contractors to bid competitively after completing the design (Papajohn *et al.*, 2019). Conversely, DB integrates design and construction under one entity, offering faster delivery and reduced risks associated with miscommunication (Tran *et al.*, 2017). While effective in conventional construction, these approaches face limitations when applied to emerging methodologies like modular construction. Modular construction, characterised by off-site fabrication and on-site assembly, disrupts traditional workflows, requiring procurement strategies that support integration and collaboration across all stages (Adekunle *et al.*, 2023a). The sequential nature of DBB can hinder modular projects due to its lack of early contractor involvement and fragmented communication. Similarly, Khan *et al.* (2023) observed that while DB aligns more closely with modular construction, it may still fail to address the complex logistics, manufacturing precision and supply chain management intrinsic to modular methods. As modular construction evolves, procurement strategies must adapt by prioritising early collaboration, innovative contracting models and robust digital tools such as building information modelling (BIM). These adjustments ensure that procurement frameworks remain flexible and responsive to the distinctive demands of modular construction, driving efficiency and project success.

2.1 Traditional procurement approaches in modular construction

Traditional procurement methods, such as DBB, follow a linear and sequential process, where the design phase is completed before construction begins (Assaf and Assaad, 2024). While effective in conventional projects, this approach presents significant challenges for modular construction due to its unique requirements. Modular construction relies on the off-site fabrication of building modules in controlled environments, which are later transported and assembled on-site. This process demands seamless integration and coordination between the design, manufacturing and assembly stages, as Adekunle *et al.* (2023b) stated. The rigid separation of phases in traditional procurement often leads to inefficiencies, misalignments and delays when applied to modular projects. To address these challenges, procurement strategies must adapt to emphasise early involvement of key stakeholders, such as contractors, manufacturers and suppliers. Collaborative models promote integrated workflows, enabling concurrent design and fabrication processes (Otasowie *et al.*, 2024b). This alignment is critical in modular construction to ensure that designs are manufacturable, logistical complexities are resolved and the final assembly proceeds efficiently and seamlessly.

2.2 Collaborative procurement models

Collaborative procurement strategies, such as partnering, integrated project delivery (IPD) and PPPs, have become pivotal in modular construction (Yuan *et al.*, 2020). These strategies emphasise early and active collaboration among key stakeholders, including clients, designers, contractors and suppliers. Modular construction relies on off-site manufacturing and on-site assembly and demands seamless coordination across all project phases. Collaborative procurement ensures that designs are optimised for manufacturability, potential logistical issues are pre-emptively addressed and on-site assembly is executed efficiently (Peiris *et al.*, 2023). IPD exemplifies the synergy required in modular projects. Nwajei *et al.* (2022) argued that a shared risk-reward model fosters stakeholder alignment, encouraging collective problem-solving and innovation. This approach minimises inefficiencies, reduces waste and enhances overall project performance. Through collaboration, modular construction projects benefit from reduced timelines, improved cost control and better-quality outcomes, making these procurement strategies indispensable for realising the full potential of this innovative construction methodology.

2.3 Design-build and modular construction

DB procurement is a highly compatible approach for modular construction due to its integrated framework, where a single entity manages both design and construction (Park and Kwak, 2017). This method allows for the simultaneous progression of design and construction phases, significantly reducing project timelines, an advantage that aligns with the speed and efficiency associated with modular construction. The integration within DB fosters streamlined communication between design and construction teams, ensuring alignment in the fabrication of modular units with the project's specifications (Roy and Abdul-Nour, 2024). DB minimises errors, rework and delays by reducing fragmentation and enhancing coordination, improving project cost-effectiveness and efficiency. In modular construction, the success of off-site fabrication and on-site assembly depends on precision and synchronisation. Kazantsev *et al.* (2022) then asserted that DB's collaborative nature supports these requirements by promoting the early involvement of contractors, enabling them to provide input on manufacturability and logistics. This synergy makes DB an ideal procurement strategy for modular projects, ensuring quality, speed and cost optimisation.

2.4 Emerging procurement strategies in modular construction

The emergence of modular construction has led to the evolution of innovative procurement models designed to meet its specific demands. Central to these models is supply chain integration, which fosters long-term partnerships with key suppliers and manufacturers (Flynn *et al.*, 2016). Such relationships ensure the consistent and timely delivery of high-quality modular components, which is essential for seamless project execution. Strategic partnerships also promote mutual trust and shared objectives, which are critical in managing the complexities of modular construction. Adopting digital tools, particularly BIM, has revolutionised procurement (Aigbavboa *et al.*, 2024). BIM facilitates real-time collaboration among stakeholders, enhancing decision-making and enabling the early identification of design and procurement challenges. This digital integration is crucial in modular construction, where precise coordination across design, manufacturing and assembly stages is critical (Otasowie *et al.*, 2024c). Together, these innovative strategies streamline processes, minimise risks and improve the efficiency and reliability of modular construction projects.

2.5 Risk allocation and contractual considerations

In modular construction, procurement strategies must carefully address risk allocation and establish robust contractual frameworks to manage the unique challenges of this approach (Wuni *et al.*, 2019). Modular projects involve intricate logistics, strict regulatory compliance and heightened quality control requirements, necessitating clear definitions of roles, responsibilities and risk-sharing mechanisms among stakeholders. Traditional contracts often fail to address these complexities, making collaborative contractual models particularly advantageous, such as those seen in IPD, Saradara *et al.* (2024) stated. IPD fosters a shared-risk, shared-reward environment, reducing disputes and promoting a unified focus on project success. Moreover, modular construction often demands customised procurement contracts tailored to its distinct needs, such as off-site fabrication, long-distance transportation and precise on-site assembly (Adekunle *et al.*, 2024b). These bespoke contracts help ensure alignment between all parties, streamline workflows and mitigate risks. Modular construction projects can achieve greater efficiency, cost control and overall success in delivering high-quality outcomes by addressing these contractual and risk allocation challenges.

2.6 Sustainability and procurement in modular construction

Sustainability has become a significant factor in shaping procurement strategies in modular construction. Modular methods inherently support sustainability by reducing material waste through precision manufacturing, minimising on-site disruptions and enabling the reuse or recycling of components (Otasowie *et al.*, 2024d). These advantages align well with global environmental goals, driving the need for procurement strategies that emphasise sustainable practices. For instance, sourcing eco-friendly materials and adhering to circular economy principles ensures modular construction contributes to resource efficiency and waste reduction. Green procurement policies further enhance this by encouraging the adoption of energy-efficient technologies, renewable materials and low-carbon processes throughout the supply chain (Gawusu *et al.*, 2022). Moreover, a modular construction manufacturing environment enables better quality control, reducing errors and waste compared to traditional methods. As sustainability becomes a key stakeholder priority, integrating these considerations into procurement strategies bolsters environmental performance. It aligns modular projects with evolving industry regulations and market demands for greener construction practices.

3. Research method

The study adopted a qualitative research design rooted in interpretivism (Shoar and Chileshe, 2021; Sun *et al.*, 2020). A qualitative approach was deemed appropriate as it allows for an in-depth exploration of experiences, perceptions and insights regarding procurement strategies in modular construction. Specifically, the research used a phenomenological viewpoint, which focuses on understanding and describing individuals' lived experiences and the essence of phenomena from their subjective perspectives (Neubauer *et al.*, 2019). To collect data, the study used an elite semi-structured virtual interview method across the provinces of South Africa. This approach aligns with previous studies, such as those conducted by Dadzie *et al.* (2018), Aziz and Zainon (2023) and Durdyev *et al.* (2022). Dadzie *et al.* (2018) used semi-structured interviews to assess the adoption of sustainable technologies for energy-efficient building upgrades. Similarly, Aziz and Zainon (2023) and Durdyev *et al.* (2022) adopted this method to investigate the implementation of BIM in the construction industry. The semi-structured interview format enables researchers to collect in-depth insights while

allowing flexibility to explore emerging themes (Saarikoski *et al.*, 2024; Ebekozien and Aigbavboa, 2023).

The study adopted a purposeful elite sampling method, a technique supported by Scally *et al.* (2021) and Firdaus *et al.* (2022), who used it for recruiting journalists in research investigations. This sampling approach was chosen to target prominent experts who could provide valuable insights into procurement strategies in modular construction. The experts' knowledge helped uncover unseen issues and potential solutions within the research context. A total of 12 (12) participants were selected for the study. These included academic staff, professional practitioners (quantity surveyors, architects, construction managers and civil engineers), research associates, government officials, professional regulatory agencies and selected property developers (see Table 1). All participants had direct or indirect involvement in modular construction projects. Each interview lasted approximately 45 min between September and December 2024. To maintain confidentiality, the study ensured that the participants' identities and affiliated institutions were anonymised following the research's ethical policy. Before conducting the interviews, an introductory letter was sent to the potential participants, and only those who expressed interest were engaged. The Supplementary Material provides a sample of the cover letter and semi-structured interview questions used in the study.

The study then used a thematic analysis to process the collected data, with codes generated manually by researchers who acted as coders to interpret participants' viewpoints. This approach aligns with the method used by Deterding and Waters (2018), who developed an open coding framework to analyse qualitative data. The coding process was conducted in two phases. The first phase, open coding, systematically breaks raw data into smaller concepts (Sun *et al.*, 2020). In the second phase, significant concepts were identified and grouped into categories, leading to the emergence of key themes. In total, 81 codes were generated, later consolidated into five categories, from which two major themes emerged, forming the study's core findings.

Several validation techniques were used to enhance the validity and reliability of the findings. Researcher reflexivity ensured that researchers critically examined their role in data interpretation, minimising bias. Triangulation was used to cross-check findings with multiple sources, ensuring consistency, while member checking allowed participants to review and validate the findings to confirm their accuracy (Ang *et al.*, 2016). In addition, the study used

Table 1. Interviewee demography

Interviewee code	Sector	Years of experience	Highest academic qualification	Discipline/Role
P1	Built environment	25	Msc.	Construction project manager
P2	Built environment	10	Msc.	Research specialist
P3	Academia	22	PhD	Civil engineer/academic staff
P4	Built environment	12	PhD	Urban and regional planner
P5	Built environment	28	MSc	Construction project manager
P6	Built environment	5	MSc	Architect
P7	Built environment	20	BSc	Housing developer
P8	Academia	8	PhD	Quantity surveyor/academic staff
P9	Built environment	12	MSc	Contractor
P10	Built environment	11	BSc	Construction project manager
P11	Built environment	5	BTech	Architect
P12	Academia	15	PhD	Quantity surveyor/academic staff

ATLAS.ti software, thematic analysis and narrative techniques for data processing and interpretation (Choe *et al.*, 2022). The research design, data collection methods and analytical techniques were carefully selected to ensure a rigorous examination of procurement strategies in modular construction. Integrating elite interviews, thematic analysis and robust validation techniques contributed to a comprehensive understanding of the research phenomenon.

4. Discussion of findings

4.1 Theme 1: Procurement strategies suitable for modular construction

The interview analysis, which involved 12 participants, revealed a range of procurement strategies suitable for modular construction. These strategies, including general contracting, design and build, construction management, joint ventures, private financing and various contractual methods such as cost-plus, turnkey and framework agreements, reflect stakeholders' diverse approaches in modular construction projects. The suitability of each method depends on factors such as project complexity, financing structures, risk allocation and the need for collaboration among key players. Participants emphasised that modular construction, a highly industrialised approach, requires procurement methods that facilitate early contractor involvement, ensure cost predictability and streamline project delivery.

A recurring theme in the analysis was the importance of design and build procurement in modular construction. Several participants pointed out that this method aligns well with modular principles, as it integrates design and construction, reducing the fragmentation often seen in traditional procurement. P6, an architect with extensive experience in modular projects, noted: "[…] […] with design and build, we can ensure that the modular units are designed with production efficiency in mind from the outset, which significantly reduces design errors and rework […] […] […]." Similarly, construction management was identified as a suitable approach, particularly for large-scale modular developments where coordination between off-site manufacturers and on-site assembly teams is crucial. In his argument, P1 explained, "In modular projects, the sequencing of on-site and off-site activities is critical. Construction management allows us to oversee the entire process, ensuring modules are manufactured and installed efficiently […] […] […] […]" Park and Kwak (2017) and Kazantsev *et al.* (2022) support the findings that design and build enhance production efficiency in modular construction by reducing errors and rework. Similarly, construction management is critical for coordinating off-site and on-site activities, ensuring seamless module delivery and installation as observed by Zhou *et al.* (2021).

Another key procurement method identified was the joint venture approach, particularly for large, high-risk modular projects requiring significant investment. Joint ventures allow multiple stakeholders, including contractors, developers and financiers, to share resources and risks (Romeli *et al.*, 2016). P4, involved in public infrastructure projects, stated: "[…] for large-scale modular housing projects, joint ventures between public and private entities help mobilise funds and expertise, making the projects more feasible […]." This view was closely linked to private financing and PPPs, highlighted as critical funding models for modular construction. A housing developer, P7, remarked, "Traditional financing models do not always suit modular projects because of the high upfront costs. PPPs allow for cost-sharing and better risk management […] […]." Huang *et al.* (2021) observed that joint ventures and PPPs improve financial accessibility, risk-sharing and knowledge integration in modular construction. The high upfront expenses of traditional financing models are a common problem. According to Akomea-Frimpong *et al.* (2024), PPPs, on the other hand, provide cost-sharing mechanisms that increase the viability of large-scale modular housing projects.

From a contractual standpoint, most interviewees discussed cost-plus and turnkey as effective strategies. Cost-plus contracts, where contractors are reimbursed for costs incurred plus a fee, were considered beneficial for modular projects involving innovation and uncertainty. P12 says "cost-plus contracts work well when we're dealing with new modular technologies. It gives contractors flexibility while ensuring they are not taking on all the financial risk […] […]" Meanwhile, turnkey contracts, where contractors deliver a fully operational facility, were favoured by clients seeking a hassle-free procurement process (P3, P5, P11). P9 then says "[…] […] turnkey procurement is attractive to clients who want a fully finished modular building without having to manage multiple suppliers […] […]." Findings agree with Chammout *et al.* (2024), who asserted that cost-plus contracts provide financial flexibility in modular construction, particularly for projects involving innovation and uncertainty, as they allow contractors to recover costs while mitigating risk. Conversely, turnkey contracts appeal to clients seeking simplified procurement, as they ensure single-point responsibility and fully operational delivery (Panakaduwa *et al.*, 2024).

Competitive bidding and negotiated contracts were also identified as viable procurement strategies, each with advantages. Competitive bidding, where contractors compete based on price and technical ability, was seen as helpful in ensuring cost efficiency. However, some participants expressed concerns about its limitations in modular projects. P2 says that "[…] while competitive bidding is cost-effective, it doesn't always account for the need for early collaboration between designers and manufacturers, which is crucial in modular construction […]." As an alternative, negotiated contracts, which allow for direct discussions between clients and contractors, were considered more suitable for ensuring quality and efficiency. Framework agreements and requests for quotations (RFQs) were also highlighted. Framework agreements enable long-term collaboration between clients and pre-approved suppliers, deemed highly beneficial for modular projects requiring repetitive procurement (Jalaei *et al.*, 2022). P8 mentioned that "Framework agreements allow us to have a steady supply of modular units without the need for separate procurement processes for each project […] […]" This aligns with the study of Molavi and Barral (2015), which found that RFQs were useful for sourcing specific modular components or specialised contractors within a short time frame.

4.2 Theme 2

The analysis of interviews with 12 participants revealed that procurement strategies significantly influence the outcomes of modular construction projects. Factors such as cost control, project timelines, quality assurance and risk management were all linked to the chosen procurement approach. Participants emphasised that modular construction, a highly industrialised and technology-driven approach, requires procurement methods that facilitate collaboration, efficiency and financial stability. The effectiveness of procurement strategies was closely tied to the level of integration between stakeholders, flexibility in contract structures and the ability to mitigate risks associated with modular production and installation.

One of the most discussed procurement strategies was turnkey, which was praised for its ability to streamline project delivery and enhance coordination between design and construction teams. Participants P1, P3, P4, P5 and P11 noted that this strategy ensures early collaboration, which is essential for modular projects where design decisions directly impact manufacturability. Turnkey procurement is ideal for clients who want a ready-to-use modular facility without involving construction complexities. Findings agree with Van Der Ham and Opdenakker (2021) and Charlson and Dimka (2021) that turnkey works well for modular construction because the contractors and designers work as a team to deliver the project to

the client. This reduces clashes between design intent and manufacturing capabilities, improving project efficiency. P12 added that "[…] […] the turnkey approach helps mitigate cost overruns and delays by integrating construction expertise into the design phase […]." This is consistent with research by Álvarez-Pozo *et al.* (2024), who highlighted that early contractor participation in turnkey procurement improves cost predictability, reduces design conflicts and expedites project timelines, especially in modular construction, where design, manufacturing and assembly coordination are crucial.

Design and Build was highlighted as beneficial, particularly for large-scale modular developments requiring precise sequencing of off-site manufacturing and on-site assembly. P10 says, "[…] […] unlike traditional procurement, design and build allows better oversight of the entire process, ensuring modules are delivered and installed at the right time […] […]" This method was particularly useful for projects involving multiple stakeholders, as it allows for continuous coordination between manufacturers, contractors and suppliers. However, participants P3, P7 and P8 cautioned that design and build require strong leadership and clear communication to prevent inefficiencies and effectively manage risk allocation. This aligns with Chadee *et al.* (2022), who emphasise that scope creep, cost overruns and misaligned stakeholder expectations can result from inadequate coordination in design and build contracts.

Financial aspects were also a significant concern, with joint ventures and PPPs emerging as key strategies for funding large modular projects. Several participants stated that joint ventures allow resource-sharing among multiple entities, reducing financial risks. P9, who was recently involved in a modular infrastructure project, remarked that "joint ventures provide access to additional funding and expertise, making it possible to scale up modular projects that would otherwise be financially unfeasible." Similarly, PPPs were identified as a viable model for government-led modular projects, particularly in the housing and healthcare sectors. Modular construction requires a significant upfront investment, and PPPs help bridge the gap by enabling cost-sharing between public and private entities (P6, P10 and P12). Joint ventures and PPPs help to reduce financial risks in modular buildings by facilitating resource sharing, access to expertise and cost-sharing between the public and private sectors, according to Rausser *et al.* (2023) and Tetteh *et al.* (2022). Competitive bidding and negotiated procurement were also compared, with varying opinions on their effectiveness. While considered a cost-effective method, competitive bidding was criticised for potentially compromising quality (P1, P2, P5), especially in modular projects where technical expertise is crucial. P7 remarked, "[…] […] lowest-cost bidding does not always yield the best results in modular construction […] […]" A contractor may win the bid but struggle with quality control or supply chain disruptions (Otasowie *et al.*, 2023). On the other hand, negotiated procurement, where clients directly engage with contractors, was favoured for ensuring quality and project customisation (P1, P2, P5, P7, P10). Through negotiated contracts, clients can select a modular manufacturer not only based on pricing but also based on knowledge (P11). Clients can choose manufacturers based on specific skills and experience thanks to negotiated contracts that put expertise and quality above cost.

Procurement approaches prioritising long-term collaboration, such as framework agreements and direct procurement, were also highlighted as beneficial for modular construction (P2, P4, P7, P8, P10). Framework agreements, which allow for pre-approved suppliers to be engaged for multiple projects, were seen as beneficial for organisations managing large-scale modular housing developments. A supply chain specialist noted: "Framework agreements provide continuity in supply, which is essential for modular projects that rely on consistent manufacturing and delivery schedules." Similarly, direct procurement, where clients engage manufacturers without intermediaries, was recognised

for its ability to reduce procurement lead time. P9 said, "[…] […] direct procurement helps us source modular components faster, reducing project delays […] […]" A relatively newer procurement approach, reverse auctions, where suppliers compete by lowering their prices, was viewed with mixed opinions. While some participants (P1, P3, P9, P11) saw it as a cost-saving tool, others (P4, P5, P7, P10, P12) warned against the risk of sacrificing quality. P12 particularly stated that "reverse auctions might work for bulk purchasing of standard modular components, but for customised modular units, price competition alone should not be the main selection criteria." Kabirifar and Mojtahedi (2019) argued that prioritising prices in complex procurements could compromise quality and supplier relationships, ultimately affecting project outcomes. This approach can strain supplier relationships by fostering a transactional rather than a collaborative dynamic, ultimately impacting project outcomes due to increased risks of delays, rework and cost overruns.

According to the study's findings, no one procurement technique is always better; instead, the decision is based on the requirements for risk management, financial structure and project goals. The main advantages of modular construction procurement strategies are supply chain efficiency, integration and financial sustainability. According to the report, PPPs and joint ventures provide financial support, design and build coordination and turnkey ensures supply chain stability. Project outputs may be more successful as a result. Modular construction procurement processes are interconnected, which emphasises the necessity of careful selection based on project-specific requirements.

5. Contribution to knowledge

The study's findings contribute to the knowledge of procurement strategies in modular construction by providing empirical insights into how different procurement approaches influence project outcomes. While previous literature has extensively discussed traditional procurement methods in conventional construction (Assaf and Assaad, 2024; Chasey *et al.*, 2012), this study builds on and extends those discussions by contextualising procurement within modular construction, a sector that relies on industrialised processes, off-site manufacturing and early-stage integration of stakeholders. The findings reinforce existing theoretical frameworks while introducing new perspectives on procurement flexibility, financial structuring and stakeholder collaboration in modular construction projects.

One significant contribution of this study is emphasising the role of design and build procurement in modular construction. Existing research highlights the benefits of design and build in reducing project fragmentation and improving efficiency (Jones *et al.*, 2021). However, this study deepens the understanding by demonstrating how design and build align with modular construction principles, ensuring that manufacturing considerations are embedded in the early design stages. The study also supports the literature by affirming that early contractor involvement in design and build procurement minimises design errors and accelerates project timelines.

Furthermore, the study contributes to knowledge by expanding discussions on financial models in modular construction procurement. While joint ventures and PPPs have been explored in infrastructure procurement (Jayasena *et al.*, 2022), this study provides specific insights into their application in modular projects. It highlights how joint ventures facilitate knowledge-sharing and resource pooling, making large-scale modular projects more financially feasible. Similarly, it confirms the findings of Chauhan and Marisetty (2019), who identified PPPs as a means of leveraging public and private sector expertise for efficient project delivery. The study closes a gap in the literature on how procurement techniques

might maximise financial sustainability in the modular building industry by showing how these financial models directly affect the industry.

Another important contribution is the study's nuanced discussion on risk management through procurement strategies. Prior research suggests modular construction faces unique risks related to supply chain disruptions, logistics and quality control (Wuni and Shen, 2020). This study adds to this discourse by linking specific procurement strategies, such as cost-plus contracts and framework agreements, to risk mitigation. The findings align with previous literature recommending cost-plus contracts for projects involving innovative construction techniques (Laryea, 2019). In addition, the study reinforces that framework agreements provide long-term supply chain stability.

Finally, the study offers a critical perspective on procurement efficiency and project customisation. While competitive bidding has been widely studied in construction procurement, this study challenges its applicability in modular construction, emphasising the need for negotiated and direct procurement to ensure quality and customisation. The findings extend Mayouf *et al.*'s (2024) work by illustrating how procurement strategies can be adapted to meet modular-specific needs, such as just-in-time manufacturing and factory-controlled production. This study adds a practical component to procurement research in modular construction by fusing theoretical talks with actual data from professionals in the field. This allows for the development of fresh insights that can guide practice, policy and future research.

6. Conclusion and recommendation

This study has explored the influence of different procurement strategies on modular construction project outcomes, highlighting their impact on efficiency, cost management, risk mitigation and stakeholder collaboration. The findings emphasise that no single procurement strategy is universally optimal for modular construction; rather, the success of a project depends on selecting strategies that align with the unique demands of modular construction, including off-site manufacturing, logistical coordination and early-stage stakeholder integration. Procurement approaches such as design and build, joint ventures and PPPs facilitated collaboration and financial sustainability, while framework agreements and direct procurement contributed to supply chain stability. Conversely, the study revealed concerns about competitive bidding and reverse auctions, which may compromise quality and fail to address the complexities of modular construction.

The study's contributions extend the existing literature by offering empirical evidence on how procurement strategies influence modular construction, reinforcing the importance of procurement flexibility and strategic financial planning. The study offers a valuable framework for enhancing procurement efficiency in this expanding industry by connecting logistics concerns and manufacturing lead times to modular-specific purchase decisions. Ultimately, the study underscores the need for policymakers, developers and construction professionals to adopt procurement strategies that enhance integration, reduce project risks and ensure cost-effectiveness. To improve the efficiency of modular construction procurement, the study recommends digital procurement tools, integrated supply chain models and policy changes. Stronger stakeholder engagement is also necessary to enhance coordination, lower risks and guarantee the smooth implementation of procurement strategies for improved project results. Future research could explore further refinements in procurement frameworks tailored specifically for modular construction, incorporating evolving technological advancements and regulatory considerations.

References

Adekunle, P., Aigbavboa, C., Otasowie, K. and Adekunle, S. (2023a), "Benefits of robotic utilization in the prefabricated construction industry. Proceedings of the ", 31st Annual Conference of the International Group for Lean Construction (IGLC31), pp. 746-754, doi: 10.24928/2023/0134.

Adekunle, P., Aigbavboa, C., Otasowie, O., and Ikuabe, M. (2023b), "Benefits of blockchain technology in the prefabricated construction industry", In Ahmed, S. M., Azhar, S., Saul, A. D., Mahaffy, K. L. and Farooqui, R. U. (Eds), *Proceedings of the 13th International Conference on Construction in the 21st Century, CITC 2023 (International Conference on Construction in the 21st Century*, Vol. 2023. East Carolina University.

Adekunle, P., Aigbavboa, C., Otasowie, O. and Idowu, A. (2024a), "Economic factors influencing the adoption of modularity methodology in the built environment", *Transforming Construction with Off-Site Methods and Technologies*.

Adekunle, P., Aigbavboa, C., Otasowie, O., Akinradewo, O. and Pheza, N. (2024b), "Benefits of integrating advanced composite materials into modular construction for enhanced structural performance", *Transforming Construction with Off-Site Methods and Technologies*.

Aigbavboa, C., Adekunle, P., Ikuabe, M. and Otasowie, K. (2024), "Digitisation of the construction industry for economic growth: Implementation strategies", In: Arai, K. (Eds), *Proceedings of the Future Technologies Conference (FTC)*, Springer, Cham, Vol. 1157, doi: 10.1007/978-3-031-73128-0_34.

Akomea-Frimpong, I., Jin, X. and Osei-Kyei, R. (2024), "Fuzzy analysis of financial risk management strategies for sustainable public–private partnership infrastructure projects in Ghana", *Infrastructures*, Vol. 9 No. 4, p. 76, doi: 10.3390/infrastructures9040076.

Álvarez-Pozo, A.H., Parma-García, M.I., Ortiz-Marcos, I., Bautista, L.F. and Atanes-Sánchez, E. (2024), "Analysis of causes of delays and cost overruns as well as mitigation measures to improve profitability and sustainability in turnkey industrial projects", *Sustainability*, Vol. 16 No. 4, p. 1449, doi: 10.3390/su16041449.

Ang, C.K., Embi, M.A. and Md Yunus, M. (2016), "Enhancing the quality of the findings of a longitudinal case study: Reviewing trustworthiness via ATLAS.ti", *The Qualitative Report*, doi: 10.46743/2160-3715/2016.2480.

Assaf, G. and Assaad, R.H. (2024), "A decision-support system for choosing between traditional and alternative project delivery methods for bundled projects", *Engineering Construction and Architectural Management*, doi: 10.1108/ECAM-01-2024-0043.

Aziz, N.M. and Zainon, N. (2023), "Driving factors for lean-BIM implementation in Malaysia's construction industry: qualitative interview-based study", *Smart and Sustainable Built Environment*, Vol. 12 No. 4, pp. 872-891, doi: 10.1108/SASBE-01-2022-0019.

Chadee, A.A., Martin, H.H., Mwasha, A. and Otuloge, F. (2022), "Rationalizing critical cost overrun factors on public sector housing programmes", *Emerging Science Journal*, Vol. 6 No. 3, pp. 647-666, doi: 10.28991/esj-2022-06-03-016.

Chammout, B., El-Adaway, I.H., Abdul Nabi, M. and Assaad, R.H. (2024), "Price escalation in construction projects: examining national and international contracts", *Journal of Construction Engineering and Management*, Vol. 150 No. 9, p. 04024109.

Charlson, J. and Dimka, N. (2021), "Design, manufacture and construct procurement model for volumetric offsite manufacturing in the UK housing sector", *Construction Innovation*, Vol. 21 No. 4, pp. 800-817, doi: 10.1108/ci-10-2019-0108.

Chasey, A.D., Maddex, W.E. and Bansal, A. (2012), "Comparison of public–private partnerships and traditional procurement methods in North American highway construction", *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2268 No. 1, doi: 10.3141/2268-04.

Chauhan, Y. and Marisetty, V.B. (2019), "Do public-private partnerships benefit private sector? Evidence from an emerging market", *Research in International Business and Finance*, Vol. 47, pp. 563-579, doi: 10.1016/j.ribaf.2018.10.002.

Choe, Y., Lee, J. and Lee, G. (2022), "Exploring values via the innovative application of social media with parks amid COVID-19: a qualitative content analysis of text and images using ATLAS.ti", *Sustainability*, Vol. 14 No. 20, p. 13026, doi: 10.3390/su142013026.

Dadzie, J., Runeson, G., Ding, G. and Bondinuba, F.K. (2018), "Barriers to adoption of sustainable technologies for Energy-Efficient building upgrade—Semi-Structured interviews", *Buildings*, Vol. 8 No. 4, p. 57, doi: 10.3390/buildings8040057.

Deterding, N.M. and Waters, M.C. (2018), "Flexible coding of In-depth interviews: a twenty-first-century approach", *Sociological Methods and Research*, Vol. 50 No. 2, pp. 708-739, doi: 10.1177/0049124118799377.

Durdyev, S., Ashour, M., Connelly, S. and Mahdiyar, A. (2022), "Barriers to the implementation of building information modelling (BIM) for facility management", *Journal of Building Engineering*, Vol. 46, p. 103736, doi: 10.1016/j.jobe.2021.103736.

Ebekozien, A. and Aigbavboa, C. (2023), "Evaluation of built environment programmes accreditation in the 21st century education system in Nigeria: stakeholders' perspective", *International Journal of Building Pathology and Adaptation*, Vol. 41 No. 6, pp. 102-118, doi: 10.1108/IJBPA-02-2022-0027.

Firdaus, A., Aksar, I.A. and Gong, J. (2022), "Small world sampling: Qualitative sample reliability and validity for efficient and effective recruitment of journalists as research participants", *Journalism*, Vol. 25 No. 2, pp. 466-485, doi: 10.1177/14648849221124997.

Flynn, B.B., Koufteros, X. and Lu, G. (2016), "On theory in supply chain uncertainty and its implications for supply chain integration", *Journal of Supply Chain Management*, Vol. 52 No. 3, pp. 3-27, doi: 10.1111/jscm.12106.

Gawusu, S., Zhang, X., Jamatutu, S.A., Ahmed, A., Amadu, A.A. and Miensah, E.D. (2022), "The dynamics of green supply chain management within the framework of renewable energy", *International Journal of Energy Research*, Vol. 46 No. 2, pp. 684-711, doi: 10.1002/er.7278.

Hsu, P.-Y., Aurisicchio, M. and Angeloudis, P. (2019), "Risk-averse supply chain for modular construction projects", *Automation in Construction*, Vol. 106, p. 102898, doi: 10.1016/j.autcon.2019.102898.

Huang, Y., Xu, W. and Li, C. (2021), "Information integration framework for a public–private partnership system of an urban railway transit project (part A: System architecture)", *Journal of Industrial Information Integration*, Vol. 25, p. 100244, doi: 10.1016/j.jii.2021.100244.

Hussein, M. and Zayed, T. (2021), "Critical factors for successful implementation of just-in-time concept in modular integrated construction: a systematic review and meta-analysis", *Journal of Cleaner Production*, Vol. 284, p. 124716, doi: 10.1016/j.jclepro.2020.124716.

Jalaei, F., Masoudi, R. and Guest, G. (2022), "A framework for specifying low-carbon construction materials in government procurement: a case study for concrete in a new building investment", *Journal of Cleaner Production*, Vol. 345, p. 131056, doi: 10.1016/j.jclepro.2022.131056.

Jayasena, N.S., Chan, D.W.M. and Kumaraswamy, M.M. (2022), "Is public–private partnership (PPP) a preferred strategy for procuring smart infrastructure in developed countries: an empirical study of the perceived benefits, barriers and recommended strategies", *Sustainability*, Vol. 14 No. 11, p. 6421, doi: 10.3390/su14116421.

Jones, K., Mosca, L., Whyte, J., Davies, A. and Glass, J. (2021), "Addressing specialization and fragmentation: product platform development in construction consultancy firms", *Construction Management and Economics*, Vol. 40 Nos 11-12, pp. 918-933, doi: 10.1080/01446193.2021.1983187.

Kabirifar, K. and Mojtahedi, M. (2019), "The impact of engineering, procurement and construction (EPC) phases on project performance: a case of large-scale residential construction project", *Buildings*, Vol. 9 No. 1, p. 15, doi: 10.3390/buildings9010015.

Kazantsev, N., Pishchulov, G., Mehandjiev, N., Sampaio, P. and Zolkiewski, J. (2022), "Investigating barriers to demand-driven SME collaboration in low-volume high-variability manufacturing", *Supply Chain Management: An International Journal*, Vol. 27 No. 2, pp. 265-282, doi: 10.1108/SCM-10-2021-0486.

Khan, A.A., Yu, R., Liu, T., Gu, N. and Walsh, J. (2023), "Volumetric modular construction risks: a comprehensive review and Digital-Technology-Coupled circular mitigation strategies", *Sustainability*, Vol. 15 No. 8, p. 7019, doi: 10.3390/su15087019.

Laryea, S. (2019), "Procurement strategy and outcomes of a new universities project in South Africa", *Engineering, Construction and Architectural Management*, Vol. 26 No. 9, pp. 2060-2083, doi: 10.1108/ECAM-04-2018-0154.

Mayouf, M., Jones, J., Elghaish, F., Emam, H., Ekanayake, E.M.A.C. and Ashayeri, I. (2024), "Revolutionising the 4D BIM process to support scheduling requirements in modular construction", *Sustainability*, Vol. 16 No. 2, p. 476, doi: 10.3390/su16020476.

Molavi, J. and Barral, D.L. (2015), "A construction procurement method to achieve sustainability in modular construction", *Procedia Engineering*, Vol. 145, pp. 1362-1369, doi: 10.1016/j.proeng.2016.04.201.

Neubauer, B.E., Witkop, C.T. and Varpio, L. (2019), "How phenomenology can help us learn from the experiences of others", *Perspectives on Medical Education*, Vol. 8 No. 2, pp. 90-97, doi: 10.1007/s40037-019-0509-2.

Nwajei, U.O.K., Bølviken, T. and Hellström, M.M. (2022), "Overcoming the principal-agent problem: the need for alignment of tools and methods in collaborative project delivery", *International Journal of Project Management*, Vol. 40 No. 7, pp. 750-762, doi: 10.1016/j.ijproman.2022.08.003.

Otasowie, K., Aigbavboa, C., Oke, A., and Adekunle, P. (2024a), "Factors influencing circular economy adoption in the South African construction sector", In: Rotimi, J.O.B., Shahzad, W.M., Sutrisna, M., Kahandawa, R. (eds) *Advances in Engineering Management, Innovation, and Sustainability. EPPM 2023. Lecture Notes in Civil Engineering*, Springer, Cham, Vol. 480, doi: 10.1007/978-3-031-56544-1_43.

Otasowie, K., Aigbavboa, C., Oke, A., Adekunle, P. and Ntuli, N. (2024b), "Adopting digital technologies in construction and demolition waste (C&DW) management: Benefits for developing nations", In: Arai, K. (Eds), *Proceedings of the Future Technologies Conference (FTC)*, Springer, Cham, Vol. 1157, doi: 10.1007/978-3-031-73128-0_29.

Otasowie, O.K., Aigbavboa, C., Adekunle, P. and Oke, A. (2024c), "Challenges to circular economy adoption: South African built environment professionals' perspective", *Towards a Carbon Neutral Future. ICSBS 2023. Lecture Notes in Civil Engineering*, vol 393 Springer, Singapore, doi: 10.1007/978-981-99-7965-3_19.

Otasowie, O.K., Aigbavboa, C., Adekunle, P. and Oke, A. (2024d), "Drivers of circular economy adoption in the South African construction industry", *Towards a Carbon Neutral Future. ICSBS 2023. Lecture Notes in Civil Engineering*, Springer, Singapore, Vol. 393, doi: 10.1007/978-981-99-7965-3_18.

Otasowie, K., Aigbavboa, C., Oke, A., Adekunle, P. and Zanele, B. (2023), "Exploring the drivers of blockchain technology adoption in construction project logistics: a case of South Africa", In: Arai, K. (Eds), *Proceedings of the Future Technologies Conference (FTC) 2023, Springer, Cham*, Vol. 815, doi: 10.1007/978-3-031-47457-6_22

Panakaduwa, C., Coates, P. and Munir, M. (2024), "Analysis of procurement routes and contract types for housing retrofit in the United Kingdom", *Buildings*, Vol. 15 No. 2, p. 199, doi: 10.3390/buildings15020199.

Papajohn, D., Asmar, M.E. and Molenaar, K.R. (2019), "Contract administration tools for design-build and construction manager/general contractor highway projects", *Journal of Management in Engineering*, Vol. 35 No. 6, doi: 10.1061/(asce)me.1943-5479.0000718.

Park, J. and Kwak, Y.H. (2017), "Design-Bid-Build (DBB) vs. Design-Build (DB) in the U.S. public transportation projects: the choice and consequences", *International Journal of Project Management*, Vol. 35 No. 3, pp. 280-295, doi: 10.1016/j.ijproman.2016.10.013.

Peiris, A., Hui, F.K.P., Duffield, C., Wang, J., Gil Garcia, M., Chen, Y. and Ngo, T. (2023), "Digitalising modular construction: Enhancement of off-site manufacturing productivity via a manufacturing execution & control (MEC) system", *Computers and Industrial Engineering*, Vol. 178, p. 109117, doi: 10.1016/j.cie.2023.109117.

Rausser, G., Choi, E. and Bayen, A. (2023), "Public–private partnerships in fostering outer space innovations", *Proceedings of the National Academy of Sciences*, Vol. 120 No. 43, doi: 10.1073/pnas.2222013120.

Romeli, N., Halil, F.M., Ismail, F. and Shukor, A.S.A. (2016), "Economic challenges in joint venture infrastructure projects: towards contractor's quality of life", *Procedia – Social and Behavioral Sciences*, Vol. 234, pp. 19-27, doi: 10.1016/j.sbspro.2016.10.215.

Roy, M.-A. and Abdul-Nour, G. (2024), "Integrating modular design concepts for enhanced efficiency in digital and sustainable manufacturing: a literature review", *Applied Sciences*, Vol. 14 No. 11, p. 4539, doi: 10.3390/app14114539.

Saarikoski, H., Vikström, S. and Peltonen, L. (2024), "Knowledge co-production around the cormorant-fishing conflict using a joint fact-finding approach", *Environmental Science and Policy*, Vol. 151, p. 103628, doi: 10.1016/j.envsci.2023.103628.

Saradara, S.M., Khalfan, M.M.A., Jaya, S.V., Swarnakar, V., Rauf, A. and El Fadel, M. (2024), "Advancing building construction: a novel conceptual framework integrating circularity with modified lean project delivery systems", *Developments in the Built Environment*, Vol. 20, p. 100531, doi: 10.1016/j.dibe.2024.100531.

Scally, G., Black, D., Pilkington, P., *et al* (2021), "The application of 'elite interviewing' methodology in transdisciplinary research: a record of process and lessons learned during a 3-Year pilot in urban planetary health research", *Journal of Urban Health*, Vol. 98 No. 3, pp. 404-414, doi: 10.1007/s11524-021-00542-1.

Shoar, S. and Chileshe, N. (2021), "Exploring the causes of design changes in building construction projects: an interpretive structural modeling approach", *Sustainability*, Vol. 13 No. 17, p. 9578, doi: 10.3390/su13179578.

Sun, C., Xu, H. and Jiang, S. (2020), "Understanding the risk factors of BIM technology implementation in the construction industry: an interpretive structural modeling (ISM) approach", *Engineering, Construction and Architectural Management*, Vol. 27 No. 10, pp. 3289-3308, doi: 10.1108/ECAM-09-2019-0508.

Tetteh, M.O., Chan, A.P.C., Darko, A., Yevu, S.K., Boateng, E.B. and Nwaogu, J.M. (2022), "Key drivers for implementing international construction joint ventures (ICJVs): global insights for sustainable growth", *Engineering, Construction and Architectural Management*, Vol. 29 No. 9, pp. 3363-3393, doi: 10.1108/ECAM-07-2020-0512.

Tran, D.Q., Nguyen, L.D. and Faught, A. (2017), "Examination of communication processes in design-build project delivery in building construction", *Engineering, Construction and Architectural Management*, Vol. 24 No. 6, pp. 1319-1336, doi: 10.1108/ECAM-12-2015-0192.

Van der Ham, M. and Opdenakker, R. (2021), "Overcoming process-related barriers in modular high-rise building projects", *International Journal of Construction Management*, Vol. 23 No. 10, pp. 1779-1789, doi: 10.1080/15623599.2021.2007593.

Vuorinen, L. and Martinsuo, M. (2019), "Value-oriented stakeholder influence on infrastructure projects", *International Journal of Project Management*, Vol. 37 No. 5, pp. 750-766, doi: 10.1016/j.ijproman.2018.10.003.

Windapo, A., Adediran, A., Rotimi, J.O.B. and Umeokafor, N. (2022), "Construction project performance: the role of client knowledge and procurement systems", *Journal of Engineering, Design and Technology*, Vol. 20 No. 5, pp. 1349-1366, doi: 10.1108/JEDT-06-2020-0219.

Wuni, I.Y. and Shen, G.Q. (2020), "Barriers to the adoption of modular integrated construction: Systematic review and meta-analysis, integrated conceptual framework, and strategies", *Journal of Cleaner Production*, Vol. 249, p. 119347, doi: 10.1016/j.jclepro.2019.119347.

Wuni, I.Y., Shen, G.Q. and Hwang, B.-G. (2019), "Risks of modular integrated construction: a review and future research directions", *Frontiers of Engineering Management*, Vol. 7 No. 1, pp. 63-80, doi: 10.1007/s42524-019-0059-7.

Yuan, J., Li, X., Ke, Y., Xu, W., Xu, Z. and Skibnewski, M. (2020), "Developing a building information modeling–based performance management system for public–private partnerships", *Engineering, Construction and Architectural Management*, Vol. 27 No. 8, pp. 1727-1762, doi: 10.1108/ECAM-06-2019-0328.

Zhou, J.X., Shen, G.Q., Yoon, S.H. and Jin, X. (2021), "Customization of on-site assembly services by integrating the internet of things and BIM technologies in modular integrated construction", *Automation in Construction*, Vol. 126, p. 103663, doi: 10.1016/j.autcon.2021.103663.

Supplementary material

The supplementary material for this article can be found online.

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