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Innovating for performance: the role of lean construction and strategic partnerships in construction firms

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Abstract: This study examines the effects of lean construction and strategic partnerships on firm performance, with business model innovation as a mediating mechanism in the construction industry. A quantitative research design was employed, using data collected from 226 large-scale construction firms registered as national contractors. The data were analysed using PLS-SEM. The results indicate that lean construction has a positive direct effect on firm performance and a stronger indirect effect when mediated by business model innovation. Strategic partnerships do not exert a significant direct influence on firm performance, but they contribute positively when their impact is channelled through business model innovation. In addition, business model innovation shows a strong and positive direct effect on firm performance. These findings suggest that operational efficiency and inter-organisational collaboration yield optimal performance outcomes only when supported by systematic innovation across value creation, value proposition, and value capture.

Keywords: lean construction; LC; strategic partnership; business model innovation; BMI; firm performance.

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1 Introduction

The construction industry has experienced substantial disruption following the COVID-19 pandemic, which led to the suspension of projects and the mandatory implementation of strict health protocols across ongoing operations (Ilatova et al., 2022). These conditions resulted in a significant deterioration of both operational performance and financial outcomes, forcing many construction firms to scale down or terminate their activities. National statistics reflect this downturn, showing that the total value of completed construction projects declined from IDR 1,594,196 billion in 2019 to IDR 1,311,418 billion in 2020, representing a contraction of 17.74% (Badan Pusat Statistik, 2022).

Beyond its immediate financial impact, the pandemic also intensified supply and demand instability within the construction sector, leading to considerable losses, particularly in the form of underutilised inventory and disrupted material flows (Siagian

et al., 2021). These challenges exacerbated long standing inefficiencies related to cost overruns, quality inconsistencies, and schedule delays, which have historically constrained construction project performance (Kim and Nguyen, 2018). Collectively, these pressures highlight the growing vulnerability of construction firms to environmental turbulence and underline the need for strategic responses that extend beyond short term operational adjustments.

In this context, business model innovation (BMI) has gained prominence as a critical mechanism through which firms can adapt to volatile conditions and secure sustainable performance outcomes. By reconfiguring how value is created, delivered, and captured, BMI enables organisations to respond more effectively to external shocks and evolving market demands. Prior research suggests that successful innovation management not only facilitates the development of new revenue streams but also supports the continuity and renewal of innovation cycles over time (Saviotti and Metcalfe, 2018).

Within the construction industry, lean construction (LC) represents an operational approach that is closely aligned with the principles of BMI. LC is a systematic project management methodology designed to eliminate waste, including excessive material use, time inefficiencies, labour redundancies, and safety risks, while maximising value for the end customer throughout the project lifecycle (Demirkesen, 2020; Sarhan et al., 2020). Rather than focusing solely on efficiency improvements, LC emphasises value creation through process integration, stakeholder coordination, and continuous improvement.

Extensive empirical evidence demonstrates that the adoption of lean practices generates multiple performance benefits. These include improved resource efficiency through enhanced risk management, cost reductions, decreased rework and material waste, and shorter project completion times. LC also supports better workflow coordination, more effective communication among project stakeholders, higher productivity levels, and improved quality outcomes (Ingle and Waghmare, 2015; Sarhan et al., 2020; Shaqour, 2022). From a broader operational perspective, lean practices contribute to improved occupational safety standards and stronger environmental performance within construction projects (Ahmed et al., 2021).

However, the implementation of lean principles and BMI in isolation may be insufficient to generate sustained competitive advantage. Construction projects are inherently complex and interdependent, often requiring extensive coordination across multiple organisations, supply chains, and contractual arrangements. In response, strategic partnerships have increasingly been recognised as critical enablers of business model transformation, particularly in large scale projects that demand substantial capital, specialised expertise, and network resources. Effective strategic partnerships are characterised by mutual trust, shared values, knowledge exchange, and long term commitment, all of which facilitate collaborative problem solving and resource sharing (Cantele and Cassia, 2020; Cho et al., 2021).

Strategic alliances also function as mechanisms for enhancing competitive advantage and organisational resilience. When construction firms establish enduring partnerships that support joint information sharing, technological integration, and risk allocation, these relationships can lead to improved financial and operational performance, reduced costs, and enhanced quality outcomes (Iranmanesh et al., 2019; Cho et al., 2021). Conversely, poorly structured or misaligned partnerships may result in resource misallocation, coordination failures, and missed strategic opportunities (Guertler et al., 2020).

Despite the growing recognition of LC, strategic partnerships, and BMI as strategic levers, empirical evidence on how these elements interact to influence firm performance

remains limited, particularly within emerging market contexts. The mediating role of BMI in linking operational strategies and inter organisational collaboration to performance outcomes has not been sufficiently explored in the construction sector.

Accordingly, this study aims to examine the interrelationships among LC, strategic partnerships, BMI, and firm performance. The research seeks to analyse both the direct and indirect effects of LC and strategic partnerships on firm performance, with BMI positioned as a mediating mechanism. Specifically, the objectives of this study are to assess the extent to which LC influences firm performance directly and indirectly through BMI, to examine how strategic partnerships affect firm performance both directly and via BMI, and to evaluate the overall impact of BMI on firm performance.

By empirically testing this conceptual framework, the study is expected to contribute to the strategic management and construction innovation literature by clarifying how operational excellence and collaborative strategies translate into superior performance through business model transformation. From a practical perspective, the findings offer guidance for construction firms in emerging markets by demonstrating how integrated approaches to lean implementation, partnership development, and innovation can support long term competitiveness and sustainability in an increasingly uncertain industry environment.

2 Literature review

2.1 Lean construction as a strategic driver of firm performance

LC, which originates from lean production theory, has evolved into a comprehensive approach that integrates technical efficiency with cultural and organisational transformation within construction firms (Li et al., 2020). The primary objective of LC is to eliminate various forms of waste, including overproduction, delays, defects, and excess inventory, while simultaneously improving process quality and overall project efficiency (Akanbi et al., 2019).

Empirical evidence indicates that lean methods have been increasingly adopted in large scale infrastructure projects, where they have delivered measurable improvements in cost control, project duration, and quality outcomes (Hanna et al., 2010). Despite these demonstrated benefits, the diffusion of lean practices remains uneven, particularly within certain public sector construction contexts. Koskela characterises LC as a process oriented system that emphasises value creation and the systematic reduction of non essential activities throughout the project lifecycle (Mishra and Aithal, 2022). This conceptualisation highlights the shift from traditional input driven management approaches towards value based process optimisation.

The relevance of lean principles is further reinforced by the project management body of knowledge (PMBOK), which recognises lean thinking as an effective mechanism for optimising resources and improving performance in project management environments (Rebaiaia and Rodrigues Vieira, 2014). Within this framework, LC is not merely a set of operational tools, but a strategic philosophy that reshapes how construction firms plan, execute, and control project activities.

From a strategic perspective, LC extends beyond operational efficiency to enhance a firm's ability to compete in dynamic and uncertain environments. By reducing resource waste and improving process reliability, lean practices strengthen organisational

responsiveness and performance consistency. Mishra and Aithal (2022) demonstrate that LC implementation can result in substantial reductions in material waste and process inefficiencies, thereby contributing directly to improved organisational performance. These insights suggest that LC serves as both an operational and strategic driver of firm performance in the construction industry. Based on the theoretical and empirical arguments presented, this study proposes the following hypothesis:

H1 LC has a positive and significant effect on firm performance.

2.2 Business model innovation as a mediator in the lean performance nexus

LC is widely recognised for improving operational performance through efficiency gains and waste reduction. The ability of these improvements to translate into sustained firm competitiveness, however, increasingly depends on the role of BMI. BMI refers to the reconfiguration of an organisation's value creation, value proposition, and value capture mechanisms in response to market dynamics and technological change (Clauss, 2017). Through such strategic reconfiguration, firms can align operational efficiency with broader organisational renewal, enabling performance improvements that extend beyond short term outcomes.

The implementation of lean principles often requires firms to reconsider how value is delivered and monetised, thereby encouraging a reassessment of existing business models (Birkel and Müller, 2021). Lean initiatives challenge conventional approaches to organising activities, coordinating stakeholders, and structuring revenue mechanisms. Empirical studies suggest that lean systems foster conditions that support digital transformation and inter organisational collaboration, both of which are recognised as key antecedents of BMI (Hossain, 2017; Rachinger et al., 2019).

Process simplification, enhanced transparency across value chains, and a renewed focus on client value enable lean practices to support business model experimentation and redesign. In addition, organisations that adopt lean principles are more likely to engage in ecosystem based partnerships that facilitate new forms of value creation and value capture. Through these mechanisms, BMI functions as a strategic channel that transforms operational efficiency into more durable and scalable improvements in firm performance.

In this study, BMI is conceptualised as a mediating mechanism that strengthens the relationship between LC and firm performance. The mediating role of BMI reflects its capacity to translate operational improvements into strategic outcomes that support long term competitiveness. To empirically examine this relationship, the following hypothesis is proposed:

H2 LC has a positive and significant effect on firm performance through BMI.

2.3 Strategic partnerships and their influence on construction firm performance

Strategic partnerships represent enduring and trust based collaborative arrangements through which firms leverage complementary resources, capabilities, and knowledge to enhance performance outcomes (Dubrovski, 2020). Within the construction industry, such partnerships commonly take the form of joint ventures between contractors and subcontractors, as well as public private collaborations in large scale infrastructure projects. These cooperative arrangements enable firms to address project complexity and resource constraints more effectively than through standalone operations.

Prior research emphasises that both the breadth and depth of strategic partnerships play a critical role in shaping innovation outcomes and organisational performance. Kobarg et al. (2019) demonstrate that partnerships characterised by strong relational ties and diverse collaboration networks enhance firms' ability to access external knowledge, manage uncertainty, and co create value that would otherwise be difficult to achieve. In a similar vein, Gao et al. (2019) find that although the number of strategic partners may be limited, these partners often occupy pivotal positions in facilitating resource sharing, coordination, and overall project success.

Beyond their operational contributions, strategic partnerships function as strategic mechanisms that strengthen a firm's market responsiveness, innovation capacity, and long term competitiveness. Through sustained collaboration, construction firms are better positioned to share risks, integrate specialised expertise, and adapt to changing project and market conditions. These characteristics suggest that strategic partnerships serve as an important driver of firm performance in the construction sector. Based on the theoretical and empirical arguments presented, the following hypothesis is proposed:

H3 Strategic partnerships have a positive and significant effect on firm performance.

2.4 The mediating role of business model innovation in strategic partnerships

Strategic partnerships provide a collaborative context that supports BMI through the joint exploration of new market opportunities, emerging technologies, and alternative revenue models. By engaging in collaborative innovation activities, firms are able to co develop new value propositions and reconfigure their business models to better address changing customer demands and competitive conditions (Clauss, 2017; Rachinger et al., 2019).

Partnerships characterised by shared objectives and aligned incentives are particularly supportive of innovation processes. Dubrovski (2020) argues that such relationships facilitate access to external expertise while simultaneously fostering the trust required to experiment with new organisational arrangements and business configurations. Through sustained collaboration, firms can more effectively integrate complementary resources and capabilities, enabling the redesign of value creation and value capture mechanisms.

Within this context, BMI functions as a strategic mechanism that converts the collaborative potential of strategic partnerships into tangible performance outcomes. By mediating the relationship between partnerships and firm performance, BMI enables firms to transform relational resources and joint learning into scalable and sustainable competitive advantages. The mediating role of BMI reflects its capacity to link inter organisational collaboration with strategic renewal and performance improvement. To empirically examine this mediating mechanism, the following hypothesis is proposed:

H4 Strategic partnerships have a positive and significant effect on firm performance through BMI.

2.5 Business model innovation as a direct enabler of firm performance

BMI has increasingly been recognised as a central driver of firm performance in environments characterised by digital disruption and intensifying competitive pressures. Prior research indicates that digitalisation encourages firms to develop new forms of collaboration, enhance client engagement, and redesign revenue generation mechanisms as part of their strategic response to environmental change (Rachinger et al., 2019). In

this regard, sustained firm performance is closely linked to the ability of organisations to continuously adapt and renew their business models.

From a conceptual perspective, BMI comprises three interrelated dimensions, namely value creation innovation, value proposition innovation, and value capture innovation (Clauss, 2017). These dimensions reflect how firms redesign internal processes, redefine customer offerings, and restructure revenue mechanisms in response to market and technological shifts. When implemented effectively, BMI enables firms to deliver superior customer experiences, enhance operational efficiency, and achieve improved financial performance.

By aligning organisational strategies with evolving market conditions and technological developments, BMI functions as a direct enabler of sustained competitiveness and profitability. Through strategic renewal and continuous adaptation, firms that actively pursue BMI are better positioned to capture emerging opportunities and mitigate performance risks. This direct relationship between BMI and firm performance provides the basis for the following hypothesis:

H5 BMI has a positive and significant effect on firm performance.

3 Methods

3.1 Research design

This study adopts a quantitative research approach that utilises numerical data to examine the relationships among LC, strategic partnerships, BMI, and firm performance (See Figure 1). A correlational research design is employed to analyse the strength and direction of associations among these constructs. The unit of analysis consists of large scale construction firms operating in Indonesia, which represent the target population for empirical investigation. As explained by Devi and Lepcha (2023), correlational research designs enable the examination of statistical relationships between two or more constructs within a single population, allowing variations in both magnitude and significance to be identified. Such designs are widely used in predictive and theory development oriented studies employing structural equation modelling techniques (Putra, 2022).

3.2 Data collection

The study focuses on large scale construction companies in Indonesia, as these firms play a central role in the delivery of major national infrastructure projects. The research population comprises firms registered with the Indonesian Contractors Association (AKI) and the Indonesian Construction Executives Association (GAPENSI) as of 2024. Based on the most recent membership records, a total of 517 firms met the selection criteria. From this population, a sample of 226 firms was selected to ensure adequate statistical power and representativeness for empirical analysis, in line with sample adequacy considerations commonly applied in PLS SEM research (Hair et al., 2022).

Primary data were collected using structured questionnaires distributed to individuals occupying senior managerial positions, including Directors, Executives, and Senior Managers. These respondents were selected due to their strategic roles and decision

making authority within their respective organisations. The use of key informants at the managerial level is consistent with prior PLS SEM studies that examine strategic and organisational level constructs (Fahmi et al., 2024a).

The questionnaires were administered digitally using Google Forms. The collected data were analysed using SmartPLS, a statistical software package designed for Partial Least Squares Structural Equation Modelling and multivariate analysis. PLS SEM is particularly appropriate for this study due to its ability to analyse complex causal relationships involving multiple constructs and mediating effects, as well as its suitability for prediction oriented research and data that may not follow a normal distribution (Hair et al., 2022; Kunaifi et al., 2022). The method enables the simultaneous assessment of measurement and structural models, which is essential for examining mediation relationships within an integrated analytical framework (Putra, 2022).

Prior to full scale data collection, a pilot item analysis was conducted to assess item clarity, internal consistency, and construct validity. This step is recommended in PLS SEM research to improve measurement quality and reduce the risk of specification errors before structural model estimation (Fahmi et al., 2024b).

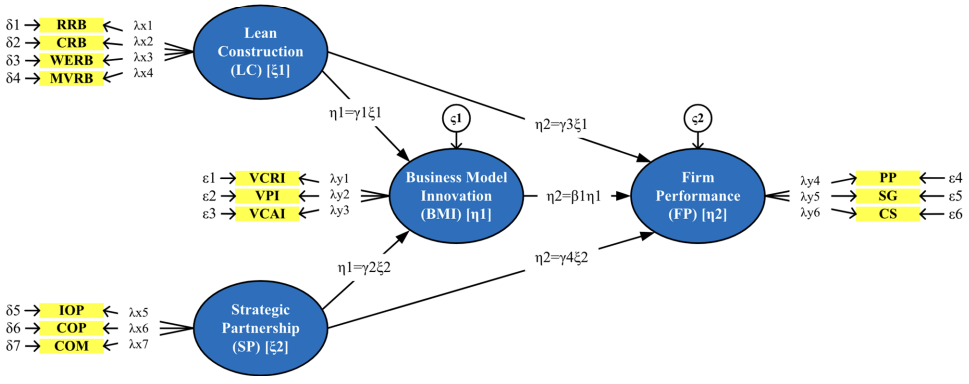
To complement and triangulate the quantitative findings, a series of semi structured interviews was conducted with participants holding comparable senior level positions. These interviews were carried out through face to face meetings as well as online platforms such as Zoom, and were intended to explore themes that emerged during the preliminary quantitative analysis. The integration of qualitative insights alongside PLS SEM results supports methodological triangulation and enhances the interpretive robustness of empirical findings (Kunaifi et al., 2022).

3.3 Measurement items

Each construct in this study was operationalised through a set of measurable dimensions and indicators that reflect its theoretical foundations and empirical applications within the construction industry. The operationalisation was designed to capture both strategic orientations and performance related outcomes, ensuring alignment between conceptual definitions and observable organisational practices.

LC is conceptualised as a value oriented management philosophy that emphasises efficiency improvement, waste reduction, and continuous improvement across the project lifecycle (Koskela, 2000; Sarhan et al., 2020). In this study, LC is measured using four dimensions that reflect its multidimensional impact on construction projects. Relationship related benefits capture the extent to which lean practices enhance coordination, collaboration, communication, and trust among project stakeholders, which are critical for integrated project delivery (Ingle and Waghmare, 2015; Sarhan et al., 2020). Cost related benefits reflect the ability of LC to reduce project costs, minimise material waste, and improve resource utilisation through process optimisation and risk reduction (Akanbi et al., 2019; Demirkesen, 2020). Work environment related benefits represent improvements in workplace safety, employee well being, and working conditions arising from more structured workflows and reduced process variability (Ahmed et al., 2021; Shaqour, 2022). Management values related benefits assess the extent to which lean implementation is supported by managerial commitment, leadership engagement, and a culture of continuous improvement within the organisation (Li et al., 2020; Mishra and Aithal, 2022).

Figure 1 Structural model (see online version for colours)



Notes: LC means lean construction; SP means strategic partnership; BMI means business model innovation; FP means firm performance; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; PP means increase profit; SG means sales growth; CS means customer satisfaction; ξ denotes exogenous latent variables; η denotes endogenous latent variables; x and y denote observed indicators; λ denotes factor loadings; γ denotes direct effects from exogenous to endogenous constructs; β denotes structural effects among endogenous constructs; δ and ε denote measurement errors; ζ denotes structural disturbance terms.

Strategic partnerships are operationalised as long term collaborative relationships established to support organisational objectives, risk sharing, and project success in complex construction environments. This construct is measured through three dimensions. Investment oriented partnership reflects collaboration arrangements that involve joint investment decisions, shared financial commitments, and long term risk allocation among partnering firms, which are essential in large scale construction projects (Iranmanesh et al., 2019; Dubrovski, 2020). Contract oriented partnership captures the formal governance structures that define roles, responsibilities, and contractual clarity, enabling effective coordination and conflict mitigation across organisational boundaries (Gao et al., 2019; Cho et al., 2021). Commitment represents the degree of mutual trust, relational stability, and long term orientation that underpin sustained collaboration and knowledge sharing between partners (Kobarg et al., 2019; Dubrovski, 2020).

BMI refers to a firm's capability to redesign and adapt its business model in response to changing market conditions and technological developments in order to sustain competitiveness (Clauss, 2017; Rachinger et al., 2019). This construct is measured using three dimensions consistent with established BMI frameworks. Value creation innovation reflects changes in internal processes, resource configurations, and activity systems that enable firms to create value more efficiently or in novel ways (Clauss, 2017; Hossain, 2017). Value proposition innovation captures the firm's ability to redefine and differentiate its offerings to better address customer needs and expectations (Clauss, 2017; Birkel and Müller, 2021). Value capture innovation represents innovations in

revenue models, pricing strategies, and cost structures that allow firms to appropriate value more effectively from their activities (Rachinger et al., 2019; Jauhary, 2020).

Firm performance is conceptualised as the extent to which an organisation achieves its strategic, financial, and market related objectives. In this study, firm performance is measured using three widely applied dimensions. Profit Increase reflects improvements in financial returns and overall profitability, indicating the firm's economic sustainability (Venkatraman and Ramanujam, 1986; Iranmanesh et al., 2019). Sales growth captures the firm's ability to expand revenue streams and market presence over time, reflecting competitive positioning and demand growth (Cho et al., 2021). Customer satisfaction represents the degree to which the firm meets or exceeds client expectations in terms of quality, reliability, and project outcomes, which is particularly critical in relationship intensive construction projects (Sarhan et al., 2020; Shaqour, 2022).

4 Results

4.1 Measurement model evaluation (second order approach)

The measurement model evaluation was conducted using a second order construct approach to reflect the multidimensional nature of the core constructs examined in this study, namely LC, strategic partnership, BMI, and firm performance. The use of higher order constructs is appropriate when a latent variable is theoretically conceptualised as being formed by several interrelated dimensions, and it allows for a more parsimonious and theoretically meaningful representation of complex organisational phenomena. In line with established methodological guidance, the second order measurement model was assessed using the repeated indicators approach within the partial least squares structural equation modelling framework (Hair et al., 2022; Putra, 2022). This approach is widely applied in strategic management and operational performance studies to ensure that higher order constructs adequately capture the variance explained by their underlying dimensions (Kunaifi et al., 2022; Fahmi et al., 2024a).

The evaluation of the measurement model focused on indicator reliability, internal consistency reliability, convergent validity, and discriminant validity, in accordance with recommended PLS SEM procedures. These criteria are essential to confirm that the constructs are measured accurately and consistently, thereby providing a robust foundation for subsequent structural model analysis and hypothesis testing (Hair et al., 2022; Fahmi et al., 2024b).

Table 1 presents the results of the convergent validity and reliability assessment for the second order measurement model. The table reports outer loadings for both first order and second order constructs, along with Cronbach's alpha, composite reliability measured by rho_A and rho_C, average variance extracted, and the highest heterotrait monotrait ratio for each first order dimension. Consistent with PLS SEM guidelines, the outer loadings of the first order indicators demonstrate satisfactory indicator reliability, while the second order loadings confirm that each dimension contributes meaningfully to its respective higher order construct (Hair et al., 2022; Putra, 2022).

Table 1 Convergent and reliability construct of second order model

Construct	*Dimension*	*Item*	*λ 1st order*	*λ 2nd order*	*α*	*rho_a*	*rho_c*	*AVE*	*Highest HTMT*
LC	RRB	LC01	0.877	0.769	0.892	0.895	0.925	0.756	0.849
		LC02	0.887	0.784					
		LC03	0.873	0.759					
		LC04	0.840	0.689					
	CRB	LC05	0.830	0.713	0.872	0.873	0.912	0.723	0.833
		LC06	0.859	0.721					
		LC07	0.841	0.693					
		LC08	0.870	0.750					
	WERB	LC09	0.836	0.766	0.875	0.876	0.914	0.728	0.849
		LC10	0.867	0.818					
		LC11	0.852	0.804					
		LC12	0.856	0.759					
	MVRB	LC13	0.872	0.686	0.848	0.849	0.898	0.688	0.778
		LC14	0.814	0.658					
		LC15	0.804	0.651					
		LC16	0.825	0.668					
SP	IOP	SP09	0.911	0.774	0.927	0.927	0.948	0.820	0.744
		SP10	0.936	0.805					
		SP11	0.923	0.815					
	COP	SP01	0.899	0.832	0.928	0.928	0.949	0.823	0.725
		SP02	0.899	0.792					
		SP03	0.918	0.815					
		SP04	0.907	0.810					
	COM	SP05	0.916	0.805	0.913	0.914	0.945	0.852	0.744
		SP06	0.896	0.788					
		SP07	0.914	0.817					
		SP08	0.902	0.818					

Notes: LC means lean construction; SP means strategic partnership; BMI means business model innovation; FP means firm performance; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; PP means increase profit; SG means sales growth; CS means customer satisfaction; λ 1st order refers to outer loadings of first order constructs; λ 2nd order refers to outer loadings of second order constructs using the repeated indicators approach; α refers to Cronbach's alpha; rho_a refers to composite reliability rho_A; rho_c refers to composite reliability; AVE refers to average variance extracted; highest HTMT refers to the highest heterotrait monotrait ratio value for each first order construct; all reported values meet the recommended thresholds for reliability, convergent validity, and discriminant validity in PLS SEM.

Table 1 Convergent and reliability construct of second order model (continued)

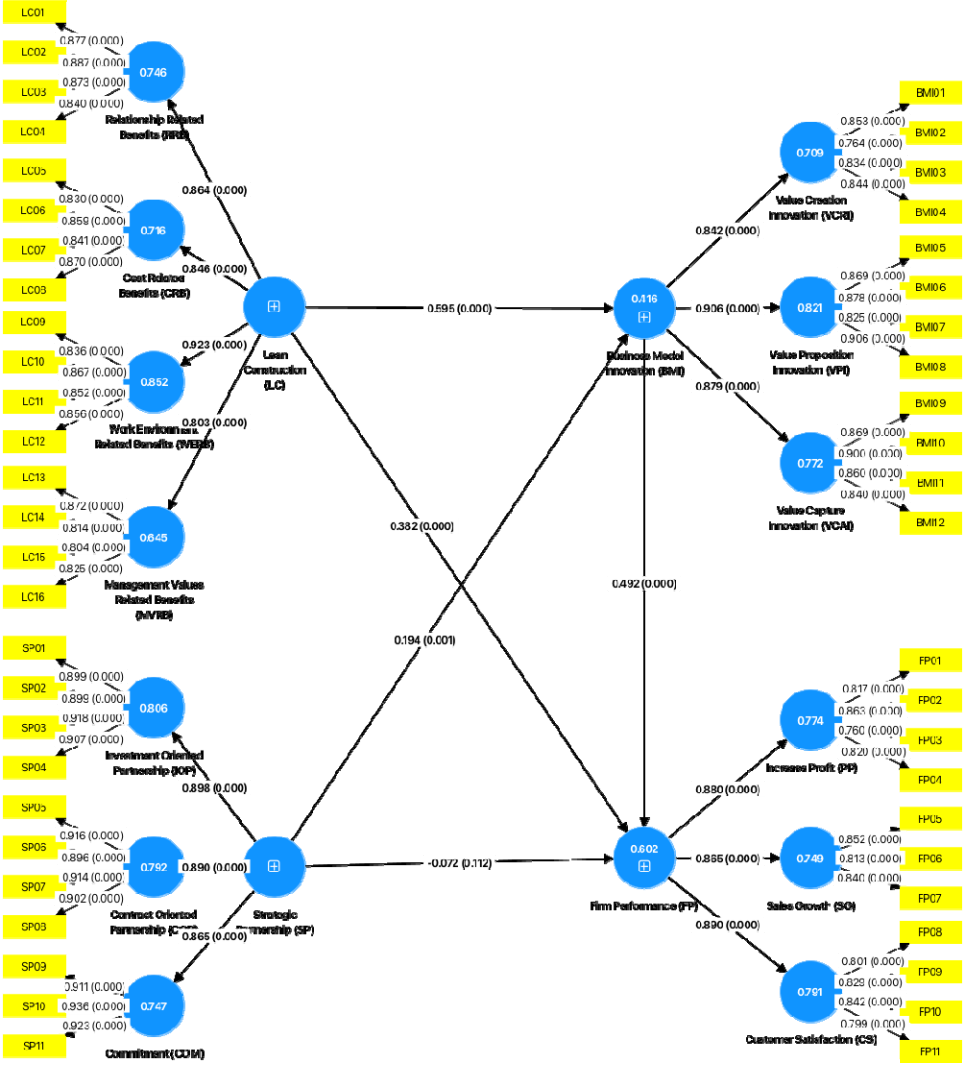
Construct	*Dimension*	*Item*	*λ 1st order*	*λ 2nd order*	*α*	*rho_a*	*rho_c*	*AVE*	*Highest HTMT*
BMI	VCRI	BMI01	0.723	0.853	0.842	0.847	0.894	0.680	0.755
		BMI02	0.629	0.764					
		BMI03	0.742	0.834					
		BMI04	0.675	0.844					
	VPI	BMI05	0.792	0.869	0.893	0.895	0.926	0.757	0.782
		BMI06	0.801	0.878					
		BMI07	0.735	0.825					
		BMI08	0.823	0.906					
	VCAI	BMI09	0.759	0.869	0.890	0.893	0.924	0.753	0.782
		BMI10	0.818	0.900					
		BMI11	0.747	0.860					
		BMI12	0.721	0.840					
FP	PP	FP01	0.748	0.817	0.832	0.836	0.888	0.665	0.810
		FP02	0.762	0.863					
		FP03	0.654	0.760					
		FP04	0.701	0.820					
	SG	FP05	0.733	0.852	0.783	0.783	0.874	0.697	0.840
		FP06	0.725	0.813					
		FP07	0.709	0.840					
	CS	FP08	0.801	0.829	0.835	0.836	0.890	0.669	0.840
		FP09	0.747	0.842					
		FP10	0.743	0.842					
		FP11	0.698	0.799					

Notes: LC means lean construction; SP means strategic partnership; BMI means business model innovation; FP means firm performance; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; PP means increase profit; SG means sales growth; CS means customer satisfaction; λ 1st order refers to outer loadings of first order constructs; λ 2nd order refers to outer loadings of second order constructs using the repeated indicators approach; α refers to Cronbach's alpha; rho_a refers to composite reliability rho_A; rho_c refers to composite reliability; AVE refers to average variance extracted; highest HTMT refers to the highest heterotrait monotrait ratio value for each first order construct; all reported values meet the recommended thresholds for reliability, convergent validity, and discriminant validity in PLS SEM.

The reliability assessment indicates that all constructs exhibit strong internal consistency, as reflected by Cronbach's alpha and composite reliability values that exceed commonly accepted thresholds. This suggests that the indicators within each construct consistently measure the same underlying concept, supporting the stability and dependability of the

measurement model. Furthermore, the average variance extracted values demonstrate adequate convergent validity, indicating that each construct explains a substantial proportion of variance in its indicators. These results align with prior empirical studies that applied PLS SEM to examine operational performance, innovation, and partnership based strategies in complex organisational settings (Kunaifi et al., 2022; Fahmi et al., 2024a).

Figure 2 Bootstrapping using second order approach (see online version for colours)



Discriminant validity is assessed using the heterotrait monotrait ratio, with the highest HTMT values reported for each first order construct. All HTMT values remain below the recommended thresholds, indicating that the constructs are empirically distinct from one another. This finding confirms that the dimensions of LC, Strategic Partnership, BMI, and Firm Performance capture conceptually different aspects of organisational practice

and performance, thereby reducing the risk of construct overlap and biased structural estimates. Overall, the results presented in Table 1 confirm that the second order measurement model meets the established criteria for reliability and validity in PLS SEM research (Hair et al., 2022; Putra, 2022).

Figure 2 illustrates the bootstrapping results for the second order measurement model. Bootstrapping is a non parametric resampling procedure used in PLS SEM to assess the stability and significance of model estimates, particularly in complex models involving higher order constructs and mediation relationships. The use of bootstrapping strengthens the robustness of the measurement model by providing confidence in the consistency of the estimated relationships across repeated subsamples (Hair et al., 2022; Garson, 2016).

The bootstrapping results shown in Figure 2 indicate that the paths linking first order dimensions to their corresponding second order constructs are stable and statistically meaningful. This confirms that the multidimensional constructs are well specified and that their underlying dimensions reliably represent the broader latent variables. Prior methodological and empirical studies emphasise that a well validated higher order measurement model enhances the interpretability of structural relationships and improves the explanatory power of PLS SEM analyses (Putra, 2022; Fahmi, Putra, et al., 2024). Consequently, the results depicted in Figure 2 provide strong support for proceeding with the structural model assessment and hypothesis testing using the validated second order constructs.

4.2 Structural model evaluation

The structural model evaluation aims to assess the explanatory and predictive capability of the proposed research framework and to determine the magnitude and relevance of the relationships among LC, strategic partnership, BMI, and firm performance. In accordance with PLS-SEM best practices, this stage focuses on examining the coefficient of determination (R-square), effect size (f-square), predictive relevance (Q^2predict), out-of-sample prediction accuracy, and global model fit indices. This approach aligns with the prediction oriented nature of PLS-SEM, which emphasises variance explanation and forecasting accuracy rather than strict model fit optimisation (Hair et al., 2022; Putra, 2022).

Consistent with recent PLS-SEM applications in operations management, innovation, and strategic performance research, the evaluation criteria adopted in this study follow the threshold recommendations proposed by Hair et al. (2022) and reinforced by empirical applications in emerging market contexts (Kunaifi et al., 2022; Fahmi et al., 2024a, 2024b). By combining explanatory power and predictive assessment, the structural model evaluation provides a comprehensive understanding of both theoretical robustness and practical relevance.

Table 2 presents the results of the structural model's explanatory power and effect size assessment. The R-square value for BMI is 0.414, indicating that LC and strategic partnership jointly explain 41.4% of the variance in BMI. According to Hair et al. (2022), R-square values of 0.25, 0.50, and 0.75 can be interpreted as weak, moderate, and substantial explanatory power, respectively. Thus, the explanatory power for BMI can be categorised as moderate, suggesting that the proposed antecedents capture a meaningful proportion of innovation related variance in construction firms.

For firm performance, the R-square value reaches 0.600, with an adjusted value of 0.595, indicating that LC, strategic partnership, and BMI collectively explain 60% of the

variance in firm performance. This level of explanatory power is considered strong in organisational and strategic management research, particularly within complex and multi actor environments such as the construction industry (Hair et al., 2022; Putra, 2022). These results suggest that the proposed model provides a solid theoretical explanation for performance differences among construction firms.

Table 2 Model fit, explanatory power, dan effect size

Evaluation aspect	*Path/construct*	*Value*
R-square	BMI	0.414
R-square adjusted	BMI	0.409
R-square	FP	0.600
R-square adjusted	FP	0.595
f-square	LC → BMI	0.597
	BMI → FP	0.351
	LC → FP	0.230
	SP → BMI	0.062
	SP → FP	0.013

Notes: LC means lean construction; SP means strategic partnership; BMI means business model innovation; FP means firm performance; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; PP means Increase profit; SG means sales growth; CS means customer satisfaction.

The f-square values further clarify the relative importance of each structural relationship. The effect of LC on BMI exhibits a large effect size (f-square = 0.597), indicating that lean practices play a critical role in enabling innovation at the business model level. Similarly, the effect of BMI on firm performance is substantial (f-square = 0.351), underscoring the central role of innovation as a performance driver. The direct effect of LC on firm performance shows a medium effect size (f-square = 0.230), confirming that lean contributes to performance both directly and indirectly.

In contrast, the effect of strategic partnership on BMI is relatively small (f-square = 0.062), while its direct effect on firm performance is negligible (f-square = 0.013). These findings reinforce the interpretation that partnerships alone do not guarantee performance improvements unless they are leveraged to support innovation. Such patterns are consistent with prior PLS-SEM studies that highlight the conditional and enabling role of inter organisational collaboration (Kunaifi et al., 2022; Fahmi et al., 2024b).

Table 3 reports the predictive relevance assessment using Q^2 predict, PLS-RMSE, LM-RMSE, PLS-MAE, and LM-MAE. The Q^2predict values for all dimensions of BMI and firm performance are positive, ranging from 0.266 to 0.377. Positive Q^2 predict values indicate that the model has predictive relevance and is capable of accurately predicting omitted data points (Hair et al., 2022; Putra, 2022).

A comparison between PLS and linear model prediction errors shows that PLS-RMSE and PLS-MAE values are consistently lower than or comparable to their LM counterparts across most indicators. This pattern suggests that the proposed structural

model demonstrates superior or at least equivalent out-of-sample predictive accuracy compared to a naïve linear benchmark. Such results confirm the suitability of PLS-SEM for prediction oriented research and align with empirical evidence reported in recent operational and innovation focused studies (Kunaifi et al., 2022; Fahmi et al., 2024a).

Table 3 Predictive relevance and out-of-sample prediction

Construct	*Dimension*	*Q^2predict*	*PLS-RMSE*	*LM-RMSE*	*PLS-MAE*	*LM-MAE*
BMI	VCRI	0.266	0.861	0.878	0.622	0.636
	VPI	0.339	0.818	0.847	0.612	0.631
	VCAI	0.292	0.845	0.851	0.616	0.617
FP	PP	0.307	0.837	0.837	0.593	0.607
	SG	0.349	0.811	0.824	0.604	0.614
	CS	0.377	0.793	0.803	0.574	0.575

Notes: LC means lean construction; SP means strategic partnership; BMI means business model innovation; FP means firm performance; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; PP means increase profit; SG means sales growth; CS means customer satisfaction.

The relatively higher Q^2predict values observed for customer satisfaction and sales growth dimensions further indicate that the model is particularly effective in predicting market related performance outcomes. This finding is theoretically meaningful, as BMI and lean practices are expected to directly influence customer value creation and revenue expansion in construction firms.

Table 4 summarises the global model fit indices. The SRMR value of 0.055 for both the saturated and estimated models falls below the recommended threshold of 0.08, indicating an acceptable level of model fit (Hair et al., 2022). The NFI value of 0.857 suggests a satisfactory incremental fit, particularly given the complexity of the second order model and the exploratory nature of the research.

Table 4 Model fit indices

Fit index	*Saturated model*	*Estimated model*
SRMR	0.055	0.055
NFI	0.857	0.857

Although global fit indices are not the primary focus in PLS-SEM, their inclusion provides additional reassurance that the specified model structure is consistent with the observed data (Putra, 2022). Prior studies emphasise that acceptable SRMR values, combined with strong explanatory and predictive power, indicate a well specified and theoretically coherent structural model (Kunaifi et al., 2022; Fahmi et al., 2024b).

4.3 Hypothesis testing

The hypothesis testing results provide empirical evidence regarding the structural relationships among LC, strategic partnership, BMI, and firm performance. The findings

reveal differentiated patterns of direct and indirect effects, highlighting the central role of BMI in translating strategic practices into performance outcomes.

Table 5 Model fit, explanatory power, dan effect size

	Path	*Path coefficient*	*T statistics*	*P values*	*Result*
H1	LC → FP	0.385	4.436	0.000	Supported
H2	LC → BMI → FP	0.291	4.966	0.000	Supported
H3	SP → FP	−0.075	1.610	0.108	Not supported
H4	SP → BMI → FP	0.093	2.727	0.006	Supported
H5	BMI → FP	0.489	5.741	0.000	Supported
–	LC → BMI	0.595	9.428	0.000	Significant (non-hypothesised direct path)
–	SP → BMI	0.191	3.159	0.002	Significant (non-hypothesised direct path)

Notes: LC means lean construction; SP means strategic partnership; BMI means business model innovation; FP means firm performance; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; PP means increase profit; SG means sales growth; CS means customer satisfaction.

The results indicate that LC has a positive and significant direct effect on firm performance. This relationship is supported by a path coefficient of 0.385, a t statistic of 4.436, and a p value of 0.000. These values confirm that lean practices such as waste reduction, process standardisation, and workflow optimisation contribute directly to improved organisational performance. This finding supports the argument that LC functions not only as an operational improvement mechanism but also as a strategic capability that enhances firm level outcomes.

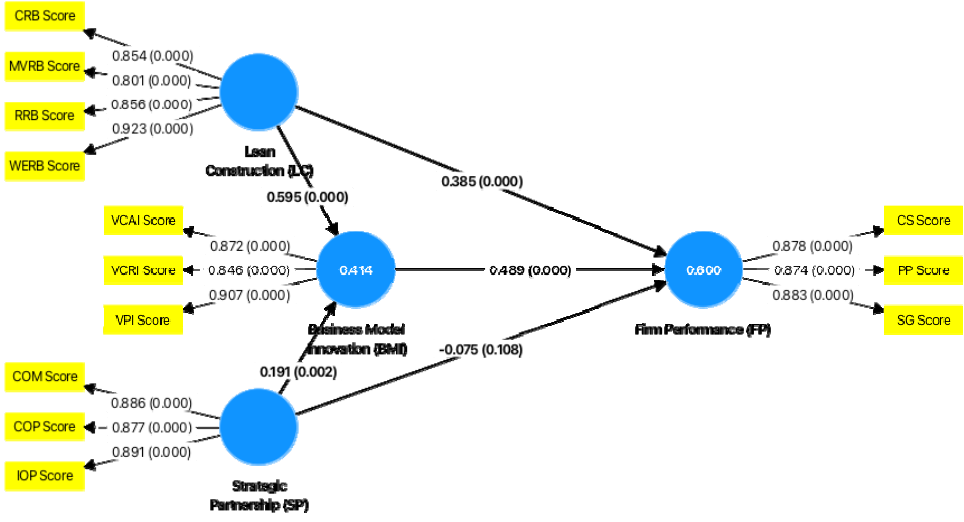
The indirect effect of LC on firm performance through BMI is also significant. The mediating pathway exhibits a coefficient of 0.291 with a t statistic of 4.966 and a p value of 0.000. Notably, this indirect effect is substantial, indicating that a significant portion of the performance gains associated with lean implementation is realised when lean practices stimulate innovation in value creation, value proposition, and value capture. This result suggests that LC achieves greater strategic impact when it is embedded within broader business model transformation initiatives.

In contrast, the direct effect of strategic partnership on firm performance is not supported. The path coefficient for this relationship is negative at minus 0.075, with a t statistic of 1.610 and a p value of 0.108. These values indicate that partnerships alone do not generate measurable performance improvements. This finding implies that collaborative arrangements without innovation oriented integration may remain transactional and insufficient to influence firm performance directly.

However, strategic partnership demonstrates a significant indirect effect on firm performance through BMI. The mediating effect shows a path coefficient of 0.093, a t statistic of 2.727, and a p value of 0.006. These results indicate that partnerships contribute to performance outcomes when they foster innovation, such as joint

development of new service offerings, shared technology adoption, or reconfiguration of revenue models. This pattern confirms that the performance value of partnerships is conditional upon their ability to catalyse BMI.

Figure 3 Bootstrapping results of main model (see online version for colours)



Notes: LC means lean construction; RRB means relationship related benefits; CRB means cost related benefits; WERB means work environment related benefits; MVRB means management values related benefits; SP means strategic partnership; IOP means investment oriented partnership; COP means contract oriented partnership; COM means commitment; BMI means business model innovation; VCRI means value creation innovation; VPI means value proposition innovation; VCAI means value capture innovation; FP means firm performance; PP means increase profit; SG means sales growth; CS means customer satisfaction.

BMI itself exhibits the strongest direct effect on firm performance among all constructs in the model. The relationship is supported by a path coefficient of 0.489, a t statistic of 5.741, and a p value of 0.000. These figures demonstrate that firms capable of continuously redesigning their value creation processes, customer offerings, and value capture mechanisms achieve superior performance outcomes. This result reinforces the strategic importance of innovation as a core driver of competitiveness in the construction industry.

In addition to the hypothesised relationships, two non hypothesised direct paths are found to be significant. LC has a strong positive effect on BMI, with a path coefficient of 0.595, a t statistic of 9.428, and a p value of 0.000. This indicates that lean practices strongly enable business model transformation by creating more efficient, flexible, and transparent organisational processes. Strategic partnership also shows a positive effect on BMI, with a coefficient of 0.191, a t statistic of 3.159, and a p value of 0.002. This result suggests that partnerships provide access to external knowledge and resources that support innovation, even though their direct contribution to performance is limited.

Overall, the hypothesis testing results demonstrate that firm performance is influenced by both operational and relational strategies, but the strongest and most consistent effects occur when these strategies operate through BMI. LC contributes to

performance both directly and indirectly, while strategic partnership contributes primarily through its innovation enabling role. BMI emerges as the central mechanism that integrates lean practices and collaborative relationships into tangible and sustainable performance outcomes.

5 Discussion

The results indicate that LC contributes to stronger firm performance in Indonesian construction firms, reinforcing the view that lean should be understood not merely as a project level efficiency toolkit but as a strategic organisational capability. Lean oriented routines that reduce waste, stabilise workflow, and enhance process reliability translate into improved delivery outcomes in terms of time, quality, and cost control, which remain persistent challenges in construction delivery systems (Akanbi et al., 2019; Hanna et al., 2010; Mishra and Aithal, 2022). This finding aligns with broader innovation and performance literature which suggests that operational excellence becomes performance relevant when it supports higher level strategic reconfiguration, rather than when it is pursued as an isolated efficiency initiative (Garzia et al., 2025).

A central insight of this study is that the performance contribution of LC becomes substantially stronger when it is channelled through BMI. Lean creates a disciplined internal environment by standardising processes, improving transparency, and reducing coordination frictions, thereby freeing managerial capacity for strategic redesign decisions. This mechanism supports a transition from incremental improvement towards systematic rethinking of how value is created, proposed, and captured, consistent with the core dimensions of BMI articulated by Clauss (2017). Empirical evidence from SMEs and manufacturing contexts similarly demonstrates that operational improvements only translate into sustained performance gains when accompanied by business model renewal (Cao et al., 2025; Garzia et al., 2025).

The mediated relationship between LC and firm performance can therefore be interpreted as a shift from operational excellence to strategic advantage. Lean strengthens internal coherence and process reliability, which enables experimentation with new delivery logics, integrated service offerings, and alternative revenue mechanisms. Digitalisation further accelerates this pathway by enhancing coordination scalability and data visibility, allowing firms to sustain more complex value configurations than would be feasible under fragmented and paper based workflows (Birkel and Müller, 2021; Rachinger et al., 2019). This interpretation resonates with recent studies on digital servitisation and digital transformation as enablers of sustainable BMI, where process discipline is a prerequisite for innovation scalability (Pizzichini et al., 2025; Venkatesh and Singhal, 2023).

The findings also reveal that strategic partnerships do not automatically translate into higher firm performance. This outcome is theoretically meaningful in construction contexts where partnerships often remain transactional, project specific, or constrained by short term contractual horizons. Under such conditions, collaboration may improve access to resources or capacity but fails to generate measurable performance benefits unless embedded in shared strategic intent, governance clarity, and joint problem solving routines (Dubrovski, 2020; Kobarg et al., 2019; Kim and Nguyen, 2018). Similar patterns have been observed in sustainability oriented innovation research, where partnerships that

lack strategic integration do not yield performance improvements despite resource sharing (Peralta and Pyka, 2025).

At the same time, the results demonstrate that strategic partnerships contribute to firm performance when they stimulate BMI. This suggests that partnerships function as enabling platforms rather than direct performance levers. Through collaboration, firms gain access to complementary knowledge, technologies, and market insights that support the redesign of value propositions and revenue logics. This finding aligns with evidence from sustainable and digital business model studies which emphasise that inter organisational collaboration becomes performance relevant only when it facilitates innovation rather than coordination alone (Chevrollier et al., 2025; Sharma et al., 2025). In this sense, partnerships help firms move from collaboration as operational alignment towards collaboration as an innovation capability.

This pattern is particularly plausible in environments characterised by uncertainty, disruption, and sustainability pressures, where performance depends more on adaptive capacity than static efficiency. BMI allows firms to respond to volatility through revised delivery systems, diversified revenue structures, and more resilient stakeholder configurations. Evidence from energy enterprises and green entrepreneurship contexts indicates that firms integrating innovation driven business models with collaborative ecosystems achieve superior sustainable performance outcomes (Wang et al., 2025). These insights reinforce the argument that partnerships enhance performance when they support adaptive and innovative capacity rather than mere scale or access.

BMI itself emerges as a decisive driver of firm performance, confirming that sustainable competitiveness increasingly depends on continuous reconfiguration of value creation and value capture mechanisms. Digitalisation pressures, sustainability demands, and evolving client expectations amplify the performance payoffs of firms that can redesign offerings, reorganise activity systems, and adapt cost and revenue structures more rapidly than competitors (Clauss, 2017; Rachinger et al., 2019). In construction, this may manifest in integrated project delivery models, lifecycle service offerings, data enabled client reporting, performance based contracting, or platform oriented collaboration, all of which fundamentally reshape how value is delivered and priced.

Overall, the findings support a system perspective in which operational practices, collaborative structures, and innovation mechanisms are interdependent. LC provides the internal discipline and visibility that reduce the risk of strategic experimentation, strategic partnerships supply external knowledge and complementary resources, and BMI converts these inputs into sustainable performance outcomes. This integrated view helps explain why the strongest performance effects occur when LC and strategic partnerships are channelled through BMI rather than treated as isolated managerial initiatives.

Contextually, the Indonesian construction sector's exposure to disruption, regulatory complexity, and sustainability pressures makes these relationships especially salient. Lean implementation in emerging market construction settings has been associated with productivity gains and waste reduction, but also with adoption barriers related to capability and strategic alignment, indicating that performance outcomes depend on the depth of integration between lean practices and strategic transformation rather than superficial application (Ahmed et al., 2021; Sarhan et al., 2020). Moreover, evidence linking lean practices to safety and environmental performance highlights that lean related gains extend beyond cost and time metrics into dimensions that shape reputation, risk management, and client trust, which ultimately influence firm performance (Demirkesen, 2020; Moaveni et al., 2019).

In summary, the results support a performance narrative in which LC enhances Firm Performance both directly and indirectly by enabling BMI, strategic partnerships contribute to performance primarily when they catalyse innovation rather than coordination, and BMI functions as the central mechanism that converts operational excellence and inter organisational collaboration into sustainable and resilient performance outcomes.

6 Conclusions

This study set out to examine the interrelationships among LC, strategic partnerships, BMI, and firm performance within the construction industry. The empirical results demonstrate that LC enhances firm performance through both direct and indirect mechanisms. Notably, the indirect effect mediated by BMI is stronger than the direct effect, indicating that the performance benefits of lean practices are maximised when operational improvements are embedded within systematic business model transformation. This finding suggests that operational excellence alone is insufficient to generate sustained performance gains, and that innovation in value creation, value proposition, and value capture is essential to amplify the strategic impact of lean implementation.

A further key finding is that strategic partnerships do not exert a significant direct influence on firm performance. Instead, their contribution becomes meaningful when partnerships stimulate BMI. This highlights that partnerships function primarily as enabling mechanisms that provide access to complementary resources, knowledge, and relational capital, rather than as direct performance drivers. Performance improvements emerge when collaborative arrangements facilitate adaptive changes in business models, reinforcing the central role of BMI in converting inter organisational collaboration into tangible outcomes. In addition, BMI itself exhibits a strong and positive direct effect on firm performance, underscoring its role as a pivotal strategic capability for firms operating in dynamic and uncertain environments.

From a theoretical perspective, this study makes several unique contributions. First, it advances the lean management literature by repositioning LC as a strategic capability rather than merely a project level efficiency tool. Second, it contributes to BMI research by empirically demonstrating its mediating role in linking both operational practices and collaborative strategies to firm performance. Third, the study enriches construction management and strategic management scholarship by integrating LC, strategic partnerships, and BMI within a single explanatory framework, thereby offering a more holistic understanding of how operational excellence and inter organisational collaboration jointly shape performance outcomes.

Despite these contributions, several limitations should be acknowledged. First, the cross sectional research design restricts the ability to draw strong causal inferences regarding the dynamic relationships among lean practices, innovation, and performance. Second, the empirical analysis is limited to firms within a single industry context, which may constrain the generalisability of the findings to other sectors. Third, strategic partnerships are conceptualised at an aggregate level and do not capture specific relational attributes such as governance mechanisms, trust intensity, or contractual complexity. Finally, the model does not explicitly incorporate contextual variables such

as market turbulence, regulatory pressure, or digital maturity, which may influence the effectiveness of lean strategies and BMI.

These limitations point to several avenues for future research. Longitudinal studies are needed to examine how lean practices, partnerships, and BMI co evolve over time and how their performance effects unfold dynamically. Comparative studies across industries or countries could enhance external validity and provide deeper insights into contextual contingencies. Future research could also disaggregate strategic partnerships by governance form, relational quality, or strategic orientation to better understand their differentiated innovation effects. In addition, incorporating moderating variables such as environmental uncertainty, digital capability, or sustainability orientation would allow for a more nuanced analysis of when and under what conditions LC and BMI are most effective.

Overall, this study underscores the importance of integrating operational excellence, collaborative strategies, and continuous business model renewal to achieve sustainable competitive advantage. By positioning BMI as the central mechanism that translates LC and strategic partnerships into performance outcomes, the findings offer both theoretical advancement and practical guidance for construction firms seeking to navigate increasing complexity and disruption.

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Ethical approval statement

This study did not require formal ethical approval as it involved voluntary and anonymous participation from industry professionals. The research focused solely on organisational and managerial practices within the Indonesian construction sector, without collecting any personal or sensitive information. All participants were informed about the research purpose, confidentiality assurance, and their right to withdraw at any time.

Declarations

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The datasets generated and analysed during the current study are not publicly available due to confidentiality agreements with participating construction firms. The data are available only to the researcher, Johan Arifin, and may be shared in anonymised form upon reasonable request to the corresponding author at johan.arifin@binus.ac.id.

The data were collected between December 2024 and March 2025 through an online survey distributed to C-level executives and senior managers of Indonesian construction firms affiliated with the Indonesian Contractors Association (AKI) and The National Association of Indonesian Contractors (GAPENSI).

The author declares that there are no conflicts of interest regarding the research, authorship, or publication of this article.

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