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The role of business model innovation as mediating and environmental dynamism as moderating variable to improve performance in Indonesia

Johan Arifin[1*], Harjanto Prabowo[2], Mohammad Hamsal[3], Elidjen Elidjen[4]

[1,2,3,4]*Management Department, BINUS Business School Doctor of Research in Management, Bina Nusantara University, Jakarta, Indonesia 11480.*

Corresponding author: Johan Arifin (*Email: johan.arifin@binus.ac.id*)

Abstract

This study investigates the role of Business Model Innovation (BMI) as a mediator between Lean Construction (LC), Supply Chain Resilience (SCR), Strategic Partnership (SP), and Environmental Dynamism (ED) on Firm Performance (FP) in the Indonesian construction industry. It explores both the direct impacts of these practices and their indirect effects through business model innovation transformation. A quantitative approach was used with survey data from 226 C-level and senior managerial respondents across major construction firms. Structural Equation Modelling (SEM) with SmartPLS tested eight hypothesised relationships among LC, SCR, SP, BMI, ED, and FP. The results show that Lean Construction significantly improves Firm Performance, both directly and indirectly through BMI, with the mediated path stronger than the direct effect. Strategic Partnership does not directly affect FP but has a positive indirect impact when mediated by BMI. This research underscores BMI as a crucial bridge linking lean practices and partnerships to stronger performance. It encourages construction firms to combine lean methods and strategic partnerships with innovative business model design to improve competitiveness and resilience. Future research should consider longitudinal analysis, cross-industry comparisons, and contextual factors such as digital maturity and regulation.

Keywords: Business model innovation, Construction industry, Environmental dynamism, Firm performance, Lean construction, Strategic partnership, Supply chain resilience.

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1. Introduction

The construction industry is one of the industries affected by the pandemic. Construction work has been halted, while work that is still ongoing must follow applicable health protocols [1]. The pandemic also caused a decline in performance and financial results and forced many companies to close. The value of construction completed decreased from IDR 1,594,196 billion in 2019 to IDR 1,311,418 billion (-17.74%) in 2020 [2]. Covid-19 also has an impact on supply and demand instability, causing losses, especially inventory that cannot be maximized [3]. In addition, the construction industry is currently also faced with cost, quality and time inefficiencies [4]. Facing this phenomenon, companies are challenged to be more innovative in managing their business model innovations. Companies that are successful in managing innovation can create a source of income, which will fund the next innovation process [5].

In the construction industry, the phenomenon of the business environment used to be relatively stable, so there was no need for an innovative business model or it tended to be the same as before, only the scope and scale of the project / work were different, for example for infrastructure work (roads, bridges, dams, water buildings, buildings, airports, ports and other public facilities). This is because the environmental dynamism that occurred at that time did not require many significant changes. In contrast to today, unpredictable rapid environmental changes occur in the company's external environment such as technological changes, and variations in consumer preferences [6] as well as within the company environment such as market changes and competition [7].External and internal factors in a dynamic environment make companies not resistant to change and become innovative product creation ideas and are considered as opportunities to develop innovative business models and new capabilities [8-10]. The failure of a plan in a company can also result from a lack of innovation in construction companies [11]. Many construction companies are more cautious in innovating because of the risks that may be caused.

Various issues that occur in the application of business model innovation, one of which is related to the application of lean construction in the construction industry. Lean construction is a construction project management system that aims to reduce waste or reduce material waste, accidents, time, and effort in order to get the maximum value from the construction process to be delivered to customers [12, 13]. The results of several previous studies prove that the application of lean construction has a huge positive impact on the construction industry, namely increasing the value of resources by mitigating risks, reducing costs, reducing waste, reducing rework, saving time, improving construction processes, improving coordination and communication, increasing productivity, quality, flexibility, and eliminating non-value activities [13-15] safety and environmental levels in the construction industry [16].

In addition to lean construction, business model innovation is also related to supply chain resilience, which deals with raw materials, material procurement, and maintaining relationships with vendors. Digitalization of business models will affect the overall capacity, processes, procedures and capabilities of the supply chain along with the increasing public interest in digital technology and transparency [17]. Moreover, the pandemic outbreak illustrates that the supply chain is currently vulnerable to change [18] as well as many issues faced in the field. For this reason, companies must be able to return from disruptive situations, followed by readiness for future changes, agility in responding to changes and vigilance which are important elements of supply chain resilience [19, 20] as well as involving customers and suppliers in dealing with disruption [3] which starts with risk prevention and how to respond to these risks [20]. Supply chain management is very important in business, especially in the construction industry, to ensure projects are completed on time and of high quality while saving money and providing benefits to the company [21]. This is due to the high logistics costs in Indonesia, which are currently the highest at 24% of GDP [22].

The process of achieving construction company performance is not easy, with business model innovation as a mediator of lean construction, supply chain resilience and as a complement to provide strength, strategic partnerships are needed. There are several factors that are important elements for creating business model innovation based on partnerships, namely: shared values, absence of opportunistic behaviour, knowledge sharing, trust and commitment [23]. The implementation of current work requires strategic partnerships in its application due to the large scope of work, this will alleviate in terms of funding, as well as being a relationship to get work. Strategic partnerships are considered the main mechanism for achieving better performance [24]. This is important to do because this collaboration will increase trust, commitment and support resource sharing between the parties [25]. Collaboration with strategic partnerships is expected to provide benefits to both parties [26]. When companies can foster long-term relationships with strategic partnerships where they can share information, technology and risks, it will have an impact on increasing operational and financial performance, reducing costs, and improving product quality [25, 27]. Therefore, mistakes in choosing strategic partnerships can lead to losses of resources and opportunities that will jeopardize the company [28].

This research aims to determine the variables that influence the performance of Indonesian construction companies, with business model innovation as a mediating variable and environmental dynamism as a moderating variable. This is to find out how much influence lean construction, supply chain resilience, strategic partnerships, business model innovation and environmental dynamism have on firm performance. Considering the many obstacles in implementing lean construction, as well as the high logistics costs in Indonesia and the many challenges in establishing strategic partnerships.

Based on the background of this research, firm performance is closely related to business model innovation. Therefore, this study intends to investigate the importance of business model innovation factors in construction companies with lean construction, supply chain resilience, strategic partnerships and environmental dynamism being a key in improving firm performance.

In general, the purpose of this research is to prove what conjectures/hypotheses can support the performance of construction companies. The model developed intends to reveal the key factors for improving the performance of construction companies. In this research, there are mediating and moderating variables that must be found and applied to strengthen the influence of determinants in terms of lean construction, supply chain resilience, strategic partnerships, business model innovation and environmental dynamism to achieve optimal company performance. In particular, this study aims to: (1) To find empirical evidence that lean construction has a significant effect on firm performance in construction companies in Indonesia; (2) To find empirical evidence that business model innovation has a significant effect as a mediator between lean construction and firm performance in construction companies in Indonesia; (3) To find empirical evidence on supply chain resilience that significantly affects firm performance in construction companies in Indonesia; (4) To find empirical evidence on business model innovation that significantly mediates between supply chain resilience and firm performance in construction companies in Indonesia; (5) To find empirical evidence on strategic partnership that significantly affects firm performance in construction companies in Indonesia; (6) To find empirical evidence that business model innovation significantly influences firm performance in Indonesian construction companies through strategic partnerships; (7) To find empirical evidence that business model innovation significantly influences firm performance in Indonesian construction companies; (8) To find empirical evidence that environmental dynamism significantly moderates the relationship between business model innovation and firm performance in Indonesian construction companies.

By testing this framework empirically, the study seeks to deliver both theoretical contributions on the interplay of operational strategy, innovation, and performance, and actionable advice for construction firms operating in emerging markets such as Indonesia. The insights gained will deepen the understanding of how collaborative and innovative approaches can enhance long-term sustainability and competitiveness in the construction industry.

2. Literature Review

2.1. Lean Construction Has a Positive and Significant Effect on Firm Performance

The lean construction theory is divided into two categories. The first of these is the fundamental lean construction theory, which is derived from the lean production theory. The second is the technical support theory of lean construction, which proposes 11 principles of lean production [29]. It is hypothesized [30] that research related to lean construction in terms of safety will yield positive results by combining lean construction principles with safety principles. In order for lean construction to evolve into a management application that is effective, it is imperative to incorporate several elements of an integral vision. This will ensure consistency between human and technical development within the organization or project [31].

A persistent tendency has been observed in the evolution of lean culture and the implementation of lean principles within the construction industry. This phenomenon involves the adaptation and refinement of the term "lean" from various industries, resulting in a form that is specifically tailored for application in the construction sector. The fundamental objective of lean principles is the elimination of waste in process activities with the aim of reducing process cycles, improving quality, and increasing efficiency [32]. In the context of lean, waste includes all forms of overproduction, over processing, delays, excess inventory and movement, failures, and defects, explains Al-Aomar in Akanbi, et al. [32].

The employment of lean techniques for the execution of large, complex projects is experiencing a rapid escalation across the country. These techniques have been demonstrated to reduce project delivery time, cost, and improve quality. However, lean techniques are not currently employed by State Highway Agencies (SHA) [33]. The employment of lean techniques in the execution of future projects has the potential to enhance their quality, expedite their completion, and optimize their efficiency.

Lean Construction (LC) is a technique for organizing creation systems to limit the misuse of materials, time and work to deliver the most necessary proportion of critical value, Koskela in Aithal and Mishra [34]. On Design for Manufacturing Competition in Aithal and Mishra [34]. LC is described as the process of removing waste, meeting or outperforming all client needs, focusing on the overall value stream, and traveling for perfection in task execution. Lean thinking is inclined as it gives a strategic to accomplish progressively more with less human effort, less stuff, less time and less space, will give clients exactly what they need [34]. Project Management Body of Knowledge (PMBOK), lean and agile are methods proposed to facilitate projects with effective deployment and organization to minimize resources, costs, duration and risks [35]. Research conducted by Aithal and Mishra [34] found that the percentage of waste found was quite low, this was due to adopting a lean construction approach at the construction site. The project under study implemented various practices of reuse strategies, such as the use of bricks in soling, pieces of reinforcement in casting were mostly used for grating drainage holes, waste sand in Hume pipes, and backfill material. In light of these insights, this study formulates the following hypothesis:

$H_{1:}$ Lean Construction has a positive and significant effect on Firm Performance.

2.2. Business Model Innovation as a Mediator in the Lean Construction to Firm Performance

While Lean Construction has been demonstrated to directly enhance operational performance, its influence on long-term firm competitiveness can be significantly amplified through Business Model Innovation (BMI). The BMI model involves a reconfiguration of an organization's value creation, delivery, and capture mechanisms [36]. This reconfiguration is imperative to ensure adaptability to evolving market dynamics and technological advancements.

The implementation of lean principles often necessitates the development of novel approaches to value delivery and monetization, compelling firms to undertake a comprehensive reassessment of their business models [37]. Lean systems have been identified as a foundational element for the initiation of digital transformation and collaboration, both of which have been demonstrated to be critical drivers of BMI [38, 39]. By streamlining processes, redefining client value, and forming strategic partnerships, lean practices can facilitate business model innovation. Consequently, BMI may function as a pivotal mechanism through which lean construction attains more substantial and enduring performance impacts.

In light of the rationale, the present investigation posits that BMI functions as a mediating factor in the following inquiry:

H_2: Lean Construction has a positive and significant effect on Firm Performance through Business Model Innovation.

2.3. Supply Chain Resilience Has a Positive and Significant Effect on Firm Performance

The success of supply chain management will be achieved if there is cooperation to provide information to each other between the companies involved, for example related to production plans, new capacity plans, service development and new products, consumer demand forecasts, marketing strategies, production dates and others related to production plans distribution, purchase and delivery [40].

The contemporary global landscape is characterized by numerous challenges and issues that have the potential to adversely impact the global economy. In such a context, it becomes imperative for companies to identify the most effective strategies for ensuring their continued viability and success in the face of these evolving circumstances. The capacity of an organization to recover from circumstances that disrupt or compromise its stability is referred to as supply chain resilience [19].

The concept of resilience capabilities encompasses four fundamental components: agility, collaboration, reengineering, and risk management culture, Christoper and Peck in Abeysekara, et al. [19]. Supply chain resilience, therefore, can be defined as a company's ability to cope with situations that disrupt the supply chain. This ability consists of preparation, vigilance, and agility.

Based on these considerations, the following hypothesis is advanced:

H^3: Supply Chain Resilience has a positive and significant effect on Firm Performance.

2.4. Business Model Innovation as a Mediator in the Supply Chain Resilience to Firm Performance

Supply Chain Resilience has been demonstrated to directly enhance operational performance; nevertheless, its impact on long-term business competitiveness can be considerably augmented through Business Model Innovation (BMI).

The advent of Industry 4.0 has precipitated transformative and disruptive changes in the value chain, engendering innovative business models, processes, products, and services [41]. An intersection between Industry 4.0 and the supply chain has been identified, resulting in vertical and horizontal integration within the supply chain value chain [37].

Digitalization and innovation in business models have been demonstrated to facilitate success in terms of resource utilization, cost reduction, increased productivity, work efficiency, supply chain optimization, and increased customer satisfaction and loyalty. In contemporary business practices, business models have evolved into catalysts for innovation and sources of competitive advantage [39].

Therefore, the following hypothesis is proposed to capture this mediating role:

H_4: Supply Chain Resilience has a positive and significant effect on Firm Performance through Business Model Innovation.

2.5. Strategic Partnerships Has a Positive and Significant Effect on Firm Performance

A strategic partnership is a customized business relationship between two or more participants based on mutual trust, transparency, and the distribution of risks and benefits, which enhances business performance [42]. The relationship with cooperation partners is predicated on the provision of benefits for both parties, with a predetermined period of cooperation, in the hope that each party can carry out their respective duties in accordance with the initial agreement, referring to all the terms and conditions stated.

The examination of the influence of corporate collaboration, defined as the nature of collaboration partner, and the depth of collaboration, defined as the intensity of interaction with related partners, on innovation performance at the project level is of significant relevance for a number of reasons. These reasons include the following: partners are considered important for driving innovation performance, shaping organizations, and influencing innovation implementation, as explained by Dubrovski [42]. in Kobarg, et al. [43]. Innovation performance at the project level, in terms of collaborative activities, necessitates meticulous management of collaborative innovation projects by practitioners [43]. The process of cooperation with supply chain partners is of paramount importance, as is the process of selecting partners while still considering environmental criteria.

The overarching objective of strategic partnerships is to achieve integrated, combined, and tailored collaboration that produces additional synergies that cannot be achieved by each company individually [42]. Therefore, it is imperative to exercise caution when selecting partners to ensure the attainment of strategic partnerships. This assertion is further substantiated by the findings of Gao, et al. [44] which underscore the significance of strategic partnerships in fostering collaboration, leveraging resources, and attaining shared objectives. These partnerships are characterized by a cohesive development process, marked by uniformity and harmony.

Based on these considerations, the following hypothesis is advanced:

H_5: Strategic Partnerships have a positive and significant effect on Firm Performance.

2.6. Business Model Innovation as a Mediator in the Strategic Partnership to Firm Performance

Strategic partnerships have the potential to catalyze business model innovation by fostering collaborative exploration of novel market opportunities, technologies, and revenue models. The joint pursuit of innovation has been shown to encourage the creation of new value propositions and the restructuring of business models, thus ensuring the adaptation to changing client needs [42]. By facilitating access to external expertise and cultivating trust, these relationships empower firms to explore innovative business configurations. Consequently, strategic partnerships have the potential to stimulate innovation in value creation and capture. Consequently, Business Model Innovation (BMI) is conceptualized as a pivotal mediator that translates the potential of strategic partnerships into enhanced firm performance.

To investigate this relationship, the study proposes the following hypothesis:

$H_{6:}$ Strategic Partnerships has a positive and significant effect on Firm Performance through Business Model Innovation.

2.7. The Direct Impact of Business Model Innovation on Firm Performance

In the context of digital disruption and increasingly fierce competition, Business Model Innovation (BMI) has emerged as a key driver of corporate performance. The advent of digital technology has compelled business entities to devise novel modes of collaboration, client engagement, and revenue enhancement [39].

In high-tech companies, the relationship between new products and corporate performance is reinforced by the application of marketing innovation. In contrast, low-tech companies exhibit a distinct pattern, whereby the innovation process exerts a direct and positive influence on company performance through innovation itself Lee, et al. [45] and Jauhary [46] underscores the necessity for businesses to perpetually recalibrate their business models to ensure sustained profitability and relevance.

There are three (3) dimensions of business model innovation that can be used for business model innovation, namely value creation innovation with influencing factors, namely new capabilities, new technologies, new processes and new partnerships, and for new value proposition innovation related to product value and for value capture innovation related to new customers [36]. By enabling organisations to align their strategies with shifting market and technological landscapes, BMI becomes a direct enabler of long-term competitiveness and profitability.

Thus, the following hypothesis is set forth to examine this direct relationship:

$H_{7:}$ Business Model Innovation has a positive and significant effect on Firm Performance.

2.8. Environmental Dynamism as a Moderates between Business Model Innovation and Firm Performance

In light of the rapid and sudden changes in the environment, as well as the unpredictable, rapidly changing, and uncontrolled changes in the business environment [47, 48] the development of innovation in business models is of great benefit. Maintaining optimal project performance necessitates the adaptation of business models to the dynamic nature of the environment [49].

The capacity of environmental dynamism to stimulate innovation among entrepreneurial team members is well-documented, with encouragement of information exchange among team members being a primary factor [50]. This dynamic stands in contrast to teams within more established organizational frameworks. Entrepreneurial teams are distinguished by a high level of external environmental dynamism, a phenomenon that sets them apart from teams within these established frameworks.

The following hypothesis is hereby proposed to test the relationship between the following variables:

$H_{8:}$ Environmental dynamism strengthens the relationship between business model innovation and firm performance.

3. Methods

The approach used in this research is quantitative research. In this case the variables consist of lean construction, supply chain resilience, business model innovation and company performance. This research method uses correlational research with the unit of analysis being a large category construction company in Indonesia. Devi, et al. [51] state that correlation research is research designed to test the relationship between two or more variables in one group which can occur at several levels.

3.1. Data Collection

The present study places its focus on large-scale construction companies in Indonesia, as these firms play a pivotal role in delivering major infrastructure projects nationwide. The research population consists of firms registered under the Indonesian Contractors Association (AKI) and the Indonesian Construction Executives Association (GAPENSI) as of 2024. Based on current membership records, the total number of firms meeting the criteria is 517. From this population, a sample of 226 companies was selected to provide robust and representative data for empirical analysis.

Data collection by distributing questionnaires to employed at a prominent construction firm, occupying a position at the director, executive, or senior management level. This designation is based on the respondent's demonstrated competence within their respective field, which is intended to facilitate more precise responses from researchers.

The data in this study were collected using Google Form questionnaires and analysed using the Smart PLS application. The questionnaire used was designed to obtain data on construction company management perception of the variables studied. To determine the quality of the questionnaire, it is necessary to analyse the items on the list of questions to be asked on the questionnaire.

While the interview is a direct, both offline and online method of research conducted by researchers on Directors/Company Leaders/Senior Managers of construction service companies in Indonesia with qualifications in accordance with the research target (via zoom). Interviews were also conducted to locate and confirm the previously identified phenomena in order to validate the data obtained from the observations.

3.2. Operationalisation of Variables

The operationalization of each variable in this study is achieved through a series of measurable indicators that reflect its conceptual definition in the context of the Indonesian construction industry. Lean construction is defined as a value-oriented management philosophy that prioritizes customer satisfaction through increased efficiency, increased productivity, proactive risk mitigation, and reduction of material, time, and process waste. Strategic partnerships are defined as the efforts of companies to identify, build, and maintain long-term collaborative relationships with reliable external stakeholders, with the aim of growing mutual benefits and supporting strategic objectives. Business model innovation (BMI) is defined as a company's capacity to adapt and redesign the mechanisms of value creation, delivery, and capture in response to evolving digital technologies and market dynamics. The objective of BMI is to ensure long-term sustainability and viability. Finally, company performance is conceptualized as the extent to which an organization achieves its operational, financial, and strategic objectives. This is reflected through various performance metrics relevant to the construction industry.

3.3. Data Analysis Method

Structural Equation Modelling, also known as SEM based on variance, will be used as the analytical method in this study. Partial Least Squares (PLS) path analysis will be used in this study, with smartPLS 4.0 software. Herman Wold pioneered structural equation modelling (SEM), which aims to maximize the variance of the dependent variable that can be explained by the dependent variable by generating an empirical covariance matrix [52].

3.4. Measurement Model (Outer Model)

The evaluation of the relationship between observed indicators and corresponding latent constructs is the purpose of measurement models, also known as external models. The emphasis of these models is on validity and reliability. The concept of convergent validity is realized when the indicators exhibit robust correlations with the measured construct, as evidenced by factor loadings that surpass 0.70. Discriminant validity is ensured through cross-loading evaluation and comparison of AVE values, where the square root of the AVE value of the construct must exceed its correlation with other constructs. The assessment of internal consistency is achieved through the utilization of composite reliability and Cronbach's Alpha, with values exceeding 0.70 denoting adequate reliability. However, values greater than 0.60 may be regarded as sufficient in an exploratory research setting.

3.5. Structural Model (Inner Model)

Structural models are utilized to evaluate hypothesized causal relationships between latent variables. The predictive power of the model is evaluated using bootstrapping techniques to obtain t-statistics and test the significance of the paths. A variety of key indicators are employed to evaluate the model, with R^2 serving as a primary metric. R^2 quantifies the proportion of variance in the endogenous construct that can be attributed to the exogenous construct. Values of 0.75, 0.50, and 0.25 represent strong, moderate, and weak explanatory power, respectively. Furthermore, Q^2 is employed to evaluate the predictive relevance of the model. A value greater than 0 indicates that the model possesses sufficient predictive capability. The Goodness of Fit (GoF) index is a metric that provides an overall evaluation of the quality of a model. It is expressed as a value ranging from 0.10 (small), 0.25 (moderate), to 0.36 (large), and serves as a benchmark for assessing the model fit.

3.6. Hypothesis Testing

The research method was developed by extracting several previous studies. In order to test the model and obtain results that meet the research objectives, an analysis method that accommodates multivariate testing is required. A hypothesis is defined as a provisional response, formulated to address empirical facts derived from data collection. Consequently, a hypothesis is defined as a theoretical response to a problem statement that has not yet been substantiated through empirical evidence. Decision on the test: (1) If t-count > t-table, and the significance p-value is less than 0.05 or a <5%, then Hl is accepted and Ho is rejected, meaning the relationship between variables is significant. Conclusion of the hypothesis: "There is a significant relationship between the independent variable and the dependent variable. It means that the hypothesis is accepted"; (2) If t-count < t-table, and the significance p-value is greater than 0.05 or a > 5%, then Ho is accepted and Hl is rejected, meaning that the relationship between variables is not significant. Conclusion of the hypothesis: "There is no significant relationship between the independent variable and the dependent variable. It means that the hypothesis is rejected".

4. Result

4.1. Results of Measurement Model Testing (Outer Model)

According to Van Riel, et al. [53] second-order model testing is conducted in three ways: the repeated indicators approach, the two-stage approach, and the hybrid approach. In this particular instance, the researcher employed a two-stage approach. The two-stage approach is comprised of two steps, with the initial step aiming to obtain latent variable scores for the first-order construct. In this initial stage of analysis, the second-order construct remains excluded. The estimation of the model containing the second-order construct is only conducted in the second stage. In the subsequent stage, the scores of the first-order construct are utilized as the manifest variables of the second-order construct. In essence, the measurement of the first-order construct is reduced to a single item. This reduction is advantageous not only for statistical reasons (e.g., to avoid multicollinearity among indicators) but also for practical reasons (e.g., to prevent "double counting").

4.2. Results of Measurement Model Testing or Outer Model Phase 1

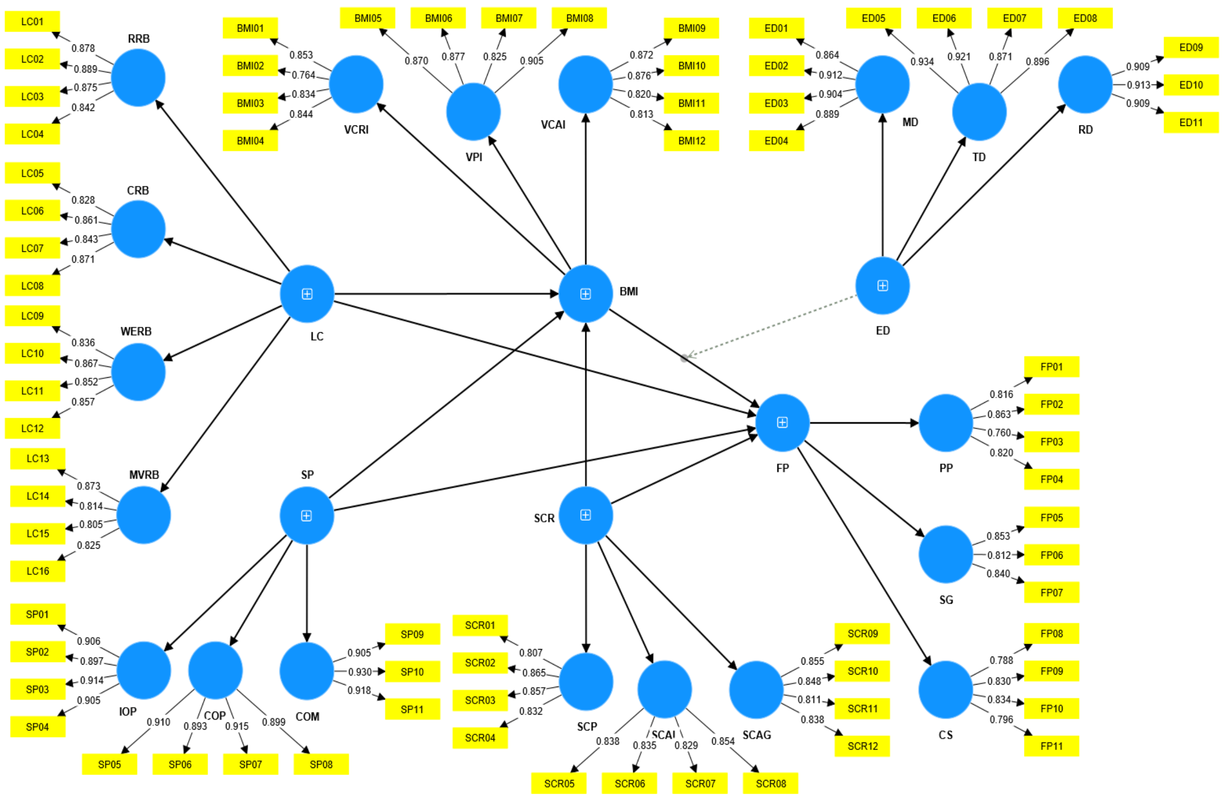

Figure 1.
Measurement Model (Outer Model) – Phase 1.

4.3. Convergent Validity Test

According to Hair, et al. [54] convergent validity testing entailed the examination of the loading factor value and the Average Variance Extracted (AVE) value. A loading factor value of ≥ 0.70 and an AVE value of > 0.50 are indicative of convergent validity, while a loading factor value of ≥ 0.40 is considered acceptable. A loading factor value of < 0.40, on the other hand, must be dropped or deleted.

Table 1.
Convergent Validity of the Lean Construction (LC) Model.

Variable	Dimension	Indicator	Loading Factor	AVE	Description
Lean Construction (LC)	Relationship Related Benefits (RRB)	LC01	0.878	0.759	Valid
		LC02	0.889		Valid
		LC03	0.875		Valid
		LC04	0.842		Valid
	Cost Related Benefits (CRB)	LC05	0.828	0.724	Valid
		LC06	0.861		Valid
		LC07	0.843		Valid
		LC08	0.871		Valid
	Work Environment Related Benefits (WERB)	LC09	0.836	0.728	Valid
		LC10	0.867		Valid
		LC11	0.852		Valid
		LC12	0.857		Valid
	Management Values Related Benefits (MVRB)	LC13	0.873	0.689	Valid
		LC14	0.814		Valid
		LC15	0.805		Valid
		LC16	0.825		Valid

As illustrated in the above table, all items in each dimension of Relationship Related Benefits (RRB), Cost Related Benefits (CRB), Work Environment Related Benefits (WERB), and Management Values Related Benefits (MVRB) have a loading factor value of at least 0.70 and an AVE value of at least 0.50. Therefore, it can be concluded that all items in each dimension of Relationship Related Benefits (RRB), Cost Related Benefits (CRB), Work Environment Related Benefits (WERB), and Management Values Related Benefits (MVRB) are valid or convergent validity has been achieved.

In the Relationship Related Benefits (RRB) dimension, the highest loading factor value of 0.889 was found in indicator LC02. Therefore, it can be concluded that indicator LC02 is the indicator that best reflects the Relationship Related Benefits (RRB) dimension compared to other indicators. In the Cost Related Benefits (CRB) dimension, the highest loading factor value of 0.871 was found in indicator LC08, indicating that indicator LC08 is the most representative indicator of the Cost Related Benefits (CRB) dimension compared to other indicators. In the Work Environment Related Benefits (WERB) dimension, the highest loading factor value of 0.867 is found in indicator LC10. Therefore, it can be concluded that indicator LC10 is the indicator that can reflect the Work Environment Related Benefits (WERB) dimension the most compared to other indicators. In the Work Management Values Related Benefits (MVRB) dimension, the highest loading factor value of 0.873 is observed in indicator LC13. This finding indicates that indicator LC13 is the most effective indicator to reflect the Work Management Values Related Benefits (MVRB) dimension in comparison to other indicators.

Table 2.
Convergent Validity of the Supply Chain Resilience (SCR) Model

Variable	Dimension	Indicator	Loading Factor	AVE	Description
Supply Chain Resilience (SCR)	Supply Chain Preparedness (SCP)	SCR01	0.807	0.707	Valid
		SCR02	0.865		Valid
		SCR03	0.857		Valid
		SCR04	0.832		Valid
	Supply Chain Alertness (SCAL)	SCR05	0.838	0.704	Valid
		SCR06	0.835		Valid
		SCR07	0.829		Valid
		SCR08	0.854		Valid
	Supply Chain Agility (SCAG)	SCR09	0.855	0.703	Valid
		SCR10	0.848		Valid
		SCR11	0.811		Valid
		SCR12	0.838		Valid

As illustrated in the above table, all elements within each dimension of Supply Chain Preparedness (SCP), Supply Chain Alertness (SCAL), and Supply Chain Agility (SCAG) exhibit a loading factor value of at least 0.70 and an AVE value greater than 0.50. This indicates that the statements within each dimension of Supply Chain Preparedness (SCP), Supply Chain Alertness (SCAL), and Supply Chain Agility (SCAG) are valid and demonstrate convergent validity.

In the Supply Chain Preparedness (SCP) dimension, the highest loading factor value of 0.865 was found in the SCR02 indicator. Therefore, it can be concluded that the SCR02 indicator is the indicator that best reflects the Supply Chain Preparedness (SCP) dimension compared to other indicators. In the Supply Chain Alertness (SCAL) dimension, the highest loading factor value of 0.854 was found in the SCR08 indicator. Therefore, it can be concluded that the SCR08 indicator is the most effective indicator of the Supply Chain Alertness (SCAL) dimension compared to other indicators. In the context of the Supply Chain Agility (SCAG) dimension, the highest loading factor value of 0.855 is observed in the SCR09 indicator. This finding indicates that the SCR09 indicator is the most effective measure of the Supply Chain Agility (SCAG) dimension when compared to other indicators.

Table 3.
Convergent Validity of the Strategic Partnership (SP) Model.

Variable	Dimension	Indicator	Loading Factor	AVE	Description
Strategic Partnership (SP)	Investment Oriented Partnership (IOP)	SP01	0.906	0.820	Valid
		SP02	0.897		Valid
		SP03	0.914		Valid
		SP04	0.905		Valid
	Contract Oriented Partnership (COP)	SP05	0.910	0.818	Valid
		SP06	0.893		Valid
		SP07	0.915		Valid
		SP08	0.899		Valid
	Commitment (COM)	SP09	0.905	0.842	Valid
		SP10	0.930		Valid
		SP11	0.918		Valid

As illustrated in the above table, it is evident that all statement items within each dimension of the Investment Oriented Partnership (IOP), Contract Oriented Partnership (COP), and Commitment (COM) categories possess a loading factor value that exceeds 0.70 and an AVE value that surpasses 0.50. This observation indicates that the statement items within these dimensions are valid and demonstrate convergent validity.

In the Investment Oriented Partnership (IOP) dimension, the highest loading factor value of 0.914 was found in indicator SP03. Therefore, it can be concluded that indicator SP03 is the indicator that best reflects the Investment Oriented Partnership (IOP) dimension compared to other indicators. In the Contract Oriented Partnership (COP) dimension, the highest loading factor value of 0.915 was found in indicator SP07, indicating that indicator SP07 is the indicator that best reflects the Contract Oriented Partnership (COP) dimension compared to other indicators. In the Commitment (COM) dimension, the highest loading factor value of 0.930 is observed in indicator SP10. This finding indicates that indicator SP10 is the most effective indicator for reflecting the Commitment (COM) dimension when compared to other indicators.

Table 4.
Convergent Validity of the Business Model Innovation (BMI) Model.

Variable	Dimension	Indicator	Loading Factor	AVE	Description
Business Model Innovation (BMI)	Value Creation Innovation (VCRI)	BMI01	0,853	0,680	Valid
		BMI02	0,764		Valid
		BMI03	0,834		Valid
		BMI04	0,844		Valid
	Value Proposition Innovation (VPI)	BMI05	0,870	0,757	Valid
		BMI06	0,877		Valid
		BMI07	0,825		Valid
		BMI08	0,905		Valid
	Value Capture Innovation (VCAI)	BMI09	0,872	0,715	Valid
		BMI10	0,876		Valid
		BMI11	0,820		Valid
		BMI12	0,813		Valid

As illustrated in the above table, all items in each dimension of Value Creation Innovation (VCRI), Value Proposition Innovation (VPI), and Value Capture Innovation (VCAI) have a loading factor value of at least 0.70 and an AVE value of at least 0.50. Therefore, it can be concluded that all statement items in each dimension of Value Creation Innovation (VCRI), Value Proposition Innovation (VPI), and Value Capture Innovation (VCAI) are valid or that convergent validity has been met.

In the Value Creation Innovation (VCRI) dimension, the BMI01 indicator demonstrated the highest loading factor value of 0.853, indicating its superior reflection of the VCRI dimension in comparison to other indicators. In the Value Proposition Innovation (VPI) dimension, the highest loading factor value of 0.905 is found in indicator BMI08, indicating that indicator BMI08 is the most effective indicator in reflecting the Value Proposition Innovation (VPI) dimension compared to other indicators. In the Value Capture Innovation (VCAI) dimension, the BMI10 indicator demonstrated the highest loading factor value of 0.876, indicating its superior reflection of the VCAI dimension in comparison to other indicators.

Table 5.
Convergent Validity of the Environmental Dynamism (ED) Model.

Variable	Dimension	Indicator	Loading Factor	AVE	Description
Environmental Dynamism (ED)	Market Dynamism (MD)	ED01	0.864	0.797	Valid
		ED02	0.912		Valid
		ED03	0.904		Valid
		ED04	0.889		Valid
	Technology Dynamism (TD)	ED05	0.934	0.821	Valid
		ED06	0.921		Valid
		ED07	0.871		Valid
		ED08	0.896		Valid
	Regulatory Dynamism (RD)	ED09	0.909	0.829	Valid
		ED10	0.913		Valid
		ED11	0.909		Valid

As illustrated in the above table, all items in each dimension of Market Dynamism (MD), Technology Dynamism (TD), and Regulatory Dynamism (RD) exhibit a loading factor ≥ 0.70 and an AVE > 0.50. This indicates that the items in each dimension of Market Dynamism (MD), Technology Dynamism (TD), and Regulatory Dynamism (RD) are valid or demonstrate convergent validity.

In the Market Dynamism (MD) dimension, the highest loading factor value of 0.912 was found in indicator ED02. Therefore, it can be concluded that indicator ED02 is the indicator that best reflects the Market Dynamism (MD) dimension compared to other indicators. In the Technology Dynamism (TD) dimension, the highest loading factor value of 0.934 was found in indicator ED05, indicating that indicator ED05 is the indicator that best reflects the Technology Dynamism (TD) dimension compared to other indicators. In the Regulatory Dynamism (RD) dimension, the highest loading factor value of

0.913 is observed in indicator ED10. This finding indicates that indicator ED10 is the most effective indicator for reflecting the Regulatory Dynamism (RD) dimension in comparison to other indicators.

Table 6.
Convergent Validity of the Firm Performance (FP) Model.

Variable	Dimension	Indicator	Loading Factor	AVE	Description
Firm Performance (FP)	Peningkatan Profit (PP)	FP01	0.816	0.665	Valid
		FP02	0.863		Valid
		FP03	0.760		Valid
		FP04	0.820		Valid
	Sales Growth (SG)	FP05	0.853	0.697	Valid
		FP06	0.812		Valid
		FP07	0.840		Valid
	Customer Satisfaction (CS)	FP08	0.788	0.660	Valid
		FP09	0.830		Valid
		FP10	0.834		Valid
		FP11	0.796		Valid

As illustrated in the above table, all items in each dimension of Profit Increase (PP), Sales Growth (SG), and Customer Satisfaction (CS) have a loading factor value of at least 0.70 and an AVE value of at least 0.50. Therefore, it can be concluded that all items in each dimension of Profit Increase (PP), Sales Growth (SG), and Customer Satisfaction (CS) are valid or that convergent validity has been fulfilled.

In the Profit Increase (PP) dimension, the highest loading factor value of 0.863 was found in indicator FP02. Therefore, it can be concluded that indicator FP02 is the indicator that best reflects the Profit Increase (PP) dimension compared to other indicators. In the Sales Growth (SG) dimension, the highest loading factor value of 0.853 was found in indicator FP05, indicating that FP05 is the indicator that best reflects the Sales Growth (SG) dimension compared to other indicators. In the Customer Satisfaction (CS) dimension, the highest loading factor value of 0.834 was found in indicator FP10. Therefore, it can be concluded that indicator FP10 is the one that reflects the Customer Satisfaction (CS) dimension the most compared to other indicators.

4.4. Discriminant Validity Test

According to Hair, et al. [54] discriminant validity testing was conducted by examining the heterotrait-monotrait ratio (HTMT) value. The HTMT value was considered to be significant if it was greater than or equal to 0.90 for conceptually similar constructs and 0.85 for conceptually different constructs.

Table 7.
HTMT Values for Discriminant Validity.

Variable	Dimension	Highest Heterotrait-Monotrait Ratio (HTMT) Value
Lean Construction (LC)	Relationship Related Benefits (RRB)	0.849
	Cost Related Benefits (CRB)	0.834
	Work Environment Related Benefits (WERB)	0.849
	Management Values Related Benefits (MVRB)	0.779
Supply Chain Resilience (SCR)	Supply Chain Preparedness (SCP)	0.840
	Supply Chain Alertness (SCAL)	0.840
	Supply Chain Agility (SCAG)	0.797
Strategic Partnership (SP)	Investment Oriented Partnership (IOP)	0.707
	Contract Oriented Partnership (COP)	0.687
	Commitment (COM)	0.707
Business Model Innovation (BMI)	Value Creation Innovation (VCRI)	0.754
	Value Proposition Innovation (VPI)	0.801
	Value Capture Innovation (VCAI)	0.801
Environmental Dynamism (ED)	Market Dynamism (MD)	0.807
	Technology Dynamism (TD)	0.838
	Regulatory Dynamism (RD)	0.838
Firm Performance (FP)	Peningkatan Profit (PP)	0.810
	Sales Growth (SG)	0.843
	Customer Satisfaction (CS)	0.843

The results indicate that all HTMT values are below the recommended thresholds of 0.85 or 0.90, suggesting that discriminant validity is established across all constructs.

4.5. Reliability Test Result

According to Hair, et al. [54] reliability testing entailed the examination of Cronbach's alpha and composite reliability values. Reliability is indicated by Cronbach's alpha and composite reliability values greater than 0.70, while values greater than 0.95 are deemed unacceptable.

Table 8.
Reliability of Constructs.

Variable	Dimension	Cronbach's alpha	Composite reliability (rho_c)	Description
Lean Construction (LC)	Relationship Related Benefits (RRB)	0.894	0.926	Reliable
	Cost Related Benefits (CRB)	0.873	0.913	Reliable
	Work Environment Related Benefits (WERB)	0.875	0.915	Reliable
	Management Values Related Benefits (MVRB)	0.849	0.898	Reliable
Supply Chain Resilience (SCR)	Supply Chain Preparedness (SCP)	0.861	0.906	Reliable
	Supply Chain Alertness (SCAL)	0.860	0.905	Reliable
	Supply Chain Agility (SCAG)	0.859	0.904	Reliable
Strategic Partnership (SP)	Investment Oriented Partnership (IOP)	0.927	0.948	Reliable
	Contract Oriented Partnership (COP)	0.926	0.947	Reliable
	Commitment (COM)	0.906	0.941	Reliable
Business Model Innovation (BMI)	Value Creation Innovation (VCRI)	0.842	0.894	Reliable
	Value Proposition Innovation (VPI)	0.892	0.925	Reliable
	Value Capture Innovation (VCAI)	0.867	0.909	Reliable
Environmental Dynamism (ED)	Market Dynamism (MD)	0.915	0.940	Reliable
	Technology Dynamism (TD)	0.927	0.948	Reliable
	Regulatory Dynamism (RD)	0.897	0.936	Reliable
Firm Performance (FP)	Peningkatan Profit (PP)	0.832	0.888	Reliable
	Sales Growth (SG)	0.783	0.874	Reliable
	Customer Satisfaction (CS)	0.828	0.886	Reliable

The internal consistency of all constructs was found to be satisfactory, as evidenced by the Cronbach's alpha and composite reliability values exceeding 0.70 and remaining below 0.95. Consequently, the constructs can be regarded as reliable.

4.6. Results of Measurement Model Testing or Outer Model Phase 2

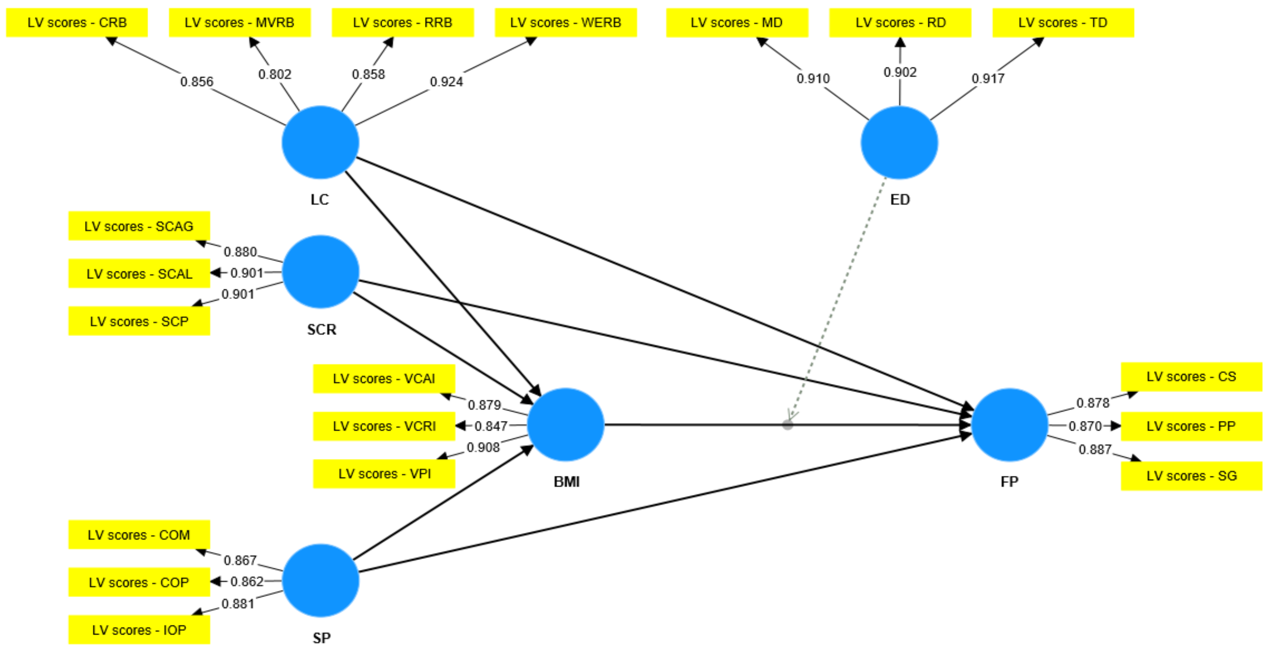

Figure 2.
Measurement Model Testing (Outer Model) – Phase 2.

4.7. Convergent Validity

According to Hair, et al. [54] convergent validity testing entailed the examination of the loading factor value and the Average Variance Extracted (AVE) value. A loading factor value of at least 0.70 and an AVE value of at least 0.50 are indicative of convergent validity. A loading factor value of at least 0.40 is generally acceptable, while a loading factor value of less than 0.40 should be removed.

Table 9.
Convergent Validity of Constructs

Variable	Dimension	Loading Factor	AVE	Description
Lean Construction (LC)	Relationship Related Benefits (RRB)	0.858	0.742	Valid
	Cost Related Benefits (CRB)	0.856		Valid
	Work Environment Related Benefits (WERB)	0.924		Valid
	Management Values Related Benefits (MVRB)	0.802		Valid
Supply Chain Resilience (SCR)	Supply Chain Preparedness (SCP)	0.9005	0.799	Valid
	Supply Chain Alertness (SCAL)	0.9008		Valid
	Supply Chain Agility (SCAG)	0.880		Valid
Strategic Partnership (SP)	Investment Oriented Partnership (IOP)	0.881	0.757	Valid
	Contract Oriented Partnership (COP)	0.862		Valid
	Commitment (COM)	0.867		Valid
Business Model Innovation (BMI)	Value Creation Innovation (VCRI)	0.847	0.771	Valid
	Value Proposition Innovation (VPI)	0.908		Valid
	Value Capture Innovation (VCAI)	0.879		Valid
Environmental Dynamism (ED)	Market Dynamism (MD)	0.910	0.828	Valid
	Technology Dynamism (TD)	0.917		Valid
	Regulatory Dynamism (RD)	0.902		Valid
Firm Performance (FP)	Peningkatan Profit (PP)	0.870	0.772	Valid
	Sales Growth (SG)	0.887		Valid
	Customer Satisfaction (CS)	0.878		Valid

As illustrated in the above table, it is evident that all dimensions of each variable of Lean Construction (LC), Supply Chain Resilience (SCR), Strategic Partnership (SP), Business Model Innovation (BMI), Environmental Dynamism (ED), and Firm Performance (FP) have a loading factor value of at least 0.70 and an AVE value that is greater than 0.Therefore, it can be concluded that all dimensions of each variable of Lean Construction (LC), Supply Chain Resilience (SCR), Strategic Partnership (SP), Business Model Innovation (BMI), Environmental Dynamism (ED), and Firm Performance (FP) are valid. This indicates that convergent validity has been achieved.

In the Lean Construction (LC) variable, the highest loading factor value of 0.924 was found in the Work Environment Related Benefits (WERB) dimension. Therefore, it can be concluded that the Work Environment Related Benefits (WERB) dimension is the dimension that most reflects the Lean Construction (LC) variable compared to other dimensions. In the Supply Chain Resilience (SCR) variable, the highest loading factor value of 0.9008 was found in the Supply Chain Alertness (SCAL) dimension. Therefore, it can be concluded that the Supply Chain Alertness (SCAL) dimension is the dimension that most accurately reflects the Supply Chain Resilience (SCR) variable compared to other dimensions. In the Strategic Partnership (SP) variable, the highest loading factor value of 0.881 was found in the Investment Oriented Partnership (IOP) dimension. Therefore, it can be concluded that the Investment Oriented Partnership (IOP) dimension is the dimension that most accurately reflects the Strategic Partnership (SP) variable compared to other dimensions. In the Business Model Innovation (BMI) variable, the highest loading factor value of 0.908 was found in the Value Proposition Innovation (VPI) dimension. Therefore, it can be concluded that the Value Proposition Innovation (VPI) dimension is the dimension that most accurately reflects the Business Model Innovation (BMI) variable compared to other dimensions. In the Environmental Dynamism (ED) variable, the highest loading factor value of 0.917 was found in the Technology Dynamism (TD) dimension. Therefore, it can be concluded that the Technology Dynamism (TD) dimension is the dimension that most effectively reflects the Environmental Dynamism (ED) variable in comparison to other dimensions. In the Firm Performance (FP) variable, the highest loading factor value of 0.887 was found in the Sales Growth (SG) dimension. Therefore, it can be concluded that the Sales Growth (SG) dimension is the dimension that can reflect the Firm Performance (FP) variable the most compared to other dimensions.

4.8. Discriminant Validity

According to Hair, et al. [54] discriminant validity testing was conducted by examining the heterotrait-monotrait ratio (HTMT) value, with a threshold value of 0.90 for conceptually similar constructs and 0.85 for conceptually different constructs.

Table 10.
Discriminant Validity via HTMT.

Variable	Highest Heterotrait-Monotrait Ratio (HTMT) Value
Lean Construction (LC)	0.804
Supply Chain Resilience (SCR)	0.783
Strategic Partnership (SP)	0.310
Business Model Innovation (BMI)	0.832
Environmental Dynamism (ED)	0.431
Firm Performance (FP)	0.832

As illustrated in the above table, the highest Heterotrait-Monotrait Ratio (HTMT) values for each variable of Lean Construction (LC), Supply Chain Resilience (SCR), Strategic Partnership (SP), Business Model Innovation (BMI), Environmental Dynamism (ED), and Firm Performance (FP) are ≤ 0.85. This finding suggests that all dimensions can predict the construct better than other constructs, or that discriminant validity has been fulfilled.

4.9. Reliability

According to Hair, et al. [54] reliability testing entailed the examination of Cronbach's alpha and composite reliability values. Reliability is indicated by Cronbach's alpha and composite reliability values greater than 0.70, while values greater than 0.95 are deemed unacceptable.

Table 11.
Construct Reliability.

Variable	Cronbach's alpha	Composite reliability (rho_c)
Lean Construction (LC)	0.883	0.920
Supply Chain Resilience (SCR)	0.874	0.923
Strategic Partnership (SP)	0.840	0.903
Business Model Innovation (BMI)	0.852	0.910
Environmental Dynamism (ED)	0.896	0.935
Firm Performance (FP)	0.852	0.910

As illustrated in the above table, the values of Cronbach's alpha and composite reliability for the Lean Construction (LC) variables, Supply Chain Resilience (SCR), Strategic Partnership (SP), Business Model Innovation (BMI), Environmental Dynamism (ED), and Firm Performance (FP) are all greater than 0.70. Notably, none of the Cronbach's alpha and composite reliability values exceed 0.95. Consequently, it can be deduced that all variables are reliable or that construct reliability has been met.

4.10. Structural Model Test Results (Inner Model)

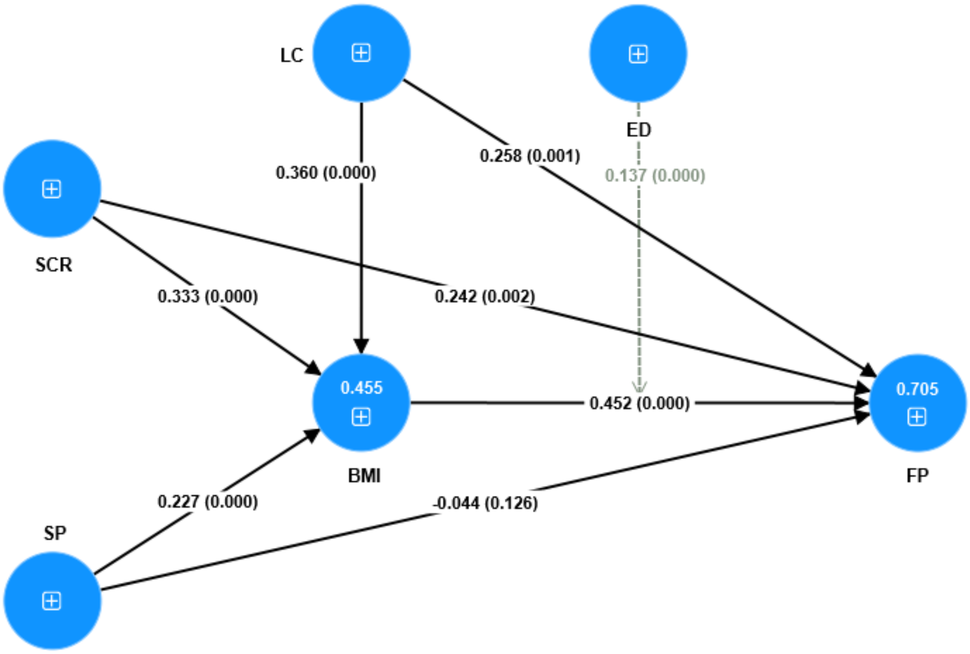

Figure 3.
Structural Model Testing (Inner Model).

4.11. Coefficient of Determination (R^2) Results

According to Hair, et al. [54] the R^2 value ranges from 0 to 1, with higher values indicating a higher level of explanatory power. In certain academic fields, an R^2 value of 0.10 is regarded as adequate. The R Square value for endogenous latent variables in a structural model indicates that the model is 0.75 (strong), 0.50 (moderate), and 0.25 (weak) [55].

Table 12.
Coefficient of Determination (R^2)

	R-square	***R-square adjusted***
Business Model Innovation (BMI)	0.462	0.455
Firm Performance (FP)	0.713	0.705

As illustrated in the above table, the R-square adjusted value of the Business Model Innovation (BMI) variable is 0.455, indicating that the Lean Construction (LC), Supply Chain Resilience (SCR), and Strategic Partnership (SP) variables can explain the Business Model Innovation (BMI) variable by 45.5%. This finding suggests that the model falls within the weak model category. Concurrently, the adjusted R-squared value of the Firm Performance (FP) variable is 0.705, suggesting that the variables Lean Construction (LC), Supply Chain Resilience (SCR), Strategic Partnership (SP), Business Model Innovation (BMI), and Business Model Innovation (BMI) moderated by Environmental Dynamism (ED) are capable of explaining the Firm Performance (FP) variable by 70.5%. This finding indicates that the model falls within the moderate model category.

4.12. F^2 Effect Size Results

The F^2 value is indicative of the change in the R^2 value when a specific exogenous construct (independent variable) is removed from the model. The F^2 value is determined by calculating the effect of removing an exogenous construct (independent variable) from the structural model on the endogenous construct (dependent variable) [55]. The F^2 value is determined to be less than 0.02, indicating no effect; 0.02, indicating a small effect; 0.15, indicating a moderate effect; and 0.35, indicating a large effect [54, 55]. Meanwhile, the F^2 values for interaction variables are 0.005 (small effect), 0.01 (moderate effect), and 0.025 (large effect) [54]. It is important to note that no F^2 value exists for indirect effects, as indirect effects test the influence of independent variables on dependent variables through intervening variables or mediation. Therefore, the process of removing exogenous constructs (independent variables) from the structural model is not present in indirect effects.

Table 13.
F^2 Effect Size

	F Square
LC -> FP	0.112
SCR -> FP	0.106
SP -> FP	0.006
BMI -> FP	0.360
ED x BMI -> FP	0.103

The F^2 value for the pathway from Lean Construction (LC) to Firm Performance (FP) is 0.112, which indicates a moderate effect. Meanwhile, a value of 0.106 for the F^2 value for the path from Supply Chain Resilience (SCR) to Firm Performance (FP) is indicative of a moderate effect. In contrast, the F^2 value for the pathway from Strategic Partnership (SP) to Firm Performance (FP) was found to be negligible which is 0.006, suggesting that this pathway does not contribute significantly to the model. Meanwhile, the F^2 value for the pathway from Business Model Innovation (BMI) to Firm Performance (FP) is 0.360, demonstrating a substantial effect on the endogenous construct. Meanwhile, the F^2 value of the interaction between Environmental Dynamism (ED) and Business Model Innovation (BMI) on Firm Performance (FP) is 0.103, which is greater than 0.025. This indicates that the contribution of the Environmental Dynamism (ED) variable in changing the R Square value or in increasing the R Square value of the Firm Performance (FP) variable is in the category of significant influence.

4.13. Q^2 Predictive Relevance Results

According to Hair, et al. [54] the predictive relevance of Q2 is considered satisfactory if its value is greater than 0, indicating that the exogenous latent variables are appropriate as explanatory variables capable of predicting the endogenous variables.

Table 14.
Q^2 Predictive Relevance

	SSO	**SSE**	**Q^2 (=1-SSE/SSO)**
Business Model Innovation (BMI)	678.000	441.401	0.349
Firm Performance (FP)	678.000	315.462	0.535

The Q² value for BMI is 0.349, demonstrating that LC, SCR and SP possess predictive relevance for this construct. Similarly, the Q² value for FP is 0.535, indicating that LC, SCR, SP, BMI, and ED jointly have predictive power in explaining FP.

Subsequently, the Q^2 predictive relevance value of each dimension should be examined. If the Q Square Predictive dimension > 0, a comparison of the Root Mean Square Error (RMSE) or the Mean Absolute Error (MAE) with the following criteria is warranted [54]: All values are PLS RMSE or MAE < LM RMSE or MAE, the model demonstrates a high degree of predictive capacity; Majority of values PLS RMSE or MAE < LM RMSE or MAE, the model exhibits moderate predictive power; The number of values is either equal to or less than the minority number PLS RMSE or MAE ≤ LM RMSE or MAE, the model exhibits low predictive power; All values are PLS RMSE or MAE > LM RMSE or MAE, this phenomenon does not demonstrate any predictive capacity.

Table 15.
Q² Predictive Relevance by Dimension.

Variable	Dimension	Q²predict	PLS-SEM_RMSE	LM_RMSE	PLS-SEM_MAE	LM_MAE
Business Model Innovation (BMI)	Value Creation Innovation (VCRI)	0.279	0.853	0.881	0.609	0.642
	Value Proposition Innovation (VPI)	0.390	0.786	0.826	0.583	0.614
	Value Capture Innovation (VCAI)	0.322	0.828	0.860	0.606	0.634
Firm Performance (FP)	Increase Profit (PP)	0.382	0.790	0.814	0.552	0.586
	Sales Growth (SG)	0.449	0.746	0.759	0.553	0.555
	Customer Satisfaction (CS)	0.444	0.750	0.761	0.552	0.561

For all dimensions of both BMI and FP, the PLS-SEM RMSE and MAE values are lower than those of the linear model. This finding indicates that the model has high predictive power at the dimensional level.

4.14. Goodness-of-Fit (SRMR) Results

The Standardized Root Mean Square Residual (SRMR) is a metric used to evaluate the model's overall goodness of fit. A value below 0.08 indicates a satisfactory fit between the model and the observed data [54, 56]. The SRMR value of the estimated model is 0.053, which is well below the 0.08 threshold. This finding serves to substantiate the hypothesis that the structural model exhibits an adequate degree of fit.

5. Discussion

5.1. Hypothesis Test Results

Hair, et al. [54] posit that t-statistics and p-values are utilized in the process of hypothesis testing. In the event that the t-statistics value is found to be greater than 1.65 (i.e., for a one-tailed hypothesis or one tail with a significance level of 5%), or if the p-value is determined to be less than 0.05, then the hypothesis is deemed to be accepted.

Table 16.
Hypothesis Test Result.

	Coefficient	T Statistics	P Values	Direction of Relationship	Description
LC -> FP	0.258	3.174	0.001	Positif	H1 Accepted
LC -> BMI -> FP	0.163	3.245	0.001	Positif	H2 Accepted
SCR -> FP	0.242	2.940	0.002	Positif	H3 Accepted
SCR -> BMI -> FP	0.150	3.797	0.000	Positif	H4 Accepted
SP -> FP	-0.044	1.145	0.126	Negatif	H5 Rejected
SP -> BMI -> FP	0.102	2.957	0.002	Positif	H6 Accepted
BMI -> FP	0.452	6.419	0.000	Positif	H7 Accepted
ED x BMI -> FP	0.137	3.403	0.000	Positif	H8 Accepted

5.2. The Direct Impact of Lean Construction on Firm Performance (H1)

The findings indicate that the coefficient value of the Lean Construction (LC) -> Firm Performance (FP) pathway is positive, namely 0,258 with a t-statistic value of 3.174 > 1.65, or a p-value of 0.001 < 0.05. Therefore, H1 is accepted, meaning that Lean Construction has a positive and significant effect on Firm Performance.

These results are theoretically aligned with the studies of Li, et al. [29] and Akanbi, et al. [32] which highlight the role of LC in enhancing technical efficiency and promoting organisational transformation. The core principles of LC, including waste reduction, workflow optimisation, and process reliability, contribute to improved performance metrics such as cost, time, and quality [33] and Koskela in Aithal and Mishra [34]. Consequently, LC functions as both an operational methodology and a strategic framework that enables construction firms to thrive in challenging environments.

5.3. Business Model Innovation as a Mediator in the Lean Construction to Firm Performance (H2)

Hypothesis 2 is also supported by the data, as the indirect effect of Lean Construction (LC) -> Business Model Innovation (BMI) -> Firm Performance (FP) pathway is positive, namely 0,163 with a t-statistic value of 3,245 > 1,65 or a p-value 0,001 < 0,05. Therefore, H2 is accepted, meaning that Lean Construction has a positive and significant effect on Firm Performance through Business Model Innovation.

The results reinforce the idea that LC goes beyond mere efficiency gains, stimulating strategic shifts through BMI. According to Clauss [36] and Birkel and Müller [37] lean implementation encourages firms to rethink their approach to value creation, delivery, and monetization. By simplifying processes and enhancing flexibility, LC enables the design of novel business models that drive long-term competitiveness. Thus, BMI acts as a key mechanism for converting operational improvements into enduring competitive strength.

5.4. The Direct Impact of Supply Chain Resilience on Firm Performance (H3)

The findings indicate that the coefficient value of the Supply Chain Resilience (SCR) -> Firm Performance (FP) pathway is positive, namely 0,242 with a t-statistic value of 2,940 > 1,65 or a p-value of 0,002 < 0,05. Therefore, H3 accepted, meaning that Supply Chain Resilience has a positive and significant effect on Firm Performance.

The results of this study reinforce the idea that Supply Chain Resilience, which includes the dimensions of redundancy, agility, and collaboration, has a positive and significant effect on Firm Performance in the construction industry [19].

5.5. Business Model Innovation as a Mediator in the Supply Chain Resilience to Firm Performance (H4)

The test results show that the results of the Supply Chain Resilience research have a positive and significant effect on Firm Performance through Business Model Innovation. This is evidenced by the path coefficient value of Supply Chain Resilience (SCR) -> Business Model Innovation (BMI) -> Firm Performance (FP), which is positive at 0.150, with a t-statistic value of 3.797 > 1.65 or a p-value of 0.000 < 0.05. Therefore, it can be concluded that Supply Chain Resilience is able to improve Firm Performance through Business Model Innovation, thus accepting Hypothesis H4.

This assertion is further substantiated by the findings of Casciani, et al. [41] who determined that enhancing supply chain resilience through augmented adaptability and coordination prompts companies to restructure their business models in innovative ways. This, in turn, enables them to effectively address disruption and uncertainty, thereby enhancing overall performance within the construction and manufacturing sectors.

5.6. The Non-significant Direct Effect of Strategic Partnership on Firm Performance (H5)

The analysis reveals that Strategic Partnership (SP) does not have a significant direct effect on Firm Performance, as indicated by a negative coefficient of -0.044, a t-statistic of 1.145 (< 1.65), and a p-value of 0.126 (> 0.05). Therefore, Hypothesis 5 is rejected.

While theoretical perspectives posit that strategic partnerships (SP) can enhance innovation and resource integration [42, 43] the results suggest that partnerships alone may not be sufficient to produce measurable performance outcomes without the presence of transformative mechanisms. Strategic Partnerships in the construction industry do not always have a positive and significant influence on Firm Performance [26]. The efficacy of SP is contingent upon its implementation, which is contingent upon strategic alignment and innovation. Absent strategic alignment or innovation, significant performance gains are unlikely to be realized. Consequently, the relationship between SP and performance appears to be conditional rather than unconditional.

5.7. Business Model Innovation as a Mediator in the Strategic Partnership to Firm Performance (H6)

Hypothesis 6 is confirmed, with Strategic Partnership exerting a significant indirect effect on Firm Performance via Business Model Innovation. The corresponding coefficient is 0.102, with a t-statistic of 2.957 (> 1.65) and a p-value of 0.002 (< 0.05).

The findings indicate that partnerships have the potential to unlock strategic potential when aligned with an innovation-focused approach. Strategic collaborations that facilitate joint market exploration, technology synergies, and innovative business models can result in substantial performance enhancements [36, 39]. By mediating the relationship between partnerships and performance, BMI transforms the latent benefits of collaboration into tangible organizational gains, thereby highlighting its critical role in complex construction markets.

5.8. The Direct Effect of Business Model Innovation on Firm Performance (H7)

Hypothesis 7 is also supported, with Business Model Innovation exhibiting the strongest direct effect on Firm Performance among all constructs in the model. The path coefficient is 0.452, with a t-statistic of 6.419 (> 1.65) and a p-value of 0.000 (< 0.05).

This finding aligns with the research of Clauss [36] and Rachinger, et al. [39] who theorize that BMI plays a pivotal role in fostering sustainable competitiveness. By reconfiguring the value creation, proposition, and capture processes, firms can enhance their resilience in the face of external shocks, digital disruption, and evolving customer expectations. As posited by Bouwman, et al. [57] businesses demonstrating the capacity to modify components of their business models, including but not limited to value propositions, revenue structures, and partnerships, exhibit heightened adaptability to market and technological shifts. Jauhary [46] similarly underscores the imperative of continuous innovation in business models for ensuring long-term profitability and relevance, particularly within industries characterized by elevated uncertainty and rapid transformation.

5.9. The Influence of Environmental Dynamism in Strengthening the Relationship between Business Model Innovation and Firm Performance (H8)

Hypothesis 8 is confirmed, with The value of the interaction coefficient between Environmental Dynamism and Business Model Innovation (ED x BMI) and Firm Performance (FP) is positive, namely 0.137, with a t-statistic value of 3.403 > 1.65 or a p-value of 0.000 < 0.05. Consequently, it can be concluded that Environmental Dynamism strengthens the relationship between Business Model Innovation and Firm Performance, thereby accepting Hypothesis H8.

This finding is consistent with the research by Zhang, et al. [49] that demonstrates the enhancement of the positive relationship between business model innovation and firm performance by environmental dynamism. In the context of a rapidly changing and uncertain market, companies that engage in business model innovation, such as adjusting bargaining power, revenue strategies, and operational structures, are better able to respond adaptively to external challenges. The findings of the present study demonstrate a positive correlation between environmental dynamism and the impact of business model innovation on firm performance. This correlation is evident in various dimensions, including financial aspects, growth, and strategic competitiveness.

5.10. Indirect Effects

In addition to the primary hypotheses, this study also examines the indirect effects among the variables:

Table 17.
Indirect Effects and Their Significance.

	Coefficient	T Statistics	P Values	Direction of Relationship	Description
LC -> FP	0.258	3.174	0.001	Positive	H1 Accepted
LC -> BMI -> FP	0.163	3.245	0.001	Positive	H2 Accepted
SCR -> FP	0.242	2.940	0.002	Positive	H3 Accepted
SCR -> BMI -> FP	0.150	3.797	0.000	Positive	H4 Accepted
SP -> FP	-0.044	1.145	0.126	Negative	H5 Rejected
SP -> BMI -> FP	0.102	2.957	0.002	Positive	H6 Accepted
BMI -> FP	0.452	6.419	0.000	Positive	H7 Accepted
ED x BMI -> FP	0.137	3.403	0.000	Positive	H8 Accepted
LC -> BMI	0.360	4.025	0.000	Positive	Influential
SCR -> BMI	0.333	4.133	0.000	Positive	Influential
SP -> BMI	0.227	3.551	0.000	Positive	Influential

When comparing direct effects with indirect effects, it is not possible to use coefficient values. This phenomenon can be attributed to the inherent properties of the coefficient values for indirect effects, which invariably yield smaller values due to the multiplication of decimals. This principle underlies the reduction of the F-square value by half for indirect effects [58]. Consequently, the comparison between direct and indirect effects is based on the t-statistic value; the larger the t-statistic value, the greater the effect.

5.11. Lean Construction Has a Positive and Significant Effect on Firm Performance through Business Model Innovation

Preliminary findings indicate that Lean Construction exerts a positive and significant effect on Firm Performance through Business Model Innovation, as substantiated by empirical evidence from rigorous testing. This finding suggests a positive correlation between the enhancement of Lean Construction and the subsequent improvement in Business Model Innovation, which in turn can lead to an enhancement in Firm Performance. This is evidenced by the positive coefficient value of Lean Construction on Business Model Innovation, which is 0.360, and the t-statistic value of 4.025 > 1.65 or p-value of 0.000 < 0.05. Furthermore, the coefficient value of Lean Construction on Firm Performance is positive, at 0.258, with a t-statistic value of 3.174 > 1.65 or a p-value of 0.001 < 0.05. The t-statistic value of the path from Lean Construction to Firm Performance through Business Model Innovation is 3.245, which is greater than the t-statistic value of the path from Lean Construction to Firm Performance, which is 3.174. This finding suggests that the indirect influence of Lean Construction on Firm Performance through Business Model Innovation is more significant than the direct influence of Lean Construction on Firm Performance.) lebih besar dibandingkan pengaruh langsung Lean Construction terhadap Firm Performance.

This outcome aligns with the arguments of Clauss [36] and Birkel and Müller [37] who assert that lean environments foster the conditions necessary for firms to innovate their value propositions and revenue mechanisms. Thus, Lean Construction should not merely be viewed as a set of operational tools, but rather as a catalyst for broader strategic renewal.

5.12. Supply Chain Resilience has a positive and significant effect on Firm Performance through Business Model Innovation

Preliminary findings indicate a positive and significant relationship between Supply Chain Resilience and Firm Performance, as measured by Business Model Innovation. This suggests that enhancing supply chain resilience may lead to an increase in business model innovation, which, in turn, can positively impact firm performance. This is evidenced by the coefficient value of Supply Chain Resilience on Business Model Innovation, which is positive at 0.333 and the t-statistic value of 4.133 > 1.65 or p-value of 0.000 < 0.05, as well as the coefficient value of Supply Chain Resilience on Firm Performance, which is positive at 0.242 and the t-statistic value of 2.940 > 1.65, with a p-value of 0.002 < 0.05. The t-statistic value of the path from Supply Chain Resilience to Firm Performance through Business Model Innovation is 3.797, which is greater than the t-statistic value of the path from Supply Chain Resilience to Firm Performance, which is 2.940. This finding suggests that the indirect influence of supply chain resilience on firm performance through business model innovation is more significant than the direct influence of supply chain resilience on firm performance.

5.13. Strategic Partnership have a positive and significant effect on Firm Performance throught Business Model Innovation

Preliminary findings indicate that Strategic Partnership exerts a positive and significant effect on Firm Performance through Business Model Innovation, as substantiated by empirical evidence from rigorous testing. This suggests that enhancing Strategic Partnerships is conducive to Business Model Innovation, which in turn can positively impact Firm Performance. This is evidenced by the coefficient value of the Strategic Partnership pathway on Business Model Innovation, which is positive at 0.227, with a t-statistic value of 3.551 > 1.65 or a p-value of 0.000 < 0.05. Furthermore, the coefficient value of the Strategic Partnership pathway on Firm Performance is negative at -0.044, with a t-statistic value of 1.145 < 1.65 or a p-value of 0.126 > 0.05 (not significant). The t-statistic value of the path from Strategic Partnership to Firm Performance through Business Model Innovation is 2.597, which is greater than the t-statistic value of the path from Strategic Partnership to Firm Performance, which is 1.145. This finding suggests that the indirect influence of strategic partnerships on firm performance through business model innovation may exceed the direct influence of strategic partnerships on firm performance. The degree to which business model innovation exerts a positive influence on firm performance can result in strategic partnerships exerting a positive and significant influence on firm performance through business model innovation.

The findings of this study corroborate the proposition advanced by Rachinger, et al. [39] and Dubrovski [42] that strategic alliances can function as incubators for business model innovation. The integration of external expertise, the reduction of uncertainty, and the facilitation of joint exploration of new market opportunities are all possible through partnerships, which can drive innovation. Consequently, managerial efforts should prioritize leveraging partnerships to transform value delivery mechanisms through strategic innovation.

5.14. Managerial Implications

The findings of this research have significant practical implications for construction executives, project managers, and strategic planners, particularly in emerging economies such as Indonesia, where the industry faces mounting demands for efficiency, innovation, and competitiveness. The specific managerial implications for construction companies are:

- Operational transformation through Lean Construction: It is imperative for prominent construction enterprises to undertake a comprehensive restructuring of their operational processes, adopting a lean approach that encompasses pull-based scheduling, value stream mapping, and the eradication of waste. Managerial actions have included the establishment of special lean units at the project and corporate levels, the integration of the Last Planner System into project planning, and the repositioning of the organizational culture towards continuous improvement and efficiency measurement based on field data.
- The objective of this initiative is to enhance the resilience of supply chains. Construction companies consider this a pivotal factor in maintaining project continuity, particularly in the face of global disruption and material price volatility. A number of actions must be taken by management to ensure the success of this initiative. These include the identification of strategic Tier 1 and Tier 2 suppliers with whom to share risk, as well as the development of a real-time monitoring system based on technology, such as the Internet of Things (IoT), Enterprise Resource Planning (ERP), and artificial intelligence (AI). Furthermore, collaboration with vendors is imperative to ensure long-term supply through the implementation of umbrella contracts or analogous arrangements.
- The recalibration of strategic partnerships is a critical component of contemporary business strategy. The focus should be on value co-creation with partners, rather than on short-term work contracts. Partnerships should be built based on innovation and performance, such as Integrated Project Delivery (IPD), and partners should be included in joint innovation, such as modular design with fabrication partners.
- The present study explores the notion of business model innovation as a catalyst for performance enhancement. Construction companies must be able to transform old approaches into new models that are more agile, customer-focused, and technology-based. A number of management actions have been implemented, including the establishment of a Business Model Innovation sub-directorate within the Corporate Strategy Unit. The Business Model Canvas has been employed to facilitate the continuous generation of new revenue streams, derived from asset development and the promotion of the digitization of services such as BIM-as-a-service, precast as a platform, the development of novel product models such as modular, and new PPP model contracts, Design, Build, Operation, Maintenance, Finance (DBOMF), and others.

- Adaptation to Environmental Dynamics: Construction companies are aware that changes in regulations, technology, and markets are inevitable. Consequently, it is incumbent upon management to implement measures aimed at fortifying corporate strategy and risk management. This imperative necessitates the integration of environmental scanning and scenario planning capabilities, as well as the augmentation of corporate business development and marketing through the utilization of external data and construction market intelligence. Moreover, it is essential to achieve a harmonious balance between government, state-owned enterprises, and private markets.

6. Conclusion

This study set out to examine the relationships between Lean Construction (LC), Supply Chain Resilience (SCR), Strategic Partnerships (SP), Business Model Innovation (BMI), Environmental Dynamism and Firm Performance (FP) within the context of the Indonesian construction industry. The conclusions of this study are as follows: (1) The findings of this study suggest that the three independent variables—lean construction, supply chain resilience, and strategic partnership—exert a substantial influence on firm performance, with business model innovation serving as a mediating factor. This finding lends further credence to the notion that operational efficiency, supply chain resilience, and strategic partnerships serve as critical underpinnings in the development of novel business models that are adaptable to firm performance in the construction sector. (2) The findings of this study demonstrate that business model innovation plays a mediating role in the relationship between the three independent variables and firm performance. Consequently, innovative business models function as a unifying element, thereby augmenting the direct impact of operational strategies on overall company performance. The integration of business model innovation engenders a competitive advantage in the face of market volatility. (3) Preliminary research indicates that lean construction is the most effective strategy for enhancing internal efficiency and increasing company productivity. Lean construction practices have been shown to reduce waste, enhance collaboration among project teams, and expedite project production cycles. (4) Supply chain resilience is a critical component of ensuring operational sustainability, particularly in the context of global crises and supply chain disruptions. Companies that demonstrate robust supply chain resilience have demonstrated a propensity to adapt and maintain service levels to customers with greater expediency. (5) The existence of strategic partnerships has been demonstrated to exert no direct positive and significant effect on firm performance. This finding suggests that the presence of strategic partnerships, in the absence of innovative plans for managing business models, is inadequate to directly enhance company performance. However, when the relationship between strategic partnership and firm performance is moderated by business model innovation, the effect becomes positive and significant. This finding suggests that the innovation in business models plays a pivotal role in optimizing the benefits of strategic partnerships, particularly in the context of long-term partnerships that are thoroughly integrated into the company's business strategy. In essence, business model innovation functions as a catalyst that enhances the efficacy of strategic partnerships in promoting firm performance enhancement. (6) The present study demonstrates that environmental dynamism exerts a significant moderating effect on the relationship between business model innovation and firm performance. This suggests that environmental dynamics amplify the impact of business model innovation on organizational performance. This finding suggests that companies must adapt to external changes in order to survive and thrive in the modern business landscape. (7) An analysis of interview findings suggests that large construction companies, confronted with complex and extensive projects, often possess a greater degree of flexibility and resources, enabling them to respond to external dynamics with greater efficacy compared to their smaller counterparts. Consequently, environmental dynamism emerges as a pivotal differentiating factor within the context of large companies. However, further research is necessary to ascertain its applicability to medium and small companies.

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