

Article

A Synergetic Effect of the Integration of Lean, Sustainable Construction Practices and Alliance Contract on Operation Performance in the Indian Construction Industry

Praveenkumar Thaloor Ramesh * and Elangovan Nattanmai Swaminathan

Department of Civil Engineering, Jerusalem College of Engineering, Chennai 600100, India

* Correspondence: pravirami@gmail.com

Abstract: By pioneering a comprehensive analysis of lean integration within the construction sector, this research provides novel insights into optimizing project outcomes. The construction industry is generally known for its frequent deadline slip-ups, budget overruns, and issues with upholding proper quality. It is usual practice to integrate different management techniques which are successful in the production industry in order to avoid such issues. Several researchers adopted sustainable construction management, lean management and alliance contract practices individually on construction sites to improve the profit, productivity, quality and transparency of the project. In this study, the synergetic integration of sustainable construction management, lean management and alliance contract practices have been studied. A questionnaire survey was conducted among 345 practitioners, resulting in 309 responses after screening. These respondents, comprising various roles in the AEC sector, provided insights into their experience, project involvement, and business sectors. The study identified 23 factors associated with lean practices, sustainable construction, and alliance contracts, examining their relationships and benefits through Structural Equation Modeling (SEM). The results demonstrate significant effects of lean practice, sustainable construction, and alliance contract factors on the benefits derived from their integration. Measures of reliability and validity affirm the robustness of these relationships. The discussion underscores the benefits of integration, including enhanced efficiency, reduced environmental impact, improved collaboration, shared risk and reward, superior project outcomes, and competitive advantage. Overall, this research elucidates the potential advantages of integrating these methodologies within construction projects.

Keywords: sustainable management; lean construction; Structural Equation Modeling; alliance contract



Citation: Thaloor Ramesh, P.; Nattanmai Swaminathan, E. A. Synergetic Effect of the Integration of Lean, Sustainable Construction Practices and Alliance Contract on Operation Performance in the Indian Construction Industry. *Sustainability* **2024**, *16*, 1857. <https://doi.org/10.3390/su16051857>

Academic Editor: Ripon Kumar Chakraborty

Received: 29 January 2024
Revised: 16 February 2024
Accepted: 17 February 2024
Published: 23 February 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Lean project management, sustainability and alliance contract are considered to major themes among the construction industry and researchers. A significant percentage of Indian GDP is contributed by the construction industry and is growing steadily. The significant expansion of this construction industry is mostly due to the rapid rise in the urban population. The rapid rise in the urban population imposes on the government the need to make necessary developments in the urban area, including road, railway and infrastructure development. This significant development in the construction industry also consumes enormous amounts of energy and resources and generates waste. This waste needs to be recycled, and can be minimised. Sustainability development has gained lot of attention due to problems like ozone layer depletion, global warming, and other environmental problems [1]. As a result of increased global competition, the global economy has brought significant challenges to industries, including the need to satisfy customers, deliver on time, and maintain high standards of quality to survive in the market. High-quality products, lowered production time, cost-effectiveness, and environmental protection are all vital and crucial for sustainable development for the enterprises. In addition, there is a growing

emphasis on environmentally responsible production methods, such as those that reduce or eliminate waste [2,3].

The concept of lean construction was first developed by Toyota in the year 1950, and found that implementation of lean concepts helps to eliminate waste and improve the value in the manufacturing process. Lean construction signifies various aspects, including continuous improvement, waste reduction and the importance of collaboration in the construction process [4–8]. In recent years, several of the world’s most successful businesses have begun initiatives to create lean methods of construction. Many have been successful in doing so, and the results have been enhanced quality, increased profits, and a more positive reputation. The ensuing “sustainable” solutions have strengthened the image of firms as socially responsible enterprises, while decreasing waste production, energy consumption and the usage of hazardous materials. Since energy costs, pollution, and global warming are all on the rise, rigorous environmental performance rules need to be put in place immediately [9]. Several tools were employed in lean construction practices, including 5S, kanban, the Last Planner System (LPS), Value Stream Mapping (VSM), PDCA, kaizen, etc. [10,11]. Most of the lean tools are shown in Table 1. The construction project quality, reduction in rework, and efficient schedule management can be carried out by adopting the LPS system. The Last Planner System (LPS) enables all stakeholders to engage in the project, which enables all the team members to understand the project objectives and goals. LPS leads to improved collaboration and communication among the stakeholders, which improves the project quality and reduces the rework [12,13]. Similar to LPS, the Value Stream Mapping (VSM) technique provides several advantages for construction projects, including an increase in productivity, reduced lead time, improved customer satisfaction and reduced costs. VSM helps to identify waste and bottlenecks in construction sites, which reduces lead time and improves productivity. In addition, the implementation of VSM in construction site improves the flow of information and materials, which helps to improve customer satisfaction and to reduce costs [14,15].

In general, alliance contracts were incorporated into complex and large projects where a high degree of uncertainty is involved. The risk involved in the complex projects was shared between the parties involved in the project. The alliance contract provides guidelines for managing risks and incentivizes both the parties to collaborate and work towards a common goal. The key feature of adopting the alliance contract in the construction process is that the risk and reward is shared among the parties. This signifies that the parties share the profits as well as the risks involved in the project, which incentivizes the team to collaborate and work efficiently [16]. This research mainly emphasises the synergetic integration of the alliance contract, lean methodology and sustainable construction factors. Several factors pertaining to the alliance contract, lean methodology and sustainable construction practices were identified based on expertise suggestion, and the relationship between the factors were analysed using the SEM approach.

Table 1. Lean construction tools.

Lean Construction Practices	References
5S	[1–8]
Kanban	[9–11,17–20]
Just in Time	[21–31]
Pareto Analysis	[32–34]
Value Stream Analysis	[14,15,35–40]
Six Sigma	[41–44]
PDCA	[9,45,46]
Root Cause Analysis	[47–49]
Poka Yoka	[3,50–52]
Kaizen	[53–57]
Last Planner System	[12,13,58,59]
Statistical Process Control	[60,61]

2. Contextual Background

2.1. Lean Construction Practices

The aim of lean construction is to minimise the waste, including time, materials and cost. Unnecessary waste in a construction site can be eliminated by means of improved efficiency and by adopting the lean technique. The lean philosophy was first introduced in the Toyota manufacturing sector by means of minimising waste and improving the customer value. Adopting lean tools and techniques is mainly incorporated into a construction project to reduce unnecessary waste. In general, lean construction is adopted in a construction site to minimise construction time and money by increasing the productivity and efficiency of construction projects. The construction projects are complex in nature, and mainly deal with cost overruns, delays and quality problems. In order to overcome those issues, most of the construction companies have implemented lean construction techniques, which eliminate unnecessary factors and improve efficiency [28,29]. Two of the most popular lean tools used in construction are the Last Planner System (LPS) and Value Stream Mapping (VSM). This paper will explore the implementation of LPS and VSM in the construction industry and their benefits in improving project delivery. Subhav Singh and Kaushal Kumar studied the implementation of visual management tools and lean construction through cluster analysis. In the study, several lean tools were incorporated to enhance the value of construction projects. The data were collected using cluster analysis, reliability analysis and the relative importance index. They found that significant lean tools were considered to be 5S, the Last Planner System, BIM and Big Rooms [2]. Piotr Nowotarski et al. [62] proposed the implementation of the lean management principle in the construction of office buildings in Poland. They conducted a more thorough investigation on implementing the suggested technique in three processes: ordering scaffolding, managing storage areas, and concreting columns. The researchers of the study concentrated on the financial elements of one of them, demonstrating how the proposed alternative management style can affect the expenses of the activities, and the storage area management, which were being studied. To evaluate key risks and identify viable solutions that would have an impact on cutting the overall time and cost of the evaluated tasks, lean approaches were utilized. Bhargav Dave et al. [63] identified possible opportunities to enhance the lean management in construction using IOTs. The conventional Last Planner System has long lookahead planning cycles to respond to the construction production requirements. New approaches have been put forth, such as KanBIM, VisiLean, etc., in this study; however, once more these construction management systems demand that workers have access to, and proximity to, computers. In this research, the authors explore ways to further enhance the communication framework supporting such construction management system in order to fully or partially automate a variety of communication tasks throughout the construction project lifecycle. The author integrates IOT and associated standards to enhance the performance of the construction project. With this new approach, the efficiency of the construction project can be improved by managing the flow of information through the new lean-IOT integrated approaches. According to Drevland and Tillmann (2018), [64] determining whose value matters requires understanding the motive for value delivery. As greater attention is paid to lean construction around the globe, rich technologies and techniques are being adopted to fulfil LC goals, and academic viewpoints on lean construction are growing more diversified. Xu et al. [65] suggested a cloud-based platform to facilitate lean prefabricated-project delivery in the building industry. The authors emphasise the value and high quality of prefabricated panels for building projects. This results in cost and time savings, as well as enhanced safety and quality standards. They suggest a solution that integrates lean construction and cloud-based IoT to oversee the functioning of prefabricated panels in infrastructure projects. The authors employed XML-based coding to create a framework model for integrating lean construction methodologies with cloud-based IoT. To validate the framework, a case study technique was used, and the framework was tested on a building project. The research concludes that the suggested framework of lean construction and cloud-based IoT will save costs and increase productivity and safety on building sites. Koseoglu et al. [66]

conducted research on the complementary nature of mobile BIM implementation and lean construction on building sites. Tools like Building Information Modeling (BIM) and Lean Construction have been created to speed up and reduce costs without sacrificing quality in the building industry. In this study, the authors made an effort to combine lean construction with mobile BIM. The research concluded that the construction project's QA/QC procedure was improved due to the implementation of lean construction and mobile BIM.

2.2. Sustainable Construction Paradigm

The major contribution to the economy is contributed by the construction industry, and it also accounts for the negative impact on the environment, due to large energy consumption. The construction industry is major contributor of greenhouse gas emissions, due to excessive use of fossil fuels and cement. To avoid the negative impact, it is advised to practice sustainable management practices [67]. Sustainable construction management practices include recycling and reuse, which mitigates the negative impact of the construction industry. These practices generally reduce the amount of waste generated in the construction industry. Sustainable development can be achieved and reduction in environmental impact can be achieved by means of reusing and recycling the construction waste [68]. Recently, the term energy efficiency has become popular, due to the implementation of sustainable management practices in the construction industry. It generally involves the use of technologies which reduces the energy consumption in the buildings. By adopting the energy efficient technologies, the energy consumption can be reduced, along with a reduction in greenhouse gas emissions. Energy efficiency can also be achieved by utilising the sustainable materials in the construction industry, which reduces the negative impact and promotes sustainable development. Sustainable development can also be achieved by means of proper waste management practices [69]. Proper waste management practices reduce the amount of waste generated during construction, saves the energy consumed, and also conserves the resources [70]. Life cycle assessment can also reduce the negative impact, along with sustainable development. It helps to identify where the environmental impact is higher and gives the solution for the reduction [71]. Recently, researchers have focussed on implementing sustainable management practices in the construction sector to achieve sustainable development and to reduce the environmental impact. The following factors were to be considered in developing a sustainable environment in the construction sector, include recycling and reusing, green design, incorporating sustainable materials, BIM, water conservation, waste management, and life cycle assessment. Incorporating those sustainable management factors reduces the negative impact on the environment and promotes sustainable development.

2.3. Alliance Contract

Alliance contracting is one form of contracting that is gaining popularity in the construction industry and has been used for certain larger public sector contracts. While the use of external parties, who frequently bring with them specialised expertise and capabilities, might increase the project's success, the relationship dimension offers the opportunity to decrease the possibility of opportunism. An incentive scheme like this one encourages desirable actions by bringing principal and agent closer together in terms of their shared goals and risks. Most construction companies in underdeveloped nations are too small to handle major building projects independently. As a result, alliances between contractors are attractive because they allow for the completion of massive, complex projects that no single contractor could carry out alone. However, there are cooperative and competitive aspects to any collaboration between businesses doing similar work. However, the latter often encourages linked enterprises to engage in competitive racing to study the competence of the partner(s) for private gains, as opposed to the former, which allows the firms to use their complementary strengths for common benefits [16]. Upon completion of the training, the necessity to maintain the alliance diminishes, potentially resulting in its dissolution. Alliance contracts have proven to be effective in numerous construction projects worldwide.

An instance of this is the establishment of the Sydney Water Alliance in Australia in 1999. Its purpose is to execute various water and wastewater infrastructure projects under an alliance contract. This alliance has been successful in delivering projects on time and within budget, while also achieving high levels of safety and environmental performance [72]. Similarly, the Construction Management at Risk (CMAR) alliance model has been used in the United States to deliver construction projects. This model involves the owner, designer, and contractor forming an alliance to work together collaboratively. Studies have shown that this approach has resulted in better project outcomes, including fewer change orders and higher levels of satisfaction among project stakeholders [73]. The research conducted by Laan et al. (2011) [74] offered insight into project alliance contracts that encourage cooperation between contractor and client firms during a complex project. Both parties have made serious efforts to break the partnership arrangement by minimising their residual dispositions. Alliance contracts were introduced by Davis and Love (2011) [75] to deepen the relationship between the parties, and they discovered that trust and organisational growth were the most important variables in developing relationships. An alliance contract is a contractual arrangement that provides a framework for managing risk and incentivizes parties to work collaboratively towards a successful project outcome. This type of contract can be an effective way of managing risks and achieving better project outcomes in large and complex construction projects.

2.4. Integration of Lean, Sustainable Construction Practices and Alliance Contract

This research mainly focuses on the integration of lean, sustainable construction practices and the alliance contract. This synergetic implementation approach improves the construction performance, sustainability, and construction waste. Lean practices in construction projects necessitate the participation of all stakeholders—including suppliers, contractors, and subcontractors—in a collaborative effort. Assuring that all stakeholders are in agreement with the project's goals and objectives is the initial phase in LC practice implementation. Following the establishment of goals and objectives, LPS can be employed to generate an elaborate strategy for the execution of the project. The VSM process can be used to identify waste and opportunities for improvement in the production process. The implementation of LPS and VSM requires a cultural shift in the construction industry. It necessitates a shift from the conventional adversarial approach to one in which all stakeholders are actively engaged in the planning process. Moreover, it necessitates an emphasis on waste elimination and continuous improvement throughout the production process. Alliance contracts have surfaced as a novel procurement approach within the construction sector, wherein project participants collaborate and share risk management responsibilities in an effort to enhance project outcomes. An examination of the current state of research on alliance contracts in construction, including their advantages, disadvantages, and critical success factors, is the objective of this study. Sustainable construction practices aim to minimize the waste and improve the productivity of the construction by utilizing the local resources. The integrated approach reduces environmental damage, improves system efficiency, reduces waste, and improves the process. The research hypothesis of the current study is as follows:

H1: *Lean practice key factors have a positive effect on the beneficial factors of synergetic integration of lean, sustainable construction practices and the alliance contract in construction.*

H2: *Sustainable construction practice key factors have a positive effect on beneficial factors of synergetic integration of lean, sustainable construction practices and the alliance contract in construction.*

H3: *Alliance contract key factors have a positive effect on beneficial factors of synergetic integration of lean, sustainable construction practices and the alliance contract in construction.*

2.5. Structure Equation Modelling (SEM)

SEM is a complex statistical technique, and it is important to have a strong understanding of the underlying theory and assumptions before using it. However, SEM can be a valuable tool for researchers who are interested in understanding the complex relationships between variables. Figure 1 depicts the hypothetical model of relationship between the lean factors, sustainable construction practices and alliance contract. These relationship between the variables were analysed using SEM approach.

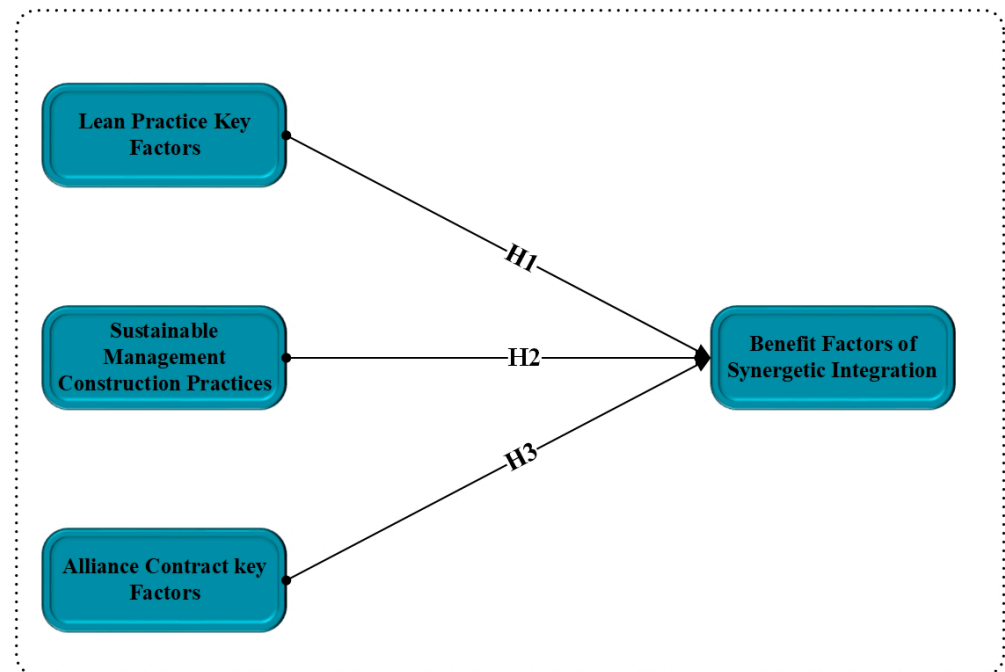


Figure 1. Hypothetical model to analyse synergetic integration of lean, sustainable construction practices and alliance contract.

3. Research Methodology

3.1. General Information about Respondents

There was a questionnaire survey which took place among 345 people who diligently practice LC and have knowledge of the alliance contract and sustainable construction practices, and after the screening process we were left with 309 responses. The sample space included various people from the AEC industry, including consultants, researchers, the project head, contractors, the planning engineer, architects, the junior site engineer, interior designers, and construction managers. They were further divided by criteria such as work experience, and the number of projects with LC and the alliance contract that they had handled. It was observed that most of the respondents have worked in a private company, with more than approximately 10 years of experience. Though the people were LC practitioners, only a mere 27.3% of them had handled more than 10 projects using the LC process and 13% of the people had been involved in executing alliance contract. When the business type is considered, commercial construction was the dominant sector that the practitioners have handled. About 55% of them had worked on building construction projects, whereas 18.1% had been handling road projects, 7.1% were involved in the transmission industry, 12% were engaged in the oil/gas industry, and the remaining 7.8% were engaged in railway projects. A total of 46% of the respondents agreed that the integration process would be carried out by site personnel, while 13% agreed that it would be carried out by management personnel, 11% agreed that it would be carried out by the accounts department, and 30% agreed that the lean, sustainable practice and alliance integration would be carried out by the R&D team of the organisation. Implementation of lean, sustainable practice and alliance integration in construction projects is based on

project cost, skilled personnel, and time of implementation. Most of the respondents agreed that implementation is entirely based on the cost of the project. Using the factors found, a questionnaire was prepared and sent out to the Indian construction companies. To obtain information from respondents, a 5-point Likert scale was used. On the scale, 1 meant “very low impact”, 2 meant “low impact”, 3 meant “neutral”, 4 meant “high impact”, and 5 meant “very high impact”. There were a total of 345 questionnaires sent out, and the study is based on the 309 responses.

3.2. Research Gap

The novelty of the study is the synergetic integration of lean, sustainable construction practices and the alliance contract in construction projects. The relationship between lean methodology, sustainable construction practices, alliance contract, and the benefits of integration is studied using structure equation modelling.

3.3. Significant Factors Identified for Integrated Approach

Based on the literature and suggestions of industry experts, several factors were identified for lean methodology, sustainable construction practices and alliance contract. As a result, 23 factors were identified and are represented in Table 2. Table 3 shows the benefit factors of synergetic integration of lean, sustainable construction practices and alliance contract.

Table 2. Identified factors for lean methodology, sustainable management construction practices and alliance contract.

Lean Practice Key Factors (LPKFs)	Sustainable Management Construction Practices (SMCPs)	Alliance Contract Key Factors (ACKFs)
Waste reduction in construction (LPKF_1)	Increase in construction profit (SMCP_1)	Shared accountability and co-ordination (ACKF_1)
Enhancement of safety and health conditions (LPKF_2)	Improvement in working conditions (SMCP_2)	Increased transparency (ACKF_2)
Improvement in productivity (LPKF_3)	Reduction of waste (SMCP_3)	Reduction of risks by enabling robust risk management practices (ACKF_3)
Increased labour productivity (LPKF_4)	Improvement in product responsibility (SMCP_4)	Quick dispute resolution (ACKF_4)
Reduction of maintenance and operational cost (LPKF_5)	Effective communication among labourers (SMCP_5)	Efficient use of resources (ACKF_5)
Minimization of energy (LPKF_6)	Optimum use of resources (SMCP_6)	Enhancement of construction quality (ACKF_6)
Better inventory management (LPKF_7)	Decrease in construction cost (SMCP_7)	Ease of entry into new environment (ACKF_7)
Better control of project activities (LPKF_8)		Control of market uncertainty (ACKF_8)

Table 3. Benefit factors of synergetic integration of lean, sustainable construction practices and alliance contract.

Key	Integration Benefit Factors (BFSIs)
BFSI_1	Improved efficiency
BFSI_2	Reduced environmental impact
BFSI_3	Improved collaboration and communication
BFSI_4	Shared risk and reward
BFSI_5	Improved project outcomes
BFSI_6	Competitive advantage

4. Results and Discussion

4.1. Structure Equation Modelling (SEM) Approach

The synergetic integration of lean practice key factors, sustainable management construction practices and alliance contract key factors was analysed using the SEM approach and is shown in Figure 2. It was found that H1, the lean practice key factors, have significant effect on the benefits of synergetic integration, with a 0.238 β value. This suggests that implementing lean practices contributes positively to the overall integration benefits, enhancing efficiency, reducing waste, and improving project outcomes. H2, the sustainable management construction factors, have significant effect on the benefits of synergetic integration, with a 0.339 β value. This underscores the critical role of sustainability in enhancing the integration benefits, highlighting its importance in reducing environmental impact, promoting resource efficiency, and contributing to the long-term viability of construction projects. H3, the alliance contract key factors, have significant effect on the benefits of synergetic integration, with a 0.270 β value. This finding suggests that alliance contracts, which emphasize collaboration, shared risks, and rewards among project stakeholders, are crucial for maximizing the benefits of integration, leading to better risk management, dispute resolution, and project success rates. Table 4 depicts the hypothesis testing results. In addition, to check the reliability, several factors were calculated, including Cronbach's Alpha (Alpha), Composite Reliability (CR) and Average Variance Extract (AVE). Table 5 displays the reliability analysis using measures like Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extract (AVE) for each construct: the constructs show high reliability ($\alpha > 0.7$, CR > 0.7) and acceptable convergent validity (AVE > 0.5). The results of the model fit observed was depicted in Figure 3, and signify how well the model aligns with the observed data. The SEM analysis provides empirical evidence supporting the positive impact of lean practices, sustainable management construction practices, and alliance contract key factors on the benefits of synergetic integration in construction projects. The high reliability and validity of the variables, along with a satisfactory model fit, affirm the strength and significance of the findings. This analysis highlights the importance of integrating these practices to achieve enhanced project outcomes, sustainability, and efficiency in construction management.

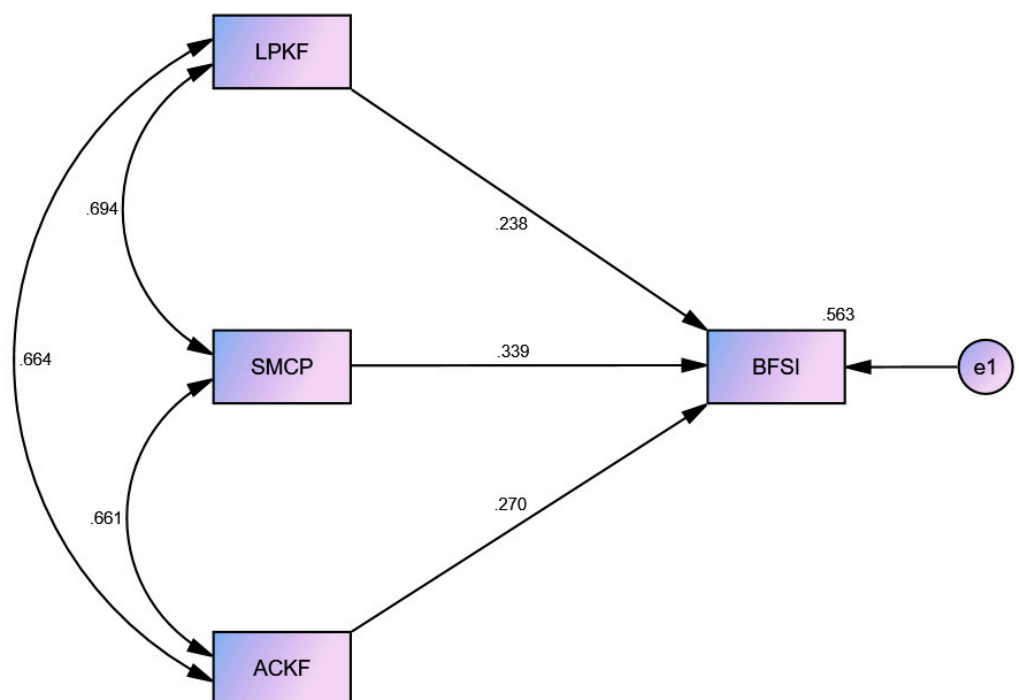


Figure 2. Graphical representation of structural model.

Table 4. Hypotheses testing:direct.

Hypothesis	Direct Relationships	Std. Beta	Std. Error	T Values	p Values
H1	LPKF → BFSIL	0.238	0.059	4.034	***
H2	SMCP → BFSIL	0.339	0.057	5.947	***
H3	ACKF → BFSIL	0.270	0.060	4.500	***

Asterisk indicates significant paths: *** $p < 0.001$, NS = not significant.

Table 5. Alpha, CR, and Validity Analysis.

Construct	Items	Loading	Alpha >0.7	CR >0.7	AVE >0.5
Lean practice key factors	LPKF_1	0.765 ***	0.912	0.912	0.564
	LPKF_2	0.771 ***			
	LPKF_3	0.753 ***			
	LPKF_4	0.739 ***			
	LPKF_5	0.703 ***			
	LPKF_6	0.755 ***			
	LPKF_7	0.784 ***			
	LPKF_8	0.734 ***			
Sustainable management construction practices	SMCP_1	0.741 ***	0.895	0.895	0.550
	SMCP_2	0.741 ***			
	SMCP_3	0.758 ***			
	SMCP_4	0.744 ***			
	SMCP_5	0.754 ***			
	SMCP_6	0.734 ***			
	SMCP_7	0.718 ***			
Alliance contract key factors	ACKF_1	0.739 ***	0.915	0.915	0.573
	ACKF_2	0.790 ***			
	ACKF_3	0.747 ***			
	ACKF_4	0.761 ***			
	ACKF_5	0.741 ***			
	ACKF_6	0.794 ***			
	ACKF_7	0.742 ***			
	ACKF_8	0.741 ***			
Beneficial factors of synergetic integration	BFSI_1	0.751 ***	0.888	0.888	0.570
	BFSI_2	0.784 ***			
	BFSI_3	0.756 ***			
	BFSI_4	0.741 ***			
	BFSI_5	0.762 ***			
	BFSI_6	0.736 ***			

*** $p < 0.001$.

The study successfully identifies significant relationships between the key factors of lean construction, sustainable practices, and alliance contracts concerning the benefits derived from their synergetic integration. The model demonstrates strong reliability and validity, affirming the robustness of the relationships examined.

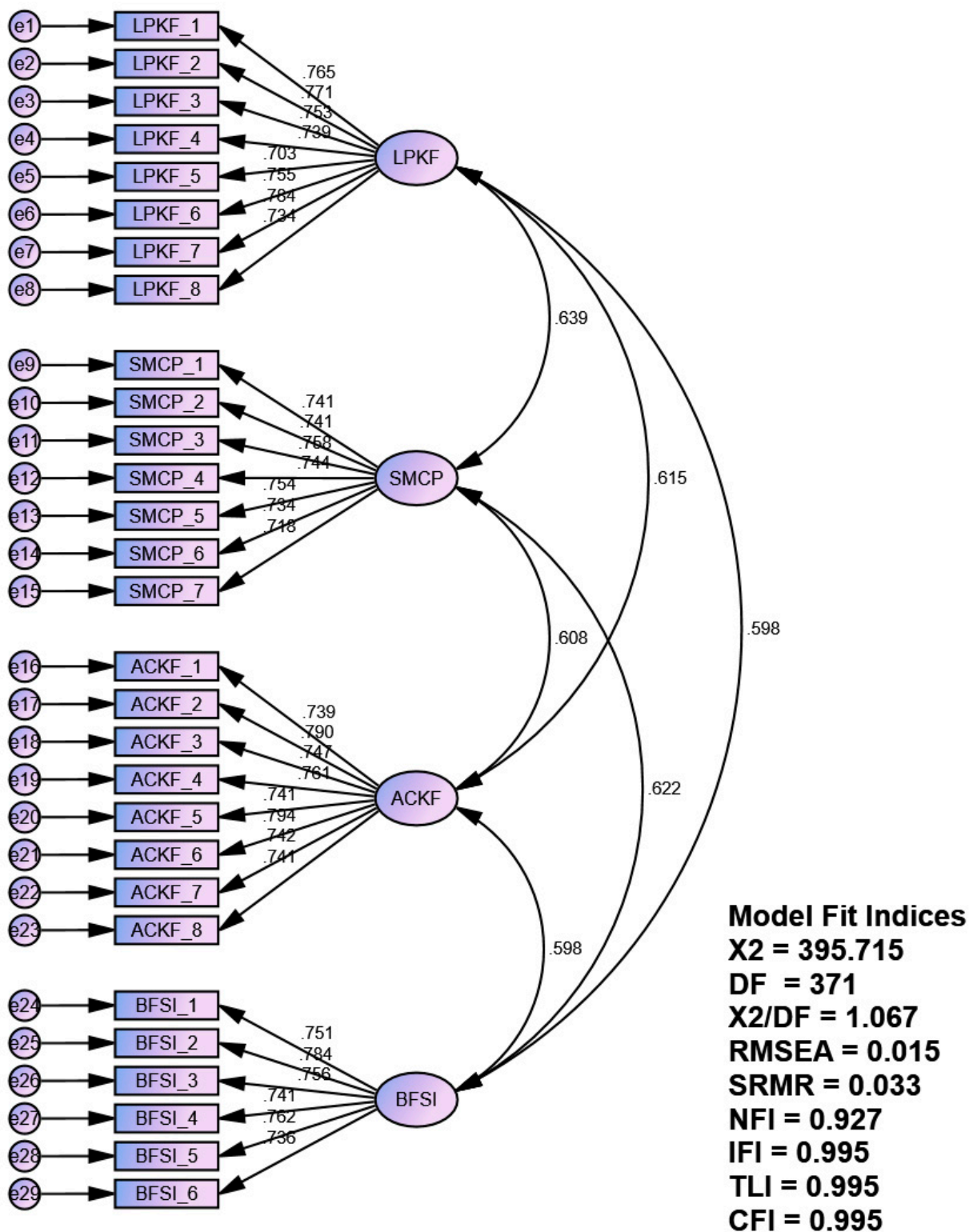


Figure 3. Graphical representation of assessment of measurement model.

4.2. Discussion of Integration of Lean, Sustainable Construction Practices and Alliance Contract

- Improved efficiency: the integration of lean, sustainable construction practices and the alliance contract in the construction site improves the efficiency of the projects. By means of integration, a construction company reduce the costs and construction waste, improves the productivity, optimises the construction project, and shortens the project schedule.

- Reduced environmental impact: sustainable construction management practices can reduce the environmental impact of construction activities by minimising resource consumption and promoting environmentally responsible design and construction. Implementing those practices reduces the construction waste and carbon emissions, along with improved air and water quality.
- Improved collaboration and communication: alliance contracts promote collaboration and communication between the client, designer, and contractor. Improved collaboration between the parties reduces the likelihood of construction delays and disputes and, improves construction project outcomes, along with improvement in construction quality.
- Shared risk and reward: alliance contracts promote shared risk and reward among the project team. When risks and rewards are shared, each party effectively contributes to the success of the project. Sharing risks can help distribute the potential negative impacts across multiple parties. If one party faces difficulties or setbacks, the others can provide support, reducing the overall impact. The project goals and objectives can be achieved effectively by collaboration between the parties, which brings different perspectives and skills, leading to better solutions.
- Improved project outcomes: integrating lean, sustainable construction management practices and alliance contracts can lead to improved project outcomes, including cost savings, improved quality, and reduced risk. By means of integration, improved customer satisfaction and an increase in reputation of the construction company can be achieved.
- Competitive advantage: integrating these practices can provide a competitive advantage for construction companies by differentiating them from their competitors and demonstrating their commitment to sustainability, efficiency, and collaboration.

4.3. Factors Affecting Synergetic Implementation of Lean, Sustainable Construction Practices and Alliance Contract in Indian Construction Industry

As far as synergetic implementation is concerned in India, though there is a widespread progression in its usage, when factors like enterprise size, the geographical location, type of project, etc., are taken into consideration, it seems to be lopsided. Thus, there is an immediate requisite to observe the various advantages and disadvantages of the practice, in order to promote the same in India.

The lean construction management involves the proper management of various criteria such as the quantity of the materials used and its storage space, so as to provide a detailed work schedule and decide on the workflow. All this can eventually decrease the waiting time, which is the least preferred factor in the construction sector. Using the procured data, it is easily possible to assist with the workflow and reduce the waste production in the process. Thus, the preliminary or the initial stage of LCM requires a tedious process of scheduling the workflow to be followed, which can in turn indirectly impact the usage of the resources. It has been found that more than about 90% of the flaws can be avoided when the scheduling in the initial stage is properly accounted for. Moreover, proper scheduling can also lead to under-usage of labour and transportation. As the work schedule is followed very stringently, there can be no over-usage or exploitation of the resources at site.

However, in terms of energy efficiency, it can be found that the waste of energy usually happens in the designing department, which can also be managed via BIM collaboration. But, when the design is being constructed on-site, it was found from the construction related personnel that it led to various complications and lack of harmony among the fellow workers. This is also due to the fact that the labourers provided by the contractor are less educated on this perspective, and the work schedule and the workflow are at stake. It was also found that, though they are educated about this method, when the concept was put into action it lacked the primary essence of the whole process. From the view of the project stakeholders, it can be noticed that there is a choice of opinion among the client and the contractors. From the contractors' point of view, using less labour for more amount

of time can create profit for them, whereas from the clients' point of view, using a greater quantity of labour and resources can reduce the time period of the whole process. Due to this gap, there is always a contradiction in the LCM process. Eventually, this process has to find a middle ground which is advantageous for the clients as well as for the contractors. The responsibility on the clients' side involves deciding on the design and work schedule and in on-site monitoring, and the responsibility on the managers' side involves assigning various tasks to the labourers, according to the work schedule.

4.4. Suggestions for Promoting Integration of Lean, Sustainable Construction Practices and Alliance Contract Implementation

To promote the integration of lean, sustainable construction management practices and alliance contracts in construction projects, the following suggestions can be implemented:

- **Develop training programs:** In order to develop the employees regarding the synergetic integration and application of lean, sustainable construction management practices, and alliance contracts in construction contracts, training programmes are found to be effective. Conducting training programmes helps the employees to identify the waste, optimizes the construction process, and promotes sustainable practices on the construction site.
- **Promote collaboration:** The likelihood of construction delays and disputes can be minimised by promoting the collaboration among the project members, along with improved communication and building trust. This can be achieved by the conduction of regular meetings and workshops to discuss and achieve the project objectives and goals. By means of successful collaboration, team members generate better ideas and solutions, which the project needs. Collaboration also generates new perspectives in achieving the project objectives, which resolves the project challenges efficiently.
- **Develop guidelines and standards:** the standards and guidelines need to be prepared by construction companies for synergetic integration of lean, sustainable construction management practices and alliance contracts in their projects. Proper guidelines and standards promote internal consistency and a clear framework, so that project members can follow them, and can ensure the best practices in the construction project.
- **Provide incentives:** the major advantage of providing incentives is to encourage the project team members and to obtain a better performance to achieve the company's goals. It enables the employees to put extra effort into the project and accomplish things in an efficient manner. Construction companies can provide incentives for project teams to integrate lean, sustainable construction management practices and alliance contracts. In addition, incentives can also improve the quality of work and improve the morale of the employee.
- **Utilise technology:** the utilisation of software tools like Primavera P6 for project planning, scheduling and monitoring, along with the use of Building Information Modelling (BIM) can be implemented in the construction project to achieve the project goals and objectives. Construction firms have the ability to encourage the incorporation of alliance contracts and lean, sustainable construction management practices into their projects through the use of efficient software tools and technologies.
- **Engage with stakeholders:** construction companies can engage with stakeholders, clients, and suppliers to promote the integration of lean, sustainable construction management practices and alliance contracts into their projects. Engaging the stakeholders can minimise the risks in the project. A comprehensive assessment of the project's risks can be attained through active stakeholder involvement; furthermore, stakeholder engagement promotes confidence, which in turn influences the project outcomes.

The integration of lean, sustainable construction practices and alliance contracts in construction projects requires factors including stakeholder engagement, utilising advanced technology, incentives, developing standards and guidelines, promoting collaboration, and conducting training programmes. Construction companies can enhance project outcomes

and foster sustainable, collaborative, and efficient construction practices by adopting and implementing the aforementioned recommendations.

5. Conclusions

This research contributes significantly to understanding the synergistic integration of lean construction, sustainable practices, and alliance contracts in the construction industry. The study's findings, validated through Structural Equation Modeling, underscore the substantial impact of integrating these methodologies on project outcomes. The identified 23 factors related to lean practices, sustainable construction, and alliance contracts elucidate their interconnectedness and significance in achieving enhanced efficiency and sustainability within construction projects. The empirical analysis reveals substantial findings regarding the effects of these integrated methodologies on project benefits. The Structural Equation Modeling demonstrates significant relationships: Lean Practice Key Factors (LPKFs) exhibit a significant effect ($\beta = 0.238, p < 0.001$) on the benefits of integration; Sustainable Management Construction Practices (SMCPs) display a notable impact ($\beta = 0.339, p < 0.001$) on the integrated benefits; similarly, Alliance Contract Key Factors (ACKFs) also significantly influence ($\beta = 0.270, p < 0.001$) the benefits derived from integration.

Moreover, measures of reliability and validity, including Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extract (AVE), further confirm the significance of these relationships. The constructs exhibit high reliability ($\alpha > 0.7, CR > 0.7$) and acceptable convergent validity ($AVE > 0.5$), ensuring the credibility of the identified factors and their impact on the integrated benefits. The empirical evidence supports the contention that integrating these practices leads to improved collaboration, reduced environmental impact, shared risk and reward mechanisms, and competitive advantages for construction companies. The study's robustness is evident through measures of reliability and validity, ensuring the credibility of the relationships examined. Ultimately, this research provides empirical evidence supporting the holistic integration of lean practices, sustainable methodologies, and alliance contracts, offering a pathway for the construction industry to achieve enhanced efficiency, sustainability, and competitiveness.

6. Limitations and Recommendations

One of the foremost requirements for the integration process is that the stakeholders must be aware of the lean principles and the alliance contract and its sustainable construction techniques. Only then it is possible for them to implement the same in an efficient way. But, when the local firms are taken into consideration, there is still a question mark over whether it is possible for them to adapt to the newer way of the process. Moreover, the process should be more interpretative of the local area's needs and the construction methods. Thus, it is required to explore the integration process in accordance with the domestic needs and requirements. When building type is taken into consideration, it has been observed that the industrial construction projects are different when compared to the other types with regard to the lower tolerance of quality flaws and the assembly process. Thus, it is also a concern that the LC process should also be in accordance with the various building types.

Author Contributions: P.T.R.: Conceptualization, investigation, methodology, writing—original draft and reviewing; E.N.S.: conceptualization and supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data used for this study are included in the manuscript itself.

Acknowledgments: Our grateful acknowledgement goes to the Jerusalem College of Engineering for the extensive support.

Conflicts of Interest: The authors declare no conflicts of interest.

References

- Gehlot, M.; Shrivastava, S. Sustainable construction Practices: A perspective view of Indian construction industry professionals. *Mater. Today Proc.* **2022**, *61*, 315–319. [\[CrossRef\]](#)
- Singh, S.; Kumar, K. A study of lean construction and visual management tools through cluster analysis. *Ain Shams Eng. J.* **2021**, *12*, 1153–1162. [\[CrossRef\]](#)
- Bajjou, M.S.; Chafi, A.; Ennadi, A.; El Hammoumi, M. The Practical Relationships between Lean Construction Tools and Sustainable Development: A literature review. *J. Eng. Sci. Technol. Rev.* **2017**, *10*, 170–177. [\[CrossRef\]](#)
- Salem, O.; Solomon, J.; Genaidy, A.; Luegring, M. Site implementation and assessment of lean construction techniques. *Lean Constr. J.* **2005**, *2*, 1–21. [\[CrossRef\]](#)
- Berroy, F.; Harbouche, L.; Botton, C. Top down vs. Bottom up approaches regarding the implementation of lean construction through a French case study. In Proceedings of the 23rd Annual Conference of the International Group for Lean Construction, Perth, Australia, 29 July 2015; pp. 73–82.
- Hiwale, A.; Wagh, A.; Waghmare, V.; Khairnar, D.; Champanerkar, S.; Mane, P. Effectiveness of 5s implementation in lean construction (commercial building construction project). *Int. J. Res. Appl. Sci. Eng. Technol.* **2018**, *6*, 62–65. [\[CrossRef\]](#)
- Singh, S.; Dixit, S.; Sahai, S.; Sao, A.; Kalonia, Y.; Kumar, R.S. Key benefits of adopting lean manufacturing principles in Indian construction industry. *MATEC Web Conf.* **2018**, *172*, 05002. [\[CrossRef\]](#)
- Bashir, A.M.; Suresh, S.; Proverbs, D.; Gameson, R. A critical, theoretical, review of the impacts of lean construction tools in reducing accidents on construction sites. In Proceedings of the 27th Annual ARCOM Conference, Bristol, UK, 5–7 September 2011; Association of Researchers in Construction Management: Edinburgh, UK, 2011; pp. 5–7.
- Zhang, L.; Chen, X. Role of lean tools in supporting knowledge creation and performance in lean construction. *Procedia Eng.* **2016**, *145*, 1267–1274. [\[CrossRef\]](#)
- Jang, J.W.; Kim, Y.W. Using the kanban for construction production and safety control. In Proceedings of the 15th Annual Conference of the International Group for Lean Construction (IGLC), East Lansing, MI, USA, 18–20 July 2007.
- Zeng, N.; Ye, X.; Liu, Y.; König, M. BIM-enabled Kanban system in construction logistics for real-time demand reporting and pull replenishment. *Eng. Constr. Archit. Manag.* **2023**; ahead-of-print. [\[CrossRef\]](#)
- Aslam, M.; Gao, Z.; Smith, G. Development of innovative integrated last planner system (ILPS). *Int. J. Civil Eng.* **2020**, *18*, 701–715. [\[CrossRef\]](#)
- Gao, S.; Low, S.P. The Last Planner System in China’s construction industry—A SWOT analysis on implementation. *Int. J. Proj. Manag.* **2014**, *32*, 1260–1272. [\[CrossRef\]](#)
- Rosenbaum, S.; Toledo, M.; González, V. Improving environmental and production performance in construction projects using value-stream mapping: Case study. *J. Constr. Eng. Manag.* **2014**, *140*, 04013045. [\[CrossRef\]](#)
- Zahraee, S.M.; Esrafilian, R.; Kardan, R.; Shiwakoti, N.; Stasinopoulos, P. Lean construction analysis of concrete pouring process using value stream mapping and Arena based simulation model. *Mater. Today Proc.* **2021**, *42*, 1279–1286. [\[CrossRef\]](#)
- Aravindh, M.D.; Sriram, N.S.; Nakkeeran, G.; Jayakeerti, M.; Velan, C.; Krishnaraj, L. Synergistic effect of alliance contract and lean methodology on project performance measures in the construction industry: SEM analysis. *Technol. Forecast. Soc. Change* **2023**, *192*, 122545. [\[CrossRef\]](#)
- Sacks, R.; Treckmann, M.; Rozenfeld, O. Visualization of work flow to support lean construction. *J. Constr. Eng. Manag.* **2009**, *135*, 1307–1315. [\[CrossRef\]](#)
- Yücenur, G.N.; Şenol, K. Sequential SWARA and fuzzy VIKOR methods in elimination of waste and creation of lean construction processes. *J. Build. Eng.* **2021**, *44*, 103196. [\[CrossRef\]](#)
- Ramnath, B.V.; Elanchezian, C.; Kesavan, R. Application of Kanban system for implementing lean manufacturing (a case study). *J. Eng. Res. Stud. I* **2010**, *13*, 138–151.
- Lerche, J.; Enevoldsen, P.; Seppänen, O. Application of Takt and Kanban to modular wind turbine construction. *J. Constr. Eng. Manag.* **2022**, *148*, 05021015. [\[CrossRef\]](#)
- Bamana, F.; Lehoux, N.; Cloutier, C. Simulation of a construction project: Assessing impact of just-in-time and lean principles. *J. Constr. Eng. Manag.* **2019**, *145*, 05019005. [\[CrossRef\]](#)
- Jeong, W.; Chang, S.; Son, J.; Yi, J.S. BIM-integrated construction operation simulation for just-in-time production management. *Sustainability* **2016**, *8*, 1106. [\[CrossRef\]](#)
- Bajjou, M.S.; Chafi, A.; En-Nadi, A. A comparative study between lean construction and the traditional production system. *Int. J. Eng. Res. Afr.* **2017**, *29*, 118–132. [\[CrossRef\]](#)
- Pheng, L.S.; Chuan, C.J. Just-in-time management in precast concrete construction: A survey of the readiness of main contractors in Singapore. *Integr. Manuf. Syst.* **2001**, *12*, 416–429. [\[CrossRef\]](#)
- Abbasi, S.; Taghizade, K.; Noorzai, E. BIM-based combination of takt time and discrete event simulation for implementing just in time in construction scheduling under constraints. *J. Constr. Eng. Manag.* **2020**, *146*, 04020143. [\[CrossRef\]](#)
- Salem, O.; Solomon, J.; Genaidy, A.; Minkarah, I. Lean construction: From theory to implementation. *J. Manag. Eng.* **2006**, *22*, 168–175. [\[CrossRef\]](#)
- Babalola, O.; Ibem, E.O.; Ezema, I.C. Implementation of lean practices in the construction industry: A systematic review. *Build. Environ.* **2019**, *148*, 34–43. [\[CrossRef\]](#)

28. Pheng, L.S.; Chuan, C.J. Just-in-time management of precast concrete components. *J. Constr. Eng. Manag.* **2001**, *127*, 494–501. [[CrossRef](#)]
29. Dallasega, P.; Rauch, E. Sustainable construction supply chains through synchronized production planning and control in engineer-to-order enterprises. *Sustainability* **2017**, *9*, 1888. [[CrossRef](#)]
30. Rahman, A.H.; Wang, C.; Lim, I.Y.W. Waste processing framework for non-value-adding activities using lean construction. *J. Constr. Manag.* **2012**, *1*, 8–13.
31. Aziz, F.R.; Hafez, M.S. Applying lean thinking in construction and performance improvement. *Alex. Eng. J.* **2013**, *52*, 679–695. [[CrossRef](#)]
32. Ariyanti, F.D.; Putri, A.C.; Ningtyas, D.A. Implementation of lean construction and critical chain project management (CCPM) for waste management and work estimation on the Ciawi dam construction project. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *794*, 012074. [[CrossRef](#)]
33. Ahmed, S.; Hossain, M.M.; Haq, I. Implementation of lean construction in the construction industry in Bangladesh: Awareness, benefits and challenges. *Int. J. Build. Pathol. Adapt.* **2021**, *39*, 368–406. [[CrossRef](#)]
34. Radhika, R.; Sukumar, S. An overview of the concept of lean construction and the barriers in its implementation. *Int. J. Eng. Technol. Manag. Res.* **2017**, *4*, 13–26.
35. Yu, H.; Tweed, T.; Al-Hussein, M.; Nasser, R. Development of lean model for house construction using value stream mapping. *J. Constr. Eng. Manag.* **2009**, *135*, 782–790. [[CrossRef](#)]
36. Ramani, P.V.; KSD, L.K. Application of lean in construction using value stream mapping. *Eng. Constr. Archit. Manag.* **2021**, *28*, 216–228. [[CrossRef](#)]
37. Gunduz, M.; Naser, A. Value stream mapping as a lean tool for construction projects. *Int. J. Struct. Civ. Eng. Res. Issue* **2019**, *8*, 69–78. [[CrossRef](#)]
38. Vilventhan, A.; Ram, V.G.; Sugumaran, S. Value stream mapping for identification and assessment of material waste in construction: A case study. *Waste Manag. Res.* **2019**, *37*, 815–825. [[CrossRef](#)]
39. Pasqualini, F.; Zawislak, P.A. Value stream mapping in construction: A case study in a Brazilian construction company. In Proceedings of the 13th International Group for Lean Construction Conference, Sydney, Australia, 19–21 July 2005; International Group on Lean Construction: Sydney, Australia, 2005; pp. 117–125.
40. Gunduz, M.; Fahmi Naser, A. Cost based Value Stream Mapping as a sustainable construction tool for underground pipeline construction projects. *Sustainability* **2017**, *9*, 2184. [[CrossRef](#)]
41. Banawi, A.; Bilec, M.M. A framework to improve construction processes: Integrating Lean, Green and Six Sigma. *Int. J. Constr. Manag.* **2014**, *14*, 45–55. [[CrossRef](#)]
42. Al-Aomar, R. A lean construction framework with Six Sigma rating. *Int. J. Lean Six Sigma* **2012**, *3*, 299–314. [[CrossRef](#)]
43. Beary, T.M.; Abdelhamid, T.S. Production planning process in residential construction using lean construction and six sigma principles. In Proceedings of the Construction Research Congress 2005: Broadening Perspectives, San Diego, CA, USA, 5–7 April 2005; pp. 1–10.
44. van den Bos, A.; Kemper, B.; de Waal, V. A study on how to improve the throughput time of Lean Six Sigma projects in a construction company. *Int. J. Lean Six Sigma* **2014**, *5*, 212–226. [[CrossRef](#)]
45. Demirkesen, S.; Sadikoglu, E.; Jayamanne, E. Investigating effectiveness of time studies in lean construction projects: Case of Transbay Block 8. *Prod. Plan. Control* **2022**, *33*, 1283–1303. [[CrossRef](#)]
46. Wang, Y.; Thangasamy, V.K.; Tiong, R.L.; Zhang, L. Improved Workflow for Precast Element Design Based on BIM and Lean Construction. *J. Constr. Eng. Manag.* **2022**, *148*, 04022065. [[CrossRef](#)]
47. Laika, M.; Heravi, G.; Rostami, M.; Ahmadi, S. Improving the Performance of Precast Concrete Production Processes by Simultaneous Implementation of Lean Techniques and Root Cause Analysis. *Iran. J. Sci. Technol. Trans. Civ. Eng.* **2022**, *46*, 2649–2666. [[CrossRef](#)]
48. Enshassi, A.; Saleh, N.; Mohamed, S. Application level of lean construction techniques in reducing accidents in construction projects. *J. Financ. Manag. Prop. Constr.* **2019**, *24*, 274–293. [[CrossRef](#)]
49. Doggett, A.M. Root cause analysis: A framework for tool selection. *Qual. Manag. J.* **2005**, *12*, 34–45. [[CrossRef](#)]
50. Locatelli, G.; Mancini, M.; Gastaldo, G.; Mazza, F. Improving projects performance with lean construction: State of the art, applicability and impacts. *Organ. Technol. Manag. Constr. Int. J.* **2013**, *5*, 775–783. [[CrossRef](#)]
51. Widjajanto, S.; Purba, H.H.; Jaqin, S.C. Novel POKA-YOKE approaching toward industry-4.0: A literature review. *Oper. Res. Eng. Sci. Theory Appl.* **2020**, *3*, 65–83. [[CrossRef](#)]
52. Bajjou, M.S.; Chafi, A.; En-Nadi, A. The potential effectiveness of lean construction tools in promoting safety on construction sites. *Int. J. Eng. Res. Afr.* **2017**, *33*, 179–193. [[CrossRef](#)]
53. Ikuma, L.H.; Nahmens, I.; James, J. Use of safety and lean integrated kaizen to improve performance in modular homebuilding. *J. Constr. Eng. Manag.* **2011**, *137*, 551–560. [[CrossRef](#)]
54. Vivan, A.L.; Ortiz, F.A.; Paliari, J.C. Model for kaizen project development for the construction industry. *Gestão Produção* **2016**, *23*, 333–349. [[CrossRef](#)]
55. Nahmens, I.; Ikuma, L.H. Effects of lean construction on sustainability of modular homebuilding. *J. Archit. Eng.* **2012**, *18*, 155–163. [[CrossRef](#)]

56. Shang, G.; Sui Pheng, L. Understanding the application of Kaizen methods in construction firms in China. *J. Technol. Manag. China* **2013**, *8*, 18–33. [[CrossRef](#)]
57. Omotayo, T.; Awuzie, B.; Egbelakin, T.; Obi, L.; Ogunnusi, M. AHP-systems thinking analyses for Kaizen costing implementation in the construction industry. *Buildings* **2020**, *10*, 230. [[CrossRef](#)]
58. Heigermoser, D.; de Soto, B.G.; Abbott, E.L.; Chua, D.K. BIM-based Last Planner System tool for improving construction project management. *Autom. Constr.* **2019**, *104*, 246–254. [[CrossRef](#)]
59. AlSehaimi, A.O.; Tzortzopoulos Fazenda, P.; Koskela, L. Improving construction management practice with the Last Planner System: A case study. *Eng. Constr. Archit. Manag.* **2014**, *21*, 51–64. [[CrossRef](#)]
60. Kim, Y.W.; Han, S.H. Implementing Lean Six Sigma: A case study in concrete panel production. In Proceedings of the 20th Annual Conference of the International Group for Lean Construction, San Diego, CA, USA, 18–20 July 2012; pp. 18–20.
61. Uddin, M.M. Lean construction quality assurance opportunities in highway construction. In Proceedings of the 28th Annual Conference of the International Group for Lean Construction, Berkeley, CA, USA, 6–12 July 2020.
62. Nowotarski, P.; Paslawski, J.; Matyja, J. Improving construction processes using lean management methodologies—Cost case study. *Procedia Eng.* **2016**, *161*, 1037–1042. [[CrossRef](#)]
63. Dave, B.; Kubler, S.; Främling, K.; Koskela, L. Opportunities for enhanced lean construction management using Internet of Things standards. *Autom. Constr.* **2016**, *61*, 86–97. [[CrossRef](#)]
64. Drevland, F.; Tillmann, P.A. Value for whom? In Proceedings of the 26th Annual Conference of the International Group for Lean Construction, Chennai, India, 16–22 July 2018; pp. 261–270.
65. Xu, G.; Li, M.; Chen, C.H.; Wei, Y. Cloud asset-enabled integrated IoT platform for lean prefabricated construction. *Autom. Constr.* **2018**, *93*, 123–134. [[CrossRef](#)]
66. Kahvandi, Z.; Saghatforoush, E.; Ravasan, A.Z.; Mansouri, T. An FCM-based dynamic modeling of integrated project delivery implementation challenges in construction projects. *Lean Constr. J* **2018**, *87*, 6.
67. Ding, Y.; Huang, Y.; Li, Y. Energy Efficiency in Buildings: A Review of Sustainable Management Practices in Construction. *J. Clean. Prod.* **2020**, *257*, 120501.
68. Du, J.; Li, R. Sustainable Management Practices for Construction Waste Reduction in China. *Sustainability* **2021**, *13*, 3177.
69. Araujo, A.G.; Carneiro, A.M.; Palha, R.P. Sustainable construction management: A systematic review of the literature with meta-analysis. *J. Clean. Prod.* **2020**, *256*, 120350. [[CrossRef](#)]
70. Matar, M.M.; Georgy, M.E.; Ibrahim, M.E. Sustainable construction management: Introduction of the operational context space (OCS). *Constr. Manag. Econ.* **2008**, *26*, 261–275. [[CrossRef](#)]
71. Butera, S.; Christensen, T.H.; Astrup, T.F. Life cycle assessment of construction and demolition waste management. *Waste Manag.* **2015**, *44*, 196–205. [[CrossRef](#)] [[PubMed](#)]
72. Bakker, H.; Koenders, M.; Boons, F. Creating Value through Alliance Contracting: Lessons from Sydney Water’s Infrastructure Program. *J. Constr. Eng. Manag.* **2011**, *137*, 1113–1122.
73. Hinze, J.W.; Thurman, P.W.; Weigel, D.R. Construction management at risk (CMAR): Lessons learned. *J. Constr. Eng. Manag.* **2011**, *137*, 224–232.
74. Laan, A.; Voordijk, H.; Dewulf, G. Reducing opportunistic behaviour through a project alliance. *Int. J. Manag. Proj. Bus.* **2011**, *4*, 660–679. [[CrossRef](#)]
75. Davis, P.; Love, P. Alliance contracting: Adding value through relationship development. *Eng. Constr. Archit. Manag.* **2011**, *18*, 444–461. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.