Gestión en el Tercer Milenio
Vol. 27 - N.º 54 - 2024, pp. 61 - 86
https://doi.org/10.15381/gtm.v27i54.27640

Online ISSN: 1728-2969
Print ISSN: 1560-9081
Facultad de Ciencias Administrativas UNMSM

Original Article

Lean Construction and its Impact on the Productivity of Puno Private Civil Construction Companies

Julimar Ximena Aguilar Quenta

julimar.aguilar@gmail.com

ORCID: https://orcid.org/0009-0002-2136-9272

Universidad Nacional del Altiplano, Facultad de Ciencias Administrativas y Humanas, Puno, Perú

ABSTRACT

In the aftermath of the COVID-19 health crisis, the Peruvian government's policy of stimulating economic revitalization led to strong investment in the construction sector, particularly in the city of Puno. However, the demand for construction projects challenged many companies to adopt new strategies and methodologies. In this context, the purpose of this study was to determine the extent to which the Lean Construction method affects the productivity of Puno private civil construction companies. To this end, a quantitative approach methodology was used, at a descriptive-correlational level, with a non-experimental cross-sectional design, using a validated questionnaire that was applied to five representatives of 16 authorized Puno private civil construction companies. The results indicated a strong positive correlation of 0.912 between the variables, as well as in the dimensions of the Transformation, Flow, and Value (TFV) model. Finally, it was concluded that the Lean Construction method has a significant impact on the productivity of Puno private civil construction companies. However, despite the obvious correlation between the variables, companies showed a limited adoption of this methodology, which was reflected in the occasional adoption of these practices, and this was evidenced in the fluctuating productivity rates, which suggests a significant challenge in taking full advantage of the benefits that Lean can offer to the construction sector.

Keywords: lean construction; productivity; construction; transformation theory; flow; Value (TFV).

Submitted: 03/25/2024 - Accepted: 08/21/2024 - Published: 12/30/2024

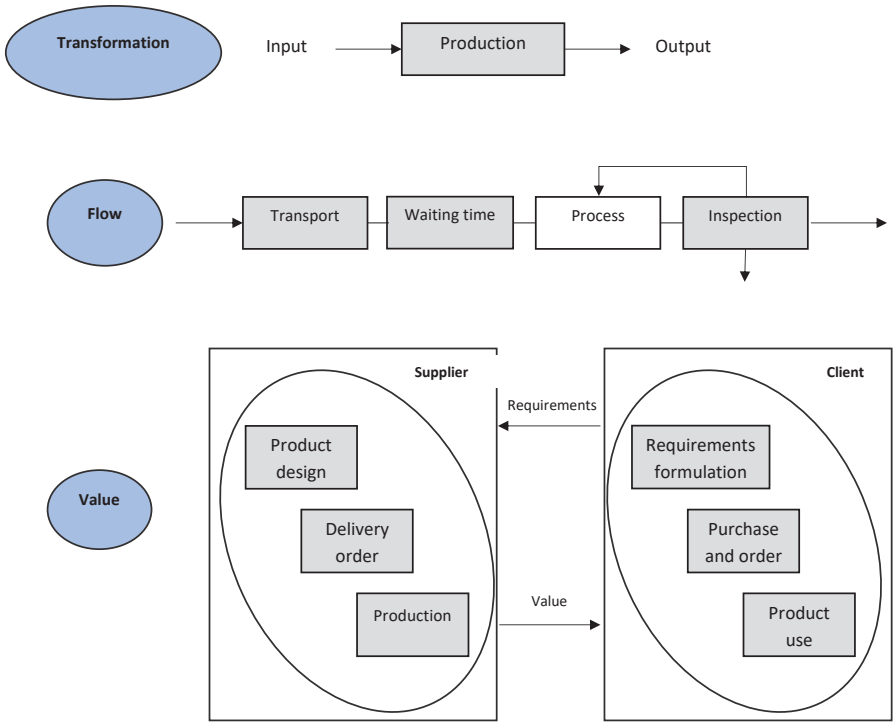
INTRODUCTION

The construction industry is one of the most important and omnipresent worldwide; it is constantly evolving and searching for more efficient and sustainable methods to carry out projects (Blandín, 2023; Pérez *et al.,* 2019). In this context, Lean Construction is proving to be a revolution in the traditional paradigms of construction (Li *et al.,* 2019a; Singh & Kumar, 2020).

Lean Construction is a philosophy that arises from the beneficial effects of the lean manufacturing principles established by the Toyota Production System (TPS) in the manufacturing industry (Karatas & Budak, 2023; Koskela *et al.,* 2019; Saieg *et al.,* 2018). However, the term was first coined in the early 1990s by Professor Lauri Koskela (Koskela, 1992, 2000); this was due to the demands of the construction industry, as there was a need to optimize competitiveness, reduce waste, seek continuous improvement and optimization of processes to maximize value and efficiency (Ghosh & Burghart, 2021). Traditionally, the production model in construction has been conceived as a series of transformation activities (transformation of inputs), ignoring activities that do not add value (waiting, reprocessing, etc.) and are not present in traditional planning and control models (Avelar *et al.*, 2019; Igwe *et al.*, 2022; Martínez *et al.*, 2019).

In this context, Professor Koskela proposed the TFV production model as the basis of the Lean Construction System, which aims to eliminate all types of waste in the production process, thus improving the efficiency and effectiveness of the production system (Botero, 2021; Meng, 2019). The TFV model is shown in Figure 1. The first is the transformation model, which focuses on transforming inputs (materials, labor and machinery) into outputs through well-defined and sequential processes;

Figure 1
TFV model



Note. The transformation model facilitates controlling and improving production processes in a simpler way, while the flow model seeks to optimize efficiency by minimizing interruptions, waste and waiting time, and achieving better synchronization of activities. The value perspective, on the other hand, focuses on ensuring that production activities generate value for the customer, aligning project objectives with customer expectations and ensuring that each operation contributes effectively to the final result. Adapted from Koskela, 2000.

the second is the flow model, which focuses on the efficiency of the process, minimizing interruptions and eliminating waste; and the third is the value model, which focuses on creating products and services that meet customer expectations and needs. (Schonberger, 2019). By applying this production system correctly, companies can significantly improve the quality, deadlines, and costs of their projects (Ahmed & Sobuz, 2019; Albalkhy and Sweis, 2021; Carvajal *et al.,* 2019).

Table 1 shows a summary of the Lean production model, based on its principles, methodology and practical applications.

However, although this methodology has been in use and updated for decades, it has only been widely developed and successfully applied in developed countries. In Latin American countries, it has faced several challenges, such as resistance to change due to an organizational culture rooted in traditional methods and a lack of knowledge and training in Lean principles (Enshassi *et al.,* 2021). Furthermore, poor communication and collaboration between project stakeholders, coupled with hierarchical and rigid organizational structures, hinder the effective adoption of these innovative practices (De Sousa & Muller, 2022).

In 2020, after the COVID-19 pandemic crisis, the construction sector in Peru decreased significantly due to the stoppage of construction projects and the decline in demand for real estate (Aguilar & Vértiz, 2023). In addition, confinement measures, lack of availability of materials, low labor capacity and disruptions in the global supply chain affected project implementation, leading to a general contraction in the sector (Delgado & Grados, 2022).

However, in 2021, the Peruvian government promoted economic reactivation; and taking advantage of such policies, numerous companies and the general population of the city of Puno decided to invest their resources in the construction or remodeling of their establishments and homes. This phenomenon generated a significant demand for companies, materials, and labor for civil construction, thus boosting the sector's economic activity.

However, in response to this demand, many private civil construction companies emerged, but only a few had the proper legal authorization, the capacity and resources necessary to handle the various construction projects. In addition, there were delays in delivery, variations in budgets, and a decline in the quality of work, which led to discontent and dissatisfaction among many of Puno's citizens.

This was a recurring problem as the complexity and demands of projects compared to the requirements of clients, users or investors meant that traditional project delivery models were limited in the face of the need for value creation, effective communication, efficiency, and productivity (Bhamu & Singh, 2014).

In this context, reducing costs and eliminating unproductive losses is the basis for the

Table 1
Lean Production Model

Design Features	Transformation	Flow	Value Generation
Conceptualization	Transformation of input data: information and requirements in product design.	Flow of information parallel to transformations affected by movements, waiting time, and reprocessing.	Value is added from the client's requirements in the design.
Principles	Hierarchical decomposition.	Elimination of losses, time reduction and uncertainty in the design.	Rigorous and systematic analysis and requirements optimization.
Methods and practices	Work breakdown structures, critical path method and organizational chart.	Structured design matrix, integration tools, and teamwork.	Value engineering and quality function deployment.
Practical contribution	Considerations to ensure that everything is "done right"	Considerations to minimize the unnecessary as far as possible.	Considerations for the client's requirements to be included in the design.

Note. Adapted from Koskela, 2000.

survival and success of a company in a turbulent situation, which are principles of the Lean Construction philosophy (Herrera *et al.,* 2021; Rashidian *et al.,* 2023; Uvarova *et al.,* 2023).

A construction company adopting this methodology could reap significant benefits, as reduced waste leads to more efficient management of resources, while improved flow allows projects to be delivered faster and more efficiently; at the same time, quality would be improved by focusing on valuable activities, thereby increasing customer satisfaction. This, in turn, would make the company more competitive and enable it to adapt quickly to changes in the market, thereby promoting its long-term sustainability.

However, the application and impact of this methodology on the productivity of private construction companies in the city of Puno was unknown. With this in mind, the following research objective was proposed: determine the extent to which the Lean Construction method affects the productivity of private construction companies in the city of Puno.

The specific objectives were as follows:

- To determine the extent to which the transformation model of the Lean Construction method impacts the productivity of Puno private civil construction companies.
- To determine the extent to which the flow model of the Lean Construction method impacts the productivity of Puno private civil construction companies.
- To determine the extent to which the value generation model of the Lean Construction method impacts the productivity of Puno private civil construction companies.

To this end, a bibliographic review was conducted, considering the following background:

Aristizábal *et al.* (2022) addressed the lack of focus on sustainability during the construction phase of buildings, proposing Lean Construction as a solution. However, they found that there was a limited understanding of the methodology, which hindered its implementation. Their research revealed a conceptual lack of knowledge about the benefits of Lean Construction in reducing environmental damage.

Evans *et al.* (2021) investigated Critical Success Factors (CSFs) that enhance the integration between Building Information Modelling (BIM) and Lean Construction (LC) practices in mega construction projects. To do so, they used a Delphi survey with 16 experts, analyzing their responses with statistical techniques. 30 critical factors were identified, the most important being "collaboration in design, construction and engineering management". Other key factors focused on people, data, and technology. The results are valuable for those implementing these practices in megaprojects, such as organizations, contractors, engineers and local authorities.

Xing *et al.* (2021) presented a case of Suzhou, where it was shown that the implementation of Lean practices, such as the Last Planner system, Kanban, Just-In-Time, Quality and Safety Management, and Continuous Improvement improved project performance. They did so by interviewing stakeholders and surveying global Lean experts. They found that these practices reduced lead times and defects, and improved workflow, productivity and project quality. However, they identified a lack of stakeholder trust and skills as the biggest challenges.

Aslam *et al.* (2020) highlighted that despite the innovation that Lean Construction represents in the management of construction projects for sustainability, companies face difficulties in achieving initial success. To address this, they proposed the provision of Lean tools to achieve immediate results from the start of a project through a questionnaire and systematic literature review. The results underlined the need for a clear approach and commitment from all stakeholders, as well as the appropriate selection of tools compatible with construction processes.

Bajjou and Chafi (2020) investigated critical waste factors in construction projects through literature review, expert interviews, and a structured questionnaire answered by

330 participants in Morocco. Key factors identified included delays in starting activities, rework, failure to harness the creativity of staff, lengthy approval processes and waiting for work to be completed. The analysis highlighted inefficient site management, poor planning, inadequate communication, rework, and quality issues as underlying factors.

Carvajal *et al.* (2019) highlighted the growing interest of construction professionals in sustainability and the use of Lean Construction towards improving process efficiency. After analyzing 171 papers, they concluded that Lean Construction and sustainable construction are closely related, sharing goals such as reducing waste and increasing productivity.

Li *et al.* (2019b) argued that Lean Construction techniques could reduce waste and increase profits in construction. They assessed the maturity of five Lean tools and found that Total Quality Management (TQM) was the most developed in performance. They concluded that their study provided guidance for companies to select the best Lean tools for their projects.

Moaveni *et al.* (2019) reviewed the Lean Construction theory from a safety perspective and proposed a hybrid model that integrated safety as a critical factor for project success. The methodology included categorizing the challenges identified in previous research and introducing concepts related to efficient project delivery. The principles of the lean construction framework were explained and the changes needed to incorporate safety into the framework were discussed. The results showed a model that revised the TFV approach to emphasize safety in construction projects. This conceptual model was proposed to improve the safety situation in projects and to optimize safety costs and waste elimination.

Salem *et al.* (2005) assessed the effectiveness of Lean Construction tools in medium-sized construction companies. Their field study evaluated tools such as Last Planner, visualization, daily meetings, first-run studies, 5S process, and safeguards against quality failures. Data collection included direct observations, interviews, questionnaires, and document analysis. The results showed the benefits of using these tools but highlighted the need to train workers towards improving effectiveness.

Pillo (2021) argued that the application of Lean Construction improved the efficiency of building real estate projects, reducing wasted time and costs. He concluded that this methodology optimized the use of resources and increased profitability, without compromising quality, highlighting the importance of a favorable work environment for all those involved.

Gómez and Morales (2016) investigated productivity in housing construction in Bogotá, with the aim of reducing losses in the construction process. They used field sampling and surveys to identify factors such as material waiting time and working conditions that affected productivity. They concluded that lack of planning and job dissatisfaction were common problems. Digital simulation helped to suggest improvements and provide an accurate view before implementation, reducing uncertainty and additional costs.

Latorre *et al.* (2019) proposed a model towards improving efficiency in drafting construction projects by combining Lean Construction and BIM. They compared productivity in construction with other sectors and proposed this model after a literature review and their own research. They evaluated the model in six case studies, showing significant improvements in productivity and quality. However, they acknowledge that the model can still be improved and highlight the future challenge of adapting it to more collaborative project development methods.

Botero and Alvarez (2004) conducted an initial test in 2002 on 17 construction sites of 9 construction companies in Medellin and launched a construction management improvement program based on Lean Construction in 2003. They developed a guide to improving productivity in housing projects with the aim of increasing the competitiveness of the sector. The results showed that lean approaches contributed to optimizing productivity, but that specific conditions, such as the commitment of senior management and the active participation of workers, were needed to achieve positive results.

METHODS

The study had an applied methodology with a quantitative approach, which is supported by Hernández and Mendoza (2018), who mention that this approach is appropriate when seeking to calculate magnitudes or frequencies of phenomena. In addition, it has a descriptive-correlational level and a non-experimental design since there was no intentional intervention in the variables. In terms of the temporal dimension, or the number of moments or points in time in which the data were collected, the research is transversal, as the data were collected at a single moment in time.

The total number of respondents was 80. Using a purposive non-probability sampling method, five representatives (architect, civil engineer, safety engineer, administrator, site resident) were selected from the 16 construction companies duly formalized in the Puno National Superintendence of Customs and Tax Administration (SUNAT), during 2021. The period under study was the post-pandemic phase, and at that time many construction companies were created to take advantage of the economic reactivation policies; however, this was a relevant limitation, since only formal companies were considered, excluding those that did not have this characteristic, thus reducing the research population and limiting the results to this context.

To this end, a questionnaire consisting of 27 items for each study variable was designed and validated by expert judgment of two master's degree holders from the Universidad Nacional Mayor de San Marcos. The reliability of the instrument was measured using Cronbach's Alpha.

Subsequently, due to the amount of data, the Smirnov Kolmogorov normality test was conducted, where it was determined that the data did not come from a normal distribution. Therefore, the nonparametric Spearman's Rho test was used.

RESULTS

Reliability Analysis

Table 2 shows the reliability analysis carried out using the SPSS software, with the following results for each variable, showing good reliability for each instrument:

Table 2
Instrument Reliability

Variable	Cronbach's alpha	Number of Items
Lean Construction	0.933	27
Productivity	0.896	27

Note. Prepared by the author, 2024.

Descriptive Statistical Analysis

Similarly, Table 3 shows the descriptive statistics using the SPPS software, noting that due to the Likert-type scaling, data were only recorded in 3 levels of the scale.

On the one hand, 47.5% of respondents sometimes apply the Lean Construction method, while 46.3% said they almost always apply it, and only 6.3% said they always apply it. This shows that the methodology is not entirely predominant in Puno civil construction companies.

Table 3
Frequencies and Percentages of the Study Variables and Dimensions

Likert scale	Lean Construction		Productivity		Transformation Model		Flow Model		Value Generation Model	
	F	%	F	%	F	%	F	%	F	%
Sometimes	38	47.5%	30	37.5%	39	49%	39	49%	41	51%
Almost always	37	46.3%	45	56.3%	34	43%	32	40%	31	39%
Always	5	6.3%	5	6.3%	7	9%	9	11%	8	10%
Total	**80**	**100%**	**80**	**100%**	**80**	**100%**	**80**	**100%**	**80**	**100%**

Note. Prepared by the author, 2024.

On the other hand, 37.5% of respondents said that they sometimes have optimal productivity in their company's construction projects, while 56.5% said that they almost always have good productivity and only 6.3% said that there is always productivity in their company. These results make it clear that productivity in Puno civil construction companies is not constant.

These results show that the Lean Construction method has not been uniformly integrated into companies. Although a significant group of respondents mention that they apply it occasionally or frequently, very few do so consistently. This could reflect challenges such as lack of training, resistance to change, or resource limitations, which prevent a full and effective implementation of the methodology. The consistent low adoption of Lean Construction suggests that companies have not yet fully internalized the benefits that this methodology can offer, which could be limiting its potential for improvement.

In terms of productivity, the responses indicate a lack of consistency in its optimization within the sector. While some companies manage to maintain high productivity on certain occasions, few achieve this continuously. This variability could be related to the irregular application of methodologies such as Lean Construction, as well as other factors such as resource planning and management. The instability of productivity suggests the need for greater standardization of processes and possibly a change in organizational culture to achieve more sustainable performance.

In terms of dimensions, 49% of respondents said they only sometimes apply the transformation model, 43% said they almost always apply it, and only 9% said they always apply the model. This shows that the model is not used continuously to improve the production processes of each construction project in companies.

While 49% of respondents say they sometimes apply the principles of the flow model, 40% said they almost always apply it, and only 11% say they apply the model. This shows that the flow model did not help to reduce losses optimally in the production processes of each construction project of companies in the city of Puno.

Finally, 51% stated that they only sometimes applied the value generation model, 39% stated that they almost always applied it, and only 10% stated that they always applied this model, which reflects that the model is not frequently used to provide higher quality to each construction project of the companies.

Such figures reveal an inconsistent application of transformation, flow and value generation models in Puno's construction companies, suggesting that these approaches have not been fully integrated into their daily practices. This reflects a missed opportunity to improve production processes, reduce losses and increase project quality. The lack of continuous and effective use of these models indicates the need for further training, adaptation to local realities and a stronger commitment by companies to take advantage of the advantages that these models can offer.

Inferential Analysis

Smirnov's normality test performed Kolmogorov and verifying that the data did not come from a normal distribution, the general hypothesis test and specific hypotheses were conducted.

Considering the decision rule:

- Sig. < 0.05, Ha is accepted, and Ho is rejected.
- Sig. >= 0.05, Ha is rejected, and Ho is accepted.

From Table 4 the following results were interpreted:

The Spearman's Rho correlation coefficient result of the general hypothesis was 0.912, which indicated that there is a perfect positive correlation between the variables, with the two-tailed significance level (Sig. = 0.000 < 0.05). In this context, the null hypothesis is rejected, and the alternate hypothesis is accepted; it is concluded that the Lean Construction method impacts the productivity of Puno private civil construction companies.

The Spearman's Rho correlation coefficient result of specific hypothesis 1 was 0.791, which indicated that there is a very strong positive correlation between the Transformation Model dimension and the Productivity variable, with the two-tailed significance level (Sig. = 0.000 < 0.05). In this context, the null hypothesis is rejected, and the alternate hypothesis is accepted, thus concluding that the transformation model of the Lean Construction method impacts the productivity of Puno private civil construction companies.

The Spearman's Rho correlation coefficient result of specific hypothesis 2 was 0.855, which indicated that there is a very strong positive correlation between the Flow Model dimension and the Productivity variable, with the two-tailed significance level (Sig. = 0.000 < 0.05). In this context, the null hypothesis is rejected, and the alternate hypothesis is accepted, thus concluding that the flow model of the Lean Construction method impacts the productivity of Puno private civil construction companies.

The Spearman's Rho correlation coefficient result of specific hypothesis 3 was 0.800, which indicated that there is a very strong positive correlation between the Value Generation Model dimension and the Productivity variable, with the two-tailed significance level (Sig. = 0.000 < 0.05). In this context, the null hypothesis is rejected, and the alternate hypothesis is accepted, thus concluding that the Lean Construction Value Generation Model method impacts the productivity of Puno private civil construction companies.

In summary, the very strong correlations observed in the specific dimensions of the transformation, flow and value models indicate that these components are essential to improve operational efficiency, reduce waste and maximize the value generated in construction projects. These results reinforce the idea that the rigorous adoption of Lean Construction can be a determining factor in the continuous improvement and success of companies in the sector.

DISCUSSION

The results support the idea that Lean Construction positively impacts the overall productivity of companies. This conclusion is in line with the claims of Pillo (2021), who found that the application of Lean Construction led to increased efficiency and profitability in construction projects, suggesting that the methodology can not only reduce time and cost waste, but can also increase overall productivity.

Furthermore, the specific results of the correlations between the different dimensions of Lean Construction (Transformation Model, Flow Model and Value Generation Model) and

Table 4
Correlation between the Lean Construction Variable and the TFV Production Model with the Productivity Variable

		Productivity
Lean Construction	Spearman's Rho correlation coefficient	.912**
	Next (two-tailed)	0
	N	80
Transformation Model	Spearman's Rho correlation coefficient	.791**
	Next (two-tailed)	0
	N	80
Flow Model	Spearman's Rho correlation coefficient	.855**
	Next (two-tailed)	0
	N	80
Modelo de Generación de Valor	Coeficiente de correlación Rho de Spearman	.800**
	Sig. (bilateral)	0
	N	80

Note. Prepared by the author, 2024.

productivity reinforce the idea that each aspect of this methodology contributes significantly to improving operational results. This is in line with the findings of Latorre *et al.* (2019), who proposed a model that combined Lean Construction and BIM to improve efficiency in drafting construction projects, demonstrating significant improvements in productivity and quality.

However, despite these positive results, it is important to recognize the challenges and barriers of this methodology such as lack of standardization, insufficient knowledge, minimal control of the entire value stream, and limited vision Tezel *et al.* (2016). Previous studies such as those by Aristizábal *et al.* (2022) and Aslam *et al.* (2020) also highlighted this limited understanding and the difficulties in achieving initial success in implementing Lean Construction, emphasizing the need for a clear approach, commitment from all stakeholders and an appropriate choice of tools that are compatible with construction processes.

Furthermore, Salem *et al.* (2005) found benefits in the use of Lean tools in construction companies, but emphasized the need for training to improve effectiveness, suggesting that the long-term success of Lean Construction may depend largely on preparation and skills development of the teams involved.

In summary, the results provide compelling evidence that Lean Construction has a positive impact on the productivity of Puno's construction companies. However, many companies still struggle to achieve successful and sustainable Lean implementation. Existing research suggests that both organizational and technical barriers are critical, such as lack of management support and commitment, poor employee involvement, unwillingness to change the existing culture, lack of management commitment, the fragmented and cyclical nature of the construction project, and poor communication between all project stakeholders (Ahmed *et al.*, 2020; Albalkhy & Sweis, 2021; Lodgaard *et al.*, 2016). Therefore, continued engagement of all stakeholders and careful selection of tools and approaches that align with specific construction processes will be required.

CONCLUSIONS

The results showed a clear correlation between the study variables, but it should be noted that the companies have a limited adoption of this methodology, as evidenced by the descriptive statistics. Lean construction is not the predominant method in these companies, but its implementation is sporadic, which is reflected in variable productivity rates. This finding points to a significant challenge in fully optimizing the benefits that Lean can bring to the construction sector. The reasons for this underutilization could be many and varied, ranging from organizational barriers to training deficiencies or simply a lack of knowledge. It is also plausible that economic factors and resource availability influence the reluctance to adopt more effective practices. Companies that do not consistently apply Lean Construction run the risk of remaining less competitive and missing out on optimization opportunities, so it is recommended that they implement ongoing training programs in this methodology, focusing on overcoming organizational barriers and improving resource.

With regard to the Lean Construction Transformation Model, it was found to have a significant impact on the productivity of private construction companies in Puno. However, according to the descriptive statistics, these results suggest that most companies in this sector have significant rates of resource waste, less efficient workflow management, a possible decrease in the quality of work and less competitiveness in the market. Likewise, they could face difficulties in meeting deadlines, higher production costs and a greater risk of customer dissatisfaction. In summary, the lack of application of the transformation principle can have a significant impact on the efficiency, productivity, and profitability of construction companies in the city of Puno. The lack of application of the transformation principle negatively affects the efficiency, productivity and profitability of construction companies in Puno; therefore, it is recommended that companies conduct regular audits of their construction processes to identify areas for improvement in resource management and commit to applying the transformation principle in a comprehensive manner to reduce waste and improve quality.

As for the Flow Model of the Lean Construction method, it was concluded that there is a significant impact on the productivity of Puno private civil construction companies. However, the descriptive part showed that the flow model is not fully implemented, which could lead to interruptions, unproductive activities, and bottlenecks in the execution of projects, resulting in delays and cost increases. In addition, inefficiencies in the use of resources and longer execution times could affect the profitability of each project, ultimately reducing the overall productivity of construction companies. Incomplete implementation of the flow model can lead to greater inefficiencies and increased operating costs; therefore, it is recommended that companies focus on optimizing workflow by implementing specific lean tools, such as process mapping and bottleneck elimination, to ensure a continuous and efficient flow in construction projects.

On the other hand, the Lean Construction Value Generation Model has a significant impact on the productivity of Puno private civil construction companies. Also, according to the descriptive statistics, it is not often used to improve the quality of each construction project, which could mean that the requirements of each client are not adequately considered. This affects not only the final result of the product, but also the productivity and reputation of the company in the construction industry. The lack of focus on value generation affects customer satisfaction, and it is suggested that construction companies implement a customer-centered approach, aligning their processes with the specific values and needs of each project, and promoting a culture of continuous improvement that prioritizes quality and satisfaction.

Finally, the implementation of the Lean Construction method in Puno civil construction companies has a significant impact on their productivity. The absence of a consistent application of this approach is directly reflected in a noticeable decrease in operational efficiency, affecting the ability to deliver projects on time and with optimal quality. The lack of constant adherence to Lean principles leaves a tangible mark on the overall performance of construction operations. In addition, it has been observed that the TFV (Transformation, Flow and Value) production model is often relegated, either due to a lack of knowledge of its potential or due to the absence of an optimal organizational structure for its effective application. This situation highlights the urgent need to promote greater dissemination and understanding of Lean practices in the construction industry in the city of Puno. Full adoption of these methods has the potential to catalyze significant improvements in efficiency, quality, and competitiveness in construction companies in the region and beyond. It is essential to promote an organizational culture that embraces and systematically applies Lean principles, recognizing their ability to radically improve the productivity and execution of construction processes in the Puno region.

Recommendations

For future research, it is advisable to keep abreast of advances in both Lean Construction method and construction productivity. Each year, the International Group for Lean Construction (IGLC) presents innovative and updated approaches to meet the growing demands of the construction industry. These approaches aim not only to optimize processes, but also to reduce times and costs through a greater focus on human capital management, supported by the use of advanced technologies.

In the context of the city of Puno, where numerous construction companies are emerging each year in response to population growth, it is essential that these companies seek to formalize and implement the Lean Construction production system. This must be accompanied by a continuous training program, from the design of a project to its final delivery, which must involve all members of the company, from management to operational staff, in order to optimize the quality and efficiency of the services offered.

It is also proposed that comparative studies be carried out between different regions of Peru where the Lean Construction methodology has been implemented. These studies would make it possible to identify both the strengths and weaknesses of its application, providing a clearer picture and strategic vision to guide the development of the sector in the coming years. Such progress would benefit not

only those directly involved in the industry, but also indirect stakeholders and the population in general, promoting sustainable and efficient growth in the construction sector.

REFERENCES

Aguilar, T., & Veliz, W. (2023). *Análisis de la reactivación del sector construcción en el Perú debido al impacto originado por la pandemia del COVID-19: Caso de dos obras privadas y dos obras estatales.* [Tesis de pregrado, Pontificie Universidad Católica del Perú]. http://hdl.handle.net/20.500.12404/24156

Ahmed, S., & Sobuz, M. (2019). Challenges of implementing Lean Construction in the construction industry in Bangladesh. *Smart and Sustainable Built Environment*, 9(2), 174–207. https://doi.org/10.1108/SASBE-02-2019-0018

Ahmed, S.; Hossain, M., & Haq, I. (2020). Implementation of Lean Construction in the construction industry in Bangladesh: awareness, benefits and challenges. *International Journal of Building Pathology and Adaptation*, 39(2), 368–406. https://doi.org/10.1108/IJBPA-04-2019-0037

Albalkhy, W., & Sweis, R. (2021). Barriers to adopting Lean Construction in the construction industry: a literature review. *International Journal of Lean Six Sigma*, 12(2), 210–236. https://doi.org/10.1108/IJLSS-12-2018-0144

Aristizábal, P.; Vásquez, A., & Botero, L. (2022). Perceptions on the processes of sustainable rating systems and their combined application with Lean construction. *Journal of Building Engineering*, 46, 103627. https://doi.org/10.1016/j.jobe.2021.103627

Aslam, M.; Gao, Z., & Smith, G. (2020). Exploring factors for implementing Lean Construction for rapid initial successes in construction. *Journal of Cleaner Production*, 277, 123295. https://doi.org/10.1016/j.jclepro.2020.123295

Avelar, W.; Meiriño, M., & Tortorella, G. (2019). The practical relationship between continuous flow and Lean Construction in SMEs. *The TQM Journal*, 32(2), 362–380. https://doi.org/10.1108/TQM-05-2019-0129

Bajjou, M., & Chafi, A. (2020). Identifying and Managing Critical Waste Factors for Lean Construction Projects. *Engineering Management Journal*, 32(1), 2–13. https://doi.org/10.1080/10429247.2019.1656479

Bhamu, J., & Singh, K. (2014). Lean manufacturing: literature review and research issues. *International Journal of Operations and Production Management*, *34*(7), 876–940. https://doi.org/10.1108/IJOPM-08-2012-0315

Blandín, F. (2023). La metodología Lean Construction: una revisión sistemática a la bibliografía (2019-2023). *South Florida Journal of Development*, 4(6), 2413–2431. https://doi.org/10.46932/sfjdv4n6-016

Botero, L. (2021). *Principios, herramientas e implementación de Lean Construction*. Editorial EAFIT. https://doi.org/10.17230/9789587207040lr0

Botero, L., & Álvarez, M. (2004). Guía de mejoramiento continuo para la productividad en la construcción de proyectos de vivienda (Lean Construction como estrategia de mejoramiento). *Revista Universidad EAFIT*, 40(136), 50–64. https://publicaciones.eafit.edu.co/index.php/revista-universidad-eafit/article/view/864

Carvajal, D.; Bahamón, S.; Aristizábal, P.; Vásquez, A., & Botero, L. (2019). Relationships between lean and sustainable construction: Positive impacts of lean practices over sustainability during construction phase. *Journal of Cleaner Production*, 234, 1322–1337. https://doi.org/10.1016/j.jclepro.2019.05.216

De Sousa, P., & Muller, B. (2022). Desafios e barreiras do BIM e do Lean na construção civil brasileira. *Revista Pensamento Contemporâneo Em Administração*, 16(3), 181–198. https://doi.org/10.12712/rpca.v16i3.54259

Delgado, M., & Grados, M. (2022). *Aplicación de la metodología Lean Construction en un proyecto de infraestructura educativa para optimizar los rendimientos ante las medidas sanitarias impuestas por COVID-19, Trujillo* [Tesis de pregrado, Universidad Privada Antenor Orrego]. https://hdl.handle.net/20.500.12759/9709

Enshassi, A.; Saleh, N., & Mohamed, S. (2021). Barriers to the application of Lean Construction techniques concerning safety improvement in construction projects. *International Journal of Construction Management*, 21(10), 1044–1060. https://doi.org/10.1080/15623599.2019.1602583

Evans, M.; Farrell, P.; Mashali, A., & Zewein, W. (2021). Critical success factors for adopting building information modelling (BIM) and Lean Construction practices on construction mega-projects: a Delphi survey. *Journal of Engineering, Design and Technology*, 19(2), 537–556. https://doi.org/10.1108/JEDT-04-2020-0146

Ghosh, S., & Burghart, J. (2021). Lean Construction: Experience of US Contractors. *International*

Journal of Construction Education and Research, 17(2), 133–153. https://doi.org/10.1080/15578771.2019.1696902

Gómez, A., & Morales, D. (2016). Análisis de la productividad en la construcción de vivienda basada en rendimientos de mano de obra. *INGE CUC*, 12(1), 21–31. https://doi.org/10.17981/ingecuc.12.1.2016.02

Hernández, R., & Mendoza, C. (2018). *Metodología de la investigación: las rutas: cuantitativa, cualitativa y mixta*. Mc Graw Hill Educación.

Herrera, R.; Mourgues, C.; Alarcón, L., & Pellicer, E. (2021). Comparing Team Interactions in Traditional and BIM-Lean Design Management. *Buildings*, 11(10), 447. https://doi.org/10.3390/buildings11100447

Igwe, C.; Hammad, A., & Nasiri, F. (2022). Influence of Lean Construction wastes on the transformation-flow-value process of construction. *International Journal of Construction Management*, 22(13), 2598–2604. https://doi.org/10.1080/15623599.2020.1812153

Karatas, I., & Budak, A. (2023). Investigating the impact of lean-BIM synergy on labor productivity in the construction execution phase. *Journal of Engineering Research*, 11(4), 322–333. https://doi.org/10.1016/j.jer.2023.10.021

Koskela, L. (1992). *Application of the new production philosophy to construction*. Stanford University.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. VTT Publications.

Koskela, L.; Ferrantelli, A.; Niiranen, J.; Pikas, E., & Dave, B. (2019). Epistemological Explanation of Lean Construction. *Journal of Construction Engineering and Management*, 145(2). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001597

Latorre, A.; Sanz, C., & Sánchez, B. (2019). Aplicación de un modelo Lean-BIM para la mejora de la productividad en redacción de proyectos de edificación. *Informes de la Construcción*, 71(556), 313. https://doi.org/10.3989/ic.67222

Li, L.; Li, Z.; Li, X., & Wu, G. (2019b). A review of global Lean Construction during the past two decades: analysis and visualization. *Engineering, Construction and Architectural Management*, 26(6), 1192–1216. https://doi.org/10.1108/ECAM-03-2018-0133

Li, S.; Fan, M., & Wu, X. (2019a). Lean Construction Techniques and Individual Performance. Proc. 27th Annual Conference of the International Group for Lean Construction (IGLC) , 1469-1478. doi.org/10.24928/2019/0136

Lodgaard, E.; Ingvaldsen, J.; Gamme, I., & Aschehoug, S. (2016). Barriers to Lean Implementation: Perceptions of Top Managers, Middle Managers and Workers. *Procedia CIRP*, 57, 595–600. https://doi.org/10.1016/j.procir.2016.11.103

Martínez, E.; Reid, C., & Tommelein, I. (2019). Lean Construction for affordable housing: a case study in Latin America. *Construction Innovation*, 19(4), 570–593. https://doi.org/10.1108/CI-02-2019-0015

Meng, X. (2019). Lean management in the context of construction supply chains. *International Journal of Production Research*, 57(11), 3784–3798. https://doi.org/10.1080/00207543.2019.1566659

Pérez, G.; Del Toro, H., & López, A. (2019). Mejora en la construcción por medio de Lean Construction y Building information modeling: caso de estudio. *Revista de Investigación en Tecnologías de La Información*, *7*(14), 110–121. https://doi.org/10.36825/RITI.07.14.010

Pillo, D. (2021). *Mejora de la productividad en la construcción de proyectos inmobiliarios en la ciudad de Quito mediante la aplicación de Lean Construction.* [Tesis de maestría, Universidad Central del Ecuador]. http://www.dspace.uce.edu.ec/handle/25000/25927

Rashidian, S.; Drogemuller, R., & Omrani, S. (2023). Building Information Modelling, Integrated Project Delivery, and Lean Construction Maturity Attributes: A Delphi Study. *Buildings*, 13(2), 281. https://doi.org/10.3390/buildings13020281

Saieg, P.; Sotelino, E.; Nascimento, D., & Caiado, R. (2018). Interactions of Building Information Modeling, Lean and Sustainability on the Architectural, Engineering and Construction industry: A systematic review. *Journal of Cleaner Production*, 174, 788–806. https://doi.org/10.1016/j.jclepro.2017.11.030

Salem, O.; Solomon, J.; Genaidy, A., & Luegring, M. (2005). Site Implementation and Assessment of Lean Construction Techniques. *Lean Construction Journal*. 2. https://www.researchgate.net/publication/228676008_Site_implementation_and_assessment_of_lean_construction_techniques/citation/download

Schonberger, R. (2019). The disintegration of lean manufacturing and lean management. *Business Horizons*, 62(3), 359–371. https://doi.org/10.1016/j.bushor.2019.01.004

Singh, S., & Kumar, K. (2020). Review of literature of Lean Construction and lean tools using systematic literature review technique (2008–2018). *Ain Shams Engineering Journal*, *11*(2), 465–471. https://doi.org/10.1016/j.asej.2019.08.012

Tezel, A.; Koskela, L., & Tzortzopoulos, P. (2016). Visual management in production management: A literature synthesis. *Journal of Manufacturing Technology Management*, 27, 766–799. https://doi.org/10.1108/JMTM-08-2015-0071

Uvarova, S.; Orlov, A., & Kankhva, V. (2023). Ensuring Efficient Implementation of Lean Construction Projects Using Building Information Modeling. *Buildings*, 13(3), 770. https://doi.org/10.3390/buildings13030770

Xing, W.; Hao, J., Qian, L.; Tam, V., & Sikora, K. (2021). Implementing Lean Construction techniques and management methods in Chinese projects: A case study in Suzhou, China. *Journal of Cleaner Production*, 286, 124944. https://doi.org/10.1016/j.jclepro.2020.124944

Conflict of Interest

The author has no conflicts of interest to declare.

Author Contribution

Julimar Ximena Aguilar Quenta (lead author): conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, visualization, writing (original draft, review, and editing).