ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 11, Issue, 07, pp. 48386-48392, July, 2021
https://doi.org/10.37118/ijdr.22325.07.2021

RESEARCH ARTICLE OPEN ACCESS

BARRIERS TO IMPLEMENTING LEAN CONSTRUCTION PRACTICES IN THE BRAZILIAN CONSTRUCTION INDUSTRY

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ARTICLE INFO

Article History:
Received 22nd April, 2021
Received in revised form
06th May, 2021
Accepted 08th June, 2021
Published online 25th July, 2021

Key Words:

Barriers, Implementation, Lean Construction, Brazilian Construction Industry.

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ABSTRACT

Objective: Lean construction (LC) is associated with the promotion of benefits to the management of works, reducing waste and increasing the value of the product for the customer. The objectives of this study are to assess the current level of knowledge about Lean practices in construction companies to identify the benefits and potential challenges for the implementation of lean construction in the Brazilian industry. And based on the results of the study propose recommendations. **Design / methodology / approach Design:** The initial literature review aimed to contextualize Lean Construction, its benefits and its main global challenges. Based on similar studies, such as in India by Devaki and Jayanthi, (2014), in Nigeria by Olamilokun (2015), in the Kingdom of Saudi Arabia by Sarhan *et al*. (2017), in Morocco by Bajjou and Chafi (2018), a questionnaire was used for the study of multiple cases. 56 construction companies were evaluated. The results were analyzed statistically by frequency distribution, by weighted average (MIS) to assess the degree of agreement and prioritize them, and by Cronbach's alpha coefficient to measure the reliability of the questionnaire.**The results:** The study reveals that the Lean Construction situation in Brazil is critical. The level of knowledge about Lean Construction is low, and consequently the adoption as well. As in other countries, fluency in traditional practices is the highest barrier, but other critical barriers point to lack of knowledge about lean construction, lack of technical qualification, and difficulties in understanding lean construction concepts at very high levels not found in similar studies. The Study points out universities as a great opportunity to change the LC scenario in the Brazilian industry. **Originality / value:** Brazil is the fifth largest country in the world, the eighth largest economy in the world. Conducting studies on LC in the Brazilian civil construction industry in comparison with similar international studies can reveal gaps and consequently solutions that may be important for the academic community and industry worldwide.

Citation: ***Edson Neves da Silva, MSc, PMP and Luiz Carlos Brasil de Brito Mello, DSc.*** "Barriers to Implementing Lean Construction practices in the Brazilian construction industry*", International Journal of Development Research*, 11, (07), 48386-48392.

INTRODUCTION

The construction industry is inextricably linked to the economic development of any country in the world (Sarhan *et al*., 2017; Tezel *et al*. 2018). In Brazil, the 5th largest country in the world, currently the 8th largest economy in the world, the construction sector has great representativeness among developing countries. Regardless of the negative impacts of the pandemic in Brazil and in the world in 2020, under normal conditions the construction sector has great economic and social prominence due to its great capacity to generate jobs and income.

The Brazilian Chamber of the Construction Industry (CBIC, 2018) reinforces the direct and indirect influence that civil construction has on the government, with more than 12.5 million direct, indirect and informal jobs. The sector's annual revenue exceeds R $ 1.1 trillion, with a quarter going back to the government in the form of taxes.On the other hand, assessments of the efficiency of Brazilian civil construction show that Brazil is deficient in all the important factors for productivity, such as innovation, education, and infrastructure, requiring the adoption of a comprehensive program to increase productivity, with multiple coordinated initiatives. And Lean Construction is cited by these studies as an initiative for the general improvement of the construction industry (CBIC, 2018).

Lean practices originate from Toyota factories, and have gained recognition and acceptance in several sectors over the years, for their sets of techniques and principles that aim to reduce the variability of processes and the pursuit of creating value for customers through the elimination of waste (Shang and Sui Pheng, 2014; Ahmed *et al*. 2019) Since its introduction in civil construction through the work of Koskela 1992, the LC concept has evolved over time, and global collaborations have been widely pursued in all over the world (Li *et al*. 2018).Over the past ten years, studies carried out in different parts of the world such as Europe, Africa and Asia have contributed to the identification of the benefits of LC for civil construction, as well as the main barriers and major challenges for the adoption of LC.

Oakland and Marosszeky (2017), showed in his research that LC is the most effective and applicable method for quality, safety and productivity in the construction industry when compared to any other. Ahmed (2019) highlights the benefits of LC with an emphasis on sustainability, productivity, quality and better waste management. These benefits were also perceived in the United Arab Emirates by Salama and Hana (2010), in Malaysia by Marhani*et al*. (2012), in the United Kingdom by Ogunbiyi*et al*. (2014) and in Saudi Arabia by Sarhan *et al*. (2018).Barriers to LC implementation are similar in several studies. Such barriers point to the main global challenges for the adoption of LC. The research aimed to assess the current level of knowledge about Lean construction practices, to identify the potential benefits and challenges for the implementation of lean construction in the Brazilian industry. And based on the study, recommend guidelines that can favor the advancement of Lean Construction in Brazil.

LITERATURE REVIEW

Lean Construction: The LC was presented as a “break of paradigm” for the construction industry (Koskela, 2000). In other words, it aimed to change the way the construction processes were implemented, giving a new meaning to production methods and practices.For Koskela (1992), the LC is determined by a set of interconnected principles that must be applied in an integrated way in the management of processes to obtain the expected results. These principles are basically: to reduce the participation of activities that do not add value; increase the value of the product considering the needs of the customer; reduce variability; reduce cycle time; simplify, reducing the number of steps or parts; increase production flexibility; increase the transparency of the process; focus on controlling the global process; introduce continuous process improvement; maintain a balance between flow improvements and conversions; and benchmarking.The lean concept has evolved over time. Until 2007 the theory was Transference-Flow-Value, the focus of the research was on productivity, lean production, cost management (Li, 2018). After 2007 Koskela rethought the TFV theory and renamed it Theory of workflow value. He thought "Work" is more focused on integrating resources, incorporating the real and complex internal realization of process theory (Koskela and Rooke, 2007; Li *et al*. 2018).Over the past 10 years, studies carried out in different parts of the world, such as Europe, Africa and Asia, have contributed to the identification of the benefits of LC for civil construction, as well as the main barriers and challenges for its adoption of LC.

RESEARCH METHODOLOGY

The type of research and methodology used in this study is similar in India by Devaki and Jayanthi, (2014), in Nigeria by Olamilokun (2015), in Kingdom of Saudi Arabia through the study by Sarhan *et al*. (2017), in Morocco by Bajjou and Chafi (2018), in Bangladesh by Ahmed *et al*. (2019). The methodology uses a questionnaire for data collection, with a Likert scale at 5 levels (I totally disagree, Partially disagree, Neither disagree nor agree, Agree, Totally Agree) to record the level of agreement or disagreement with a given statement. This method is in line with the quantitative research methodology that allows the statistical test of data derived from varied but significant explanations that increase the understanding of the object of investigation (Abawi, 2008).

The questionnaire has 31 questions, divided into 3 categories such as table III. The questionnaires were sent to 150 construction companies. Data analysis was performed using Frequency and Percentage Distribution summarizing the respondents' basic information (part I), while the items weighted mean (MIS) score was used to analyze the main responses. The MIS, based on equation (I), is the sum of the item scores for each identified barrier for lean construction divided by the number of items that contribute to it (Taffe*et al*., 2008). Given that a five-point Likert scale is used, the current barriers to lean construction are those with an MIS higher than the midpoint (2.5) of the Likert scale used (Johns, 2010).

$$MIS = \frac{5V_5 + 4V_4 + 3V_3 + 2V_2 + V_1}{V_5 + V_4 + V_3 + V_2 + V_1}$$

Equation I

The study sought to assess the reliability of the research instrument through Cronbach's alpha coefficient. Cronbach's alpha coefficient measures the correlation between the responses in a questionnaire based on the variance of the individual items and the variance of the sum of the items of each evaluator using the same measurement scale. It provides internal consistency data for the question in order to demonstrate the reliability of the research by (Leontitsis and Pagge, 2007).

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{k} S_i}{S_t}\right)$$

K: number of items

S_i : variance of each item

S_t : variance of the sum of all items

Equation II

According to application of the methodology, the next item presents and discusses the results.

RESULT AND DISCUSSIONS

General information about respondents: The survey obtained 81 responses, 56 construction companies (37.3%). This response rate was considered adequate in similar surveys. Langar and Pearce (2014), when carrying out similar surveys, also obtained an effective response rate close to 15%. Akintoye (2000) indicates that an acceptable response rate for surveys under construction is between 20% and 30% using snail mail. However, Crawford *et al*., (2001) suggest that this response rate may be lower in cases of surveys using online applications.Given the hierarchical position of respondents (all at coordination and management levels), and the length of experience (over 5 years), the survey assumed that all respondents are aware of the organization or institution they represent.

Table I. The general information about the respondents can be seen in the

Questions	Builders
Position of respondents	- 52% Project Coordinator - 20.6% Engineer - 27.4 Manager
Position time	- 100% over 5 years
Sector (public or private)	- 100 private

Source: Authors (2020)

Response of the assessment of the level of knowledge, adoption and promotion of Lean Construction: Table V presents the result of the Lean Construction assessment regarding the level of knowledge, its benefits, degree of adoption or promotion and the attribution of the interested party with the greatest capacity to contribute to raising the level of LC adoption in the Brazilian industry.

Table II shows the barriers for implementing lean construction encountered by the researchers cited in their studies.

Barrires to Lean Construction implementation	Bashir *et al*. (2015)	Ayarkkwa*et al*. (2012)	Shang and Sui Pheng (2014)	Olamilokun (2015)	Devaki and Jayanthi (2014)	Omran and Abdulrahim (2015)	Sarhan and Fox (2013)	Abdullah *et al*. (2009)
Influency of traditional management practices	x						x	x
Unfavorable organizational culture		x		x	x	x	x	
Lack of technical skills, training and understanding of lean techniques		x			x	x	x	x
Lack of knowledge about lean construction approaches	x	x	x	x	x	x	x	x
Lack of committed leadership from top management		x	x			x		x
Ineffective communication channels between construction teams	x	x				x	x	x
Lack of a robust performance measurement system	x					x	x	x
Lack of technological adaptations				x				x
Difficulties in understanding the concepts of lean construction.	x	x			x		x	
Traditional design approach	x	x		x			x	x
Long period of implementing lean concepts in construction processes	x	x						
Lack of customer and supplier involvement		x						x
End user preference				x				
Additional costs and high inflation rates	x			x			x	
Slow decision-making processes due to complex organizational hierarchy		x	x	x	x			
Inadequate resource management	x	x		x	x			
Lack of clear customer job specifications				x		x	x	x
Lack of performance benchmark offer								
Lack of government support for technological advances						x		
Uncertainty in the production process		x	x	x				x
Use non-standard of components								x
Uncertainty in the supply chain.		x	x	x	x		x	x

Table III. The questionnaire has 31 questions, divided into 3 categories such as

Questionnaire Structure	Question quantity	Goals
Part I - General Respondent Information	3	Evaluate respondents' information regarding position in the company, time in the position, education. The name of the company or institution and the respondent is confidential.
Part II - Assessment of the level of knowledge about the LC	6	Assess the level of knowledge, benefits, adoption and responsibilities
Part III - Assessment of 22 Global Barriers	22	Assess the 22 global barriers to implementing LC in the Brazilian industry

Table IV. Presents the correlation between the result of applying the Cronbach's alpha coefficient equation and the level of reliability

Nº	Cronbach's alpha coefficient	Reliability Level
1	More than 0.90	Excellent
2	0.80- 0.89	Good
3	0.70-0.79	Acceptable
4	0.6-0.69	Questionable
5	0.5-0.59	Poor
6	Less than 0.59	Unacceptable

The first assessments linked to the level of knowledge and adoption of LC reveal the great challenges for the implementation of Lean Construction in Brazil. According to Johns (2010), the higher the MIS, the higher the level of agreement, concern or knowledge about Lean. This criterion was also used by Ayarkkwa*et al* (2012) and Sarham (2017).In Brazil, the knowledge of Lean Construction by construction companies is low (MIS 2.39), and therefore the level of adoption is even lower (MIS .159). When compared to similar studies, such as KSA, Morocco, China, and Bangladesh, all have MIS> 2.5, which demonstrates the need for greater promotion of Lean Construction in Brazil. As for the recognition of Lean benefits, even in a low-knowledge environment, it has a MIS > 2.5 (MIS 3.93), that is, the perception by builders is that LC can contribute positively to the construction sector, although not having deep knowledge. This result when compared with the research in India by Devaki and Jayanthi, (2014), in Nigeria by Olamilokun (2015), in the Kingdom of Saudi Arabia through the study by Sarhan *et al*. (2017), in Morocco by Bajjou and Chafi (2018), in Bangladesh by Ahmed *et al*. (2019) is the lowest among similar studies both in terms of knowledge and in terms of adoption. In other words, developing countries like Brazil are ahead in the knowledge and adoption of LC in their industries.The last three questions in this stage of the research sought to assess, in the perception of construction companies, who has the greatest capacity to contribute to raising the LC in Brazilian civil construction. The result points to universities (MIS of 4.77), followed by construction companies (MIS 3.95) and Class Organizations (MIS 2.88). Thus, from the perspective of construction companies, universities appear as the most responsible for the current situation of the level of LC adoption in Brazil. Assessing the perception of construction companies regarding other interested parties, such as universities and organizations that support professionals and companies (Professional Class Organization), is relevant given the results of research on the subject, which reveal barriers to implementing the LC linked to outside factors. of the construction companies' internal processes, such as government support, supply chain, customers and factors related to the training of professionals through education. This analysis could not be compared with other studies, as similar studies did not address these issues, being original to this research.

The final stage of the assessment consists of evaluating, in the Brazilian scenario, the 22 global barriers to the implementation of Lean Construction. Table VI presents the result of the Brazilian scenario regarding the assessment of the 22 global barriers identified through research by Abdullah *et al*. (2009), Ayarkkwa*et al*. (2012), Sarhan and Fox (2013), Shang and Sui Pheng (2014), Devaki and Jayanthi (2014), Olamilokun (2015) and Omran and Abdulrahim (2015).Based on the survey results, the main factors related to the barrier to the implementation of Lean Construction in the Brazilian industry are: Influency of traditional management practices (MIS 4.80), Lack of knowledge about lean construction (MIS 4.80), Difficulties in understanding the concepts of lean construction (MIS 4,68), Lack of technical skills, training and understanding of lean techniques (MIS,4.66), Traditional design approach (4.61), Lack of committed leadership from top management (MIS 4.41), Unfavorable organizational culture (MIS 4.18).

Traditional practices identified as the first barrier in Brazil are also mentioned in previous similar studies, such as in India by Devaki and Jayanthi, (2014), in Nigeria by Olamilokun (2015), in the Kingdom of Saudi Arabia through the study by Sarhan *et al*. (2017), in Morocco by Bajjou and Chafi (2018), in Bangladesh by Ahmed *et al*. (2019. According to the study by Dulaimi and Tanamas (2001), this unanimity in relation to traditional practices refers to the operators' aversion to changing the traditional approach to construction management. This statement is confirmed in the studies by Abdullah *et al*. 2009; Sarhan and Fox 2013 on the inflexibility of organizations and senior management in adopting lean construction ideas However, unlike other studies, in Brazil Lack of knowledge about lean construction, are barriers to the adoption of LC occupies the first position with Fluency of traditional management practices, are barriers to the adoption of LC. No other study similarly presents and results, which shows that in Brazil the lack of knowledge about LC is critical and actions need to be taken to reverse this situation. Considering the second and third obstacles in Brazil for the adoption of LC, Difficulties in understanding the concepts of lean construction (MIS 4.68), Lack of technical skills, training and understanding of lean techniques (MIS, 4.66), corroborates the understanding that the lack of education about LC in Brazil has been the main responsible

Table V. Response of the assessment of the level of knowledge, adoption and promotion of Lean Construction

	MIS	Rank
Levelofknowledgeabout Lean Construction	2,39	5
Lean Construction is beneficial totheconstructionindustry	3,63	3
Levelofadoptionorpromotionof Lean Construction for theBrazilianIndustry	1,59	6
Biulders has the greatest capacity to contribute to raising the level of adoption of Lean Construction in the Brazilian construction industry.	3,95	2
Universitieshasthegreatestcapacitytocontributetoraisingthelevelofadoptionof Lean Construction in theBrazilianconstructionindustry.	4,77	1
Class Organizations has the greatest capacity to contribute to raising the level of adoption of Lean Construction in the Brazilian construction industry.	2,88	4

Table VI. Evaluation of the 22 global barriers for the implementation of LC for Brazil

	MIS	Rank
Influencyoftraditional management practices	4,80	1
Unfavorableorganizationalculture	4,18	7
Lackoftechnical skills, training andunderstandingofleantechniques	4,66	4
Lackofknowledgeaboutleanconstruction approaches	4,75	2
Lackofcommittedleadershipfrom top management	4,41	6
Ineffective communication channelsbetweenconstructionteams	2,96	13
Lackof a robust performance measurement system	2,91	14
Lackoftechnologicaladaptations	2,79	15
Difficulties in understandingtheconceptsofleanconstruction.	4,68	3
Traditional design approach	4,64	5
Longperiodofimplementingleanconcepts in construction processes	2,66	16
Lackofcustomerandsupplierinvolvement	2,46	17
Enduserpreference	1,61	20
Additionalcostsand high inflation rates	1,98	19
Slowdecision-making processes duetocomplexorganizationalhierarchy	3,41	8
Inadequateresource management	2,39	18
Lackofclearcustomerjobspecifications	2,39	18
Lackof performance benchmark offer	3,14	11
Lackofgovernmentsupport for technologicaladvances	3,29	9
Uncertainty in theproductionprocess	2,39	18
Use non-standard ofcomponents	3,11	12
Uncertainty in thesupplychain.	3,18	10

for the low level of knowledge and adoption of LC in the Brazilian industry. Added to the Lack of knowledge about lean construction, in no similar study these three factors were ranked at such high levels and followed. Second place in the KSA was the customer-related barrier, followed by standardization and technology Sahan*et al* (2017). Similar result to that found in China in 2014 by Shang and Sui Phehng 2014). In India, uncertainty in the production process is seen as the second barrier to implementing Lean Construction (Devaki and Jayanthi, 2014). Considering the first 7 barriers to the implementation of LC in the Brazilian industry, all of them have a MIS > 4.0 among construction companies. This result is based on two thematic axes: Education and Traditional Project Management Culture. Considering that culture can be changed through an education process, theresearch suggests that education about Lean Construction is the great challenge to overcome the main obstacles to the adoption of LC in the Brazilian industry.The barriers considered intermediate by the construction companies are: by the stakeholders they are: Slow decision-making processes due to the complex organizational hierarchy (MIS 3.14), Lack of government support for technological advances, (MIS 3.29), Uncertainty in the supply chain, (MIS 3.18), Lack of performance benchmark offer (MIS 3.14), Use of non-standard components (MIS 3.11), Ineffective communication channels between construction teams (MIS 2.96), Lack of a robust performance measurement system (MIS 2.91), Lack of technological adaptations (MIS 2, 79), Long period of implementing lean concepts in construction processes (MIS 2.79).

This result, when compared to similar studies where the understanding of CL is at higher levels, attributes the lack of standardized components among the main barriers (de Sarhan *et al*. (2017), Bajjou and Chafi (2018), Ahmed *et al*. (2019), while concerns such as performance and supply chainuncertainty are minor concerns.With a MIS <2.5 they are Lack of involvement of customers and suppliers (MIS 2.46), Inadequate resource management, Lack of clear customer job specifications, Uncertainty in the production process occupy the same Rank as (MIS 2, 39). Additional costs and high inflation rates (MIS 1.98) and end-user preference (MIS 1.61) are the lowest concerns among Brazilian respondents. In studies from India by Devaki and Jayanthi, (2014), in Nigeria by Olamilokun (2015), in the Kingdom of Saudi Arabia through the study by Sarhan *et al*. (2017), in Morocco by Bajjou and Chafi (2018) costs appear to be the barrier with the lowest level of concern. This is confirmed in the study from Brazil. Despite not appearing as the lowest barrier, the result is similar to that of other countries. Sarhan *et al*. (2017) states that the literature shows that barriers in developed and developing countries are similar, however there is no unanimity between the rank of the position of barriers.Given the low knowledge of LC in Brazil, the research suggests that the recommendations initially focus on actions to resolve the shortcomings in the first 7 barriers. And future studies will carry out a new assessment of the situation in Brazil regarding Lean Construction.

Recommendations to promote lean construction in Brazilian industry: In Brazil, to overcome the main barriers, the solutions suggested at a global level are investing in education in Lean Construction. The most common barriers are fluency in traditional practices and lack of knowledge about LC, followed by barriers related to lack of mastery of LC techniques and tools, that is, the great challenges of LC in Brazil are concentrated in two major axes, as already mentioned: Education and Traditional Culture of Project Management. Considering that culture can be changed through an education process, the research suggests that education about Lean Construction is the great challenge to overcome the main obstacles to the adoption of LC in the Brazilian industry. Contents about the LC must be within the courses that work directly with the construction sector, such as engineering, architecture, among others.Lean construction training should be implemented at all levels in construction organizations, especially to include mid-level managers and subcontractors and suppliers, to ensure that the concept spreads to all levels (Devaki and Jayanthi, 2014). Management of construction organizations should also seek to retain qualified and newly trained employees and encourage them.Builders must seek changes in the culture of organizations to accommodate the construction principles in their organizational policies. According to Devaki and Jayanthi (2014) and Sarhan *et al*. (2017), if that happened, employees and organizational partners would be compelled to embrace a lean construction culture. Collaborating for a change in traditional practices, Shang and Sui Peng, 2014; Devaki and Jayanthi (2014), Sarhan and Fox (2013) suggest that the traditional design approach be replaced by the integrated design approach to reduce the dichotomy between the design and construction phases of project delivery for easy Lean Construction implementation, and that the same must be done incrementally, step by step and not a radical attempt. According to Bashir *et al*. (2015), rather than an aggressive and punctual implementation approach, a step-by-step or streamlined implementation of lean construction is needed to allow operators to adapt to the technological sophistications involved. Management of construction organizations should have greater responsibility for providing and sponsoring avenues such as seminars, conferences and workshops to train their employees on lean construction.In Brazil, it is initially necessary to solve the problem with the low level of knowledge, this way it will be easier to deal with the other challenges, as the knowledge about the LC is satisfactory. This opinion is accepted based on the studies by Sarhan *et al*. (2018) in KSA and Shang and Sui Peng, 2014 in China.

Assessment of the reliability of the questionnaire: To assess the reliability of the questionnaire, the Cronbach's alpha value was calculated considering part II and part III referring to the 28 questions about the LC, excluding general information from the respondents.Figure I presents the tabulated results of the 56 respondents in the 28 questions about the LC in the questionnaire.

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{k} S_i}{S_t}\right) = \frac{28}{28-1}\left(1 - \frac{18,77727}{380,6857143}\right) = 0,98$$

Through the calculation, the result of Cronbach's alpha obtained was 0.98, it concludes that the result through the instrument used is satisfactory and reliable.

Conclusion

Based on similar studies carried out in KSA, Morocco, Bangladesh, Malaysia, United Kingdom and China on the benefits and barriers to the implementation of Lean Construction, given the importance of Brazil among developing countries, it sought to assess the scenario of the Brazilian construction industry, identify similarities and differences in the face of international barriers and propose recommendations that can face global challenges. Through a questionnaire, the survey had 56 respondent construction companies. The reliability of the research instrument was measured using the Crombach's alpha coefficient and obtained an alpha of 0.98, which indicates a high level of reliability of the instrument used.The survey revealed that Brazil is deficient in knowledge about Lean Construction and, consequently, has a low rate of adoption by construction companies.The research revealed that the perspective of the interviewees point to universities being the most responsible for the current situation of Lean Construction in Brazil, given the attribution of being the one with the greatest capacity to promote, disseminate and qualify professionals to work with methods, techniques and LC tools.

Based on 22 global barriers, prioritization through MIS revealed equality in Brazil compared to similar studies in countries such as KSA, Morocco, Bangladesh, China, UK, in fluency in traditional practices. However, in Brazil there is a high level of barrier regarding knowledge about Lean, the lack of qualified professionals and the difficulty in understanding the Lean Construction concepts. This rating was not found in any other similar search. This result demonstrates a lack of knowledge about Lean and needs to be fixed urgently.As a recommendation to overcome the major challenges of implementing LC in the Brazilian industry, the research suggests that

actions should initially focus on improving the knowledge of the construction sector stakeholders about the concepts, benefits, methods and techniques of Construction. It is believed that with a higher level of knowledge, other challenges can be more easily resolved.Given the limitation of the research that evaluated only construction companies, it is recommended that future studies assess the perception of customers, the government, universities, trade organizations and suppliers of the civil construction supply chain so that, through these studies, coordinated actions can favor the adoption of LC in Brazil.

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