An empirical study of the impact of lean on the performance of the construction industry in UAE

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Received 22 September 2017
Revised 22 January 2018
Accepted 29 May 2018

Abstract

Purpose – The purpose of this study is to propose a conceptual framework for the exploration of appropriate lean techniques applicable to medium and large construction companies and measure their impact on the competitiveness and economic performance of construction companies in United Arab Emirates.

Design/methodology/approach – A questionnaire survey is conducted on 215 construction professionals in UAE to investigate the lean technique's effect on the construction companies' performance. The data collected were analyzed with SPSS 20.0 version software using the Cronbach's a reliability test, correlation coefficient test and Kaiser–Meyer–Olkin test.

Findings – Analysis of lean techniques in the construction industry reveals 21 lean techniques. These techniques were categorized into the six types of lean core values. Process focus was found to be the most applied type of construction core value in the surveyed companies. This is required to focus on applying other core values as it will impact the company's economic performance positively.

Research limitations/implications – The integrity of the research findings is based on the accuracy and reliability of collected data from 215 respondents working for construction companies in UAE, implementing lean construction techniques within a their daily activates and not achieving significant project achievements in terms of quality improvement, speed and cost reduction without adopting the overall lean construction framework.

Practical implications – This research recommends a systematic approach for the implementation of the anticipated framework within a cyclical look-ahead period and emphasizes the practical implications of the proposed approach in the construction companies.

Originality/value – Research significance emphasizes increasing the effectiveness of the construction industry and influences the development of lean construction framework, which improves lean construction practices using the lean techniques. This contributes to the effort of applying lean techniques in the construction industry. Limited studies have been done in the construction industry, mainly in UAE, compared to lean manufacturing.

Keywords Lean manufacturing, Lean, Construction, Waste

Paper type Research paper

1. Introduction

To survive in today's competitive market, it has become essential for construction companies to develop the quality of their work, increase work effectiveness, reduce costs and waste and increase profit. This is even more pressing within the current financial and economic situation. Subsequently, the combination of project completion time, low cost and high quality is the cornerstone of managerial and engineering determinations to navigate the strong competition faced in the construction business (Ogunbiyi *et al.*, 2012). Therefore, most construction managers agree that the industry is subject to delays, errors, misspending and project inefficiency (Ogunbiyi *et al.*, 2012). Projects occasionally finish on time, within the agreed

Journal of Engineering, Design and Technology
Vol. 16 No. 5, 2018
pp. 694-710

1726-0531
DOI 10.1108/JEDT-09-2017-0095

budget or even at a quality level that is acceptable to the customer. As a result, several cost-effective project management methodologies have emerged to improve the construction business' performance, including value-engineering, lean construction and lean project management, which can reduce product cost, result in quicker delivery and improve product quality (Singh and Singh, 2012; Patyal and Koilakuntla, 2017).

Toyota Production System (TPS) is considered the source of lean methodology and has influenced businesses to improve their efficiency. The lean concept was originally applied to automotive companies and moved to manufacturing companies; other sectors, such as health-care services, later adopted the lean concept to manage budget reduction and demand (Poksinska, 2010; Hussain *et al.*, 2016). Recently, the construction industry has begun the process of applying lean thinking to complete projects, thereby maximizing the value received by the customer, reducing waste and pursuing perfection (Womack and Jones, 2003).

As defined by the Lean Construction Institute, lean construction is a production management-based project delivery system that highlights the reliable and speedy delivery of the value (Construction Institute, 2016). The Lean Construction Institute adopted the concepts of lean thinking and lean principles to create a new method to manage construction projects. Overall, lean could be understood as a production system in between the craft and mass production systems (Womack and Jones, 2003).

However, there are a few concepts that refer to lean most of the time, according to Pettersen (2009). These are the just-in-time concept, resource reduction, strategies improvement, standardization, defect control and management techniques. Al-Aomar and Hussain (2018a); Jorgensen and Emmitt (2008) argued that lean construction can be defined by a number of specific characteristics, such as waste elimination, the reduction of waste sources, end-user requirements and preferences, supply chain management and production as a pull approach (not a push approach), process focus and process flows in production management.

Despite studies on how the lean methodology has been applied in construction businesses, there is a lack of framework that can explain the relationship of the construction lean techniques and their influence on the construction firm's business performance (Al-Aomar, 2012).The objective of this paper is to identify the lean construction techniques in the construction industry, investigate the application of lean construction techniques in the construction industry and develop a practical framework that incorporates business performance, including organizational economic performance and competitiveness, into the best practices of lean construction.

The developed framework was transformed into a questionnaire that was distributed to mid- and senior-level construction industry professionals from Abu Dhabi and Dubai in the UAE. The collected data were assessed using a standard research analysis software known as Statistical Package for Social Sciences (SPSS) 20.0.

Implementing a lean construction techniques framework is expected to achieve significant gains for construction companies in terms of economic performance and combativeness, speed and cost without adopting the overall lean construction framework. This study's results will have implications for the UAE construction industry, as the construction industry contributes significantly to the economic performance of UAE. In total, 11 per cent of the UAE's GDP in 2015 came from the construction industry (Dubai Chamber, 2016). The City Scape Global (2016) exhibition announced projects worth US$8bn (30bn UAE dirhams); therefore, improving construction performance is fundamental for both accomplishing short-term business objectives and developing long-term competitive advantages.

The remnants of this paper are organized as follows: Section 2 provides a review of relevant literature, Section 3 outlines the details the proposed framework conceptual framework and section 4 presents research methodology. The analyses of study results are carried out in Section 5, followed by the study discussion and implications.

2. Literature review

2.1 Lean management

Lean is the westernization of a Japanese perception that has carried numerous names. It has variously been recognized as the TPS, just-in-time (JIT), pull manufacturing, and several other names. Each of these names integrates some aspects of lean and vice versa. Lean has received attention from academics and practitioners alike as a competitive advantage source in both developing and developed economies. Lean implementation is one of the key issues and boundaries of practices such as total quality management, (JIT) and total project management, which are not clearly defined due to the high similarities among these concepts (Al-Aomar and Hussain, 2018b). It is characterized by an enhanced emphasis on product quality and an integrated overall approach to the different aspects of manufacturing. Shah and Ward (2003) explained that its fundamental thrust is to build a streamlined system that provides an output at the control of customer demand with little or no waste. Successful applications of a lean strategy ought to provide greater flexibility, reduced lead times, improved processing speed, smaller batch sizes and increased profits (Hussain and Malik, 2016). Therefore, due to the dynamic nature of these perceptions, lean will continue to appeal to both academics and practitioners.

2.2 Lean in construction

Construction industry activities are mainly concerned with the regulation, design, planning, manufacturing, construction and maintenance of buildings (Burtonshaw, 2009). The industry and the problems that affect construction projects are difficult to fully understand, as the relationships among the parts are not always clear and the limits of the industry are unclear (Murdoch, 2008). Thomassen and Bonke (2004) noted that the industry is generally considered to have low productivity, cost overages and delayed schedules, faults, poor reputation, poor safety and a shortage of skilled labor. Moreover, he stated that certain characteristics of the construction industry distinguish it from other industries:

- the physical description of the product;
- the product being mostly manufactured at the client site;
- most projects having unique designs;
- design mostly being separate from construction;
- the organization of the construction process; and
- the pricing method.

The Lean Project Delivery System, which was developed by the Lean Construction Institute, defined lean project delivery as dedication to implementing the guiding principle of lean (Ballard, 2008) that includes, but is not restricted to, lean design, lean supply, lean production, lean assembly and lean delivery system. The lean description provides a value-based scope of work, effective master production schedule (MPS) and cost assessments. At the construction site, the MPS is implemented as small work chunks that are pulled as needed from a look-ahead plan (Al-Aomar, 2012). The industry is clearly facing a variation of paradigm; however, the early adopters in the industry are acquiring benefits, which

cannot be accomplished without a change in the current attitude, as suggested by previous studies (Miller *et al.*, 2009).

2.3 Core elements of lean construction

2.3.1 Waste reduction. The furthermost important core element for lean construction is waste reduction (Jorgensen and Emmitt, 2008). A dominant aspect of waste reduction is housekeeping, which ensures that a construction site is well organized, tidy and clean by using the 5S process: sort, straighten, standardize, shine and sustain (Salem *et al.*, 2006). Each step of 5S is based on how to increase efficiency and decrease non-value-added activities, which matches the core of lean construction-eliminating waste. The 5S process is an indicator of the lean site management and is a powerful endorsement for the implementation of lean construction (Huang and Zhanshe, 2012). Therefore, workers should be encouraged to clean the jobsite as soon as the activity has been completed (Paez *et al.*, 2005). However, maintaining efficient material delivery and storage is crucial for waste reduction in lean construction, and this is labeled as JIT delivery (Jorgensen and Emmitt, 2008). From a JIT standpoint, inventories are not valuable and should be viewed as waste (Salem *et al.*, 2006). When applying JIT, contractors struggle to receive smaller batches of material at a site when needed to reduce stockholding and double-handling (Salem *et al.*, 2006).

Another feature of waste reduction is using information technology (IT) and joint IT tools, as the 3D-modelling software allows the early detection and correction of most errors before production (Woksepp and Olofsson, 2008). Joint IT tools also enhance the integration among the supply chain actors and clear their tasks, consequently increasing the chance of cost and schedule reduction (Woksepp and Olofsson, 2008). The fourth central feature of waste reduction is the off-site manufacturing of parts and units (Green and May, 2005). The prefabrication process also has many advantages for construction industries, such as shortening the construction duration, reducing material waste and improving the work environment. Hence, increased prefabrication makes lean construction more similar to lean production in manufacturing industries (Al-Aomar, 2012). Moreover, Japanese firms used waste elimination techniques more effectively to achieve global competitiveness (Mclean *et al.*, 2017).

2.3.2 Processes focus. Managing production using processes focus and flow is a core element of the lean construction industry (Jorgensen and Emmitt, 2009). The last planner system is considered to be a significant aspect of the processes focus that improves efficient production planning and control (Ballard and Howell, 2003; Winch, 2006; Jorgensen and Emmitt, 2008). Each individual should take immediate action regarding their own tasks (self-control) to avoid defects at the source and obstructing the flow within the process. The last planner system main tools are master schedule, reverse-phase scheduling, six-week look ahead, weekly work plan and percent plan complete (Green and May, 2005; Salem *et al.*, 2006; Ballard, 2008). This characteristic should be used in all activities during the buying process (Salem *et al.*, 2006). Conventionally, contractors are used to being controlled by clients, which will adequately reduce their performance and self-control. Additionally, the design consultants cannot perform self-control satisfactorily due to a surplus of time (Andi, 2003).

Empowering all workers to manage and control their own tasks and work is, therefore, critical (Ballard, 2008; Höök and Stehn, 2008). A third aspect that improves the focus of the production plans and the schedule is to establish project milestones (Salem *et al.*, 2006). By clarifying the significance of production milestones and making them obvious to everyone, project participants will be more involved in the execution of the project (Salem *et al.*, 2006);

moreover, Winch (2006) argued that a pull plan underneath the last planner system is more powerful and better for guiding the real operation than a traditional plan is.

2.3.3 End customer focus. End customer focus is presenting a core element of lean construction (Jorgensen and Emmitt, 2009). Furthermore, in reference to the dimension of the customer, some researchers argue that demand variability can prevent lean implementation (Höök and Stehn, 2008) because it is used to maximize the value of lean construction (Salem *et al.*, 2006; Winch, 2006; Jorgensen and Emmitt, 2008). Contractors and suppliers should understand the needs of the customer so they can provide customers with what they need, not what they want (Styhre *et al.*, 2004). Freire and Alarcón (2002) concluded that customer satisfaction is dependent on the process used or applied and the end product. Therefore, to increase the end customer focus, it is important to adopt lean principles in the design stage (Maloney, 2002). Moreover, the early involvement of contractors during the design integration and concurrent engineering is an important aspect of lean construction (Green and May, 2005; Salem *et al.*, 2006; Winch, 2006; Jorgensen and Emmitt, 2009). Concurrent engineering improves the contractors' understanding of customer needs and increases teamwork and cooperative problem-solving while providing significant time savings (Song *et al.*, 2009).

Using competitive bidding is not effective when customized products are procured in lean construction (Green and May, 2005, Elfving, 2010). A focus on the lowest tender price will activate the self-protecting attitudes of the contractors (Eriksson and Laan, 2007) rather than approaches targeting customer satisfaction. Thus, the limited bid invitation for honest and capable contractors should be integrated with a bid evaluation based on soft parameters that will ensure that partners who are capable of satisfying customers' needs are selected (Eriksson and Laan, 2007). The overall perspective of professionals within the industry shows that benefits such as increased compliance with customer expectations are realized following the principles of lean construction (Ogunbiyi *et al.*, 2012).

2.3.4 Continuous improvements. The long-term perception of continuous improvements (named Kaizen in the TPS) is an important element of lean construction. First Run Studies and Fail Safes are effective tools for continuous improvements (Green and May, 2005; Pheng and Fang, 2005; Salem *et al.*, 2006; Jorgensen and Emmitt, 2009) to reduce waste and increase the effectiveness of the construction process over time.

Long-term contracts are an important aspect, as they decrease the traditional short-term focus on the cost reduction (Green and May, 2005) while promoting lasting improvements. By working together on a series of projects, the transfer of construction knowledge, performance experiences and improved supply chain collaboration between two projects are expedited. Measuring performance against pre-defined targets is a very important characteristic of continuous improvements (Salem *et al.*, 2006) and controlling and measuring the different kinds of performance indicators are influential in determining whether performance is improving (Freire and Alarcón, 2002).

Consequently, the explanations for unsatisfactory or satisfactory performance should be analyzed to determine the actions for potential improvement (Freire and Alarcón, 2002). In addition, all staff should be inspired to initiate ideas and higher-quality solutions to solve problems that occur on the site (Pheng and Fang, 2005). Unfortunately, the site workers' contribution to problem-solving is minimal in the construction industry compared to other industries (Green and May, 2005). Moreover, the workers believe that they do not have adequate opportunities to share their opinions (Riley and Clare-Brown, 2001).

Thus, it is important that the propositions from workers are treated seriously to increase their commitment to continuous improvements (Ballard, 2008). Although knowledge sharing and combined learning among teams from different businesses and disciplines are

vital for realizing continuous improvements in lean construction (Green and May, 2005; Jorgensen and Emmitt, 2009), they are occasionally realized as the result of suitable methods absence (Styhre *et al.*, 2004). Such learning can be achieved by establishing quality circles and providing the project staff with opportunities to contribute to the improvement process (Salem *et al.*, 2006).

2.3.5 Cooperative relationships. Cooperative relationships among project actors (often referred to as partnering), similar to daily huddle meetings (tool-box meetings), are an important element of lean construction (Green and May, 2005; Jorgensen and Emmitt, 2008) that simplifies the integration of different actors' capabilities and efforts in combined problem-solving. As the traditional methods of construction and governance procedures are often criticized for producing waste, adversarial relationships and long lead times (Elfving, 2010), they had to be changed to a lean contracting approach (Pheng and Fang, 2005). Further, subcontractors participate in most project values, and because the project activities are fully connected, synchronization between main contractors and subcontractors is important for both partnering and lean construction.

Consequently, Humphreys (2003) concluded that it is vital to involve key subcontractors in the partnering team, allowing all actors to contribute to the combined objectives (Eriksson, 2010). However, previous researchers have encountered practical troubles when trying to involve a wider range of actors in lean construction initiatives (Jorgensen and Emmitt, 2009). Good communication is central to the establishment of such cohesive partnering, coordination and integration (Elfving, 2010). Partnering is facilitated by numerous collaborative tools, such as joint project, joint objectives and teambuilding activities (Green and May, 2005; Eriksson and Laan, 2007). It is important that all participants benefit from the improved performance caused by the implementation of lean construction (Green and May, 2005). An equitable and fair rewarding system is vital for building cooperation and trust among all construction business actors (Khalfan *et al.*, 2007). Hence, gain share/pain share is an incentive-based compensation arrangement that encourages the actors' commitment to contributing to the joint objective (Eriksson and Laan, 2007).

2.3.6 Systems perspective. An additional core element of lean construction is a systems perspective (Jorgensen and Emmitt, 2009), which is compulsory to increase the overall efficiency of lean construction projects (Pheng and Fang, 2005; Green and May, 2005; Winch, 2006). A consistent workflow in the overall system is more significant than is the individual activity cost or time (Elfving, 2010). An important aspect of this is to consider the entire design and construction processes by making coherent decisions that support or complement one another (Eriksson and Laan, 2007). Furthermore, the construction process will be simplified by reducing the number of working steps (Pheng and Fang, 2005).

Lean construction cannot be achieved by considering design, operation and construction in isolation. Therefore, a readjustment of the contractual restrictions among all parties is required (Green and May, 2005). As a result, large-scope contracts are required instead of dividing the project into smaller portions that involve many different actors for short periods of time. The systems perspective is also the central issue in terms of reaching the end result of the process (Green and May, 2005). To obtain appropriately balanced objectives, such as cost, schedule and quality, each objective of the project should receive an appropriate amount of attention related to its importance throughout the project. It is also important that the project objectives are specified and that the values are clear to all actors (Jorgensen and Emmitt, 2009).

Various lean tools and techniques for enabling better performance have been discussed by several authors. Some studies have explored various issues of performance with lean techniques and established the benefits that can be derived by applying the lean core values and techniques (Ogunbiyi *et al.*, 2012). Lean design approaches such as joint IT tools (integrated design, target costing and 3D modeling) can be applied during the design of a lean project.

2.4 Business performance

2.4.1 Economic. It is generally accepted that companies' business performance can be assessed using financial ratios; this practice is generally understood and long accepted as a method of establishing a company's financial configuration and characteristics (Cheah *et al.*, 2004) and as a way of evaluating that company against industry benchmarks. Financial ratios can also be used as input to analyze the financial risk and can provide substantial and reliable information about the company's financial strength. Although there is considerable debate on the value of financial ratios and their ability to directly impact share prices, they are easy to acquire and are useful for presenting information to long-term investors who are more interested in the prolonged existence of a company. Analysts have developed acceptable ranges and standards for financial ratios. Companies operating outside those ranges face potential risks. However, these ranges are subjective and are not always accepted (Basha *et al.*, 2007).

The financial performance of firms is affected by the better utilization of resources, improved efficiency and higher productivity and reduced operating costs (Hussain and Al-Aomar, 2018). Therefore, the better use of resources will impact firm marketing advantage, which will lead to enhanced revenue, new market opportunities and a higher market share. Therefore, organizations that improve their processes and reduce waste are prepared to expand their markets. However, whether these advantages have a direct impact on firm financial performance is yet to be explored (Rao and Holt, 2005).

Rao and Holt (2005) suggested that to investigate the relation between lean construction techniques and economic performance, a number of variables that constitute the construct measuring economic performance should be considered:

- market opportunities;
- increase in product price;
- profit margin;
- sales increase; and
- market share increase.

2.4.2 Competitiveness. In addition to possessing management and marketing capabilities, a construction firm must ensure that it is competitive and capable of enduring any challenges in the competitive construction industry market. Therefore, the competitive advantage factor is included in this study as a variable that is influenced by lean techniques. Competitive advantage is the degree to which an organization can establish a defensible position over competitors (Chen *et al.*, 2006). Competitive advantage is simply defined as how companies enter the market with the goal of optimizing their operations to achieve better results for short- and long-term objectives (Safarnia *et al.*, 2011). Therefore, this paper explores the relation between lean construction techniques and competitiveness.

Consequently, the variables considered in this study to investigate competitiveness are (Rao and Holt, 2005):

- efficiency improvement;
- improved quality;
- productivity improvement; and
- cost savings.

3. Conceptual framework

The lean project is expected to result in an effective product and process that is transformed through the project execution stage into a complete cost-effective, on-time and quality project delivered to the client. A conceptual framework (Figure 1) was developed based on extensive literature review, which is summarized in Table I. The framework will assess the lean techniques of six lean construction core values and their impact on the business performance of the construction companies in the UAE, including the companies' financial performance and competitive advantage.

4. Research methodology

The research design was developed based on the research plan, which is shown in Figure 2 as the details of the research plan and approaches adopted to identify the objectives and the findings of the research.

The questionnaire survey was developed based on existing questionnaires, general information, (Ogunbiyi, 2014), waste reduction (Dainty and Brooke, 2004), process focus (Nunez, 2014), end customer focus (Nunez, 2014), continuous improvement (Nunez, 2014), system perspective (Kulatunga *et al.*, 2006), economic performance (Rao and Holt, 2005) and competitive advantage (Rao and Holt, 2005).

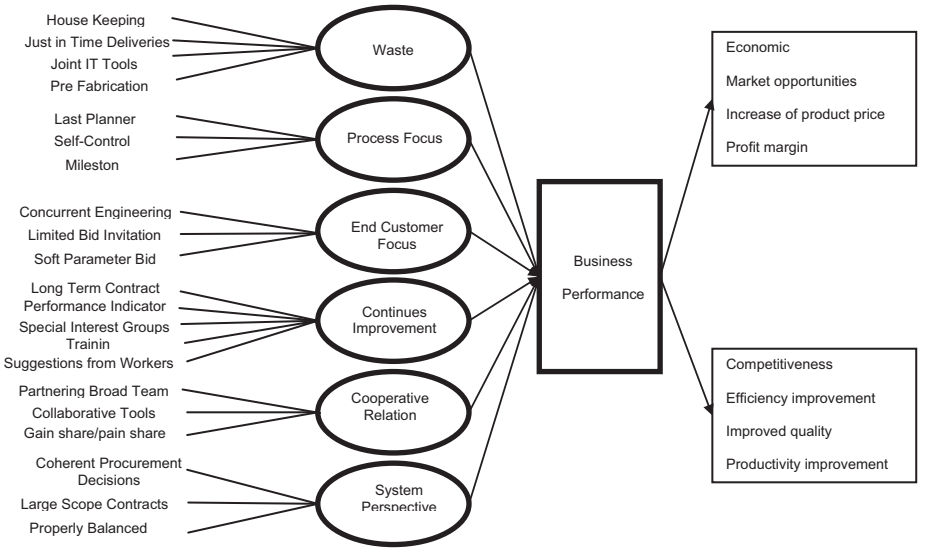

Figure 1.
Conceptual frame work

Lean construction core values	Lean construction techniques	Reference
Waste reduction	Housekeeping	Green and May (2005), Salem *et al.* (2006), Woksepp and Olofsson (2008)
	Just in time deliveries	
	Joint IT tools	
	Pre-fabrication	
Process focus	Last planner	Salem *et al.* (2006), Winch (2006), Jorgensen and Emmitt (2009)
	Self-control	
	Milestones	
End customer focus	Concurrent engineering	Green and May (2005), Jorgensen and Emmitt (2009)
	Limited bid invitation	
	Soft parameters in bid evaluation	
Continuous improvement	Long-term contracts	Freire and Alarcón (2002)
	Performance indicator	
	Special interest groups	
	Training	
	Suggestions from workers	
Business performance Indicators	Business performance measurements	Reference
Economic	Market opportunities	Rao and Holt (2005)
	Increase of product price	
	Profit margin	
	Sales increase	
	Market share increase	
Competitiveness	Efficiency improvement	Rao and Holt (2005)
	Improved quality	
	Productivity improvement	
	Cost saving	

Table I.
Lean construction core values, lean construction techniques (measures) matrix and business performance measurements units

In the study, a survey-based approach was used to test the lean practices in the construction industry. The items for each construct were structured in the form of a survey questionnaire, with all questions evaluated on a five-point Likert scale ranging from 1 to 5. The questionnaire was distributed randomly to a total of 300 construction industry professionals including project managers, project engineers, site foremen, architects and QA/QC inspectors. Sample selection criteria used were:

- having experience of at least four years at middle or senior level; and
- working in special, first, second and third rank as per the UAE Chamber of Commerce Ranking.

These respondents were selected from medium and big construction companies listed in the UAE Chamber of Commerce. Respondents were communicated through an online questionnaire using the Survey Monkey. In total, 225 participants completed the survey, for a response rate of 71 per cent. Next, 10 responses were removed due to incompleteness, leaving 215 valid responses for data analysis. The characteristics of the survey participants are provided in Table II.

Exploratory factor analysis (EFA) and confirmatory factor analysis was applied to confirm the extent to which the observed variables specified in the model represent the constructs; this relationship is determined by the strength of the regression path between them. The collected data were analyzed using the SPSS 20.0 version software, with a reliability test and coefficient of concordance. The collected data were assessed using a standard research analysis software package, SPSS 20.0.

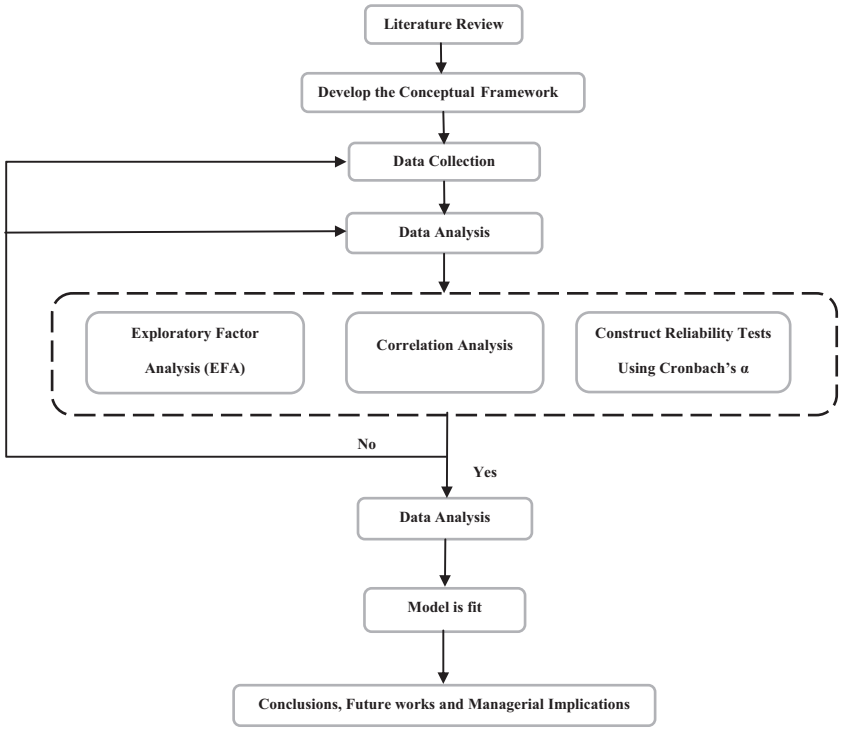

Figure 2.
Research plan

Variable	No.	(%)
Size of organization (by staff)		
Up to 50 employees	70	33
51-249 employees	66	31
Above 250 employees	79	37
Professional discipline		
Architect	66	31
Quantity surveyor	54	25
Construction manager	60	28
Engineering	35	16
Work experience		
<5 years	43	20
6-10 years	26	12
11-15 years	40	19
16-20 years	68	32
21 years and above	38	18

Table II.
Summary of respondents' demographic data

5. Data analysis

5.1 Exploratory factor analysis

EFA is an extensively used and widely applied statistical technique in the social sciences. In recently published studies, EFA had different applications, including expanding an instrument for evaluating school principals (Lovett *et al.*, 2002), evaluating the students' motivation at Puerto Rican high schools (Morris, 2001) and defining what types of services should be presented to college students (Majors and Sedlacek, 2001).

There are several factor analysis extraction methods to choose from. SPSS has six methods (in addition to principal component analysis, statistical analysis system and other packages with similar options): generalized least squares, unweighted least squares, maximum likelihood, alpha factoring, principal axis factoring and image factoring. Information on the relative weaknesses and strengths of these techniques is limited and is often only available in unknown references. Moreover, it is often difficult to parse out which method a journal article or textbook author is describing whether it is available in the software packages the researcher is using.

EFA was applied to confirm the refinement and evaluation of tests, scales and measures applied. Factor analysis is a method of choice for interpreting self-reporting questionnaires and is used to reduce a large number of variables into a smaller number of variables. Moreover, it creates underlying dimensions between the measured variables and the latent constructs, thus allowing the formation and refinement of the theory. Finally, it provides the evidence construct validity of self-reporting scales (Williams, 2016). The EFA test, as shown in Table II, found the conformity of the proposed scale and distributed questionnaires to have a value of 0.648, which is higher than 0.5.

5.2 Construct reliability tests

A reliability analysis was performed using the collected survey data to validate the constructs of lean practices and assess the reliability and internal consistency of the survey instrument. The reliability of the data was confirmed by the values of Cronbach's α analysis (Cronbach, 1915) and was calculated using the SPSS data analysis software. Cronbach (1915) suggested that for an empirical study, the Cronbach's α should be above the threshold limit of 0.70 to confirm the constructs' internal reliability and consistency. The reliability of the eight constructs was confirmed by further analysis of the Cronbach's α; 0.785 is above the threshold limit of 0.70, which confirms the constructs' internal consistency and reliability.

5.3 Descriptive statistics

The descriptive statistics showed that the means of the 215 responses collected for lean practices ranged from 3.4 to 4.4 and that the standard deviations ranged between 0.42 and 0.63 (Table III). This indicates that lean practices are valid for implementation in the construction industry to a certain extent. Correlation analysis is one of the most extensively used and reported statistical methods in summarizing research data. Moreover, the characteristics of the survey participants are provided in Table IV.

Table III.
Kaiser–Meyer–Olkin and Bartlett's EFA test

Kaiser–Meyer–Olkin measure of sampling adequacy	0.648
Bartlett's test of sphericity	
Approximate χ^2	170.558
df	28
Significance	0.000

5.4 Correlation analysis

Table V shows the correlation results for each of the lean practices and business performances using Pearson correlation coefficients. The lean practices were positively correlated with one another to some extent, and most of them were significant at $p = 0.01$. A high level of correlation occurs more frequently between lean practices and business performance. Positive relationships are likely to support previous empirical studies by showing that lean practices impact the business performance of construction companies and should thus be applied to enhance the economic performance and competitive advantages of construction companies in UAE. Furthermore, the goals of lean practices are synergistic in terms of their focus on eliminating waste and reducing inefficiency.

6. Results and discussion

This study assessed the extent to which lean practices are impacting the construction industry using data collected from 215 professionals in the UAE construction industry. The study was based on the survey instrument of six lean practices identified from numerous sources in the literature. The reliability analysis suggests that these practices are reliable, with a Cronbach's α of 0.789, as per Table III.

Constructs	Mean	SD
Waste reduction	4.15	0.42
Process focus	4.31	0.42
End customer focus	4.11	0.55
Continues improvement	4.41	0.40
Cooperative relation	4.05	0.60
System perspective	3.94	0.49
Economic performance	3.46	0.63

Table IV. Descriptive statistics

	Waste reduction	Process focus	End customer focus	Continues improvement	Cooperative relation	System perspective	Economic performance
Waste reduction							
Process focus	*0.376***						
End customer focus	0.173	*0.501***					
Continues improvement	*0.416***	*0.705***	*0.383***				
Cooperative relation	0.193	*0.348**	*0.452***	0.198			
System perspective	0.219	*0.544***	*0.480***	*0.346**	*0.724***		
Economic performance	0.087	0.081	0.176	0.049	0.081	*0.291**	
Competitive advantage	*0.314**	*0.348**	0.232	*0.3215**	0.083	*0.490***	*0.634***

Notes: **Correlation is significant at the 0.01 level (two-tailed); *correlation is significant at the 0.05 level (two-tailed)

Table V. Correlation matrix of the lean practices and business performance

As apparent from Table III, continuous improvement is the most dominating construct for lean practices in the construction industry, with a mean value of 4.4. The significance of the constructs waste reduction, process focus, end customer focus, continuous improvement, cooperative relation, system, perspective, economic performance and competitive advantage is given in Table V; process focus is the most highly related to the other lean practices, as it has a significant correlation to four lean practices and the company competitive advantage. The least related was cooperative advantage, which was significantly correlated only to system perspective.

The literature review findings assisted the frame of reference in the research of the lean construction industry. The findings demonstrate that lean construction used a range of lean-related aspects, corresponding to the items on the lean construction questionnaire that focused on business performance. There is a long way to go to reach such a fully lean approach. This was verified by the survey results indicating that the construction lean practices were more satisfied with aspects related to competitive advantage than with those related to economic performance. The Pearson correlation analysis provided empirical evidence that lean practices are positively associated with competitive advantage. The positive relationship between lean practices and business performance shows that they should be linked to enhance the construction industry performance.

6.1 Implications

This study draws attention to appropriate ways that UAE construction industry professionals could implement lean practices. First, management has direct implications for employees. Therefore, a change in management perspective is required to promote lean implementation. Moreover, top management must understand the benefits of lean and put more effort into the adoption of lean techniques. Second, management skills and capabilities are essential for successful lean implementation. These include leadership, coaching, readiness to take responsibility, being proactive in decision-making and establishing trust with employees and others. Third, introductory training is necessary for employees to understand lean and its benefits.

Although the issue of applicability of various lean practices in different types of the construction industry has been argued in earlier studies, little attention has been paid to the use of these practices in the UAE construction industry. Additional effort is required to increase the level of lean practice implementation in the construction industry. This has implications for the future success of lean construction initiatives, mainly on their enforcement and incentives in UAE. Therefore, there is an urgent need to secure both cultural and positional transformations to introduce the essential principles of lean construction to all stakeholders.

Thus, there is a need to ensure that the regulations cover lean techniques for all types of projects and are formally monitored for compliance. This could be supported by government lean project incentive schemes, as observed in other countries, including the USA, UK and Australia. This may also motivate contractors who practice and comply with the existing lean requirements to continue their approach. Moreover, it may motivate them to act as motivators for organizations that do not. The government should promote the use of lean techniques and their environmental benefits directly with contracting staff via toolbox meetings and staff training programs. This would help change workers' attitudes and behavioral intentions, thereby creating a favorable disposition to the use of lean techniques during the project execution stage.

The objective of this study was to conduct an empirical analysis for assessing the applicability of lean practices through the survey questionnaire method, which was achieved by applying several statistical analyses.

6.2 Limitations and future research

Overall, the study determined that the construction industry in the UAE has held back the implementation of lean practices. Specifically, the most significant barrier that can be found from the responses is a lack of a long-term managerial philosophy to introduce and implement lean culture in the organization. Williams (2016) concluded that to overcome the barriers of implementing lean practices, establishing a long-term lean philosophy and developing a lean culture are of paramount importance for firms embarking on the lean journey.

Further research on lean practices should be encouraged to establish the main drivers of lean construction and sustainability and develop a conceptual framework to evaluate the lean implementation efforts and the benefits of the lean approach in sustainable construction and focus on areas for improvement. Consequently, the contribution of lean construction techniques to sustainable construction cannot be over-emphasized.

This study has certain limitations, which provide avenues for future research. First, this study included a sample size of 215 responses from construction industry professionals, which is fairly low. This sample size could be expanded in future studies. Second, the data were collected from various categories of the construction industry, such as small, medium and large firms, which apply different project management procedures. The lean practices within each construct are assumed to have similar effectiveness in almost every construction firm because their purposes are similar; however, different values may apply to different firms, depending on their context. Therefore, for better results, similar categories of the construction industry should be considered collectively in specific data analyses. Third, lean practices should be communicated clearly to respondents, as many of them are applying it without realizing that they are using lean practices.

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