Barriers in the way of implementing lean construction in the UAE – Potential solutions from the Swedish context

Master's thesis in Master Programme Design and Construction Project Management (DCPM)

WAJAHAT ALI

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022
www.chalmers.se

MASTER'S THESIS 2022

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WAJAHAT ALI

Supervisor: Dimosthenis Kifokeris
Examiner: Dimosthenis Kifokeris, Architecture and Civil Engineering

Master's Thesis 2022
Department of Architecture and Civil Engineering
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone +46 31 772 1000

Printed by Chalmers Reproservice
Gothenburg, Sweden 2022

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WAJAHAT ALI
Department of Architecture and Civil Engineering
Chalmers University of Technology

Abstract

Today, the construction industry has become highly competitive worldwide, demanding that organizations improve their efficiency by reducing waste, time & cost and maximizing production. Therefore, the companies are trying to change their working pattern by adapting new production philosophies, tools, and techniques. The lean construction production management approach has widely been used in many countries for design & construction production, and benefitted from this phenomenon. Research shows that lean implementation varies geographically; some countries started the lean journey a long time ago, while somewhere, it is at the initial or middle level of implementation. This study will investigate the lean implementation barriers in the UAE construction industry and view them with a Swedish lean lens to develop the potential solutions to identified barriers. It is not about tools and techniques that limit the lean implementation because they are present; it is about identifying barriers that hinder implementation. This study is based on a comprehensive literature and empirical study, in which the literature data has been collected from scientific articles, reports, and web pages. The literature captures the concept of lean, tools, and techniques used for lean implementation. It later more preciously captures the barriers in lean adaptation at the industry level in UAE. While the empirical part is based on semi-structured interviews with the lean practitioners from Sweden and the UAE, which cover the current stage of lean implementation at the industry level, barriers, and potential solutions to highlighted barriers. Research identifies nine different barriers to lean implementation, including nature of the industry, multiple stakeholders involvement, behavioral or cultural issue, financial issue, managerial issues, lean awareness or lean knowledge, communication issue, organizational issues, and type of contract. While the empirical studies highlight the countries' current standing on lean construction, they present the barriers that show synergy with the barriers highlighted in the literature, afterward presenting the possible potential solution to identified barriers. The research conclude that, industry needs to develop a standardized working framework, build long term relationships with stakeholders, initiate pilot activities or projects, develop in-house capacity for multiple facilities, initiate training and skill development, promote innovation & change culture, gender diversification within the industry, increase R&D, set KPIs for assessment of improvements, standard and transparent communication model, follow international standards, make long term contracts and develop strategic & trustworthy relationship. This study presents a layout for the organizations by viewing the barriers and how to overcome them in order to smooth and effective implementation of lean construction tools and techniques.

Keywords: *Barriers, UAE, Sweden, lean construction, potential solution*

Acknowledgement

First and foremost, I would like to thank my supervisor **Dimosthenis Kifokeris** for his continuous support and valuable guidance throughout this thesis.

I would also like to thank all the lean construction experts from the Swedish construction industry, first of all, **Jimmy Dahlström**, chairman of lean forum bygg(Lean construction forum), Sweden, for his valuable insights on the topic, and **David Baumann from JM** and **Fredrik Anheim from Anebyhusgruppen** for providing the relevant information about the thesis. I would also like to express my gratitude to the **Tareq Qazizadeh** – Lean Engineer at Engineering Contracting Company(ECC) from UAE, for presenting the current situation regarding lean implementation in the industry. The author would also thank all the Architecture and Civil Engineering Department members at Chalmers.

Last but not least, I would like to acknowledge and be grateful to my family and friends who encouraged and supported me throughout this journey till the end. Thank you all!

Wajahat Ali, Gothenburg, June 2022

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Abbreviations:

LC: Lean Construction
UAE: United Arab Emirates
KPIs: Key Performance Indicators
TPS: Toyota Production System
LPS: Last Planner System
IPD: Integrated Project Delivery
LFB: Lean Forum Bygg
BIM: Building Information Modeling
ECC: Engineering Contracting Company
ANE: Anebyhusgruppen
SDGs: Sustainable Development Goals
R&D: Research and Development
ECI: Early Contractor Involvement
ISO: International Organization for Standardizations

1 Introduction

The Construction industry has become highly competitive all around the globe and contributes effectively to the gross economy (Small, Al Hamouri, & Al Hamouri, 2017), due to which companies are focusing on improving their production and minimizing wastage at all levels (Shurrab & Hussain, 2018). Construction organizations are being challenged in two ways; the challenging environment of the industry (Shurrab & Hussain, 2018) and the ever high demand from the client to finish the project with greater efficiency in terms of time, cost, and quality (Watfa & Sawalha, 2021). While traditional project management practices are inadequate to cope with modern-day challenges and handle the highly complex projects, which ultimately cause different types of waste, i.e., overproduction, high project lead time, defective processing method, rework and waste of resources (human, material, mechanical) (Ansah, Sorooshian, Mustafa, & Sciences, 2016). As a result, the industry causes time and cost overruns; according to the Lean construction institute(2014), about 57% of production time waste is found in the construction industry, while it is only 12% in the manufacturing industry (Ansah et al., 2016). Moreover, according to Mckinsey(Institute, 2017), the labor productivity growth in the construction industry has been about 1% per year in the last two decades compared to 3.6 percent in the manufacturing industry. According to (Koskela, Howell, Ballard, Tommelein, & value, 2002), the industry produces around 40% of wastage globally, demanding some robust measures from global and local communities. Therefore, there is a dire need to improve the industry strategically to decrease the lead time, which ultimately leads to less cost. In the construction sector, two types of waste are being produced *(i)* demolition or end life waste(material waste) *and (ii)* waste in the production phase(human, material, time, potential, etc.); the first type can avoid through methodologies, i.e., circular economy while, the second one can avoid through adaptation of new construction management strategies like lean construction (Koskela et al., 2002).

The lean construction(LC) concept introduced by Koskela(1992) is based on Toyota's production model(TPM); the foundation of this concept rests upon the three harmonizing pillars, Transformation(T), Flow(F), and Value(V) generation (T. S. Abdelhamid). Later, over the years, different themes and approaches developed by different researchers strengthened the foundation of this notion (Tzortzopoulos, Kagioglou, & Koskela, 2020). Lean construction(LC) defines as "*the production method which helps to minimize the wastes(material, time and efforts) and maximize the value for the customer*," according to the Lean Construction Institute(Small et al., 2017).

As mentioned above, conventional management methods cannot deal with the present day's industry challenges; therefore, the industry demands more robust management methods that minimize the waste and create the proper value for the customer (Ansah et al., 2016). Lean construction adopts the principles of lean thinking or lean production, where the ultimate goal is to attain maximized value, minimize waste and pursue perfection (Al-Aomar, 2012). The lean approach distinguishes itself from other conventional management practices because it focuses on the process which creates value for the customer, designing a collective production system having all stakeholders on board, an integrated delivery system, product, and process design together, whole project lifecycle consider in the design, interests are aligned, activities are performed at last possible moment(Ansah et al., 2016; Ballard & Howell, 2003). Moreover, the lean construction strategy creates value by eliminating non-value adding activities and waste throughout the project life cycle(design, construction, and demolition). It applies the pull strategy instead of push, based on the actual demand(Bajjou, Chafi, & En-Nadi, 2017). The planning and coordination in the lean environment involve all the stakeholder's collaboration, creating a learning environment, solving the

problem through cooperation, leading them to continuous improvement as an organization, and the performance evaluated on PPC(percentage of promise completed)(Bajjou et al., 2017).

The lean construction(LC) trend varies geographically regarding research and practical implementation at the industry level (Engebo, Drevland, Lohne, Shkmot, & Laedre, 2017). According to(Small et al., 2017), lean construction topic has been researched, promoted, and implemented more in the western world over the last three decades, while some countries(i.e., UAE) although having very dynamic, impactful, and vibrant construction industry still lacks in order to fully benefit from this phenomenon. Different studies reveal that similar barriers have been seen in lean implementation at the organizational level to industry. However, some countries have gone through them years ago and attained a high level of maturity, while others are at the initial or middle level in the lean journey (Engebo et al., 2017).

1.1 Statement of purpose, aim of the project

This study aims to identify and analyze current lean implementation barriers in the UAE construction industry reported in the literature and the construction practitioner faces. Several studies have been made to identify different lean barriers and possible solutions in different countries (Sarhan, Fox, & Review, 2013); this study is unique because it reviews the lean construction barriers of one country through the lens of other. It aims to propose some robust solutions to the highlighted barriers in the literature and then propose the best possible potential solution propose by the Swedish lean practitioner.

Research Question

1. Identify lean construction(LC) implementation barriers in the UAE construction industry?
2. View the identified barriers in the context of the Swedish construction industry, and present the solutions to overcome these barriers?

1.2 Research work and sustainable goals

Construction researchers around the globe are working to transform the AEC industry to make it a more sustainable sector and develop different strategies and tools to make it more sustainable environmentally, socially, and economically(Marhani, Jaapar, Bari, Zawawi, & Sciences, 2013). According to(Carvajal-Arango, Bahamón-Jaramillo, Aristizábal-Monsalve, Vásquez-Hernández, & Botero, 2019) , lean construction shows strong synergy with sustainable construction in different aspects, i.e., waste reduction, improvement of working environment, health and safety, value maximization, energy consumption minimization, contentious improvement, and cost reduction, etc. Lean construction and sustainable construction are interdependent; initially, lean construction aims to minimize waste and maximize production to gain economic benefit, but at the broader scale, these gains are interconnected with other pillars of sustainability, environmental and social aspects (Carvajal-Arango et al., 2019). The future of lean construction is associated with the standardized structured implementation policy; it should be linked with sustainability measures (Francis & Thomas, 2020).

The research topic directly or indirectly relates to many sustainable development goals(SDGs) settled by the organization of the united nations organization (UNO)(United nations).

- It ensures sustainable consumption and production pattern(SDG#12)
- Lean construction's primary targets are to make the production efficient by eradicating the wastage and help to form a decent working environment on the site(SDG#8)

- Backed the industry innovation and infrastructure improvement in a more sustainable way(SDG#9)
- A comparative study about lean helps countries advances with equality (SDG#10).
- Moreover, in the longer run, it helps to achieve good health ultimately and well-being(SDGs#3)
- Affordable and clean energy(SDG#7),
- Industry, form a more sustainable society (SDG#11)
- Combat and mitigate the climate changes with its sustainable approach (SDG#13).

2 Methodology

The study is based on two different parts; literature study and empirical studies. The data has been collected through a systematic literature search because it helps identify the most relevant data and eliminate the rubbish. The study was conducted by using the deductive approach. First, basic literature research has been conducted to check the level of maturity of lean construction in Sweden and UAE, which shows the gap in lean implementation between both countries. Literature reports various barriers in the way of successful implementation of lean in UAE; therefore, the research later focused more identification the barriers in UAE, where the lean application is relatively new compared to Sweden, later viewed the solution of barrier with Swedish lean construction practitioner.

After the first literature search, the second round was more focused and pinpointed the barriers. Initially, the research questions were formulated, identifying the different keywords; different search strings were developed based on the keywords and their synonyms. Use the formed string in different search engines; Chalmers Library, google scholar, and Scopus. Keywords used: *Barriers, Dubai, UAE, Sweden, lean construction, potential solution.*

The literature material considered during the search is both academic and grey(reports and web pages). After the second round of literature search has more relevant and research more concentric to research questions, start with the literature studies during the literature review, two more rounds of literature study take place by using backward snowballing and citation techniques to get more precise relevant literature. In total, the literature search process is based on four different rounds. Initially, the literature was considered from the UAE region; the study took place in different emirates of UAE and identified more than sixty different barriers reported in the literature; later, the grouping technique was used to accumulate the similar kind to barriers reported in different papers. After the group techniques, nine main barriers were identified to take them for empirical study, which covers several other associated barriers. Later, these barriers were analyzed through the international literature for two reasons; first, limited literature available regarding the reasons behind the identified barriers in UAE. Secondly, strong synergy has been seen between the identified UAE's barriers and other international comparative studies regarding barriers.

The second part is based on an empirical study, where four semi-structured interviews were conducted with the key practitioners of lean implementation from both the Swedish and UAE industry. A strategic approach has been used to select suitable interviewees. First of all, contact an independent forum(Lean Forum Bygg) working for lean construction promotion in Sweden and act as a bridge between industry and academic research to get their perspective on lean construction in Sweden and view the solution to identified barriers. This forum is run by a board that consists of representatives of different companies from all over the country. The interview was conducted with Jimmy Dahlström, the chairman of lean forum bygg(Lean construction forum). Later, the second interviewee was selected on the recommendation of lean forum bygg, which applies the lean at the operation level more comprehensively and claims that they are a lean practitioner. The company recommended by the Lean forum bygg was JM; the second interview was conducted with a representative of JM, who is the head of logistics at JM, David Baumann, and actively involved in lean implementation policy-making and application. He has experience in the construction and manufacturing industry(Scania), which helps the company replicate the lean model in construction. Third, the interview was conducted with the CEO of Anebyhusgruppen, Fredrik

Anaheim; Anebyhusgruppen is a house construction company working for sustainable construction, reducing waste, and improving the efficiency. The interviewee has around 40 years of field experience and was involved in a lean implementation with NCC in late 2000.

The fourth interview was conducted with a UAE construction company, Engineering Contracting Company(ECC), for two reasons; the first company applies lean construction to its project in UAE and is recommended by the Lean gulf Institute(LGI). The interviewee, Tareq Qazizadeh, is a lean engineer at ECC and has been involved in lean implementation since the company started its lean journey in 2018; moreover, he faced different as a lean engineer, especially at the beginning of the transition phase.

3 Theoretical Section

3.1 Literature Review

3.1.1 Lean

Overall, the lean journey started over a century ago when Henry Ford presented the assembly line principle in the car manufacturing industry. Later, in the 1950s, Toyota developed the lean production management principles and developed the well-known Toyota production system(TPS), which aims to transform the industry to improve the quality and maximize the value by waste elimination during the production process(Sarhan et al., 2013) (Dekier, 2012). Though the lean principles were started establishing in the early 1900s, but the "lean" term was introduced by John Krafcik in 1988 while working with his team at the International Motor Vehicle Programme at the Massachusetts Institute of Technology(MIT), where the TPS management style was labeled as lean production and differentiate it from conventional production model(Krafcik, 1988). Later, the TPS philosophy was started termed as a "lean production" system, which defines as the philosophy, which helps "to minimize the waste and maximize the production."

3.1.2 Lean Construction

The lean concept bought in the construction industry by Koskela in 1992 presented a new paradigm to enhance the quality, minimize the wastage and maximize the productivity in the industry to create the better value for the customer(Dekier, 2012). This phenomenon has gained the attention of construction researchers and practitioners worldwide, several tools and techniques are being developed, and the concept is still evolving. Lean construction gained great attention within the research community because the traditional project management methods (work breakdown structures, critical path method, earned value, etc.) cannot manage the modern day's complex projects and lead them towards failure in terms of time, cost, and quality(T. Abdelhamid, El-Gafy, & Salem, 2008). According to (Koskela et al., 2002), the failure of conventional methods is due to the discrepancy between their conceptual framework and the observed reality of the project, shows a lack of robustness, and demands a more robust construction management model(T. Abdelhamid et al., 2008). This mismatch between the existing practices and the actual project condition is avoided by implementing a lean strategy, which provides flexibility, reduces lead project time, accelerates the processing, increases profit, and creates value for the customer(Shurrab & Hussain, 2018).

3.1.3 Lean Manufacturing vs Lean Construction

As mentioned above, the lean concept initially originated in the manufacturing industry and performed well in waste reduction during the production process (Kanafani, 2015). According to (Salem, Solomon, Genaidy, & Minkarah, 2006), the construction industry is unique from other industries because the projects are complex, distinctive, dynamic, involvement of multiple stakeholders, on-site production, and, most importantly, overlapping activities, instead of separating each activity like the manufacturing industry. Moreover, the overall environment in a construction project could vary instantly, i.e., weather conditions, soil type, client change, and change in scope, sometimes demanding to change the whole plan and create a unique condition for the managers(Salem et al., 2006). These conditions make the construction industry unique from other industries, i.e., manufacturing, healthcare, etc., and a more dynamic framework that copes with construction concentric challenges (Kanafani, 2015).

Along with a lot of encouragement about the lean implementation, there are several critics also reported in the literature, which mainly related to the difference of nature of construction project to the manufacturing project; moreover, the lean principle also primarily focused on the saving to make the process cost-effective instead focus on customer value creation. Another criticism is related to the involved human resource in the transformation process; researchers believe that lean production allows tightening the grip on the workers by too much control and observation and taking the workers' autonomy instead of providing them the freedom of work. Moreover, the organization applying lean typically forms a high level of compliance on staff and continuous surveillance. It expects too much from the team regarding performance efficiency, working hours, and overtaking individual freedom(Kanafani, 2015).

3.1.4 Tools and Techniques

Lean philosophy is developing; research focuses on developing tools and techniques because lean is a very dynamic concept that applies at all levels. Though the whole concept of lean is broad, while researchers try to formulate it, (Salem et al., 2006) attempted to develop the scope of lean and highlight the associated techniques and the requirements and criteria to make the changes.

The first component of lean scope is flow variability, which highly affects the project's whole production and stresses maintaining the flow of the process. The last planner system is the highlighted technique to keep the flow, which helps maintain the flow of the process. The last planner system is a technique that makes the whole process transparent where everyone involved can assess the entire working schedule and the roles defined in it. Through LPS, all the associated parties could see ahead working plan and coordinate the interdependent activities. It helps to quality, knowledge sharing, and effective communication among the involved stakeholders within the projects. It is also considered the reference for future projects if something deviates from the set standards.

The second component of the defined scope by (Salem et al., 2006) is process variability, through which “fail-safe for quality technique” which means to ensure the check quality and safety on the job site, in the construction industry for onsite production, the operational efficiency is crucial because of it expensive rework and sometimes the operations are done, hard to view such as placement of reinforcement after concreting.

Transparent operation is key to success in construction operation to keep updated with the right information at a suitable time; therefore, 5S and developing the visual communication channel would be effective for transparency (Salem et al., 2006).

The last component of the defined scope is based on continuous improvement; for improvement, two techniques are used huddle meetings with all the stakeholders and detailed discussion on the issues and keeping in contact during the particular activities. Secondly, the first-run technique could be used based on PDCA; plan, do, check, and act. It means planning a work process first, applying it for the first run, checking its validity, and acting on where to take the staff into confidence for specific changes and improvement.

Scope	Technique	Requirements	Criteria/change	
Flow variability	Last planner	Reverse phase	Pull approach	↑
		Scheduling	Quality	↑
		Six-week look-ahead	Knowledge	↑
		Weekly work plan	Communication	↑
		Reasons for variance	Relation with other tools	↑
		PPC Charts		↑
Process variability	Fail safe for quality	Check for quality	Actions on the job site	↑
		Check for safety	Team effort	↑
			Knowledge	↑
			Communication	↑
			Relation with other tools	↑
Transparency	Five S's	Sort	Action on the job site	↑
		Straighten	Team effort	↑
		Standardize	Knowledge	↑
		Shine	Communication	↑
		Sustain	Relation with other tools	↑
	Increased visualization	Commitment charts	Visualization	↑
		Safety signs	Team effort	
		Mobile signs	Knowledge	↑
		Project milestones	Communication	↑
		PPC charts	Relation with other tools	↑
Continuous improvement	Huddle meetings	All foreman meeting	Time spent	↓
		Start of the day meeting	Review work to be done	↓
			Issues covered	↑
			Communication	↑
			Relation with other tools	↑
	First-run studies	Plan	Actions on the job site	↑
		Do	Team effort	↑
		Check	Knowledge	↑
		Act	Communication	↑
			Relation with other tools	↑

Figure 1: Lean Construction Tools(Salem et al., 2006)

Since the lean concept adaptation in the construction industry, many lean tools and techniques have been developed, which show significant success in the manufacturing industry. However, now implementing these techniques helps construction organizations improve their work efficiency and productivity. Below mentioned tools and techniques are widely used in the construction industry and benefit it.

Table 1: Lean Construction tools and techniques

Lean tools/techniques	**Definition**	**Benefits**	**References**
5S	5S is a systemic working pattern, which means sort, strengthen, shine, standardize and sustain the working processes.	Systematic work flow, eliminate the waste	(Bajjou, Chafi, & Technology, 2018) (David MacKay, 2020)
Last planner system	The last planner system(LPS) is a tool developed by the lean construction institute which helps improve project efficiency and	Detailed plan of each task and individual Improve productivity & efficiency	("Last Planner System (LPS) and the Construction Industry," 2018) (Bajjou et al., 2018)

	productivity by controlling workflow and decreasing variability.	Develop master, phase and weekly schedules	
Poka Yoke	Poka-Yoke is a Japanese word that means “mistake-proofing,” This technique in lean helps to avoid mistakes and defects in the production process.	Waste reduction, mistake proofing, improve construction quality, safety at sites	(Tommelein, 2008) (Bajjou et al., 2018)
Visual Management	Visual management is an essential loon tool that helps to improve visualization among the stakeholder involved in the project. It also improves communication, transparency, and the effectiveness of the project.	Effective communication, reduce changes. Improve visualization through standard sign, symbols and visual billboards.	(Singh & Kumar, 2021) (Bajjou et al., 2018)
First run studies	Plan-Do-Check-Act(PDCA) is an improvement cycle based on planning the change, implementing it to check the effectiveness, and taking action if further improvements are needed.	Continuous improvement, identification of problem, develop the solution, standardized the possible solution	(Salem et al., 2006) (Blog, 2015)
Building information modelling	Building information modeling (BIM) is a process supported by various tools and techniques to represent places and objects' physical and functional characteristics digitally. Initially, both lean and BIM were considered separate, but later strong synergy was seen between them. Now BIM is considered the lean tool that helps minimize waste and maximize production.	Improve efficiency, remove waste, minimize rework, better collaboration,	(ANDÚJAR-MONTOYA, GALIANO-GARRIGÓS, RIZO-MAESTRE, & ECHARRI-IRIBARREN, 2019) (Salem et al., 2006)
Just in time(JIT)	Just In Time(JIT) is a delivery and production management method used to ensure the right material is available at the right	Continuous flow, remove waste. One the prime example of JIT in construction is ready mixed concrete.	(Salem et al., 2006)

	time at the construction production site.		
Kanban System	Kanban is a visual management method used to control the production, visually representing the production flow, which shows what, when, and how much is to be produced.	Work flow prediction, safety control	(Jang & Kim, 2007)
Standardization	Standardization is one of the core methods for lean implementation, which sets the fixed practices, and working pattern and reduces variation in working methods.	Minimized the wastage, improve efficiency, continuous improvement	(MÍkva, Prajová, Yakimovich, Korshunov, & Tyurin, 2016)
Value Stream mapping(VSM)	Value stream mapping(VSM) is a lean production technique used to visualize the value stream in the production process and eliminate the waste from the process	Eliminating the waste in form of over production, repetition and non-valued activates, objects or other resources.	(Pasqualini & Zawislak, 2005) (Salem et al., 2006) (Bajjou et al., 2018)
Five why's	Five why's is a problem-solving technique used for root cause analysis of the problem.	Root cause analysis of problem and its mitigation	(Bajjou et al., 2018)
Pre fabrication	Pre-fabrication of construction components would help to minimize the on-site wastage and reduce the production time.	Improve output quality, increase safety, less variation in processes	(Bajjou et al., 2018)

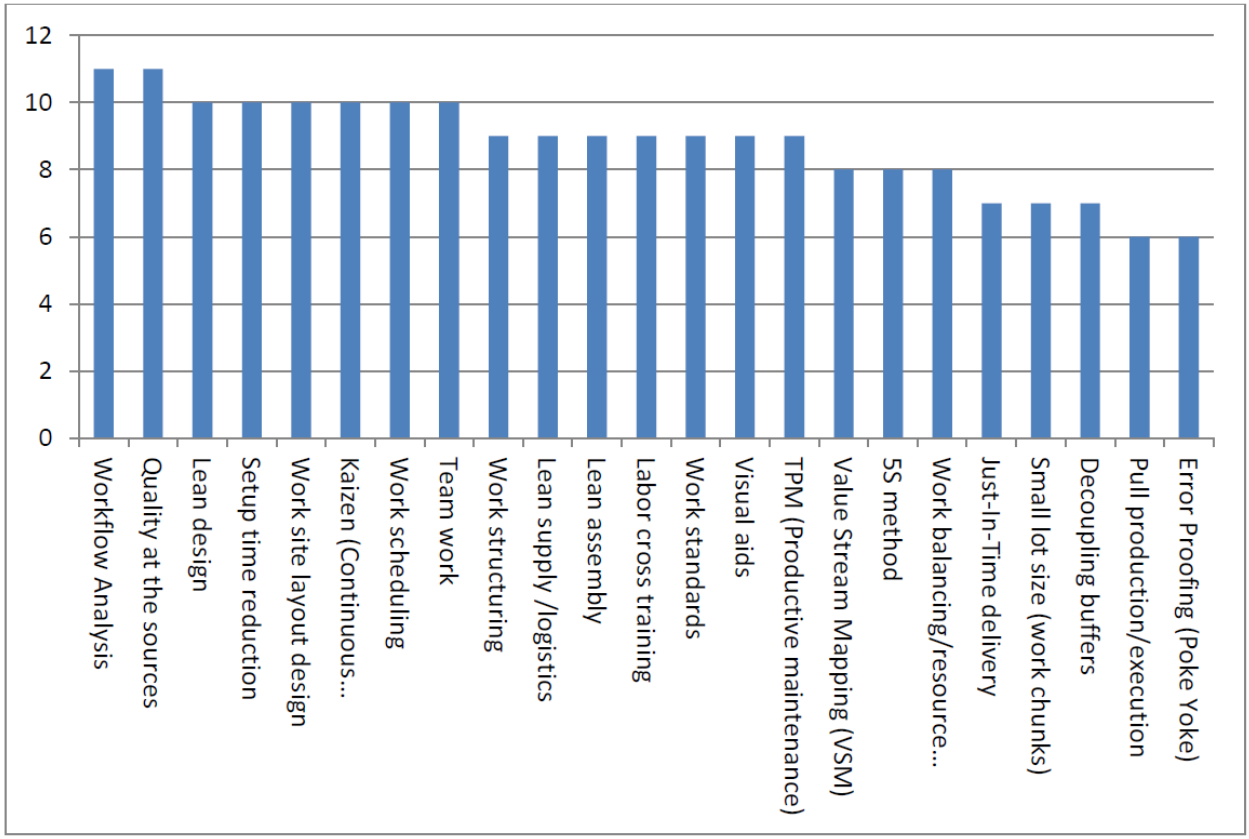

Figure 2: Bar diagram of lean techniques used in UAE (Al-Aomar, 2012)

An empirical made by (Al-Aomar, 2012) about the lean practice implementation within the UAE construction industry, the above bar diagram represents the use of lean techniques from higher to lower levels. At the top, the practitioner uses these for workflow analysis, quality check, lean design, etc. An important point to mention here is that this study was made in 2012, while the first company applied full lean in 2018 in UAE; the reason is that before it, the companies used these techniques for one or two operations rather than applying lean as a whole.

3.1.5 UAE Construction and lean

The construction sector has played a pivotal role in the UAE's economy in terms of GDP growth and employment opportunities within the country (Cherian, 2020; Shurrab & Hussain, 2018). In recent decades, the country has seen a construction boom in infrastructure development, including roads, highways, highrise buildings, airports(transit hub), parks, resorts, and hotels (Cherian, 2020). These projects bring foreign direct investment to the country and attract the world to the country for travel and tourism purposes (Cherian, 2020).

Such a dynamic construction industry in UAE would potentially achieve a certain level of improvement through lean implementation. It would help reduce the waste produced and ultimately also impact the whole economy of the country(Small et al., 2017). Moreover, (Small et al., 2017) also highlight that the application of lean construction in the dynamic construction industry, I.e., UAE, is limited compared to

Western countries. In addition, (Al-Aomar, 2012) also mentioned that the application of lean techniques and type of waste produced in the UAE construction industry may vary from other countries. However, in the following study, the highlighted barriers are generalized and observed around the globe in different literature studies.

Table 2: Waste identified in UAE construction industry(Al-Aomar, 2012)

Correction	Over-processing	Delay	Inventory	Conveyance	Over-production	Motion
Repair Work	Long Approval Process	Late Work Delivery	Damaged Material	Transport Time	Idle periods	Labor Moves
Equipment Breakdown	Clarification Needs	Activity Start Delays	Excess Materials	Material Handling	Excessive Space	
Work Defects	Excessive Safety	Work Interruptions	Pilferage			
Rework/ Re-run	Excessive Training Time	Ineffective Work				
Design Errors	Excessive Supervision					
Execution Errors	Excessive use of Equipment					
Retest Work	Overqualified Resources					
Uncompleted Work						

The study (Al-Aomar, 2012) identified 27 waste types in the UAE construction industry and then further categorized them into the seven related categories; correction, over-processing, Delay, inventory, conveyance, over-production, and motion. Having these wastes, the lean philosophy could positively affect waste reduction, which ultimately leads the project execution with better efficiency.

3.1.6 Barriers in lean implementation in UAE

The lean construction concept has been studied and implemented worldwide, and several frameworks based upon different tools and techniques have been developed for lean implementation (Engebo et al., 2017). Despite these frameworks, tools, and techniques, the implementation is not uniform around the globe; therefore, it is more important to highlight the barriers wherever they are and present the solutions to apply these developed tools and techniques effectively(Engebo et al., 2017).

A thorough literature review has shown several common barriers to implementing lean construction practices globally (Bajjou et al., 2017; Kanafani, 2015; Small et al., 2017). The study also revealed that lean construction(LC) implementation barriers are mostly linked with the company's management commitment and active participation from all the stakeholders rather than labeling these barriers to countries concentric(Ayarkwa, Agyekum, Adinyira, Osei-Asibey, & Innovation, 2012; Kanafani, 2015; Sarhan et al., 2013). Moreover, according to (Watfa & Sawalha, 2021), companies need to understand the barriers before the start of their application to avoid failure in the end; therefore, they are recommended to first identify the barriers or gaps before starting the lean journey. According to (Sarhan et al., 2013), both the developing and developed countries show similar barriers to lean implementation. These barriers are different; some are cultural, while others are structural, and some are combined (Small et al., 2017). Following are the most common barriers identified through the extensive and comprehensive literature review of the UAE construction industry. Then, the identified barriers are categorized in the following headings. The identified barriers are analyzed through the literature around the globe; to highlight the reasons behind the identified barriers.

3.1.6.1 Nature of the industry

Research shows consensus in identifying the uniqueness of the construction industry; unlike the manufacturing industry, most of the projects in the construction sector are unique, complex and non-standardized(Ayarkwa et al., 2012; Kanafani, 2015). According to (Kanafani, 2015), the main reason behind the barriers to applying lean construction principles is variation in features between the construction and manufacturing industries.

In the manufacturing industry, the product market lifecycle is sufficient to develop specific research and development capabilities; in contrast, construction projects have a relatively less product life cycle (Salem et al., 2006). Consequently, this causes the lack of interest of stakeholders to invest in research and development, loss of the capacity for innovation, and move the traditional practices through which the industry lacks to compete with the national and international competitors(Salem et al., 2006).

According to Aomar, another aspect that makes the construction sector unique from manufacturing is hidden costs during the production phase, which leads the project towards a loss or tightens the profit margin (Al-Aomar, 2012). In the construction industry, multiple stakeholders are involved, unlike in the manufacturing industry; therefore, poor communication causes hindrance to the way of effective application of lean construction philosophy in the industry(Ahmed, Sobuz, & Environment, 2019; Kanafani, 2015). The organization of a construction project also varies from manufacturing product, where the project is one-of-its-kind, temporary organization and on-site production; moreover, the organization of parties working on a construction project is short-term, weak, and tentative; in contrast, efficient and effective relation of stakeholders in the steady production unit of manufacturing(Albalkhy & Sweis, 2020).

3.1.6.2 Multiple stakeholder involvement

The construction industry is fragmented because the projects are complex and unique, demanding separate subcontractors having specialty to perform specific tasks (Ayarkwa et al., 2012; Dulaimi & Tanamas, 2001). Therefore, the multiple sub-contractors are involved in the complex nature of the project; moreover, the project activities are interrelated and dependent on each other. Therefore, the subcontractor and the main contractor relationship is crucial, demanding more cooperation and transparent coordination(Small et al., 2017). According to (Small et al., 2017), effective relationships between the sub-contractor and the main contractor should be essential throughout the project lifecycle because lean views the project as a whole rather than individual activity, which demands a smooth workflow from the top to bottom and integration in the tasks.

While (Watfa & Sawalha, 2021) view this barrier from a different perspective, though the main contractor provides the mandatory training about lean to their staff but in, the cluster of different stakeholders who do not know about lean became a barrier in the way of lean implementation; as a result, the attempt of lean implementation from the main contractor becomes useless. Since the different subcontractors are involved in the later stage of projects, they do not know the contract conditions about the budget given by the client to the main contractor; ultimately, they do not get the fair share to implement the lean(Sarhan et al., 2013). Therefore, the relationship between the main and subcontractors should be smooth, long-term, and have enough knowledge about lean principles, better coordination and communication, early involvement in the project, and an integrated work implantation plan (Albalkhy & Sweis, 2020). Moreover, subcontractors should have to schedule their activities on a broader scale in relation to other subcontractors and the main contractor to make the lean production smooth and continuous (Salem et al., 2006).

3.1.6.3 Behavioral or Cultural Issues

Implementing lean within the organization demands changes to adapt the lean principles and benefit from them. According to (Small et al., 2017), implementing lean construction within the UAE construction industry requires a cultural change in the working process; moreover, deficiency of performance measurement and reward system also hinders the lean implementation (Kanafani, 2015). According to (Kanafani, 2015), the UAE construction industry lacks to adapt to the change and innovation culture. Management and workers do not proactively present their opinions and loss their spirit to change.

According to Watfa, the prerequisite to successfully implementing the lean developed the culture of change management and considering the employees from top to bottom in the decision making process for continuous improvement. Management needs to encourage and motivate them for their active participation, which is key to the smooth implementation of lean (Watfa & Sawalha, 2021). In the construction industry, workers usually avoid being part of problem-solving like in the manufacturing industry, which may be due to their belief of lack of self-confidence or self-knowledge. So, human attitude issues and resistance to changing the culture are the main reasons for the successful diffusion of lean construction (Small et al., 2017; Watfa & Sawalha, 2021). According to small(Small et al., 2017), there should be a proper training and skill development plan at all the levels of the organization; though it is difficult to change the multicultural environment(multicultural workforce and language barrier) of the UAE construction site but the ultimate benefits are valuable(Al-Aomar, 2012). Moreover, invite the lean specialist and experts in the system, especially at the beginning of the transition phase, because the beginning of the change process is crucial (Al-Aomar, 2012). Last but not least, always try to involve the workforce to participate in the change process effectively and ensure them their job security which leads

the long term commitment and innovation, because the work pressure, lack of trust, and failure in innovation always prevent them from making changes in their working pattern(Al-Aomar, 2012).

3.1.6.4 Financial issues

The successful implementation of lean requires adequate funding to get relevant tools & techniques and to train the staff (Bashir, Suresh, Proverbs, & Gameson, 2010; Watfa & Sawalha, 2021). The financial capacity of an organization has been reported in the literature as one of the main barriers to the successful application of lean construction (Bashir et al., 2010; Olatunji, 2008; Sarhan et al., 2013; Watfa & Sawalha, 2021). The organizations usually do not have adequate funding to get the lean equipment and hire lean experts or consultants to train the employees to smoothly implement the concept (Al-Aomar, 2012; Bashir et al., 2010). According to (Bashir et al., 2010), the finance issue has been reported as the main barrier within the organizations around the globe, but the reason behind these barriers vary globally; the most common reasons behind these barriers are: inadequate project funding, inflation, implementation cost, low professional wages, lack of incentives, temporary financial policies, market uncertainties and less motivation toward the change, in the case of UAE, there is a need to raise the capital of the project and improve the R&D budget and lean implementation cost should consider as opportunity cost.

3.1.6.5 Managerial issues

Adequate knowledge of management, their commitment, and involvement is crucial in any change process within the organization; likewise, if the management has a mindset of adapting to change can easily implement the lean in their projects(Shang & Pheng, 2014; Watfa & Sawalha, 2021). According to (Abdullah, Abdul-Razak, Abubakar, Mohammad, & Geoinformation science, 2009), top management's lack of commitment and attentiveness is considered one of the main barriers to lean implementation at the organizational level (Salem et al., 2006; Watfa & Sawalha, 2021).

The study by (Ahmed et al., 2019), made the comparison of literature regarding barriers in the way of lean implementation among eight different countries(including developed and developing countries), highlighting that the only barrier of lack of top management interest found in all the countries, including UAE (Kanafani, 2015). Several factors were highlighted as the reason behind the lack of involvement of top management in this change, i.e., lean implementation added the extra cost to the company's budget, showed resistance to change their working pattern, and avoided taking the risk in mega projects(Al-Aomar, 2012). This barrier cause issues related to administrative matters, in other words, matters regarding proper time, funding, training, or other aspects required to reinforce the lean implementation lacks, which fails to apply the new philosophy within the organization(Abdullah et al., 2009; Shang & Pheng, 2014). Therefore, the top management should encourage involvement in the administrative matter, provide proper funding and time, do adequate planning and strategy for customer satisfaction, and engage the workforce in the decision-making and coordination among the stakeholders.

3.1.6.6 Lean awareness or lean Knowledge

The successful implementation of lean requires sufficient knowledge about the philosophy, its principle, and essential tool & techniques at the beginning of its startup. It requires some research on the topic at the top management level to clear the concept moreover basic training about the tools in which the company is interested(Watfa & Sawalha, 2021). Without proper alignment of activities, setting accurate key performance indicators (KPIs) and targets leads the whole process toward failure.

The study by (Bajjou et al., 2018), compared the literature of ten different countries regarding the barriers in the way of lean implementation and ranked the knowledge and awareness aspect at the top and found in all the countries, including UAE. Companies need to start a campaign for human capacity building, train the staff or hire new staff who better understand lean construction and its tools. Sometimes, employees have difficulties understanding the lean, especially the newcomer; therefore, the organizations need to form a comprehensive lean learning mechanism that helps everyone adapt and apply it effectively from the beginning(Abdullah et al., 2009).

An empirical study by (Watfa & Sawalha, 2021), shows the results of the lean awareness at the industry level about lean construction, which shows that 23% of industry representatives were unfamiliar with lean construction. While 49% were familiar with them but did not use them in practice; likewise, 15% and 10% used them rarely and frequently, respectively, in their practices. Only three percent of them are entirely aware of it and always use it in their construction projects, while the number of employees having lean knowledge is even more lesser than the presented figure.

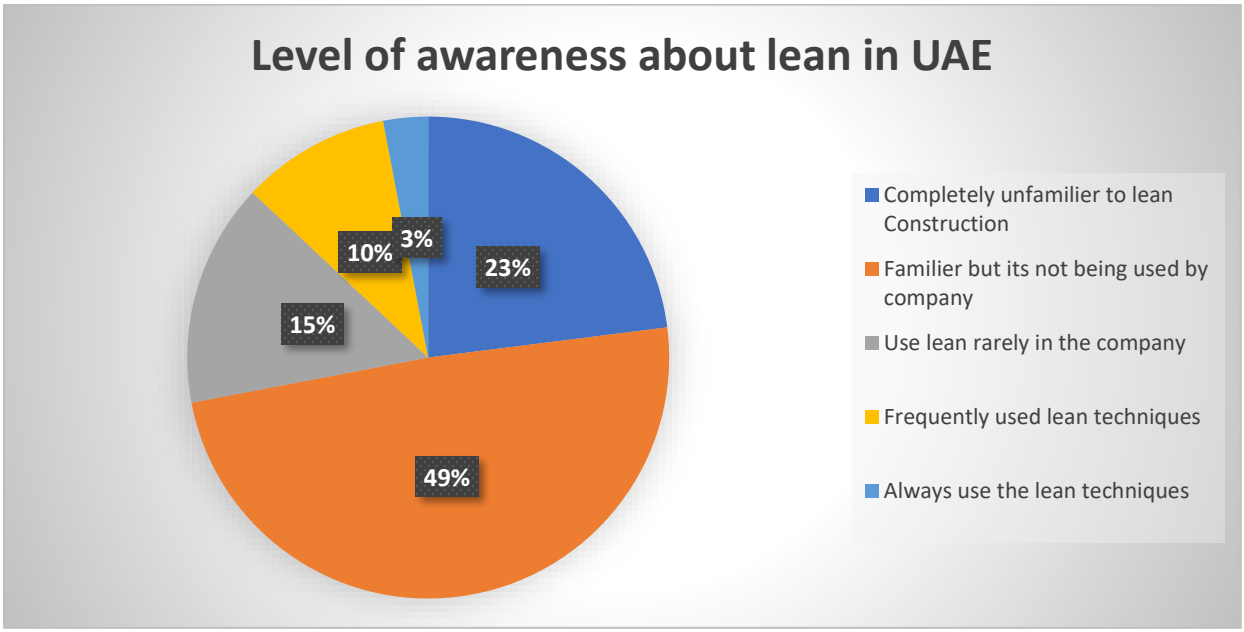

Figure 3: Level of awareness regarding lean in UAE construction industry(Watfa & Sawalha, 2021)

3.1.6.7 Communication issues among stakeholders

Effective lean implementation or any other improvement drive requires a productive and functional communication model to take all the stakeholders, i.e., client, contractor, and consultant, onboard, during the whole project life-cycle (Johansen & Walter, 2007; Kanafani, 2015; Small et al., 2017; Watfa & Sawalha, 2021). Many lean construction tools have been developed to make communication more effective than traditional communication methods (Sarhan et al., 2013). In order to optimize construction production, the utilization of lean communication tools is highly effective in making the process more productive and quality-oriented (Kanafani, 2015). According to (Watfa & Sawalha, 2021), a clear communication model or framework will guide the employees, departments, and stakeholders to keep the momentum high during the lean transformation.

The communication barrier is based on the nature of the industry where different organizations have to work together for a temporary project-based organization; moreover, the breakdown of work in different

groups causes a communication gap, resulting in low productivity and quality. Therefore, the information is scattered rather than collective, making it difficult for everyone to realize their responsibility and hindering the lean concept from reaching its maximum potential(Abdullah et al., 2009).

(Kim & Park, 2006), did a survey within the USA construction firms regarding lean transformation in the industry, which shows that the firms having effective communication and good coordination among the stakeholders makes it easy to adapt the lean concept in their organization. In contrast, organizations with poor coordination strategy and transparency in communication are the most common problem of successive lean performance(Khanh, Kim, & Management, 2013). According to (Ayarkwa et al., 2012), Inefficiencies, mistakes, and poor communication cause around a 30% cost increase in construction projects.

3.1.6.8 Organizational issues

Lean implementation demands change in the organizational working framework from the strategically planned way of working (Watfa & Sawalha, 2021). According to (Watfa & Sawalha, 2021), organizational culture is considered one of the main barriers to lean implementation, also investigated by the researcher in recent times, which shows the organization has the behavior of resisting the change and fear of failure. (Kanafani, 2015), highlights some possible organizational barriers that hinder lean implementation in the UAE, i.e., inadequate organizational culture and structure, inconsistency in the policies, lack of work standardization, and, most importantly, lack of consistent lean implementation methodology.

Literature refers to these issues with organizational inertia where the organizational process is stuck, and people resist change, leading them toward failure. According to the study by (Fernandez-Solis et al., 2013), people's behavior matters in the organizational transformation towards any change. Usually, they claim “this is how I have always done it” and consider that “the best” solution; this challenge ranked top among other challenges. Sometimes, the blame game also causes another problem in implementing the change; employees blame top management and vice versa; this behavior adversely impacts the change process. This issue could be avoided by forming a more robust change management plan within the organization by taking all the stakeholders on board, setting the specific key performance indicator which should update with time, and last but not least, respecting everyone during the whole change process including their opinion.

3.1.6.9 Type of contract and bidding

The contract type is considered one of the main barriers in lean implementation; researchers reported this barrier in different ways i.e., short term contract, less involvement of contractors and subcontractors at the early stage, less preplanning, low tender prices, lack of strategic supplier, lack of integrated procurement and transactional type of contracts(Albalkhy & Sweis, 2020; Ayarkwa et al., 2012; Kanafani, 2015; Shurrab & Hussain, 2018; Small et al., 2017; Watfa & Sawalha, 2021). According to (Shurrab & Hussain, 2018), a long-term contract could be more effective for lean than short term; it allows for good strategic relations with stakeholders and transformation collectively. In lean construction, the role of the supplier is critical because the processes are based upon the material supply; therefore, the relationship between the suppliers and contractors should be long-lasting and trustful(Watfa & Sawalha, 2021).

According to (Watfa & Sawalha, 2021), early contractor involvement could be the best option to create a lean environment because it forms a good relationship among stakeholders, takes main contractor insights in the design stage, and effectively manages risk. Traditional contracts form unfavorable for lean

culture because of the transactional form of contract where the role of parties is reciprocation over the other parties, which causes confrontation between them(Watfa & Sawalha, 2021).]. Therefore, relational design-build contracts suit the most to implement integrated project delivery(IPD) contracts and make the project leaner than the transactional contract type (Darrington, 2011). Moreover, an integrated project delivery report is the most suitable method for lean construction for many reasons, i.e., the multi-party relationship among all the stakeholders, shared risk, and appreciation to meet the cost, time, and other KPIs(Davies).

3.1.7 Effectiveness of lean construction

Overall, the lean implementation journey is long and demands a number of human resources, tools, funds, and time; but the outcome is worthy for the organization. In the world of competition, especially modern days construction industry, the industry could face more challenges related to sustainability, cost pressure, and quality(Al-Aomar, 2012; Small et al., 2017). Therefore, the lean transformation would be helpful to coup modern days and future challenges confronted by the industry. Moreover, adopting this philosophy would help the companies in different ways, i.e., develop new opportunities, improve profitability, productivity, safety, work efficiency, client satisfaction, look schedule ahead, price saving, and improve the market share(Al-Aomar, 2012; Small et al., 2017).

It would also help the organization in cost control, and if there is any deviation in that, the company can identify the deviation and rectify it for the next projects (Salem et al., 2006). It would also improve the transparency within the organization, such the tools like last planner and takt planning where the roles are defined; moreover, it helps to improve visualization among the staff and allow them to take part in the lean process and let them present their opinion on the implementation(Salem et al., 2006). According to (Small et al., 2017), lean would benefit the dynamic construction industry like UAE because it helps to bring remarkable cultural change within the industry (Small et al., 2017).

Continuous development is one of the main specifications of lean construction, which helps the companies avoid organizational inertia and change or transformation always move forward. To make this transition more sustainable and consistent, companies need to develop certain lean construction KPIs. It accesses the rate of achievement and improvement within its operations. (Al-Aomar, 2012), sets the KPIs for different operations during the project implementation at the beginning; these KPIs should be flexible in the beginning and then improve over. These KPIs should be for different waste categories, defects, delays, over-production, moment, cost efficiency, performance, etc.

Moreover, a study made by (Bajjou et al., 2018), makes a comparative study among different projects in different developed and developing countries. It shows similarities among the benefits. The projects that adopt the lean principles achieved more profit with less time, improved the environmental index values, and had less safety issues during the production phase. It helps them improve the construction quality in terms of defect, without reconstruction, and with completion of projects that took place within the settled budget of the projects. Another interesting aspect of this study is, that it shows the comparison of different countries and shows common benefits despite having the different project types(infrastructure projects, industrial housing, commercial building, modular building), which shows that lean would be fruitful for all types of project, rather only label it with a specific type of project, its effectiveness is same for onsite and offsite construction(Bajjou et al., 2018).

No.	Benefits of lean construction	Project type	Country
1.	Lower costs and faster turnoverof construction projects	Infrastructure projects Construction and civil engineering company	USA Sweden
2.	Improving safety of workers	Industrialized housing	USA
3.	Improving the environmental performance	Modular housing plan Residential,institutional, commercial, and others Modular homebuilding	USA Brazil UK
4.	Reducing the total project duration	Residential building project Industrial project Housing units	Turkey Egypt Nigeria
5.	Improving the quality	Infrastructure projects Commercial buildings Infrastructure projects	USA Iran USA

Figure 4: Benefits of lean construction reported in different countries(Bajjou et al., 2018)

This comparative study also reflects that lean could be effective in different projects and multicultural environments, but the ultimate benefits are shared and worthy. In conclusion, the lean concept helps the projects complete with better efficiency, lowering the cost, improving health and safety for the construction workers, meeting environmental standards, and reducing the duration of project completion time.

4 Empirical studies

4.1 Interviews

The empirical study is based on semi-structured interviews with the different lean practitioners to get multi-perspective insight on the topics. Therefore, three interviews were conducted with different industry players: Lean Form bygg (Lean construction forum), JM AB, and the Anebyhusgruppen AB from Sweden. Moreover, one interview was conducted with the UAE construction company, Engineering contracting company(ECC), the first company to apply the lean principles to their projects.

The following three sections, 4.1,4.2 &4.3, explain the background of Swedish lean companies, lean journey, and the interviewees, while section 4.4 explain the UAE's first lean construction company, its lean journey, and interviewee relevance to the topic. Later, section 4.4 presents the barriers to lean implementation and their potential solutions based on interviewees' lean knowledge and industry experiences.

4.2 Interview With Lean Forum Bygg

4.2.1 Lean forum bygg(LFB)

Lean forum bygg(Lean construction forum) is a non-profitable organization that works for lean knowledge sharing and induced a new working pattern in the Swedish construction industry to maximize the value & production and minimize the wastage(Bygg). The lean construction forum identifies research development areas and organizes workshops, seminars, conferences, and training about lean construction practices(Bygg). Moreover, it aims to streamline construction practices by optimizing the project delivery process without compromising quality and forming a bridge between academia and industry regarding lean knowledge sharing.

4.2.2 Interviewee

Jimmy Dahlström — Chairman of board, lean forum bygg Sweden and Head of project at Ramirent

The interviewee has more than ten years of experience as a construction consultant and has been placed in different organizations. He is chairman board of governor at Lean construction bygg and acts as a catalyst to promote lean construction practices in the construction industry of Sweden. Moreover, he regularly writes debate articles on lean construction and is part of different reference groups in the R&D project. Therefore, his insights regarding Swedish lean practices and ways to overcome the lean implementation barriers worth the whole research.

4.2.3 Swedish Lean Construction

The Swedish lean journey started about two decades ago but still does not attain the proper level of maturity like the lean Toyota model. Companies apply some lean practices or tools but still do not develop the mechanism to transform the whole working pattern towards lean. Many companies started their lean journey through digitalization, or some applied lean in logistics; while JM is the only company that applies lean widely in all of their operations, JM is also considered a huge player in lean construction in Sweden. They started their lean journey thinking about the housing shortage in Sweden and initiated the lean journey by standardization of their work.

Although Sweden is far ahead in the lean journey as compared to many countries, but the industry still does not fully benefit from this phenomenon because of different reasons, i.e., housing prices, many discussions about lean philosophy but lack in the application, scattered implementation plans where

companies pick one tool rather apply lean as a whole; and another major trap in which companies fall in about directly go to the tools and techniques without understanding that tool can never be replaced with the processes. Companies apply different tools, i.e., BIM, visual planning, and last planner but do not claim to lean in their operations.

4.3 Interview with JM

4.3.1 JM

JM AB's lean transformation took place in three-phase lean design, lean production, and lean logistics. The company started its lean journey in early 2000 when it realized that the processes have high costs and the company needed to change its operational activities. The company created the journey with work standardization without labeling it as lean. The process was called “structured project planning,” setting standards for operations, modules, design, central sourcing, product, procurement, and dealing with the sub-contractors.

In 2010, the company started with standard production, the standard for house assembly, such as kitchen standards, sequence of activities, quality control, etc. Make the processes more predictable in terms of quality and price. While in 2018, they started with lean logistics in their operations because lean production needs suitable material at the right time and sequence, improving efficiency to reduce waste and keeping the schedule.

4.3.2 Interviewee

David Baumann – Head of logistic at JM

David Baumann has been working as head of logistics at JM and being a part of the company for five years; before that, he worked in the automotive industry for more than 12 years with Scania. David utilizes his diversified experience in the automotive sector and helps the company to implement lean in construction; after all, this whole concept originates from the automotive industry. In fact, the automotive industry is far ahead in lean implementation in its manufacturing processes. He has been an active member of lean logistics implementation since its beginning in 2018.

4.4 Interview with Anebyhusgruppen(ANE)

4.4.1 Anebyhusgruppen AB

Anebyhusgruppen AB is a well-known prefabricated housing company developing detached, group, and volume houses in Sweden. The company has production facilities in different regions of Sweden and is one of Sweden's oldest wooden house manufacturers. It aims to develop a more sustainable world as a housing manufacturer and create a better and more comfortable working environment for the employees.

4.4.2 Interviewee

Fredrik Anheim— CEO Anebyhusgruppen

Fredrik being a part of the construction industry since the 1980s, has worked with NCC for many years and is also part of the development of standardization of working process and industrial construction at NCC. Right now, working as CEO of Anebyhusgruppen AB, which is one of the leading industrial housing production companies in Sweden. The company is applying lean in their working processes by using different technical tools, i.e., 5S, Takt flow, Kanban, pull flow, etc.

4.5 Interview with Engineering Contracting Company (ECC)

4.5.1 Engineering Contracting Company (ECC)

Engineering Contracting Company(ECC) is the first major company that applies lean construction principles to its projects in UAE. It aims to take the excellence in its production by applying lean principles and improving operational efficiency by minimizing the waste that ensures the creation of proper value for the client(Co(ECC)). The company started its lean journey in 2018 by applying the lean on one activity and later expanding it to all work processes, including logistics. The company got tremendous improvement in its pilot activity, which motivated them to increase the scale of transformation from construction activity to project level. ECC aims to standardize all of its processes to become more efficient and set the working pattern for all the projects, which helps to minimize non-value adding activities(wastes) and lead the organization for continuous improvement. Moreover, the company is adopting modern technical tools, i.e., Building information modeling (BIM), on their project to make greater operational efficiency and cost savings at the end(Co(ECC)).

4.5.2 Interviewee

Tareq Qazizadeh – Lean Engineer at ECC

The interviewee has diversified field experience in the construction industry and currently working as a lean engineer at ECC. He has been involved from the beginning of the lean transformation journey at ECC. The journey began with the combination of a lean manufacturing practitioner and construction practitioner, and forming good synergy between them helped them make the lean transformation smoother.

The lean journey started in 2018 with a pilot tiling activity; the company first standardized the whole tiling process starting from the cutting to its placement. Ensure that every working group follows the same guideline and optimize the working process. The success in the initial activity encourages the lean team to wider the implementation circle to other processes. The company applies lean principles with different lean tools to every project, starting from the design phase to the end, including the logistics. The main tools and techniques that the company currently uses are: 5S, value stream mapping, standardization of processes, weekly plan, last planner system, BIM, Kaizen, pull planning, TAKT, etc. Root cause analysis tool by five whys, 4M, A3.

The following section presents the barriers and analyses the identified barriers through the insights of both Swedish and UAE construction lean practitioners.

4.6 Barriers

4.6.1 Nature of the industry

In the construction industry, the project implementation is based on different phases. It needs approval from the relevant authorities, which takes a lot of time, sometimes months or even years, in mega projects (LFB, 2022). Moreover, according to (JM, 2022) manufacturing industry has a specific product where the product or the process can be improved by having a fixed setup, while in the construction sector, the projects are implemented through a temporary setup, where after every project, the place, people and environment has changed (ANE, 2022). In addition (ECC, 2022) also highlights nature as a barrier; the construction industry usually has high capital cost projects, making it hard to build a prototype like manufacturing products.

To make the process lean, the comprehensive lean implementation model must be developed based on smooth approval policies (LFB, 2022). Companies need to diversify their products and then standardize them, with sufficient space for modification according to client requirements (JM, 2022). Usually, the practitioner highlights the lack of innovation in the industry, but (ANE, 2022) made a different argument that the industry makes a lot of innovations every day, but practitioners lack in reporting and standardizing them properly.

4.6.2 Multiple stakeholder involvement

Several subcontractors are involved in the construction project even if the projects are design-build because of complex and megaprojects, which makes it hard for companies to develop in-house capacity for activity in the different phases. Therefore, multiple stakeholders (i.e., different sub-contractor, municipality, and clients) are involved in a project and later dissolved at the end of the project, forming the new team for the new project (LFB, 2022). The involvement of multiple sub-contractor becomes a hindrance in the implementation of lean because the main contractor may train its staff with complete lean process and tools, but other sub-contractor are wholly or partially unaware about lean, which makes all the efforts vain at the end(ECC, 2022).

Organizations need to make long-term relations with the suppliers, subcontractors, and other stakeholders and form an integrated procurement plan with suppliers (LFB, 2022). While (JM, 2022) emphasizes developing the in-house capacity building in terms of technical workforce and machinery, hiring the experienced employees full-time which help to steer the transformation smoothly and efficiently. Moreover, companies need to develop the division within the organization to have different specifications from the sister companies and deploy the lean engineer there (ECC, 2022). Financial constraints become the hurdle to developing every facility in-house; therefore, the subletting would remain the only solution, which can be improved through long-term relations with service suppliers, viewing their core values, and incentivize them (ECC, 2022).

4.6.3 Behavioral or Cultural issues

Mostly, the construction industry is labeled as the least changeable industry among others because of the non-changeable behavior by saying, “We build as we always build” or “This is not for me; I know how to do it.” Even though companies have developed a centralized and standardized working pattern and documentation system, they still suffer from implementing change because of a lack of interest at the implementation level (LFB, 2022). Moreover, (JM, 2020 & ANE 2020) highlights other aspects that hinder the behavioral change, i.e., language barriers and temporary hiring limit the change impacts. Sometimes, the companies focus on short-term goals, especially in construction, where the project's implementation phase is temporary, misses the long-term consequences, and lets the staff do work in their way (LFB, 2022). While (ECC, 2022) relates this behavioral change to the nature of the industry where the application of lean activity changes every day, unlike the manufacturing where “Gemba walk” is done at the same place every day.

To make the transition smoother, organizations need to develop a standardized policy and ensure its implementation at the project level. Along with the standardization, need to diversify the industry by including more women in the industry at the top management level. According to (JM, 2022), in the transition phase, even the people leave the company initially and rejoin again, admiring that this lean way is more continent, where people know what to do and how to do it. According to (JM, 2022 & ECC, 2022), to make the efforts more impactful, organizations need to involve the staff from top to bottom in their

lean journey, let them allow to participate in the lean process actively, take their opinion and share their working pattern, JM develops a system to take the ideas from the staff through the app, anonymously. Swedish Construction workers are more educated than in other countries (ANE, 2022), whereas (ECC, 2022) agreed that the workers in UAE are less literate than the western countries.

4.6.4 Financial Issues

In the construction industry, the project usually has less bottom-line (around 3-5%) profit as compared to other sectors, i.e., the tech industry has a high (about 30-40%) profit margin bottom-line, even though the construction industry has more risk-prone projects (LFB, 2022). Moreover, in the construction sector, the projects have huge investments involved and are unique, limiting the investments in a single project for innovation. According to (LFB, 2022), the construction industry spends 1.4% of its net sales on innovation while the automotive sector spends around 4.1% of its total sales, which clarifies why the industry lacks behind the automotive industry in production. While (JM, 2022) presented a different perspective that JM is a public owned company where the company needs to be more careful and limit its R&D budget because companies have to meet a set profit margin(12%) at the end, in contrast to it, this transformation is more manageable and have more freedom to utilize the resources in the privately-owned companies. ANE(2022) emphasizes that big players of the industry need to come forward to invest, but the great paradox is that major companies resist investing because of different reasons, i.e., competition among the big players, loss of their value in the stock market, and above all change demand specific time, therefore, companies usually avoid it.

The transformation and innovation need financial resources to implement new facilities better; therefore, the companies need to set the target budget for R&D and change the contract form, i.e., Samverkan(Co-operation) type of contract for risk-sharing (LFB,2022, JM, 2022). Another solution would be for someone completely outside the business to take over and take the bold decision, make the investment, and see the results. (JM, 2022, ECC, 2022), present the lean implementation as an investment, which takes some time; therefore, it focuses more on engaging the investors and waiting for the lean results. While ECC, 2022, highlights being an active practitioner of lean construction in UAE that in the lean journey, the managers give the targets or set some target, which the company tries to meet; in fact, it helps to save the money. Moreover, the role of management is crucial in fund acquisition for the change and needs to take this investment as an opportunity cost, which positively affects the whole process in the end.

4.6.5 Managerial Issues

The success factor of change implementation within the organization is based on the behavior of the staff; some are interested in change and take it as a challenge, while some try to resist it (JM, 2022). Most of the managerial issues are related to the management's commitment to implement the new practice for different reasons, i.e., reluctant to take risks on megaproject, hard to leave the comfort zone, cost pressure, meeting time deadline, etc. Moreover, other aspects like competitive bidding, market competition, funding for extra training, and sometimes owners' pressure to avoid management leading the change and thinking out of the box hinder the lean implementation.

To make the process more effective company needs to implement lean on a pilot project and take the small steps toward lean, which help to convince the management toward the new process(JM, 2022, ECC, 2022). Moreover, (ECC, 2022) highlights that the first step toward change implementation is to respect people's opinions and try to be supportive to listen to other points of view. To overcome the managerial barrier, first, try to understand the point of objection by the respective management and try to address

them strategically; moreover, need to start the journey with a single step of one activity and move on to the next step. Develop the key performance indicators (KPIs), check the level and effectiveness of lean implementation for all the relevant sections, and improve set KPIs over time. In any change implementation process, the role of top management is crucial, especially in the change processes that demand time, money, and risk management strategy (ECC, 2022).

4.6.6 Lean awareness and lean Knowledge

According to LFB(2022), mostly the organization's staff is unaware of or lacks knowledge regarding lean construction philosophy; people misunderstand the concept of lean and refer to the whole idea as removing the people from the company and accelerating the working process. Therefore, try to make the staff confident that the lean process is much more than firing the people; it helps them standardize and smoothen their work and improve their efficiency LFB(2022). Moreover, the company should arrange lean workshops or lean training within the organization to benefit from this paradigm. Another misunderstanding about lean that should vanish is that lean philosophy should not be linked with one specific tool; instead, it is a concept that helps to minimize waste and maximize production by any means (LFB, 2022).

All the Swedish interviewee shows conscience in the role of the construction union, highlighting that the union needs to come forward and explain to the contractor the importance of lean(LFB 2022, JM 2022, ANE 2022). The union could form a framework for lean implementation and explain that lean ensures job security rather than removing the people.

While (ECC, 2022) presents a different narrative than Swedish practitioners, which is about the skill of the staff, which variate individually within the companies. Therefore, make sure the users follow consistent policy, which means at that staff level, every individual does the same process repeatedly to get the full command about the specific process (ECC, 2022). Moreover, (ECC, 2020) the knowledge and awareness of working staff in Europe and UAE vary in terms of technical understanding of drawings and other documents; therefore, the supervision varies in both regions. Companies should try to develop a learning environment and take the opinion for continuous improvement, regardless of their educational background. Another important common challenge in both countries is the language barrier; therefore, organizations can develop the lean framework or lean working pattern in different languages (JM, 2022) or deploy a supervisor with bilingual skills(ECC, 2022).

4.6.7 Communication issue among stakeholders

Communication barriers caused by and themselves cause several other barriers to creating an impactful lean environment within the organization. Poor communication barrier among the stakeholders negatively affects the change process within the organization (LFB, 2022). In the construction industry, multiple stakeholders are involved, especially in the complex megaproject, where lean implementation demands a robust model of communication among the stakeholders (LFB, 2022). Moreover, the massive involvement of sub-contractors also impacts the whole process; therefore, a long-term relationship and training with them would help make the process leaner (JM, 2022). Above all, standardized communication channels would also help make the process result-oriented, where common language (visual and verbal) is used for communication among the parties involved (JM, 2022). Language could be an important barrier in the effective application of lean tools and techniques, which can be managed by developing posters, signs, and instruction Performa in different languages (JM, 2022). According to ECC (2022), the company schedules weekly meetings with different departments and stakeholders to discuss

the progress, issue, and root cause analysis. Sometimes, some sub-contractors are reluctant and avoid the regular meeting; the company should renegotiate or set some plenty mentioned in the contract initially (ECC, 2022).

4.6.8 Organizational Issues

Change in the organizational culture is a mandatory pre-requisite for applying lean at the organizational level, including working, observing the process, and, more importantly, standardizing the procedures for contentious improvement (LFB, 2022). Moreover, the organizational setup of the contractors is decentralized, which is linked with the nature of the industry because of the involvement of different parties; therefore, contractors should develop a long-term relationship with the sub-contractors and streamline the workflow (LFB, 2022). According to (ANE, 2022), the organization's culture prevents the individuals from changing because, in usual practice, one is like who safe the money; therefore, this culture limits them from taking the risk.

One solution could be for the company to start the change by applying lean in one process or department, i.e., beginning with the design phase and then using it in all the operations(JM, 2022). Another solution could be implementing some pilot projects and setting some KPIs to evaluate the effectiveness and continuous improvement. The organization needs to take small steps and follow ISO standards for change management; moreover, being a leader in change management, one should have strong emotional intelligence skills in this whole transformation process (ECC, 2022). Overall, organizations need to develop KPIs, initiate staff training, change management policy, and standardize processes, start with small steps or pilot projects and streamline the processes.

4.6.9 Type of contract and bidding

The contract type is crucial in implementing lean because it is linked with several other aspects, which could smoothen or cause hurdles in lean implementation (LFB, ANE, and ECC). While (LFB, 2022) questioned the procurement process of bidding, which negatively affects the project and increase the pressure, and suggested making the procurement process transparent and well-defined scope. The competitive bidding process is also one of the main hurdles in lean construction, limiting innovation in the industry and limiting the execution of creative ideas (ANE, 2022). Moreover, the organization needs to develop a long-term relationship with the sub-contractors, which helps them standardize processes. It gives the surety to the subcontractors for the next projects and improves their work & efficiency. According to (ECC, 2022), the traditional design-build contract type is completely ineffective for the lean execution, while design-build or early contractor involvement would be effective for lean application.

5 Discussion/Analysis

According to literature and empirical studies, lean construction started in Sweden around two decades ago, in the early 2000s, when the companies began to standardize their operations without calling it lean. The Swedish company JM interviewed for this study also initiated their journey in the same era, while in UAE started in 2018 by the Engineering contracting company(ECC), which makes the relevance between the two countries to view barriers in the context of other. Moreover, this study also shows the relevance of the barriers identified in the lean application.

Based on the studies and empirical studies, though the maturity level of lean is higher in Sweden than in UAE, but the application of lean practices is much scattered, and variation has been seen among the companies in Sweden. In contrast, the application of lean philosophy is relevantly new in UAE, but the company uses a more comprehensive lean model that tries to cover most of the aspects of lean construction. At the same time, Swedish construction companies have been applying lean since a time ago but don't report it as lean, which limits the knowledge sharing within the industry.

There are some actions that which UAE construction industry needs to take to improve the implementation level of lean construction at the industry level, i.e., government or other trade unions need to come forward to highlight the lean effectiveness, help to form a general lean implementation plan, effective training of staff and education initiate at companies level. UAE needs to develop an independent body for lean construction research and implementation, i.e., the Lean construction forum in Sweden, which helps the industry apply lean research and development. Companies need to develop the KPIs related lean to check the lean impact on their business and improve them over time and try not to link lean with specific tools or techniques; consider lean as a concept. Last but not least, the industry needs to develop a relationship with academia to make this process more effective and to know the variation regarding lean in the other part of the world.

The following section shows the analysis of identified barriers in lean implementation in UAE with the data accumulated from the empirical studies. Both literature and empirical study have shown strong synergy in the identification of lean implementation barriers; the following section explains the comparative analysis of both the studies and later provides the potential solution to overcome the identified obstacles:

- The construction project is unique in nature, complex, has high investments, and is least standardized; along with these characteristics, the project has a low-profit margin, limiting the industry's innovation investment. Moreover, the projects have temporary, project-based organization, and the formation of setups is short-term, weak, and tentative, allowing everyone to view the project individually. Therefore, companies need to form standardization and diversification in their operations for proper lean application, report and share the daily innovations, start their lean journey with a pilot project or with a specific activity, and develop long-term relationships with the working parties.
- As the construction projects are unique and complex, activities are interdependent; therefore, companies have two solutions; subletting or in-house capacity building for all the activities. Organizations are not sometimes able to develop all the facilities; therefore, it usually prefers specialized sub-contractors for relevant tasks. It should establish long term coordination and engagement plan, consider the same subcontractors for future tasks, train its own as well as a

subcontractor with lean practices, early involvement in the design process, develop an integrated work plan, and schedule subcontractor activities on a broader scale in relation to other subcontractors and view their core values and incentivize them.

- Lean implementation demands full staff engagement from top to bottom. Most people having decision-making power resist the change and limit the innovation culture because of fear of failure and focus on short-term goals. Other aspects include language barrier, lack of technical education of staff, work pressure, and, most importantly, focus on short-term goals. Companies should change their culture, make it innovative, involve the staff from top to bottom in the decision-making process to boost their confidence, initiate the skill development training, and ensure that set procedures are implemented at the implementation level and gender diversification, especially at the top management level.
- Having the tight profit margins in the projects, competitive bidding process, temporary financial policies, inadequate funding for R&D, and most importantly, lack of investment by the big companies because of loss of share limit the lean implementation. Therefore, companies need to take lean funding as an opportunity cost, spend more on R&D, change contract type for risk sharing, engage investors in the industry to invest, and wait for the improvements. Companies need to set and improve financial KPIs during the transformation.
- The initiation of any new development is usually resisted by the employees, especially when cost, risk, and resource is required; therefore, top management avoids taking this risk mostly when huge investments and tight deadline are involved. Similarly, companies need management time, funding, and training in lean implementation. Management needs to develop the time, cost, and risk management strategies and start the initiative with one activity or project. They need to involve the staff to take their ideas from staff and let their opportunity to give anonymous feedback on new developments.
- Most people have the least understanding of the lean philosophy; employees sometimes refer to it as firing the staff; moreover, the industry also lacks the lean expert, especially in the construction sector. It also observed that people linked lean as a whole with specific tools or techniques, which limited their understanding of the whole lean philosophy. Companies need to start lean awareness campaigns at the staff level, try to develop the learning environment within the organization, and develop a common lean implementation framework in different languages based on the staff background.
- Effective and timely communication is a crucial part of any change implementation process. Its role is even critical in the industry like construction because of the involvement of multiple parties and the interdependency of their working pattern. Therefore, organizations need to develop a communication model on how communication occurs during the project initially; this should also be added to the contract. Companies need to use standard signs and symbols and develop action performas, especially if the staff has a multicultural background. The main contractor should create regular meetings with different sub-contractors, where plenty should be in place if someone misses the regular meetings.
- The implementation of lean within the organization demands a robust change implantation model, consistent policies, and taking small steps toward lean and setting some KPIs at the organizational level, which should be improved overtime to make the process contentious and follow ISO standards. Mostly, the new development within the organization fails because of

organizational inertia, inadequate structure for change implementation, and inconsistencies in policies.

- Contact type and bidding process are one of the main factors which hinder effective lean implementation. Strategic relations with the stakeholders and suppliers at the planning and operational level are pivotal to the implementation lean at the project level; these relations are based on the type of contract, which should be based on trust and should be long term. Mostly, the supplier fails to adapt to changes in construction projects because of temporary relations with the main contractor and ends with the project. The most suitable contract for lean construction, especially in a dynamic working environment, would be the integrated project delivery(IPD).

Table 3: Identified barriers, their reason and potential solutions

Barriers	**Reasons of Barriers**	**Potential Solutions**
Nature of the industry	unique projects, complex, high investments, least standardized, temporary project-based organization, low-profit margins	Standardization, Operational diversification, report and share the innovation, build long term relations with subcontractors, timely approval, start pilot activities or projects
Multiple Stakeholder involvement	Dependency of subcontractors, lack of in-house capacity, poor relations with suppliers, lack of awareness of suppliers about the lean, scattered working plan	In-house capacity building, long term procurement plan, long term subcontractor engagement, training subcontractors about lean, early stakeholder involvement, integrated work plan, incentivizing sub-contractors
Behavioral or Cultural Issue	Deficiency of performance measurement and reward, lack of change and innovation culture, most minor engagement of staff in policy, fear of failure in change, job security, work pressure, trust issues, language barrier, short-term goals, and staff education level regionally vary.	Change and innovation culture, engagement from top to bottom in decision-making processes and taking their ideas, continuous improvement, training and skill development plans, Involving lean experts at the initial stage, and gender diversification at the top level.
Financial Issue	Tight profit margins, competitive bidding, inadequate funding, temporary financial policies, market uncertainty, less R&D budget, lack of interest of big companies	Increase R&D budget, change contract type(risk sharing), investor involvement, set financial KPIs, and lean funding consider opportunity cost.
Managerial Issue	Inadequate knowledge about lean, lack of commitment, extra cost, resistance to change, risk factor, cost pressure, meeting deadlines, mega projects.	Provide time and funding, staff training, discuss with stakeholders, start with pilot projects, leave the comfort zone to change, take and listen to staff opinion, set KPIs for different departments and improve over time, develop a risk management strategy
Lean awerness or lean Knowledge	Lack of knowledge about the lean philosophy, lack of lean construction experts, No lean	Lean awareness campaign, take the lean as a whole rather than link with one tool, specify the task to a person, try to develop

	transformation plan for the newcomer, misunderstanding the concept by sacking of staff, link lean with last planner or with the specific tool	the learning environment, develop the framework in a different language
Communication issue among Stakeholders	Involvement of multi-stakeholder, temporary project-based organization, scattered information loss the productivity and quality, plenty on the absence of meeting	Standard and transparent communication model, take all the stakeholders on board from the beginning, use modern tools, standard communication language, signs, symbols, organized weekly meetings, and policy on meetings set in the contract.
Organizational Issue	Organizational inertia, inadequate organizational structure to adapt to change, inconsistency in policies, non-standardization of work, standardizing the pattern for continuous improvement	Standard change management plan sets organizational KPIs, starts transformation step by step, follows ISO standards change management, and develop consistent policies.
Type of contracting and bidding	Short term contracts, competitive biding, lack of integrated procurement, use of traditional design-bid-build contract	Long-term contracts, develop strategic relationships, develop long-term and trustworthy relations, early contracting involvement, Integrated project delivery(IPD), and transparent and well-defined scope.

The above table represents the main barriers that hinder the lean implementation at the organizational level in the UAE construction industry; the second section explains the reasons behind those barriers, which identify through the literature from UAE, and the other comparative literature among the different countries and the last section explain the solution of the barriers based upon the empirical studies with lean construction practitioners from Sweden and UAE. This study provides the framework for the organizations to overcome the organizational barriers to transforming from traditional working practices to lean practices.

6 Conclusion

The UAE construction industry faces several barriers to lean implementation and is unable to benefit from the phenomenon entirely. Many barriers were reported in the literature study, which could hinder the lean construction at the operational level. On a broader scale, these barriers are categorized into nine different barriers, which mainly affect the lean-to reach its maximum potential; moreover, the number of other barriers directly or indirectly relates to them. These barriers are the industry's nature*, multiple stakeholder engagement, behavioral or cultural issues, financial issues, managerial issues, lean awareness or lean knowledge, communicational barriers, organizational issues, and contracting & bidding*. These barriers mentioned above are derived from the group of fifty barriers that are associated with them.

Literature and empirical studies report these barriers differently, but a strong synergy has been seen among them; several authors in different countries also highlight identified barriers. The lean concept originated initially from the manufacturing industry; therefore, it faces criticism by the research and practitioner because the nature of the construction industry is different, because of the involvement of multiple stakeholders, and most importantly, the project organization is temporary. Moreover, the managerial, organizational, and behavioral barriers may variate regionally, but the root causes of these barriers are similar, and the reason related to these barriers shows similarity despite variation in geographical location.

Although the construction industry is different from manufacturing, standardization in construction operations would lead the process towards smooth transformation. Companies need to strategically develop relationships with the involved parties, start a long-term engagement plan and early contractor involvement, develop in-house capacity building within the organizational setup and develop the integrated work plan. Organizations need to develop the change and innovation adaptation culture, train their staff, initiate skill development programs, involve experts, gender diversification, and most importantly, involve the staff in the policy formation, especially in the case of lean. Moreover, it demands more resources in terms of finance; companies need to increase the R&D budget, engage the investor and consider the lean funding as an opportunity cost. Change initiation is constantly challenged in many ways from top to bottom; therefore, the beginning should be step by step and take the confidence of the staff by implementing it on the pilot project and set the KPIs to succeed the continuous improvement. Top management needs to understand the level of competence of staff, be emotionally strong, develop the framework, use visual signs or symbols for easy understanding, and, most importantly, develop the organization's learning environment. For the successful implementation of lean, organizations need to revise their contract type and bidding process; contract type, i.e., design-build, ECI, and IPD methods, are suitable for lean implementation. Moreover, try to develop trustworthy and long-termed strategic relationships.

7 Limitations

The lean practices vary regionally; even variation has been seen within the same countries regarding lean implementation; therefore, there might be some cultural or behavioral differences between the countries. Moreover, the data presented is based upon the interview studies; therefore, the individual observation about the barriers may vary among the people. Other limitations would be:

- The researcher does not observe the barriers directly.
- Study based on reported literature and interviewee personal observation
- Understanding of questions may vary individually during the interview.
- Only one company found in UAE found applying lean (based on the search); the rest of the barriers are identified in the literature.
- Limited literature is available regarding the reasons behind the identified barriers; therefore, the barrier analysis through the global literature where synergy has been seen in the barriers.

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