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Barriers to the Implementation of Lean Management in the Lebanese Construction Industry

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Approval Certificate

Barriers to the Implementation of Lean Management in the Lebanese Construction Industry

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DECLARATION

I hereby declare that this thesis is entirely my own work and that it has not been submitted as an exercise for a degree at any other University.

Claudette El Hajj

ABSTRACT

Purpose – The purpose of the study is to analyze frameworks barriers and enablers of Lean construction implementation in the Lebanese industry.

Design/methodology/approach –A mixed approach in the form of a Delphi group with a prepared interview guide and a questionnaire were used to achieve the research objectives using an exploratory case study.

Findings _ The framework used in company X is a conceptual and implementation framework .The process is internal, and emphasizes on the bottom- up approach using the last planner system as a Lean tool. It consists of preparing a Lean team, focusing on a specified pilot project, and then expanding to the whole organization, the enablers of the implementation are management support, employee empowerment, and communication. The main barriers identified through the questionnaire are cultural behavior, top management resistance, unfulfilled promises, and unawareness about the benefits of Lean.

Research limitations/implications – The qualitative research was limited to the small sample size and the few number of previous researches conducted in the industry. It is limited to gathering at the perception of Lean Construction practitioners in the construction sector.
Practical implications – Other companies have the chance of learning from previous lessons to understand the barriers found during the implementation and think about ways to overcome them. In addition, this research has shown the possibility of a successful implementation in Lebanon.

Originality/value – This study is the first in conducting a research about the framework used in Lebanon to implement Lean practices; in addition, this study has presented the main barriers for the first extensive implementation of Lean techniques in Lebanon and the main enablers that have helped in the implementation.

Keywords: Lean construction, Implementation, Frameworks, Barriers, Enablers, Benefits.

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Chapter 1

INTRODUCTION

1.1 General Background

Lean thinking is a philosophy based on the concepts of Lean production (Koskela, 1997). Lean production management principles were developed by Toyota led by engineer Ohno (Womack *et al.*, 1990). Taiichi Ohno, the father of the Toyota Production System, focused his efforts into finding ways to convert waste 'muda' into value, and to alter attentions and thoughts from the narrow focus of craft production on worker productivity and mass production on machine to the entire production system (Womack *et al.,* 1990; Howell& Lichtig, 2008)

The first consideration of the ideas of Lean production for use within construction is attributed to Koskela (1992) (Garnett *et al.*, 1998; Mossman, 2009). He proposed the need to review construction production as a combination of conversion and flow processes to remove waste, when traditional thinking of construction was only focusing on conversion activities and ignoring flow and value considerations (Garnett *et al.*, 1998; Senaratne & Wijesiri, 2008).
The five principles of Lean are: Value, Value stream, Flow, Pull and Perfection (Womack & Jones, 1996). According to Garnett *et al.* (1998), Lean Project Delivery System (LPDS) is divided into four interconnected phases: project definition, Lean design, Lean supply, and Lean assembly. Lean Construction (LC) is a different project management approach because it has a clear set of objectives for the delivery process, is aimed at maximizing performance for the customer at the project level, designs concurrently product and process, and applies production control throughout the life of the product from design to delivery (Howell& Lichtig, 2008). According to Koskela (1992) LC includes: practice of just in time (JIT), use of pull-driven scheduling, reduction of variability in labor productivity, improvement of flow reliability, elimination of waste, simplification of the operation, and implementation of benchmarking.

Evidence of the use of Lean thinking has shown that there are many benefits to be made from applying Lean principles to construction. These benefits claimed include: improved productivity, increased reliability, improved quality, more client satisfaction, increased

Construction is a sector of the economy engaged with the preparation of buildings, structures and other real properties. It has been argued that buildings are different from other manufactured goods in several aspects which affect the extent to which new production processes can be deployed (Gann, 1996).Construction doesn't involve mass production of items without a designated purchaser, but it takes place on location for a known client. It starts with planning, design, and financing; and continues until the execution of the project.

Three sectors of construction exist in Lebanon: buildings, infrastructure and industrial. Big construction projects require collaboration across multiples discipline. The environmental impact of the job, the successful scheduling, budgeting, construction-site safety, availability and transportation of building materials, logistics, construction delays and bidding must be considered to reach a successful execution. Over the last decade, the construction sector has become one of the pillars of Lebanese economy. Despite facing political and economic pressures due to the spillovers of the ongoing Syrian crisis, the construction industry in Lebanon remains an attractive and promising sector of the country's resilient economy. The overall volume of real estate sales in Lebanon totaled $8.71 billion in 2015, while the number of property sales transactions reached 69,198 transactions, proving Lebanon's real estate sector to be peculiarly resilient in the face of all instabilities (Ifpinfo, 2014). All in all, investments in the sector contribute to 21% of the GDP. The overall volume of construction in Lebanon totaled more than 9$ billion in 2015(Ifpinfo, 2014). Construction loans went up by 14.7% year-on-year to almost $10 billion by end of 2014 (Ifpinfo, 2014). This increase was mainly the direct result of Banque du Liban (BDL) and the financial sector's stimuli to boost demand. This stimulus package provided was very encouraging and has led to increase in demand for housing loans especially for small sized apartments. Developers are coping with holdbacks and adapting to a shift in demand from large- or medium-sized apartments to small ones - particularly in Beirut. Profits margins are within the 20-40% range, as most developers finance projects through equity rather than debt, which limit strained sales during difficult times to meet loan obligations (Daily Star, 2012). This means developers who view the downturn in the market as temporary can afford to sit on unsold projects until the market improves.

The construction industry in Lebanon includes more than 48 contracting/design companies with more than 50 employees/workers each that work in the fields of roads and highways, civil works, hydraulic networks, infrastructure and building construction. The industry executed practices with both public and private projects, such as residential buildings and

houses, commercial centers, office buildings, hospitals, public water tanks, wave breakers, factories and ware houses. The big players of the market are the general contractors with more than 100 employees such as in table 1 (info, 2013):

Company Name	Number of employees	Field of work
CCC	4200	Construction
Kfoury S.A.R.L	500	Civil engineering
Enterprise Hourie	Up to 500	Construction
Man enterprise	500	Civil engineering
Matta and Asscocies	3500	Private work in construction
Sayfco Holding	290	Construction / sales
Tabet Construction	200	Private work in construction

Table 1: Summary of the biggest construction companies in Lebanon

Construction works on the largest real estate development in Lebanon are (info, 2013):

- $2 billion Waterfront City on the seafront of Dbayyeh.
- $500 million Sama Beirut, which is the highest tower planned in Lebanon.
- $400 million Plus Holding's two major towers in the Beirut Central District.
- $300 million Versace DAMAC Tower in the Beirut Central District.
- $200 million projects development in the Kesrouan village of Bqaatouta by Sayfco.

The region's potential developments and reconstruction could open doors to many profitable opportunities in the construction, infrastructure and real estate industries in Lebanon and the neighboring Levant countries. Nevertheless, domestic and regional political uncertainties coupled with slowdown in economic growth have posed challenges to the performance of the sector. The industry is facing a slowdown in both, transactions and construction. The revival of the construction industry is highly dependent on favorable economic conditions and political stability domestically and regionally. However, small/medium-sized contracting

companies feeling the impact of reduced real-estate activity lacks the luxury of time. Fixed overheads and fierce competition are placing increasing pressure on profit margins amid decelerating growth, as Lebanon feels the ripples of the Syrian crisis. Thus, construction companies are aiming to reduce the project's cost by monitoring all types of wastes (time and materials) in order to increase their profit margin.

It is commonly acknowledged that a very high level of waste exists in construction, eliminating or reducing this waste could yield to noticeable cost saving ,specially that construction has a direct influence on other industries by means both purchasing the inputs from some industries and providing the products to almost all other industries. Contractor firms have begun to seek ways of increasing their competitive advantage in the market by removing all kinds of waste inherent in the construction process by means of implementation of Lean construction techniques (Polat, & Ballard, 2004). Lean was first introduced in production and operations and then implemented in construction in 1992 when Koskela challenged the construction sector to implement new techniques in the industry (Pekuri et al, 2012). Having the characteristics of both "production" and "service" systems, the construction industry is shifting toward the Lean production concept (Howell& Lichtig, 2008).

1.2 Need for study

Over the past 50 years, the productivity of the construction industry has steadily declined, while general business productivity in the world has steadily improved. Using numbers from the Bureau of Labor Statistics (BLS), Dr. Paul Teicholz (2012) reported that the average construction productivity worldwide has steadily fallen 0.32% each year between 1964 and 2012. Productivity is measured by dividing industry revenues by total industry work hours. In addition, Forbes and Ahmed (2010) reported an increase of only 0.78% per year in the US construction productivity from 1969 to 2011.

Moreover, a study by the Construction Industry Institute (2004) discovered that, on average, 75% of all construction activities are considered non-value adding, which include work not done, rework, unnecessary work, errors, stoppages, waste of materials, deterioration of materials, loss of labor, unnecessary material and people movement, delays in activities, extra processing, clarification, and abnormal wear and tear of equipment (Diekmann, Krewedl, Balonick, Stewart, & Won, 2004). The remaining amount is divided into two categories; 15% is considered essential, non-value added work, while only 10% is considered value adding.

Therefore, the vast majority of all construction work is considered waste by Lean standards. The poor results from each of these studies reveal a significant need for improvement in the construction industry.

Lean construction represents a promising solution to the problem of poor productivity as it is defined as a business system that encompasses culture, planning, concepts, and tools to maximize value while minimizing all forms of waste (Rubrich, 2012).

Lean provides a way to do more output with less human effort, less equipment, less time, and less space (Liker, 2004; Liker & Meier, 2007).

Lean construction maximizes value by coordinating the requirements of all parties more intensely than traditional management approaches. This coordination benefits not only the construction firms involved, but it also adds value to the owner, the architect, and the engineers as they work together as one team. Collectively, the highly collaborative Lean team simultaneously identifies and reduces the waste that naturally occurs in any construction process (Liker, 2004; Liker & Meier, 2007).

This study will shed the light on the first extensive integration of Lean principles and tools in the Lebanese conduction industry, in addition to exploring the barriers that hinder the successful implementation in Lebanon.

1.3 Purpose of the study

The purpose of this study is to identify the barriers faced during the implementation of Lean in Lebanese construction companies. To that end, this study is divided into a qualitative approach that will focus on a case study of the company that is considered the first in implementing an extensive Lean approach in, and a quantitative approach that includes more than 100 Lebanese construction companies to identify the barriers hindering the integration of Lean principles and tools in these firms. The primary objective of the qualitative research is to observe the barriers encountered when implementing Lean Construction concepts through an in depth investigation of a case study. Later, the identified barriers will be compared to the findings of an empirical investigation of the barriers according to other firms in the industry.

The results of this study provide several overcoming strategies for newcomers to consider on their own journey towards Lean. This study offer guidance to help firms overcome setbacks that they might experience on their own implementation. Finally, the results of the study allow leaders to see the Lean potential in their own organizations.

Greater insight into the Lean process should enable more construction companies to successfully transform their own businesses. This insight should also potentially increase the speed at which organizations are able to change.

The main objectives of this thesis are to:

- Identify barriers to the successful implementation of Lean construction in the Lebanon;
- Propose overcoming strategies to get rid of the barriers.

1.4 Brief overview of all chapters

The structure of the thesis reflects a conscious choice of organizing the work so that it is easy for the reader to follow. Therefore, to aid the comprehension of this thesis a synopsis of each Chapter is provided.

Chapter 2 of this thesis contains the literature related to the principles and tools of Lean construction as practiced in the world. Frameworks, barriers and enablers to the successful implementation of Lean construction are then presented as found in the previous studies. The benefits of Lean recognized worldwide are then presented. Chapter 3 describes the research procedure and methodology used the type of study, the approach used, and a description of the sample size presented and its validity. Chapter 4 presents the results of the data obtained through the study, electronic survey and interviews are summarized and analyzed. The results and findings of the collected data are discussed and examined to determine both their validity and their impact on the aims and objectives for this study. Finally, in Chapter 5, the conclusions and the main findings of the study are summarized. Also, some reflections on the outcomes of the study and recommendations for future research are provided.

Chapter 2

REVIEW OF LITERATURE

After presenting the general background of Lean construction Management in chapter 1, this chapter aims to present a broader picture about LCM principles, tools and techniques commonly used in the construction industry, In addition, the chapter launches the frameworks used when integrating LCM, the critical success factors to such an implementation and the barriers that hinder the successful integration of Lean principles.

2. 1 Literature Review Introduction

Lean Thinking is a philosophy of business management applied to production that came after craft and mass production. It started with Toyota production system where all the Lean principles were derived from and focused on reducing waste while creating value in the eyes of the customer (Staats et al, 2011). Waste in construction is defined as "the difference between the value of those materials delivered and accepted on site and those used properly as specified and accurately measured in the work, after the deducting cost saving of substituted materials and those transferred elsewhere" (Pheng and Tan, 2005). Ohno (1988) determined the seven basic types of waste in production, and Womack and Jones (1996) added one more waste type to them. Eight basic types of waste are classified as follows:

1- Correction of defects
2- Overproduction / underproduction
3- Inventory
4- Unnecessary processing steps
5- Transportation of needless materials
6- Motion of employees with no purpose
7- Waiting by employees for process equipment to finish its work or for an upstream activity to complete
8- Goods & services that do not meet customer needs (Womack and Jones, 1997)

According to Formoso et al. (1999), waste can be categorized according to its source; namely the stage in which the root causes of waste occurs. Waste may result from the processes preceding construction, such as materials manufacturing, design, planning, and construction

(Formoso et al, 1999).The main sources of waste are classified as: Design, procurement, materials handling, operation, and others. Garas et al. (2001) grouped construction waste into two principal components:

1) Time wastes: including waiting periods, stoppages, clarifications, variation in information, rework, ineffective work, interaction between various specialists, delays in activities.

2) Material wastes: comprising over-ordering, overproduction, wrong handling, wrong storage, manufacturing defects, and theft or vandalism.

Apparently, waste is a major problem in the construction (Polat, & Ballard, 2004) and should be eliminated using Lean principles and techniques. The main objective of Lean is to deliver a custom made product, instantly delivered with nothing in stores and to organize and manage processes like product development, operations, design, production, supply chain interactions, and customer relationship (Hamzeh, 2009).

2.2 Lean Construction Management

Change in the work structure in both designs as well as building in order to take full advantage of project performance is the sole aim of tackling projects as production systems (Howell and Lichtig, 2008). According to Enache-Pommer *et al.* (2010) Principles of Lean focus on the optimization of the whole process of production through waste eradication, improving continuously, collaboration as well as satisfaction of customer by handing the end user's wanted value.

2.2.1 Lean Management Principles

From Sacks *et al.* (2010), Lean Construction application discerning to the system of production on site has heightened the consciousness of the advantages of constant work, of materials to reduce inventories of progress work as well as pull flow of teams, together with transparency process to all involved. Lean construction focus is to prevent defects (Salem *et al.* 2006).

The following are the five (5) prime principles of Lean method of production as originally outlined by Womack and Jones (Bertelsen, 2002):

a) Customer value identification

It is of great importance to bring satisfaction to a customer by meeting the required specification and to clear up any potential misunderstanding, Customer value – according to Lean –it is the value of your product or your service as perceived by the customer.

b) *Stream value mapping*

These techniques focus on operations that generate value. It is the measures between the entire process required to make available a service or product as well as the degree to which customer value is met. It represents the end-to-end process of delivery by reducing non-value added activities.

c) *Make the product flow*

This is the maintenance of good flow of work in order to actualize the greatest of work sequence. The sequential flow of work at no time stop across the whole value chain will minimize waste and increase customer's value.

d) *Usage of Pull Logistic*

This is the production of services or production in accordance to the demands of customers, meaning what the customer is looking for and when the customer wants the product or service.

e) *Seek out Perfection in all Processes*

This is to pursue perfection at all time by improving the process continually and by the implementation of right approaches to the process.

Lean principles that are widely used in operations are fundamentally driven by customer in terms of understanding customer value, value stream analysis, continuous flow, "pull not push" demand-driven flow, and perfection (Aziz and Hafez, 2013).

These principles are universal; they apply to different kinds of productions like physical production, information and design and even to construction. Lean principles and tools are widely used in the process industries, manufacturing industries, services industries, tool industries, and health care industry (Kim et al, 2006).

Lean has shown remarkable success in improving quality and efficiency in both the manufacturing and the service sector industries (Kim et al, 2006).

Table 2, presents the modern Lean techniques mostly used in each stage of the construction in order to eliminate waste (Forbes &Ahmed, 2010).

Source	Lean Construction Techniques
Design	Cross functional team, Sharing incomplete information.
Procurement	Pull scheduling, Supplier training, Kanban.
Material Handling	5S, Just in time deliveries.
Operation	First Run Studies, Last Planner, Increased visualization, Multi - skilled workers, huddle meeting.

Table 2: Modern Lean techniques mostly used in construction

2.2.2 Lean Construction Tools and Techniques

Lean production principles affords many tools and techniques which when applied in the construction industry can be used to improve its performance to effect efficient process in the pre-construction, construction as well as the post-construction phase of a project (Mostafa 2013; Salem *et al.* 2006). Lean construction techniques are gaining popularity because they can affect the bottom line of projects. The most common Lean tools and techniques that are mostly documented in the literature are briefly described as follows:

a) *Flow Process*

According to Yong-Woo Kim and Bae (2010) Lean construction system perceives production as information, labor, equipment, as well as material flow from raw material to the product. The stable flow is well thought-out to be one of the key ethics in the Lean thinking (Sacks *et al.* 2010). Numerous Lean practices are employed to advance the flow process as well as reduce waste.

b) *Process Variability Reduction*

According to Hook and Stehn (2008), building projects are exposed to frequent changes throughout the length of the projects' lifecycle leading to variability as well as uncertainties in the process. Certain activities should be taken to prevent blemishes at the source so they do not over flow the process in order to avoid variability in the process. According to Salem *et al.* (2006) in Lean manufacturing, reliable devices are employed to avoid flaws from moving to the next course. Until now, building this method was difficult as a result of the complexity in discovering defects before installation. To safeguard excellence, conformity to reliable

activities can be executed on every activity on site to prevent variations. According to Salem *et al.* (2006), these activities can be obtained by implementing a complete quality assessment as well as safety action strategies at the start of the project.

c) *Reduce Cycle Time*

Sacks *et al.* (2010) stated that "Variability reduction will lead to work cycle time reduction. Cycle time reduction in construction is characterized by activities duration reduction as well as inventory reduction". This requires team effort to restructure the progression to make it more efficient and flexible.

d) *Batch Sizes Reduction*

According to Sacks *et al.* (2010) reducing the batch size increases the flow of work. Similarly, it underwrites in reducing the cycle period of the process.

e) *Increase Flexibility*

This could be achieved by engaging multi-skilled players in the process flow. The productivity rates are increased by reducing changeover time to move from an activity to the next (O'Connor and Swain, 2013). Further, Sacks *et al.* (2010) advocated that, employing multi-skilled teams likewise assist in cycle period reduction as well as advancing the workflow.

f) *Pull Approach*

The utmost important as well as imperative Lean method features is adopting the pull planning as a suitable approach. According to Thomas *et al.* (2003), the most decisive Lean techniques to advance workflow in Building projects is pull scheduling. From Sacks *et al.* (2010), the flow is an approach of monitoring product flow in which the extent of 'Work In Progress Inventory' (WIP) between process stages is reduced, plus only products demand "pulled" by ultimate "customer" process are formed in pull system.

g) *Last Planner System (LPS)*

The Last Planner System implementation forms a great environment that embodies the principles and values of Lean thinking. The Last Planner System (LPS) directs planners away from after-the-fact detection of variances and helps them improve predictability, and reliability in planning and workflow (Ballard *et al.*, 2007). What is meant by predictability is the capability of properly defining which tasks can be done on site, and predicting variations

related to uncertainties while allocating a proper buffer for them. As for plan reliability it is measured by the Percent Plan Complete (PPC), which is the number of tasks completed over the number of tasks that were planned to be completed; it reflects how reliable a plan is (Koskela 1999). Workflow however can be understood as: (1) material flow through the supply chain, (2) task flow on a project, (3) location flow of work through locations, and (4) assembly flow that describes the flow of work from a construction phase to another (Koskela 1999). Interest in smoothening the workflow to attain an optimized continuity in work through locations and without disruptions of the work sequence (Kenley 2004).

The Last Planner System is a planning cycle that includes:

(1) The master schedule
(2) The phase schedule
(3) The look-ahead plan
(4) The weekly work plan

In the master schedule, dates for major milestones of the entire project are specified and critical path method (CPM) is done to determine the overall project duration (Ballard et al. 2007).The phase scheduling consists of a schedule broken down from the master schedule and containing more details about the project components. At this stage reverse phase scheduling is done along with first run studies to get more accurate durations and task relationships to modify the CPM logic. So far it is called the front end planning, the production planning begins with the look-ahead plan. The look-ahead plan is a further magnification of the phase schedule; it contains all activities to be done in the coming six weeks. Responsibilities are identified at this point and "making ready" is done by analyzing and removing constraints. Finally, the weekly work plan drives the process through making only quality assignments and reliable promises. Assignments are then reviewed for completeness, and reliability is measured through PPC to identify any reason for failure and promote learning (Ballard et al. 2007).

The importance of the look-ahead plan lies in the fact that it requires collaboration and it links front end planning to production planning. When look-ahead planning is not properly implemented, weekly work plans are not properly linked to the long term plans. This makes the system more reactive and loses its ability to develop foresight (Hamzeh et al. 2016). Therefore, it is necessary, at the look-ahead stage, to properly break down activities from the master schedule to anticipate all tasks that should be done, to make them ready so that they

can be done. This process goes beyond just interpretations and requires operations design to identify and start removing constraints (Ballard 1997, Hamzeh 2009, Ballard *et al.,* 2007).

h) *Just in Time Technique*

A report by Tachibana &Hirano (2016) simply put just in time as creating only what is required or wanted, when it is required, as well as in the quantity required. Just-in-time is based on the concept that inventories are not valuable and should be regarded as waste; accordingly, units should be available only when required. Three methods are associated with just-in-time: First, the kanban system is used to minimize inventories according to backward requests that flow through cards, baskets, or digital signals (Chaoiya et al. 2000). Second, production leveling ensures that fluctuation in demand can be met by the right sequence of products in minimum batches (Miltenburg, 2002). Third, decreasing the number of setup activities reduces the number of activities performed during downtime so that changeovers do not interfere with minimum batches.

JIT is as a set of principles, tools and techniques that allows a company to produce and deliver products in small quantities with short lead times to meet specific customer needs (Liker, 2004). JIT is viewed by Gyampah and Gargeya (2001) as a long-term strategy that can promote excellence and eliminate waste throughout the entire organization.

The positive results from JIT application in the construction industry include:

(1) Enhancing the competitive advantage of firms in terms of consistently and continually meeting customer requirements

(2) Improving quality of construction materials and components

(3) Productivity enhancement

(4) Cost reduction in terms of minimizing the levels of inventory

(5) Improving relationships with suppliers

(6) Completing work ahead of schedule

(7) Improving the tidiness of construction sites

(8) Eliminating site congestion and inconveniences caused to neighborhood (Pheng & Shang, 2011).

However, the benefits of JIT cannot be achieved without initial investments. For example, reducing setup time may require more sophisticated equipment, and more skilled employees will result in higher training costs (Waters, 2009). six common barriers characteristics of

developing countries and their likely impact on JIT implementation are identified :

(1) Implementation costs

(2) Costs of technology and maintenance

(3) Labor productivity and labor costs

(4) Inflation and the supply conditions

(5) The demand conditions

(6) Culture (Oral et al, 2003).

i) Collaborative *Planning*

This practice rest on gathering representatives from various parties involved with the building project to cooperatively come up with an approved target program. It may be practically employed at different points in the project life cycle to get any cost or time overrun that possibly could happen (Daniel et al., 2017). The problem is that planned tasks are not achieved as planned due to the lack of collaboration and involvement of stakeholders in the planning process (Daniel et al., 2017).

j) *Continuous Improvement*

According to Sacks *et al.* (2010), improving continuously can assist in minimizing variations as well as workflow improvement. Thus, the continuous improvement principle is supported by the Lean techniques. Furthermore, continuous improvement of the building procedure can be grouped into two forms: 'Operation Improvement' and 'Process Improvement' as opined by (O'Connor and Swain, 2013).

k) *Improvement in Process*

Improving process denotes efficiently setting means to complete a project. According to O'Connor and Swain (2013), in implementing this technique, the major advantages are: work productivity improvement, process as well as roles clarification, and reduce lead-time and minimize waste (O'Connor & Swain, 2013). Methods that are connected to this technique are: 1) establishment of current state map (CSM) to display the present process of the project as well as delays, interruptions together with any other wastes; 2) future state mapping (FSM) establishment to established a process integrating all the suitable Lean techniques in that, the work will flow efficiently (O'Connor and Swain, 2013).

m) *Operation Improvement*

This is wholly advancing the work activity process of implementation. Improving operations seeks to minimize the time cycle to accomplish improve productivity, work activity, consider right first time quality and safely support working by eradicating non-added value events, controlling and monitoring performance as well as optimizing resources (O'Connor and Swain, 2013). Controlling and monitoring performance by setting procedures related to time, quality, cost as well as safety to effectively regulate the process (O'Connor and Swain, 2013).

n) *The Five S'*

This was presented in business to identity housekeeping in plants as in Lean manufacturing. Unproductive performance as a result of inefficient deployment of resources is viewed as waste that should be removed from the system according to Edwards (2015). The 'Five S's' are namely; *Straighten, Sort, Shine, Standardize* and *Sustain.* In building, employing this tool (5S's) permit for a see-through job site, at which material flow proficiently between pertinent jobs in site and the warehouses. In Lean manufacturing, any resource that does not contribute to better performance is regarded as waste that should be eliminated from the system. The five S's are sort (Seiri), straighten (seition), standardize (sieso), shine (seiketsu), and sustain (shisuke). In construction, the five S's allow for a transparent job site, at which materials flow efficiently between warehouses and specific jobs in the field (spoore, 2013). Since construction has mobile workstations, increased visualization can help identify the work flow and create awareness of action plans on a job site (Salem et al, 2006).

Sort: is the process of separating material by reference and placing materials and tools close to the work areas with consideration of safety and crane movements. *Straighten:* materials are to be piled in a regular pattern and tools were placed in gang boxes. Each subcontractor took responsibility for specific work areas on the job site. *Standardize:* includes the preparation of a material layout design. The layout contained key information of each work activity on the job site. The visual workplace helped locate incoming material, reduce crane movements, and reduce walking distance for the crews.

Shine: Workers are encouraged to cLean workplaces once an activity had been completed. *Sustain:* The final level of housekeeping is to maintain all previous practices throughout the project. Personnel should view it as a continuous effort. According to Edawrds(2015), the benefits from implementation of 5S include improved safety, productivity, quality, and set-up-times improvement, creation of space, reduced lead times, cycle times, increased machine uptime, improved morale, teamwork, and continuous improvement (kaizen activities).

o) *Visual Management*

In construction process, visualization is significant to avoid any information ambiguity. From Salem *et al.* (2006), it assists in identifying the workflow as well as creating responsiveness of on-site action plans. Thoroughly, the visualization process can contribute in helping the Lean practice in building if employed in a style suitable to the situation. The practice comprises displaying the status of completed work, work in progress, material availability, layout changes as well as other resources locations. Undertaking the previous steps can effectively advance production planning/scheduling and control as well as minimize the propensity for errors within the course as Sacks *et al.* (2010) advocated. They further stated that, Safety signs, notice boards electric wiring, Mobile signs, project milestones as well as 'Planning Programming & Coordination' (PPC) charts are some of the visualization forms that can be employed in building projects.

p) *Multi-tasks team:*

Lean production promotes multi-skilling of teams of workers so they will be able to perform more than just a few specialist tasks and assemble a multitude of systems, thereby avoiding process fragmentation otherwise imposed by tradition or trade boundaries (Stettina & Smit, 2016). Multi-skilled workers can better support and maintain CFPs by being able to do a broader range of work, which is especially important when work flows are variable.

q) Increased visualization:

It consists of communicating key information effectively to the workforce through posting various signs and labels around the construction site. Workers can remember elements such as workflow, performance targets, and specific required actions if they visualize them (Shakeri et al, 2015) This includes signs related to safety, schedule, and quality. This tool is similar to the Lean manufacturing tool, Visual Controls, which is a continuous improvement activity that relates to the process control.

r) *Huddle meetings*

Is a brief daily start-up meeting where team members briefly give the status of what they had been working on since the previous meeting. This tool ensures rapid response to problems (Steinfeld, 2015).

Studies have focused on the advantages of Lean construction in improving cost Structure (Salem et al. 2006), productivity (Agbulos et al. 2006; Arashpour & Arashpour, (2015); Delivery times (Diekmann et al. 2004), plan reliability (Ballard *et al.,* 2007; González *et al.*, 2015); quality (Leonard, 2006), relationship between working partners, and job satisfaction to reach a lower employee turnover (Nahmens *et al.,* 2012).

Song and Liang (2011) reported potential productivity improvement for formwork installation using simulation techniques. Al-Sudairi (2007) reported 21 and 50 % increase in process efficiency for block-laying and plastering from 13 cases of low-rise residential buildings in Saudi Arabia. In the UK, Balfour Beatty (2011), a leading British contractor, reported its experience with sports stadium construction (the Emirates Stadium): it applied JIT delivery of the pipe reinforcement cages and saw a 20% improvement in productivity (Gao & Low, 2014). The application of Lean principles in construction has shown encouraging results around the world. Conte (2001) reported a 20 to 30 % reduction in construction time in a project UK, and a decrease in the overall cost of the project by 5 to 12 %.

In the USA, Salem et al. (2006) noted that the benefits of Lean construction implementation were tangible: a car park project in Ohio implemented Lean construction techniques and was completed under budget and 3 weeks ahead of schedule. The subcontractors were as well more satisfied with their relationships with the general contractor. This is consistent with the finding of Song and Liang's (2011) study shows that time saving was among the greatest benefits of using Lean construction concepts, because it helped to generate teamwork among the subcontractors.

Lean motivates staff to continuously improve and solve problems with tools like Kaizen, value-stream mapping, and root-cause analysis. Standardized work processes map the right practices to improve performance and train and cross-train employees. Visual tools like boards and TV screens engage employees to lower costs, improve quality and reduce lead times. By "going Lean", retailers can set performance goals and reward employees for exceeding them – both essential to retaining staff.

Construction is challenging because the output is a management-based project delivery system that emphasizes the reliable and speedy delivery of value. Thus, Construction industries are putting more effort on emphasizing these principles on all the project stages to improve the quality of their work and reduce their cost in order to be competitive in the market (AL Aomar, 2012)

To reach this goal Lean methods and tools are to be applied in all sectors of construction to reduce delays, reruns, and re-work.

These tools are important in structuring the supply chain, allocating resources, and designing pieces to attain reliable workflow (Koskela 1992, Hamzeh 2009). Spoore (2013) carried out a study about the possibility of applying Lean manufacturing principles to construction, the results of the study showed the potential benefits of the implementation in improving construction in terms of team work, safety, and increased machine uptime.

2.3 Current practices of Lean construction

Lean construction, much like current practice, has the goal of better meeting customer needs while using less of everything. Studies have focused on the advantages of Lean (Salem et al. 2006, Agbulos et al. 2006; Arashpour & Arashpour, 2015, Diekmann et al. 2004, Cho and Ballard 2011, Nahmens et al. 2012). As the application of Lean principles in construction has shown encouraging results around the world, up 50 % increase in process efficiency for block-laying and plastering in Saudi Arabia was reported by Al-Sudairi (2007).

In the UK, several benefits were raised in 2014: 20% improvements in productivity, 30 % reduction in construction time, up to 12% in the overall cost of the project, in addition to an increase in client satisfaction. (Conte, 2001; Gao & Low, 2014).

However, the application of Lean construction is still in its initial stages. In order to improve the implementation of Lean construction, the harmonization between main contractors and subcontractors is essential, in addition to reducing variability to improve performance and improving labor flow reliability for better productivity.

2.4 Critical Success Factors in Lean Management

Construction seeks to develop and manage a project through relationships, shared knowledge and common goals. Traditional silos of knowledge, work and effort are broken down and reorganized

for the betterment of the project rather than of individual participants (O'Connor and Swain, 2013). As a result, significant improvements in schedule with dramatically reduced waste, particularly on complex and uncertain projects are identified (Mossman, 2009).

Construction labor efficiency and productivity has decreased overtime. Currently, 70% of projects in the US are over budget and delivered late in 2012, and the industry still sees about

800 deaths and thousands of injuries per year. (O'Connor and Swain, 2013).In the last 20 years, over 2,800 people have died from injuries sustained as a result of construction work in the UK. (Hughes and Ferret, 2008; ONS, 2013) Lean construction is a response to customer and supply chain dissatisfaction with the results in the building industry, providing large benefits for its adopters. Planning is the key to buttress the scheduling process and bring significant value throughout the project. Understanding and implementing proper planning is the foundation for all activities on which project success is built. Every project workflow originates from this foundation, so if there are cracks, risk of failure is greatly increased (O'Connor and Swain, 2013).

Within the project lifecycle, there are six critical factors that can be significantly enhanced with proper planning:

1- Preconstruction: aims to minimize the amount of change between conceptual estimate and final budget by working closely with team members (owners, design team and strategic partners) to maintain the integrity of design during the development process. Plan segment reviews and collaboratively provide feedback (Mossman, 2009).
2- Safety: The focus should not be on managing incidents, but on building a safety culture that allows for feedback from subcontractors on potential improvements in order to share responsibilities. Create safety "mock-ups" for training and understanding (Gao & Low, 2014).
3- Schedule: the goal is always to achieve the original substantial completion date. The use of many resources (experience, subcontractor input, production data,) is crucial to create a truly effective schedule that focuses on the contract requirements and development at the milestone level. The project team should be engaged in review process and provide feedback in forecast updates (Mossman, 2009).
4- Change Management: practitioners should plan the way that change will be addressed as early as possible with all stakeholders, agree on ground rules for resolution, and stick to the plan (Gao & Low, 2014).
5- Quality: quality projects start with great quality planning. Practitioners should start by defining the quality of deliverables and create achievable goals for the team. They should provide checklists for on-going inspections and examine leading indicators from these checklists to improve the quality throughout the project (Mossman, 2009).

6- Close-out: In order to achieve success, teams must understand that fee erosion is a measurement that inevitably could compromise the perception of success (Mossman, 2009). A quick conclusion to site activities allows for final payment and teams to move to their next opportunity. Planning for turnover and setting goals for a short transition is a key indicator of success (Gao & Low, 2014). Create an expectation for turnover as early in the process as possible, then get feedback from facility stakeholders and incorporate it in the plan.

Despite the knowhow of the critical success factors, most of the construction projects are not able to meet the desired success, because not all the adopters are successful in reaping the benefits of the implementation, a number of barriers are hindering the successful Lean implementation and minimizing the chances of a fully successful project.

The next section will summarize the barriers found in the literature after covering a number of papers that focused on the implementation of Lean construction.

2.5 Barriers to Implementing Lean Construction Management

The aim of this section is to provide a launching pad for future researchers about the barriers of a successful implementation of Lean in the construction. Several studies have been carried out in different countries worldwide to identify the barriers in implementing the LC approach. Some of these studies focused on investigating barriers that prevent the diffusion and implementation of LC (Abdullah, Abdul-Razak, Abubakar, & Mohammad, 2009; Johansen & Walter, 2007; Mossman, 2009) while others focused on identifying barriers that exist during the execution of LC practices (Ansell, Holmes, Evans, Pasquire, & Price, 2007; Johansen & Porter, 2003; Omran & Abdulrahim, 2015).

For the literature inclusion, papers that were published in reputed scholarly journals from 1994 to 2017 on Lean construction were considered. The list of barriers was then identified after a comprehensive review of those papers.

Not all the adopters of Lean were successful in reaping the benefits of the new concept as the Toyota example was, the majority of them achieved modest levels of success due to a number of difficulties that should be overcome during the implementation. The common factors for Lean failures include: Cultural behavior issues, poor leadership, poor communication, staff resistance to change, lack of learning, and lack of resources (Jørgensen, Matthiesen, Nielsen,

Not all the adopters of Lean were successful in reaping the benefits of the new concept as the Toyota example was, the majority of them achieved modest levels of success due to a number of difficulties that should be overcome during the implementation. The common factors for Lean failures include: Cultural behavior issues, poor leadership, poor communication, staff resistance to change, lack of learning, and lack of resources (Jørgensen, Matthiesen, Nielsen, & Johansen, 2007). The difficulties encountered in sustaining Lean may be attributed to a lack of focus on the developmental progression of Lean capabilities amongst the members of the organization and lack of the long term philosophy that needs the implementation to be viewed a point of view not a set of principles and poor empowerment of employees, practitioners should then become progressively better at integrating Lean while at the same time, creating a learning environment that supports a Lean culture (Jørgensen et al., 2007). In order for the implementation not to be hindered, a significant shift in thinking and behavior is required (Omran & Abdulrahim, 2015). People need to clearly understand the reasons why the way they do things need to change in order not to resist to it. For this, the following section will define the factors that had the ability to compromise the LC implementation process.

Cultural behavior issues: is considered as one the main barriers that affect going Lean, The cultural and languages differences uncovered in Lean implementations have been of ethnic, organizational and professional nature, cultures are opportunistic, prone to conflict because of the weak communication and transparency, Cultural behavior issues, fear of taking risk, lack of incentives and motivation (Atkinson, 2010; Bhasin, 2012; Boyer & Sovilla, 2003; Deloitte & Touche, 1998; Jadhav, Mantha & Rane, 2014; Khaba & Bhar, 2017; Liker, 2004; Sarhan, & Fox, 2013; Shang & Sui Pheng, 2014).

Resistance to change: In general, people don't accept the change because they feel a loss of control and excessive uncertainty when applying new concepts (Bhasin, 2012; Deloitte & Touche, 1998; Khaba & Bhar, 2017; Sarhan, & Fox, 2013; Womack & Jones, 2005). Resistance from employees might be due to the "fear factor" that they would lose their jobs if it was found that their jobs do not add value, as LM is about eliminating non-value-added activities. The reasons for low level of Lean implementation are anxiety in changing the workers mind-set (Eswaramoorthi, Kathiresan, Prasad, & Mohanram, 2011).

Lack of resources: practitioners in general, feel time and commercial pressure throughout the project life cycle, pushing themselves to finish the project on time without the interference of

new concepts that might lead to a delay (Bhasin, 2012). This is because they are unaware of the benefits of Lean implementation, they believe not to have the time for new concepts; they are unable to identify the financial value of Lean practices, and reduce the waste of the company (Bhasin, 2012; Boyer & Sovilla, 2003; Khaba & Bhar, 2017). The cost of investment is considered as a very high ranked barrier to Lean construction since funding is needed to provide tools, equipment, sufficient professional wages, incentives and reward systems (Bhasin, 2012; Deloitte & Touche, 1998; Jadhav et al., 2014).

Lack of empowerment: Employees feel underpowered when managers don't allow them to be engaged in some of the projects decision-making steps. Management domination and command of the workplace do not nurture and sustain Lean transformation (Jadhav et al, 2014). Empowerment is not commonly seen in the construction industry, given that the frontline workers are typically unskilled and not trusted to some extent (Omran & Abdulrahim, 2015).

Lack of top management commitment: The only way to create a true Lean transformation is with a strong leadership at the top level of an organization. Top management needs to commit to providing the necessary time, money, and other resources for Lean implementation. Given it is a fairly new concept to construction professionals, the level of senior management's commitment remains unknown (Bhasin, 2012; Staudacher & Tantardini, 2007). This includes physical engagement in addition to the intellectual support. It is critical for top management to understand and give ample support to sustain the Lean concept (Jadhav et al., 2014).

Lack of consultants and formal trainings: The problem exists with middle management because their training and experience is not sufficient to provide them with the ability to manage change in thinking, responsibility and roles (Bhasin, 2012; Eswaramoorthi et al., 2011). Most of the workforce in the construction field had very basic training when undertaking new role and tasks.

Lean implementation may not reach its intended purpose if there are inappropriate training methods and knowledge transfers (Cudney & Elrod, 2010). If the new way of working requires new knowledge and skills, members must be provided with the necessary formal and informal training. Lean training helps the practitioners to learn the basic knowledge and skills for improvements (Anand & Kodali, 2010). In fact, lack of a training roadmap could become a pitfall hampering the improvement process.

Absence of Lean culture and lack of a long-term philosophy: is another stumbling block for LC, Lean requires a long-term philosophy and commitment. The ability to focus on long-term objectives is a critical factor in the success of Lean enterprises (Emiliani, Stec, Grasso & Stodder 2003; Liker, 2004; Shang & Sui Pheng, 2014). Employing LC as a set of tools rather than a viewpoint for doing businesses is the main problem (Atkinson, 2010; Boyer & Sovilla, 2003).

Design and construction dichotomy: design and construction are treated as separate activities which cause a conflict and create lots of waste such as: incomplete designs rework, and final products with significant variation from values specified in the design (Sarhan & Fox, 2013). Construction firm's limited involvement in the design is a major constraint, the lack of integration between design and construction is a reflection of the absence of Lean construction (Ballard & Howel, 1998; Omran & Abdulrahim, 2015).

Poor communication: poor communication between contractors and subcontractors has a negative impact on the effectiveness of the project delivery and coordination system (Omran & Abdulrahim, 2015). Employees need to be properly informed of the changes that are being implemented (Cudney & Elrod, 2010). Also, a lack of organizational communication may lead to the failure of the Lean wins (cost reduction, lead time reduction). Andrés-López (2105) believe that a major obstacle faced in designing a Lean process is in the communication and response to the need of the internal downstream customer and the practicality of a one-piece flow. Communication and flows of information between downstream customers and upstream suppliers are critical for a transparent flow of information (Oduoza, 2008).

Multilayer subcontracting, fragmentation and hierarchies in the structure: are considered as a major pitfall for a successful implementation. Multilayer subcontracting emphasizes the problem of non compliance to quality specifications. Fragmentation hinders the incentive for project participants to cooperate and learn together since they have different priorities (Mossman, 2009). Furthermore, in hierarchical structure, each level sets its own objectives, liabilities and targets, and carries out its individual tasks, and takes decisions that cut across a number of functions, which hinders the collaboration between parties in problem solving (Sarhan & Fox, 2013)

Insufficient knowledge of Lean processes and benefits: the lack of a defined process to implement Lean and the lack of understanding of the benefits of adopting it is a barrier toward the implementation since the level of interest in this new concept is seriously compromised (Abdullah et al., 2009; Eriksson 2009; Mossman, 2009; Sarhan & Fox, 2013).
The knowledge of Lean concepts is a must for employees and managers equally to understand how it helps in eliminating waste, reduce time and cost, and add value to the client. The awareness of such benefits, will allow them to identify the financial value of Lean practices (Bhasin, 2012; Boyer & Sovilla, 2003; Khaba & Bhar, 2017).

Limited use of off-site construction techniques: The limited use of prefabricated components can prevent standardization – one key component of Lean practice – from being adopted. JIT could be more adaptable to the prefabricated environment since a fair deal of the construction activities is thus undertaken in a factory environment (Arif & Egbu, 2010; Bhasin ,2012).

Tolerance of untidy workplace: the acceptance of untidy places and the frequency of this practice in the construction field is the main barrier for applying the "Five S" tool of Lean that embraces the cLeanliness and standardization of the workplace environment (Aminpour & Woetzel, 2006).

Use relationships to conceal mistakes: this is a major barrier for the implementation since it challenges the concept of last planner system that is based on accountability. Relationships will encourage parties to have delays and unfulfilled promises since they are depending on relationships for not losing their jobs

Poor cross functional team: that doesn't have a shared vision: in a cross functional team every member should be aware of his responsibilities, this type of teams is essential for quality improvement and process improvement (Upadhye, Deshmuk,& Garg, 2010). Hence, high interactions and accurate information sharing about customers' requirements become a prerequisite for successful implementation of Lean (Boyer & Sovilla, 2003; Eswaramoorthi et al., 2014; Liker, 2004).

Slow response to market: Failure to respond swiftly to changes in a product design and inability to meet the schedule are some of the challenging issues practitioners have to face during the first phases of Lean implementation. A well-designed Lean system allows for an

processes to formulate the goal of the project, in order to keep all employees motivated about the implementation (Pedersen & Huniche, 2011). Logistical planning is essential for procurement of input material to avoid wastage of resources. Lean advocates very few inventories and direct delivery of input material at an assembly line at predetermined schedules. It needs support of the logistic system in order for the transportation not to be an obstacle to the efforts made (Omran & Abdulrahim, 2015).

Absence of Lean culture in partners: for a successful implementation, Lean should be everywhere. Companies have to spread the new concept between their stakeholders in a way that all partners will have aligned core values (Liker, 2004).

Lack of government support: A national policy with recommendations for the adoption of Lean for the improvement of the Chinese construction industry is currently lacking in most countries.

Avoid taking responsibilities: the implementation forces managers to get their hands dirty, and go themselves to the site to check all the details. This idea is not appealing to some managers who prefer making calls without the burden of identifying the sources of obstacles (Liker, 2004; Paolini et al., 2005).

Lack of perseverance: Creating a Lean enterprise needs people to stop backsliding to the old ways of working in addition to the perseverance and propensity to revert to traditional practices when difficulties are encountered (Su, 1994).

Inability to measure performance: performance measurements are to be taken before the end of the project in order for corrective actions to be adopted. Recommendation for the use of leading measures aiming to give early warnings, identify barriers and potential problems is highlighted in the overcoming strategies section. It is important to use measures for tracking improvement and detecting the root causes of the problem (Alinaitwe, 2009)

Table 3 presents a summary of the barriers of LC implementation found in the literature (Atkinson, 2010; Ballard & Howel, 1998; Bhasin, 2012; Boyer & Sovilla, 2003; Deloitte & Touche, 1998; Emiliani et al., 2003; Alinaitwe, 2009; Jadhav et al., 2014; Khaba & Bahar, 2017; Liker, 2004; Omran & Abdulrahim, 2015; Sarhan & Fox, 2013; Shang & Sui Pheng, 2014; Terry & Smith, 2011; Vinodh & Balaji, 2001)

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Barriers	Authors																			
	Deloitte & Touche (1998)	Boyer & Sovilla (2003)	Emiliani et al. (2003)	Liker (2004)	Paolini et al.(2005)	Womack & Jones (2005)	Aminpour & Woetzel (2006)	Arif and Egbu (2010)	Alinaitwe (2009)	Cudney and Elrod (2010).	Atkinson (2010)	Tery and Slim (2011)	Eswaramoorthi et al. (2011)	Portioli and Tantardini (2012)	Bhasin (2012)	Sarhan & Fox (2013)	Jadhav et al. (2014)	Shang & Sui Pheng (2014)	Omran & Abdulrahim (2015)	Khaba & Bhar (2017)
Culture issues	X	X		X							X	X			X	X		X		
Resistance to change	X					X			X						X	X				X
Lack of time and commercial resources	X			X									X		X		X			
Lack of management support	X			X											X	X	X			
Insufficient knowledge of Lean		X													X	X				X
Limited use of off-site construction															X					
Lack of employee' s empowerment																X	X		X	
Lack of a long-term philosophy			X	X							X							X		
Fragmentation and subcontracting																X				
Design/Constructi on dichotomy																X			X	
Tolerance of untidy place																X				
Relationships to conceal mistakes							X													
Avoid taking decisions				X	X															

responsibility																			
lack of support from government				X															
Lack of perseverance			X						X										
Lack of consultants and formal trainings										X									
Poor Cross-functional team		X		X									X						
Slow response to market										X					X	X			
Lack of communication										X									
Lack of logistic support										X								X	X
Inability to measure performance									X										

Table 3: Barriers of Lean implementation

The pitfalls in the implementation are related to cultural, personal and organizational issues .The success is in overcoming the Barriers to reach the desired benefits. The ranking of the barriers in table 4 is based on the total number of resources referred in table 3.

Barriers	Nb of citation
Culture issues	8
Resistance to change	6
Time and commercial resources	5
Lack of management support and commitment	5
Lack of a long-term philosophy	4
Insufficient knowledge of Lean / Unawareness about Lean's benefits	4
Poor Cross-functional team	3
Lack of employee' s empowerment	3
Lack of communication and cooperation between parties	3
Lack of perseverance	2
Lack of logistic support and planning	2
Lack of consultants and formal trainings	2
Design/Construction dichotomy	2
Fragmentation and subcontracting	1
Using relationships to conceal mistakes / culture that accept delays and unfulfilled promises	1
Tolerance of untidy place	1
Slow response to market	1
Limited use of off-site construction techniques	1
lack of support from government	1
Inability to measure performance	1
Avoid making decisions and taken responsibility	1

Table 4: Numbers of resources cited for each barriers

It is clear from the ranking that Cultural behavior issues and resistance to change are the top two ranked barriers. Then, a certain number of barriers were equally listed and comprises: lack of resources, lack of management support and commitment, equally insufficient knowledge of Lean, unawareness about its benefits, and lack of long term philosophy in the company. Then comes equally lack of empowerment, communication and cross functional

team. The next barriers are lack of perseverance, logistic support and constants in the field, in addition to fragmentation and multilayer subcontracting. Each company experienced a lack of positive results when employees are disorganized in the implementation process. Barriers and failures should not always be considered as negative. They are part of the natural progression of the Lean implementation process.

For a successful integration of Lean, companies should overcome the barriers faced during the implementation. Companies should focus on human soft resources such as capabilities, knowledge, and experience, in addition to physical resources that comprises funds, commutation means, and machineries. Practitioners first need to have an understanding of the Lean philosophy and Lean thinking, adopt a Lean cultural change. The culture of the company cannot change by simply explaining the benefits of Lean. Companies have to first conduct a behavioral change through new routines (e. g., Last Planner System, daily stand-up meetings, and weekly meetings), then a change in attitude occurs due to the new standards, and finally, people begin to experience a cultural change within the company.

Sharing knowledge and learning quickly from mistakes should be adopted in the company. In fact, people who work in a learning environment consider the company as a place to learn continuously how to offer a better product or service. Spear (2008) summed up this strategy in a cycle consisting of 4 steps: Learn to see problems when they occur and make them visible, attack and solve problems immediately where and when they occur, share new knowledge throughout the organization and finally learn to lead the development. Companies that have implemented a system that allows them to share knowledge and learning from mistakes will be successful in implementing Lean. Quick feedback loops between employees and managers are also essential. Companies that want to succeed with Lean must move from a hierarchical command and control management towards a stage in which employees are empowered and can easily propose their ideas and implement them to improve. This way of thinking implies having leaders, who support and effectively manage ideas and daily improvements. Management must remove restraining force by motivating people to get involved in Lean implementation and empowering them to make decisions without having to follow the normal decision-making (Sarhan & Fox, 2013).

Finally, companies should adopt a holistic and systematic thinking: Lean Implementation begins with the executives' leadership and only continues forward zealously with their commitment and drive. Executives must be prepared to question their own traditional

strategies as well as the outdated tactics of the industry employee attitudes will range from negative and resistant to positive and exuberant.

2.6 Enablers of the implementation of Lean Construction Management

Lean techniques implementation has been accredited with varied factors that drive its activities. These drivers are continuous and help in efficiency improvement, waste elimination, cost savings and operational efficiency (Sacks et al, 2010). Furthermore, business pressure, increasing competitive advantage, customer requirements, government policy and regulation are also drivers of Lean. The origination of these drivers can be of external or internal nature depending on the Organization. Requests for improved efficiency as well as the need for growth of service with inadequate availability of resources are the drivers needed for the introduction of process improvement methodologies such as Lean (Sacks et al., 2010)

Important enablers for the implementation of Lean techniques were identified:
Top management support: top management support is the most important critical success factor for project s success. Senior management have an important role to play in presenting a coherent vision for their business, clearly communicating business strategy and indicating how the Lean philosophy and practices fit with the needs of the business. Employees need the financial support and the motivation from the management in order to apply new concepts successfully (Banuelas & Anthony, 2002; Ogunbiyi, 2014).

Effective communication among the design and construction teams is the important Factor to implement Lean (Banuelas & Anthony, 2002; Ogunbiyi, 2014). This is very important in a competitive market where business pressure is a driver for a Lean construction response through cost reductions, facilitating price competition to expand market share. In response to competitive pressures, these organizations have implemented Lean techniques (Radnor & Walley, 2008; Sacks et al, 2010).

They believe in a continuous training program drive cultural and behavioral change and innovation. Education and Training programs for the employees and managers on Lean knowledge is essential. Organizations should emphasize on effective Lean-related education and training programs as well as establish training assessment to measure the training impacts.
Lean education for all staff through training and communication is an important driver for a successful implementation (Banuelas & Anthony, 2002; Ogunbiyi, 2014).

Moreover, change strategy target and holistic approach by implementing Lean philosophy and techniques through the adoption of the entire system in a holistic manner, rather than applying techniques in a 'piecemeal' fashion. That trick in the successful implementation believes the organizational culture, the culture that encourages employees to propose better ways of meeting performance goals is a promoting culture that is needed to implement Lean construction successfully. Adoption of a continuous improvement culture , Benchmarking of suppliers against each other and Wide adoption of Lean and sustainability concepts are the main drivers of Lean (Conte et al , 2003). This can be achieved through a high level of management commitment. This will help to sustain the Lean focus. (Crute et al., 2003) Especially when a crisis exists, because the last creates a sense of urgency to change: and to implement new tools that are needed to overcome the crisis. Thus, it is considered one of the important enablers when thinking of an extensive integration of Lean principles (Pedersen & Huniche, 2011; Bhasin, 2012).

Automation is another driver for LCM, the presence of standardization and automation procedure such as BIM technology through the company encourages and facilitates the implementation of Lean thinking (Sacks et al, 2010; Ogunbiyi, 2014).

Previous research shows that leaders can play a critical role in shaping project spirit Effective leadership results in the project team committing to the project objectives Ozorhon et al. (2013) stated that managers should put in place the mechanisms and tools that foster knowledge sharing within a group in order to facilitate innovation. Effective knowledge sharing is essential in implementing innovation and in ensuring that these ideas are communicated to the entire project team and incorporated into future projects

Table 5 presents a summary of the enablers of Lean implementation presented in the literature.

The aim of this study is to identify the enablers and barriers that may prevent the successful implementation of LC in Lebanon; to enable the construction industry to focus its attention and resources on the real issues.

Companies gained large benefits by adopting the Lean concepts, but it does not seem to be generally applied amongst Lebanon construction organizations. There seems to be a number of barriers militating against successful Lean implementation (Mossman, 2009). Therefore, the aim of this study is to identify the barriers and the critical success factors to a successful implementation of LC in Lebanon; to enable the construction industry to focus its attention and resources on the real issues. Table 5 illustrates the enablers presented in the literature

(Conte et al., 2003; Crute et al., 2003; Pedersen & Huniche, 2011; Bhasin, 2012; Ozorhon et al., 2013; Ogunbiyi, 2014).

Author/ Enablers	Crute et al. (2003)	Banuelas & Anthony (2002)	Radnor & Walley (2008)	Sacks et al (2010)	Pedersen Hunich e (2011)	Bhasin (2012)	Ozorhon et al. (2013)	Ogunbiyi et al. (2014)
Top management support	X							X
Effective communication		X						X
Education		X						X
Change strategy target and holistic approach	X							
Organizational culture	X							
Business pressure			X	X				
Automation				X				X
Existence of crisis					X	X		
Leadership							X	

Table 5: Enablers of Lean construction's Implementation presented in the literature.

2.7 Frameworks Used in Lean Construction

A framework is the guiding torch to managers who need direction during the change management programs. It provides the "what constitute a change" and talks about "how to carry out the implementation of a given program change" (Anand & Kodali , 2010). The framework consists of the blocks needed by the company when implementing a creative methodology or changing its current way of functioning. Thus, in promoting Lean and providing the means of implementation, a framework is normally adopted to provide technical knowhow about Lean and the milestone towards Lean transformation (Yadav et al., 2017).

Different types of Lean production framework were proposed by researchers worldwide, however they can be categorized into two broader themes, namely 'design/conceptual' frameworks and 'implementation' frameworks. Conceptual framework discusses the content of Lean, i.e. what the elements of Lean production are, whereas the latter deals with

frameworks that can provide a discussion on how to implement Lean production, including what the sequence of activities should be and so on (Gao & Low, 2014).

Another comparative study was performed by Paez et al (2004), in their study; each framework was assessed with respect to its human and technological aspects. The finding implied that most frameworks did not equally take into account of both Lean tools on the shop floor and the development of the workforce.

More than thirty five different Lean frameworks were discussed in the literature. After reviewing them all , the researcher have focused only on the frameworks that are used in the implementation phase - which are 12 only- .Other frameworks that are related to Lean adoption , Lean transformation, Lean assessments, Lean design would not be discussed here. Moreover the researcher didn't include in his study the frameworks that serve as a reference for waste identification. The main purpose of the study is to analyze the frameworks that are related directly to the implementation process in order to increase the efficiency of the construction work. Below is a comparison between the frameworks presented in the literature in term of LC frameworks and the type, Approach and process used in the implementation.

1) Frameworks proposed by Anand and Kodali (2010)

It is a design framework which constituted 65 Lean elements and an implementation framework with ten stages where each stage contained different tools or practices. The implementation starts at a managerial level with one piece flow at a time and encourages the use of just in time techniques in the production.

2) *Framework proposed by Upadhye et al. (2010)*

This framework is used in medium manufacturing enterprise to help in improving the readiness to supply quality products at the right time, quantity and price. It focuses on the elements needed to implement Lean practices to ensure continuous improvement through one piece flow at a time.

3) *Framework proposed by Rose et al. (2010)*

This framework is used in small and medium enterprises and aim to improve their performance in the area of inventory level, cycle time, and delivery time and product quality

The top management considers employee empowerment and involvement, continuous improvement, Multifunction employees, 5S, Standardization, Visual control.

4) *Framework proposed by Van Aken et al. (2010)*

This framework is used by the top management and aims to assist an organization in systematic design, management and assessment of short-term rapid improvement projects or Kaizen events in a company.

5) Framework proposed by Wong and Wong (2011)

The model is based on the five Lean principles proposed by Womack and Jones (1997). It is based on workers involvement in continuous improvement tasks. These activities usually started from understanding the condition of current state before moving towards the desired future state. Practitioners need to plan, check and monitor their Lean implementation to reach a pull approach.

6) Framework proposed by Anvari et al (2011)

The model starts with an initial investigation, preparation, focus on a specified pilot project, expand to the whole organization and– pursue of perfection. It is a dynamic approach that helps top management current in defining its future state based on the current status.

7) *Framework proposed by Wanitwattanakosol and Sopadang (2011)*

The framework proposed by the top management of the company to Re-engineers the business activity, apply value stream mapping and evaluate the supply base of an organization. Computer simulation, value stream mapping and JIT scheduling method are among the suitable TTPs to be used in this context.

8) *Framework proposed by Vinodh et al. (2011)*

The framework used by senior employees claimed to understand and implement both: "What" and "How" criteria in the integration. It incorporates Six Sigma methodology "DMAIC", i.e. define, measure, analyze, improve and control with Lean principles such as value stream mapping, waste elimination, and set-up reduction.

9) Framework proposed by Suhartini et al. (2012)

The proposed Lean system Kaizen framework focuses on standardizing the process; JIT and Jidoka; and continuous improvement. Further, Kanban and visual tools are designed to attach with the trolleys. Poka-yoke is designed to improve the flow of trolleys and ergonomics of workers. It represents a well-designed and systematic problem-solving framework that uses the 5-why, fishbone diagram and PDCA to evaluate and analyze the problem.

10) *Frameworks proposed by Salimi et al. (2013)*

Top management presumed that application of Lean tools will improve the operation performance of an organization through applying just in time techniques.

11) *Framework proposed by Karim and Arif-Uz-Zaman (2013)*

The implementation framework was used to implement Lean tools in manufacturing processes as well as to develop continuous improvement techniques within organizations. The Framework consists of five phases: Value proposition, Value Stream, Flow phase, Pull, and Perfection. The culture for continuous improvement techniques will be developed and every staff who engaged to the relevant Kaizen area has to change their mindset and work in a cross functional team.

12) *Framework proposed by Jagoda et al. (2013)*

A continuous improvement model that encourages shop floor employees to focus, measure, communicate, innovate, and evaluate the previous actions. By evaluating the progress of improvement at regular intervals, adjustments can be made on an on-going basis.

Table 3 presents a summary about the frameworks proposed in the literature with mentioning the type used in terms of being conceptual only or if it provides also the "how" as part of the implementation (Chay et al., 2015)

Framework Proposed by	Type	Approach	Implementation Process
1-Anand and Kodali (2010)	Conceptual + Implementation	Top-down	Just in time , one piece flow
2- Upadhye et al. (2010)	Conceptual	Top-down	Kaizen , one piece flow
3- Rose et al. (2010)	Conceptual	Top-down	Multifunction employees, 5S, Standardization, Team work, Visual control.
4- Van Aken et al. (2010)	Conceptual + Implementation	Top-down	Kaizen
5- Wong & wong (2011)	Conceptual	Top-down	Kaizen , standardization ,(plan, do , check), Pull
6- Anvari et al (2011)	Implementation	Top-down	Kaizen, Focus on Pilot project and then expand on the whole organization.
7- Wanitwattanakosol & Sopadang (2011)	Conceptual	Top-down	Just in time, Value stream mapping.
8-Vinodh et al. (2011)	Conceptual + Implementation	Top-down	DMAIC (Six Sigma), Value stream mapping.
9- Suhartini et al. (2012)	Conceptual + Implementation	Top-down	Kaizen, Just in time, Standardization.
10-Salimi et al. (2013)	Conceptual	Not specified	Just in time.
11- Karim & Arif uz Zaman(2013)	Conceptual + Implementation	Top-down	Cross functional team, Value stream, Pull, Kaizen.
12- Jagoda et al. (2013)	Conceptual + Implementation	Bottom -up	Kaizen

Table 6: Comparison of Lean implementation frameworks presented in the literature.

Moreover it states "who" Lean -shop floor employees or the top management- are implementing the philosophy. In addition tables 4 &5 specify what are the tools and techniques presented in each of the proposed framework during the implementation phase (Chay et al., 2015). It is important to note that most of the frameworks didn't link the practitioners (employees) to the Lean elements, moreover they didn't give a clear idea about whom, why, and who will apply the principles.

	Framework											
Tool	1	2	3	4	5	6	7	8	9	10	11	12
Just in Time	X						X		X	X		
One piece flow	X	X										
Kaizen		X		X	X	X			X		X	X
Multi-function employee			X								X	
5S			X									
Standardization			X		X				X			
Visual control			X									
Pull					X						X	
Plan ,Do, check					X							
Pilot						X						
Team work			X									
Value stream mapping							X	X			X	
DMAIC								X				

Table 7: Lean tools presented in the implementation frameworks.

Framework	Advantage	Disadvantage	Main Application
1-Anand and Kodali	Very detailed	Lack of contingency	Just in time
2- Upadhye et al.	Improve the readiness	lacks the flow of the implementation	one piece flow
3- Rose et al.	Helps SME	TTP Is not well studied	5S
4- Van Aken et al.	Assist an organization in systematic design	Designed of kaizen events only	kaizen
5- Wong & wong	Comprises most of the important elements of Lean,	Lacking technical knowhow among shop floor employees	plan, do , check
6- Anvari et al.	Categorizes previous studies into 3 stages	Reasoning to apply this frameworks is no clearly mentioned	Last planner
7- Wanitwattanakosol & Sopadang	Helps SME	Suitable for Lean supply chain only	just in time
8-Vinodh et al.	Improve the first-time-right in a project	Doesn't benefit the company as a whole	DMAIC
9- Suhartini et al.	Well designed, systematic problem-solving	Applied in specific areas	Just in time
10-Salimi et al.	Identify the preferences of TTP	Doesn't include the aspects of how to implement	Just in time
11- Karim & Arif uz Zaman	Ensure long-term sustainability	biased towards top-down approach	Pull
12- Jagoda et al.	total involvement of employees		Last planner

Table 8: Analysis of the Implementation frameworks

2.8 Literature Review Conclusion

Lean construction is considered a valuable solution for the declining productivity of the construction industry. It represents a promising solution to the problem of poor productivity. When implemented correctly, Lean construction tools and techniques help in reducing waste and improving efficiency–both significant benefits for project teams

Several enablers help in reaching the stated benefits. These enablers are summarized as: top management support, effective communication, continuous training, employee empowerment, need for a change, and automation.

Despite the benefits displayed, there are a number of barriers hindering the successful implementation of Lean, especially when organizations begin their Lean journey by implementing Lean tools without understanding the underlying theory. These barriers can be summed to : design and construction dichotomy, absence of Lean culture and lack of a long-term philosophy, lack of top management commitment, lack of leadership skills , Cultural behavior issues, lack of consultants, Insufficient knowledge of Lean process , lack of resources, and resistance to change.

These barriers change from one country to another. As found in the literature the main barriers in China are lack of long term philosophy and absence of Lean culture in the organization (shang, 2014). Whereas the common barriers in UK are Lack of adequate Lean awareness and understanding and lack of top management support (Sarhan and Fox, 2013). The Libyan case emphasis on finding strategies to overcome Inadequate knowledge and skills when applying Lean and consider inability to measure performance as another major barriers(Omran et al, 2015).Whilst there are clues in the literature from other sectors regarding critical success factors, these have not been established in construction. In Jurans' (2000: 217) words:

"*Many of the strategies adopted by the successful companies are without precedent in industrial history. As such, they must be regarded as experimental. They did achieve results for the role model companies, but they have yet to demonstrate that the efforts to make such adaptations will generate new inventions, new experiments, and new lessons learned. There is no end in sight.*"

Therefore, there appears to be a gap in knowledge in terms of a definition of Lean construction and also an opportunity to test which success factors are most important for the successful application of Lean Construction.

The few numbers of studies already conducted about LC in Lebanon point out the barriers and limitations for applying the needed tools and techniques. Preceding studies show nothing

about an extensive implementation of Lean construction in Lebanon, and didn't focus on the framework used in Lebanon.

After presenting the detailed literature review of LCM , the researcher used the literature to create an idea about the research topic, and did an exploratory study in the Lebanese context in order to identify whether Lean principles and tools are applied in the Lebanese construction industry , to identify if the enablers found in the literature are applicable in Lebanon , and to identify the barriers that may prevent the successful implementation of LC in Lebanon in order to enable the construction industry to focus its attention and resources on the real issues.

Chapter 3

PROCEDURES AND METHODOLOGY

Previously, the chapters presented the general introduction of the study, as well as the literature review on the phenomenon understudy. These helped to respectively introduce the study, and put the study into perspective. This chapter goes further to present the methodology adopted for the research work to complete the various objectives. This includes the research instrument design, study population, data collection, research design, sample size determination, and data analysis. Research methodology refers to the understanding of the research and the strategy chosen to answer the research question (Greener, 2008).Research method refers to specific activities designed to generate data, for example questionnaire, interviews, focus groups and observation (Greener, 2008).

3.1 Introduction

The process of putting together a piece of good research is not something that could be done by just strictly following a set of rules about what is right and wrong(Denscombe, 2007). In practice, the researcher faces a variety of options and alternatives and has to make his own strategic decisions about which to choose. There is no 'one right' direction to take, as each choice brings with it a set of advantages and disadvantages (Denscombe, 2007). There are, though, some approaches that are more appropriate for specific types of investigation and specific kinds of problems.

For this research, the following factors kept to ensure good pieces of research in this chapter:

- The research is carried out in an unbiased fashion by ensuring that all sides or alternative views of controversial issues are presented;
- This research is ethical and not harmful in any way to the participants;
- This research ensures data protection through confidentiality and anonymity of the respondents.

This chapter presents the research methodology adopted to achieve the aim and objectives of this study. It is essential that the epistemological premise on which a study stands is established in the attempt to discuss the research methodology and research methods employed in carrying out the research of this nature. This chapter is divided into two parts.

The first part is centered on research design, research methodology, justification of the research methodology and the research approach. The second part of the chapter describes the stages of the research study, the sampling procedure, data collection methods, measurement scales and data processing procedures as well as the methods of data analysis employed for the study. Finally, we will discuss in this chapter the operationalisation of the suggested constructs and model, which enabled us to describe and quantify all the measures and variables.

3.2 Philosophical position

It is important to clarify the structure of inquiry and methodological choices adopted in a study. Therefore, an exploration of various research paradigms is necessary in order to adopt the paradigm that best fits the focus of this study. According to Easterby-Smith *et al.* (1991), deciding on suitable methodologies and research methods depend on research paradigms and their assumptions. Weaver and Olson (2006: 460) defined paradigm as —patterns of beliefs and practices that regulate inquiry within a discipline by providing lenses, frames and processes through which investigation is accomplished. Research paradigm has been referred to as research methodology by Mackenzie & Knipe (2006) and has been classified into three approaches of positivist social science, interpretive (Constructive) social science, and critical social science (Post positivist).These approaches are different ways to observe, measure, and understand social reality in the world (Mackenzie & Knipe,2006).

Constructivism is the recognition that reality is a product of human intelligence interacting with experience in the real world. Including human mental activity in the process of knowing reality is an indication of accepting constructivism in the research *(Higginbottom & Lauridsen, 2014).* Constructivism accepts reality as a construct of human mind, therefore reality is perceived to be subjective.

Positivism research paradigm studies the rules that govern behavior in society through a scientific lens. Positivist sociologists are interested in the science of society; they apply the scientific method and scientific tools to the studies to find the natural laws of human behavior within society. It emphasizes quantitative analysis of aspects of a large sample for the purpose of testing hypotheses and making statistical generalizations (Steenhuis and de Bruijn, 2006, Aliyu *et al.,* 2014). Positivism involves the utilization of empirical methodologies extracted from natural sciences and used to understudy phenomena (Berg, 2009). It encourages the

explanation of relationship between variables which are operationally defined in any given research and is the most common model used in quantitative research (Aliyu *et al.*, 2014).
The main distinction between constructivism philosophy and positivism relates to the fact that while positivism argues that knowledge is generated in a scientific method, constructivism maintains that knowledge is constructed by scientists and it opposes the idea that there is a single methodology to generate knowledge (Steenhuis and de Bruijn, 2006, Aliyu *et al.*, 2014).A post-positivist might begin by recognizing that the way scientists think and work and the way we think in our everyday life . Because all measurement is fallible, the post-positivist emphasizes the importance of multiple measures and observations, each of which may possess different types of error, and the need to use triangulation across these multiple sources to try to get a better bead on what's happening in reality (Ormston *et al.*, 2014). The post-positivist also believes that all observations are theory-laden and that scientists (and everyone else, for that matter) are inherently biased by their cultural experiences, world views, and so on. Post-positivism can be adopted by either constructivists or even subjectivists, it considers that truth or reality can be approached to a certain degree by combining theories, common sense and evidence based on experience (Trochim and Donnelly, 2001).

For the purpose of this study, the Post-positivism paradigm is the most appropriate approach to elicit information concerning the general and internal perceptions and barriers facing organizations during the implementation of Lean as well as its the resultant benefits and enablers. Post-positivism social science approach has been widely used by many researchers under an epistemological context where both qualitative and quantitative methods of research have been effectively combined (Ritchie and Lewis, 2003). The choice of this research methodology is appropriate for the research aim and objectives. In fact, previous theories and studies were explored and relevant hypotheses were tested in the construction industry since the barriers are relative to stakeholders and thus, there is no absolute reality when it comes to measuring and analyzing the critical success factors

3.3 Reasoning approach

Researchers often refer to the two broad methods of reasoning as the deductive and the inductive approaches.
Deductive reasoning works from the more general to the more specific. Researchers begin with thinking up a theory about the topic of interest, then narrow that down into more specific

hypotheses that one can test. This ultimately leads to testing the hypotheses with specific data (Fereday, & Muir-Cochrane, 2006).

Inductive reasoning works the other way, moving from specific observations to broader generalizations and theories. In inductive reasoning, one begins with specific observations and measures to detect patterns and regularities, formulate some tentative hypotheses that can be explored, and finally end up developing some general conclusions or theories (Bryam, 2015; Fereday & Muir-Cochrane, 2006). Inductive coding entails the generation of themes from the data itself, which is heavily rooted in the grounded theory approach. Inductive reasoning, by its very nature, is more open-ended and exploratory, especially at the beginning (Bryam, 2015).

Based on the above-discussed theories, deductive research was used in this research for the generation of themes about implementation of Lean construction management with the support of literature and assigning relevant barriers from a set of data. The advantage of the deductive approach in this research is the ability to connect the finding of the research, which is the ranking of the barriers that face the successful implementation in the Lebanese industry according to the experts in the field, to the existing body of knowledge found in different countries, as well as the provision of a framework to commence the analysis.

3.4 Population and Sampling

Two populations were targeted in the research study. The first population includes one Lebanese company (company X) which is the first and only enterprise that had implemented LCM on projects in construction sites in the Lebanese industry. This is a leading construction company in Lebanon and the Middle East region as it is implementing, for the first time, LC on a large scale project that has a 150,000m^2 area. The second population of this research was all Lebanese construction companies listed in the Lebanese business directory under the chamber of civil and construction work ,regardless whether they are applying or not the concepts of Lean management or not.

3.4.1 *The First population*

This research employed an exploratory case study analysis as it allows strong evidence collection, description and observation. The purpose of the study is to understand more about

Lean implementation barriers and enablers in Lebanon establishes priorities, and improve the final research design. The basic idea behind a case study is to develop as full understanding of the case studied, and to enable close, detailed and continuous observation of a work practice at an appropriate organizational level. This enabled the researcher to capture the response of participants, the manner and extent to which they adopt the concepts of Lean, the circumstances under which they apply it, the barriers faced as well as the benefits captured from the implementation. The case study approach was particularly useful for this research study because it allowed the extension of experience and added strength to what is going to be found through the questionnaire survey.

The researcher has contacted 70 % of people who are knowledgeable and experts of the implementation of Lean that took place in 2015. These people are knowledgeable about the benefits that have resulted from the integration such as: reduction in cost, less delays in the projects, more accurate planning and so on.

Two Delphi groups were identified in company X in order to get the full picture of the implementation process. The use of this method was appropriate since the researcher needed to identify the barriers and enablers of the implementation -according to all experts-. Two Delphi group were organized in order to have the full picture. The researcher needed the opinions of people who are actually implementing the principles (filed employees) and the people who are directing, monitoring and controlling the implementation. This allowed us to have a better idea about the implementation barriers and enablers according to two different groups each of them having a different stand in the company.

Delphi Group 1 (DG.1): Managers who are all engineers in different positions.

Delphi Group 2 (DG.2): Foremen in the project sites.

The population in company X consisted of five engineers (business improvement department, and planning department) who were at managerial position and were monitoring the implementation process. These personnel have prepared the guidelines for using Lean tools and techniques in the company. In addition to 15 foreman who were working on the sites where Lean concepts were integrated.

A purposive sampling followed to choose the top managers and Foreman of the departments involved in the implementation of Lean Management. The experts in DG1 were three out of five members in the business improvement and planning departments of the company who

were at a managerial position; DG.1 consisted of 60 % of the population. The experts in DG2 were 8 shop floor employees working on the project sites from the day one of implementing Lean principles; DG.2 consisted of 53.3 % of the population. Finally, information was gathered from professionals who work with a private construction company in Lebanon. Critical consideration was taken to ensure that the interview reports the research objectives when preparing the questions. The Lean champions (in the business improvement department) were recording on a weekly basis the outputs of safety, time, cost, productivity, and quality. The causes of delays were monitored as well. Several key performance indicators related to LPS were recorded such as Percent Plan Complete (PPC) by each Last Planner, root cause of delays, safety adherence score, constraint identification, and constraint resolution. Results are presented in the next chapter along with a discussion of the improvements seen, the challenges faced, enablers of the implantation and its benefits, as well as suggestions for further improvements.

3.4.2 *The Second population:*

The study targeted construction and contracting professionals in Lebanon. These professionals include Project Managers, Procurement Managers, Engineers, Architects, Quantity Surveyors, Contractors and Forman who work in private and public sector organizations. These professionals were selected because they are involved in the construction process and delivery of structural projects. Though, these respondents work in different organizations of interest. After the population of the research has been defined and selected, the researcher has to decide based on the logical constraints (size of the population, time, money, etc.), if all elements of respondents of the study can be reached. Sampling is the process of selecting units (e.g., people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen; i.e. the sample is representative (Trochim, 2006).

This sample size requires representing the population in order to make the findings of the survey generalized; however, it is important to select a sample size that would represent adequate of its population (Bartlett *et al.* 2001). The researcher has decided that the sample would be its population and has targeted all of 210 companies to reach a higher number of respondents.

A Total number of 210 copies sent out by the researcher through email to the HR department of the companies wishing for it to be sent to the employees to increase the number of

respondents through a snowball effect. The expectation was to reach at least three respondents from each company. Thus, the total population is (3*210) = 630. Out of the survey sent, a number of 254 surveys were collected, which yielded 95% confidence level with a confidence interval of 5%.Ten questionnaires were found to be incomplete with respondents missing some of the mandatory questions, thus they were considered not suitable for the analysis. Hence, the sample size used for the questionnaire survey was (254-10) =244 respondents. The response rate is the (244) /630 =38.7 % and 1.58% was the incomplete rate.

3.5 Research strategy

The selection of the most appropriate research method must be driven by the research questions and the current body of knowledge in the area researched, as well as the data accessible to the researcher (Reiter *et al.,* 2011). Many researchers have made the choice of a single method while some have used a mixed method approach for their research studies. The most important thing is that no matter what the choice may be, the method chosen should be appropriate to achieve the aim and the objectives of the research study in question.

The two common research methodologies within the research paradigms are the qualitative and the quantitative. The combination of these two methodologies is known as the mixed method can also be a choice. Qualitative research strategy is used in eliciting insights about the world founded on individual perception (Bryam, 2006). Certainly, Naoum (1998) reveals that qualitative approach to research is 'subjective' in nature and stresses on experiences, meanings, descriptions etc. Moreover, information gotten using qualitative approach encompasses complete descriptions of people, situations, events, or observed behavior, making it productive when knowledge about the topic is limited (Polit & Hungler, 2001; Naoum, 1998). In the quantitative research method, effort is made to collect accurate data, study relations among facts and ascertain how such facts including relationships match with theories as well as the previous conducted research findings (Naoum, 1998). Denscombe (2014) summarizes the characteristic feature of a mixed method approach to be the use of qualitative and quantitative approaches within a single research project. The choice of this approach is based on the assumption that value can be achieved in bringing the two types of approach together having considered the very different ontological and epistemological bases of the two paradigms (Ritchie and Lewis, 2003).

3.5.1 *for the first population*

A Qualitative research strategy was used as a case study in the company that was the first in extensively implementing Lean tools in Lebanon. This method helps in understanding in depth the barriers and enablers of this first implementation. The assessment was done by conducting interviews with the two Delphi groups in this company.

DG.1) Delphi Group 1: Managers who are all engineers in different positions

(DG.2) Delphi Group 2: Foremen on the project sites.

The rationale for choosing a case study approach is the need to investigate issues relating to the implementation of Lean such as drivers for Lean, success factors, barriers encountered and the benefits encountered in the Lebanese context for company X. The rationale behind using Delphi method is the need for a structured communication technique based on interaction among respondents. Delphi group is considered as one of the best techniques when exploring something that is unknown by relying on a group of experts, since it is a systematic interactive way of gaining opinions from a panel of independent. The use of Delphi process aims to determine the extent to which experts in the Lebanese construction industry agree about the barriers and to investigate about the areas where they disagree in order to achieve a consensus opinion. Experts have answered questions in two rounds of meetings. During the second round with the two focus groups, an anonymous summary of the experts' opinions was provided, experts were encouraged to revise their earlier answers in light of the replies of other members of their panel, and the results of the first round were validated and uncertain ideas and statements were discussed further and clarified. The outcome of the Delphi groups coding was summarized into four sections in appendix A; the first section included the frameworks used in the implementation of Lean construction management, the second section included the benefits resulting from the integration, the third section comprised the barriers faced during the implementation and the fourth section covered the enablers for a successful implementation. A summary of the interview guidelines and answers were summarized in appendix B. The choice of content analysis was made, mainly because it allowed the researcher to analyze the data. In fact, with this approach, it is possible to distil words into fewer content-related categories, and make sense out of them.

3.5.2 *The second population:*

The qualitative method facilitated the quantitative phase. The Qualitative method consisted of a set of interpretive material practices by observing people in their daily work and their natural settings; the interpretation is done with respect to these people. This method gave a clear picture about what has been implemented in company X and an idea about the barriers that faces them during the implementation, thus it has formed the base for the questionnaire that was prepared and adjusted according to what was concluded from the qualitative assessment. The quantitative approach used later has provided the snapshots of the data, and the results needed. The mixed approach gave the opportunity for each of these methods to benefit from each other thereby avoiding the weakness in each approach.

A quantitative research approach was used in forms of 210 questionnaires sent to all Lebanese contracting companies in the construction field whether applying or not the principles and tools of Lean construction management. The questionnaire started with an introduction about the aim of the survey and the way the results would be used in. A confidential statement was provided to assure the respondents that results will stay anonymous.

Part one of the survey aims to collect information about the company s characteristics. Part two contains questions about the respondent's characteristics. An introduction about Lean construction management was then presented with a video link to have a clearer idea about the concept. Questions in part three of the questionnaire were related to the degree of awareness about aspects of Lean. Part four presented the list of the barriers found in the literature with a statement asking the respondents to rank these barriers according to their significance. The quantitative approach was used in this part of the research in order to gather data about the perception of Lebanese construction professionals concerning the barriers of LCM. The procedure to collect data was presented and a copy of the questionnaire survey is presented in appendix C.

In summary, the author has adopted a '*mixed methods*' approach involving a questionnaire and Delphi group interviews. This approach is appropriate for the research aims of this project, some of which are exploratory in nature. For broader realistic results, quantitative survey method was adopted to increase the possibility of generalizing the findings.

3.6 Operationalization

3.6.1 Interview coding

The study targeted one case study firm with respondents across all the organization including strategic level-executives/management, middle management-construction managers, and bottom level - operational level/supervisors and Foremen.

Two rounds of interviews were conducted with three personnel from the business improvement department and eight Foremen from the site where the implementation took place. After receiving the approval of the human resource department, the Delphi groups were conducted in a professional atmosphere, the groups were motivated and supportive, and they enjoyed sharing their experience and point of view. The duration of the interviews ranged between 65 and 90 minutes with a total of 6 hours. The data collected was then transcribed and coded by two researchers in order to reduce bias, and to increase the inter-rater reliability.

3.7 Research Process

Referring to what have been explained in the above sections of this chapter, the full research processes used for both strategies are presented in Tables 9 and 10.

Research Process for the qualitative study
Research questions What are the barriers of the implementation What are the enablers of the implementation What are the benefits reaped from the implementation
Strategy-Qualitative assessment using a case study approach
Sample- One construction firm
Data collection - Delphi groups interviews
Data analysis- Content Analysis
Results - Main findings of the research

Table 9: The Research Process for the qualitative study

Research Process for the quantitative study
Research questions: ' What is the level of awareness about the Going Lean in the Lebanese construction industry? what is the significance of the barriers found in the literature according to the perceptions of different groups of respondents ?
Strategy-Quantitative assessment
Sample- All construction firms working as contractors in the Lebanese industry
Data collection - Questionnaires
Data analysis- Parametric Analysis
Results - Main findings of the research

Table 10: The Research Process for the qualitative study

3.7 Statistical package and technique for the quantitative research

The Statistical Package for the Social Sciences was used for the processing and the analysis of the data acquired. The data collected from the respondents were analyzed using Cronbach's Alpha for the measurement of the reliability of the survey. Data type identification was also given due consideration. The data used for defining the barriers are considered as interval scale data and will use parametric measures such as t-test, ANOVA, regression. Principal component analysis as also used in order to be able to group the barriers.

3.8 Summary

This chapter has presented the details of the research strategy adopted to address the gaps identified in the literature review. The overall research strategy adopted for this research included a two-phase study: literature review and data collection. The outputs of the literature review became inputs for designing the Delphi interview guide and the research survey questionnaire, to collect the perceptions of construction project stakeholders on awareness and barriers to Lean Construction implementation.

In this chapter, we have discussed many philosophical positions and opted for the post-positivism position since the previous theories and findings will be taken into consideration for generating relevant hypotheses related barriers hindering the implementation of LCM in Lebanon. Also since these barriers are only as perceived by the stakeholders, there is no

absolute reality to be reached, thus the findings should be as close as possible to reality. Using a deductive reasoning approach, we relied on previous theories and findings to generate appropriate hypotheses, collect relevant observations, and analyze the findings in order to confirm or reject these hypotheses that can be generalized later on with some limitations. The survey research strategy was adopted in this paper and a mixed method was applied, where a qualitative study facilitated a quantitative one. The qualitative survey was Delphi group that targeted the first population represented by mangers, engineers and foremen in company X which is implementing LCM on site projects. After coding and analyzing the results of the Delphi groups, the outcome of this qualitative method facilitated a structure questionnaire that was distributed to the second population representing stakeholders in all Lebanese construction firms whether applying or not Lean principles in their companies. It is important to note that the awareness about the philosophy of Lean is the first step towards a successful implementation. therefore, Research questions seeks to identify the level of awareness about the new concept's tools, techniques, and benefits, as well as to identify the barriers facing the implementation of Lean Construction management in the Lebanese industry.
Collecting Construction project stakeholders' general perceptions on obstacles to Lean Construction implementation, and the recommendations for the overcoming strategies was the sole purpose of this research. The researcher did not seek in-depth and detailed input from project stakeholders on their suggestions to overcome the barriers.

The next chapter will include the analysis of the collected data in order to reveal the outcome of the qualitative assessment, and then use the quantitative questionnaire's responses to test and validate the hypotheses.

Chapter 4

FINDINGS OF THE STUDY

4.1 Introduction

This chapter will include all the findings and results. We will start by defining the analysis framework for both qualitative and quantitative analysis. Then a qualitative analysis will reveal all the findings of the interviews held with the first population defined in the previous chapter. A quantitative analysis will follow and will include a descriptive statistics part in which we will cover the composition of the data set, and an inferential statistics part including the analysis of variations, a regression analysis, and finally hypotheses testing.

4.2 Analysis Framework

4.2.1 Qualitative Analysis Framework

The approved version of the Delphi interviews collected during the qualitative analysis was read and coded by three raters in order to strengthen the study through inter-rater reliability and make sure that results are homogeneous, then codes related to similar constructs were grouped which yielded in four sections as described previously in the methodology chapter.

4.2.1 Validation of the scale measurement

It is essential for a researcher to resolve from the onset of a study the scale of measurement to use based on the nature and type of data to be collected, in order to determine the kind of numerical analysis that can be performed on the data generated. In the questionnaire used in this study, the interval scale was used to measure responses to most of the questions. It measured the strength of opinion of respondents on a metric scale on various aspects of the awareness about the Lean system and the implementation's barriers.

The establishment of a logical link between the objectives of a study and the questions used in an instrument, and the use of statistical analysis to demonstrate these links are the two approaches used to establish the validity of the instrument of this research.

4.2.3 Quantitative Analysis Framework

The questionnaire was implemented on an online tool. The survey received a total of 260 responses from professional participants in the Lebanese construction industry. The average

estimated time to complete the questionnaire was 12 min, and it comprised 39 questions. All the questions were mandatory. A total of 244 participants fully completed the questionnaire and 14 participants partially completed it, thus, incomplete rate was 5.3%.

The reliability analysis allows for the study of the properties of measurement scales. According to Yin (1994), reliability is the extent to which a test or procedure produces similar results under constant conditions on all occasions. Section 4.4.1 gives the Cronbach's alpha values of the survey carried out in this study. Then, a descriptive analysis was conducted on the data set in section 4.4.2. The inferential statistics in section 4.4.4 includes an analysis of variations using One-way ANOVA and t-test for parametric variables; we have used a regression analysis between the Level of awareness about Lean construction management and the type of barriers chosen to be hindering the successful implementation. Calkins (2005) stated that descriptive statistics generally characterize or describe a set of data elements, by displaying the information graphically or describing its central tendencies and how it is distributed while inferential statistics try to infer information gathered by sampling.
All the descriptive and inferential tests were performed on SPSS software and some charts were illustrated using Microsoft Excel software. By analyzing the degree of agreement, disagreement, and neutrality of the survey respondents, this study prioritized the barriers in the implementation of Lean Construction principles and methods within construction projects in Lebanon.

4.3 Qualitative Study results

The gist of the implementation of LC in the Lebanese projects lies in communicating the LC philosophy within the participants. The implementation started in 2015 when the Lean champions had noticed the problems in their construction sites, and decided to have a radical solution.
The chronic problems of construction as mentioned by Delphi group 1 (DG 1) are:
-Poor co-ordination that is identified when milestones are never completed on time, change orders are not properly dealt with and poor coordination of workers and subcontractors is detected.
-High costs: is found in construction due to price fluctuation, delays in construction, kicks backs. -High amounts of wastes that is the result of defects, extra processing, motion, transportation waiting, and underutilized talent.

The types of wastes found in the construction company are: time, transportation, processing, movement, and rework. The construction projects involve various risk factors which have various impacts on the critical success factors (time, budget, quality and scope) that may lead to project failures (Rad, 2003; Salleh, 2009).

> *" We have noticed that the market is setting down , work is going to be less , market becoming more competitive, margins are dropping , projects are always behind the schedule, thus ; we have to face these risks , by applying and integrating new management systems. To face this threat and become industry leaders we have looked to solutions such as Lean construction"* DG.1 said.

The company faced many problems such as lack of detailed and documented previous data concern risks and lack of adapting modern techniques for minimizing the effect of risk factors on construction projects objectives.

> *"Our projects were identified to be always behind schedule and over budget through the past five years, here where the idea of applying new philosophy and techniques such as Lean has appeared".*DG1.R1 added

After indenting all the problems, the business improvement group had introduced the LC tools needed, specially last planner and visual management to other participants and conveyed to them the right information about how to apply it and how to measure the variables on site.

4.3.1 Framework used

The framework used in the Lebanese example presented in this paper, is a bottom-up process that encourages useful contributions from everyone involved with the project. Since the internal Lean Team must accommodate the work, typically the start will be relatively slow. Details are chosen from daily work issues, and the process is a bottom-up translation of tasks.

The framework used has a Bottom –Up approach.

> *"The implementation started with shop floor employees (site Foremen) and then going up top engineers, project engineers, project manager and top managers.* DG 1 said.

The frameworks presented by the company emphasize thoroughly on how to execute the Lean implementation program phase by phase; what Lean elements should be utilized in each phase; as well as who are the internal stakeholders in applying the Lean TTPs that are deemed suitable for them:

> *" The clear picture of how to implement Lean was established by the constant presence of the Lean champions on site, in doing it themselves first, then showing practitioners how to do it, and letting engineers and Forman doing it themselves with observations , and then alone. In addition a manual/practical guideline that defines what are the system meeting, system reports, key roles and responsibilities for every position is available*" DG1 & DG2 added.

Besides the identified "What" and "How" element, another important dimension which the practitioners should consider is "Why". "It is presented in the guidelines and brings the reason behind the implementation of the tools or practices of Lean. "Why" requires practitioners to understand and think about the problems they face, their capabilities and resources, shop floor employees' or managers' skills to solve the problems, The managers said.

4.3.2 Implementation process

The implementation process consists of preparing a Lean team, focus on a specified pilot project at a selected stream value and then expand to the whole organization. Once the pilot project is well established, they expand the improvement effort to the next value stream and thereafter to the whole organization. This is the framework presented by Anvari et al in the literature above.

> *"We have started in ABC achrafiyeh, as a pilot case to see if the principles can be applied in Lebanon"* Both DG s agreed on.

It is important to note that Lean practices are still internal within the company. But they are trying to take it to the next level through involving some of the external stakeholders, such as: owner representative, consultants, designer, project managers, and big contractors in the weekly progress meeting.

> *"We are sharing with the external stakeholders the agenda of the next meetings, the Key performance indicators, the float of delay per zone, the percent plan to give them the idea*

about the implementation". "Big contractors, are filling the weekly work log, giving their promises, and receive results concerning (cost, quality, Safety) weekly". Group 1 added.

The aim of the company is to make Lean embedded in the supply chain to eliminate more waste.

4.3.3 Tools Implemented

Once the company's planning goals were defined, the team came across Last Planner System (LPS) in their research and realized that these new systems will meet their requirements and reach the desired goal of creating a culture of making and meeting promises, if implemented correctly.

The Concept of LPS was embedded in the implementation. The system integrates "should-can-will-did planning " (pull planning, make-ready, look-ahead planning) with constraint analysis, weekly work planning based upon reliable promises, and learning based upon analysis of PPC (plan percent complete) and reasons for variance .

> *"We are engaging the last planners (foremen & Engineers) in pull planning sessions to collaboratively establish the flow of work for the project milestones Foremen are involved in the weekly meeting to be aware about the risks and the constraints Foremen now take their own decisions concerning the number of workers needed every week, and number of hours needed to finish a task. We Specify handoffs between trades within each phase schedule to ensure smooth and reliable workflow for the next 6-8 weeks of work."* DG.1 said.

The Lean team has engaged the last planners (foremen & PM's) in pull planning sessions to collaboratively establish the flow of work for the project milestones. The main goals of applying the LPS in this company according DG1 are: to be able to plan for the tasks in detail as soon as they near execution, to involve the people who are going to perform the work in the planning, to identify and remove constraints ahead of time in order to clear the path for the execution team, to coordinate between team parties and trade partners in order to make

reliable promises to execute the planned work, and the most important one is to identify the root causes of the problems and learning from failures to continuously improve.

The "Make Work Ready" planning is then prepared by the team; it involves looking out several weeks and identifying any constraints that would keep work from starting as scheduled. The plans for the upcoming 4-6 weeks are reviewed to make work ready by removing constraints. Finally promise for work execution in an effective manner and re-plan are done

The Weekly Work Planning is then prepared by the team. They talk through the upcoming week and make commitments to perform work in a certain sequence. Planners are asked to only promise work that is unconstrained and start work that is ready. An evaluation of the successes and failures of the previous week's plan is done. The results are conveyed to the employees to be able to know the constraints for the next task and we review the percent plan complete (PPC) and variance categories. Identify root causes of plan failures and develop a plan for implementing them.

> *"It is important to note that we have also developed what it is called constraints management to be able not only to track the barriers but to solve them for the next stage. Assigning responsibilities, dead line, communicating them continually, daily reminders of constraints to be resolved involving the Forman and shop floor employees. I n addition we have developed manuals / a practical guidelines for each position that defines what are the system meeting, system reports, key roles and responsibilities for every position".* DG1.R1 said.

In addition the LPS, Huddle meeting is also used as another Lean tool in the company. A 10 minutes daily start-up meeting is held where team members briefly give the status of what they had been working on since the previous day's meeting.

Visual management was also used in order to put an eye on safety issues on the site .observations on safety were recorded daily. The visual workplace is a continuous improvement paradigm that is closely related to Lean; the TPS offers its own comprehensive

methodology for significant financial and cultural improvement gains, any abnormalities will stand out and be easy to identify as a problem.

> *"Applying BIM (Building Information Modeling) Company wise with office team is our next priority, we are aiming to use BIM to find the percent plan complete, budget control, and even field management where Forman have tablets to check his work"*. DG1 said.

The company is considering applying other aspects of Lean tools: 5s, just in time, value stream mapping, Multitasks workers and benchmarking.

4.3.4 Benefits of Lean construction Management

Both Delphi groups have insisted on the benefits aroused from the implementation of Lean construction management in their company in terms of completing more jobs per year and producing significantly less waste. This will increase profits and keep costs down. It helped the firm to make more money in less time than is possible with traditional construction practices. The most important ones are summarized as:

Improved Visual Management: it is the management by sight. Visual management helped identify when things are out of place, any abnormalities will stand out and be easy to identify as a problem. In terms of safety observations, it was found that the improper supervision and visualization was the root reason for accidents and unsafe work conditions. The number of non-compliance forms has dropped due to visual management application, as mentioned by DG.1 R1. The improved visualization -whether by posting safety signs or quality standards or schedules -, has effectively communicated he needed information to the workforce.

Increased efficiency: the process will ensure that each person is working in the most efficient manner. Standardized work will ensure they are doing it correctly following the same method every time. This leads to increased efficiencies. Prior to implementing LC, projects' planning was handled by the planning department only. Planners would send out emails indicating the dates that they want other departments or projects to adhere to. The planning process was not collaborative. But now, the planning cycle starts by performing work on site for a given week

based on what each team believes they can do, given the available resources and the cleared activities at that point in time. A schedule update is performed by the planning department after incorporating the actual progress. The updated results and floats are then sent back to the site and to the client as an after-the fact reporting. This have led to an increase in the PPC done by the last planner in a way that they are now able to reach an average work of 80% of what was promised . Table 1 shows the results of the weekly PPC attained by the Last Planner in first week of March 2016.

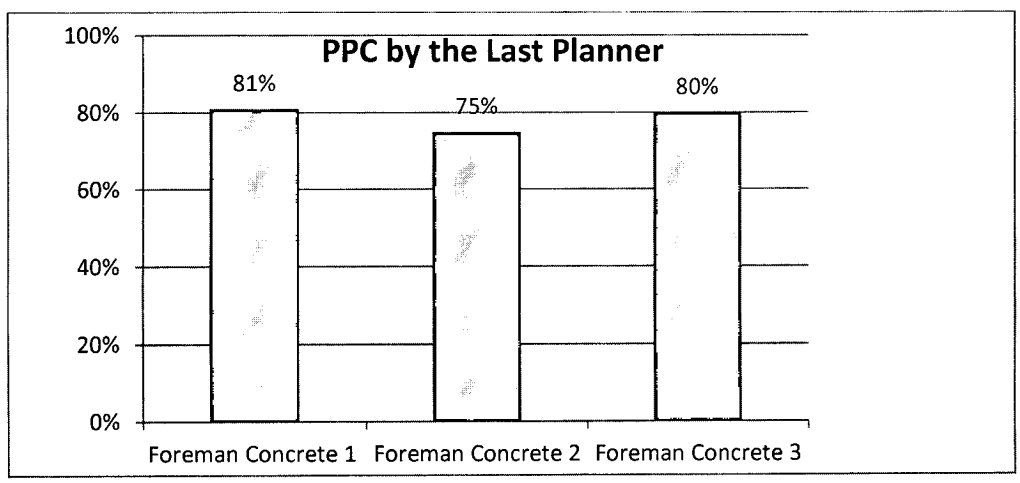

Figure 1: PPC by the last planner

They have noticed fewer requests for information due the organized work.

"These people have noticed opportunities for improvement in their daily work. Perhaps, they find ways to make their job more efficient" DG.1 said.

Behavioral change: One of the major benefits of Lean concluded in the company is getting more done with less people.

> *"The ability to do the job with less people becomes a very real possibility" "The Forman is asking for fewer workers and less time to finish a task and is aiming to be on schedule and even ahead of schedule"*.DG.1 added.

Meet some of the critical success factors: the implementation of Lean principles has helped the company in reducing the delays in the total project, and thus save time to focus on other tasks.

> *"We noticed that the delay have decreased from 60 days to 6 days, plus we are on budget, with very few reworks. ABC Achrafiyeh was the first project to be finish on time for the past 15 years. Our projects are huge and very tight in time" DG.1 & DG2 reported.*

Moreover, the implementation has offered a safer work environment. Safety is considered one of the crucial interests of the company, since the presence of injuries and work accidents is considered a source of waste that increases work variability, if not regulated properly . The implementation has helped the company to reduce the disruption in the workflow and stabilize the flow, and organize the work. DG1.R2 added: *"We have focused for the first time on safety. Results are shown of incidents and observations on site about safety such as risk behaviors to alert them weekly about the safety. We noticed a drop in the number of injuries due to the increased number of observations.* The number of injuries has dropped". The champions of Lean agreed that the new environment is saving more money in term of offering a lower number of turnovers, since low safety level was very costly in terms of paying for human sufferance and compensation time, and lost productivity. Moreover the company has proceeded with work accident insurance, the thing that few construction companies in Lebanon grant.

Image of the company: The implementation of Lean enhances the company reputation and boosts its image, especially through the publications done on it.

> *"Lean is considered as a part of the pre-qualification when we are applying for bids"* said DG.1.

Improved quality mistake proofing: is put in place to strengthen the process and prevent recurrence. As a result, the quality is improved. In terms of quality, the number of rejected inspection per person per zone are measured and reported. In addition, the number of nonconformance reports by person by zone are reported, this helps to identify the problem and

solve it. Moreover, the team wanted to follow the Toyota way presented by Ohno in Chapter1, and monitor the quality management indicators. They have tracked the Inspection approval rate for every month. As they have found, the percent of approved inspections has increased throughout the month and reached an average of 92.25% approved. Figure 1, shows the Inspections approval rate for the month of February 2016 (Hamzeh et al., 2016).

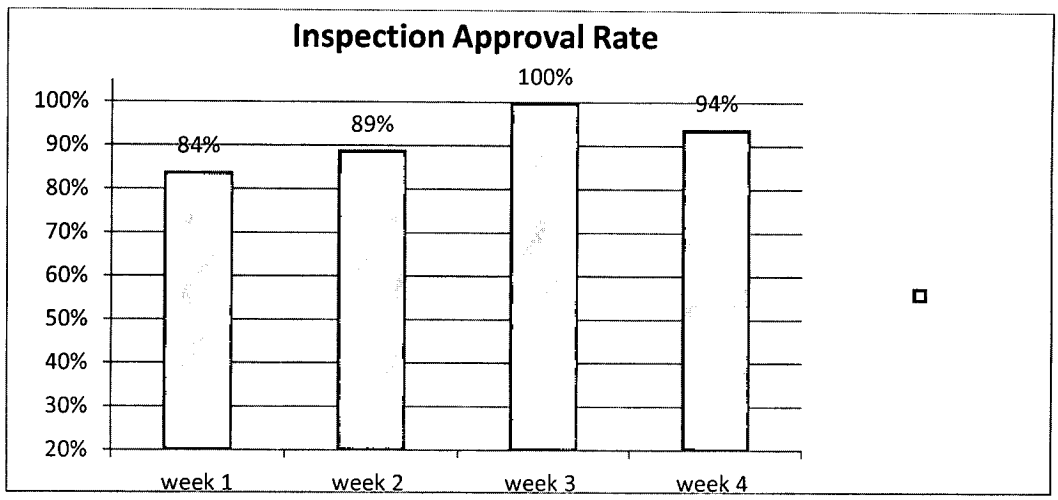

Figure 2: Inspection Approval Rate

4.3.5 Barriers of the Implementation

Both groups have found barriers when implementing Lean construction management, below are a summary of the barriers found in the Lebanese industry:

- *Cultural behavior:* Cultural behavior is one of main barriers faced when the company first implemented LCM. DG1 agreed that the main barrier was that people are giving promises, but not reliable promises. They were not sticking to what they said and they don't identify the constraints before giving the promises. This was the results of non-planning before promising or doing.

"The problem is that the culture itself accepts unfulfilled promises and delays. Suppliers and workers are not afraid of losing their job /not being part of future job, if they do not stick to the exact planning schedule already established. "that there is a kind of work relationship

that links you to this supplier , and you already know him so you don't bother yourself looking for new people in the second project ". DG1 added.

This group added that when a supplier or a Forman tells you that his work will be finished in 2 weeks / or he will shows up in 2 weeks , you already know that this will not happen and they are used to give them few more weeks to finish their job .

- *Resistance to change:* is another barrier found during the implementation. According to the professionals in this company, workers have not accepted the change easily. The misunderstanding about the need for change encouraged the workers not to accept the change and not to work for it. Especially from those who strongly believe the current way of doing things works well and has done for twenty year. In addition, one of the most common reasons for resistance of the Lean implantation was the fear of the unknown. People will only take active steps toward the unknown if they genuinely that the risks of standing still are greater than those of moving forward in a new direction. At the beginning the shop floor employees in this company didn't feel the trust toward the new concepts When people don't believe that they can competently manage the change they start to be resistant especially that they feel they lack the competence and the skills need for the adoption, and some people feel that they won't be able to make the transition very well. As mentioned by DG1:

> *"People didn't accept the change done easily. They have the fear of taking risk of applying the new concepts just because it is "New" for them".*
> *"The reason why we have first resisted the change is that we are used to the old ways of working and we are coping with it, and we see no need to implementing new management principles."* GD2 added.

- *Unawareness about Lean benefits*: is another barrier. Professionals in this company from DG2 mentioned that the problem with integrating the new principles is that they believe in not having the time to do the implementation due to the tight time of the projects. So they don't have time neither for paper work nor for on-site tasks planning. DG1 mentioned that workers are not aware of the time and cost reduction that will result from the successful implementation that why they are not pushing for it.

4.2.6 Enablers of the Implementation

Lean implementation enablers are comprehensive non-mandatory practices and recommendations containing collective wisdom on how to be perorated to implement Lean techniques and principles on construction sites. Both Delphi groups have agreed on the importance of following factors for a successful implementation of LCM:

-*Top Management Support:* one the critical success factor the implementation was that top managers have started to be involved in the results of Lean, and are pushing more for it. The top management is supporting the team by all means in terms of money, researches, time and involvement, without their help, the team wouldn't be able to reach the promising results they got as reported by DG.1.

-*Employee empowerment*: was implemented through a leadership management approach through empowering and engaging employees in all the steps of the implementation, and involve them in the decisions making process for some issues , shop floor employees are now feeling more empowered and more satisfied. Giving the workers the trust to pick the team , the team number , the number of days needed to fulfill the tasks and the resources , have let the them eel empower and responsible about the A to Z of the task .

> *"The adaptation of an Inclusive Leadership Approach was the main enabler for the implementation.* GR1 said.

-*Good Communication*: The communication management processes with internal stakeholders and then with the external ones at all levels was one of the most important enablers of Lean. The communication was achieved through holding weekly meeting where all the parties are involved and have to give their feedback about the last week work, constraints, and improvements. Appropriate communication among the employees has facilitated the Lean implementation process. Communication has led to a good and clear understanding and application of Lean tools and techniques and the constraints found repeatedly on site.

Moreover, it removes the ambiguity in employee's roles and responsibilities.

"Communicating the Lean pilot project success increased the support from the shop floor employees as well as managers to expand the Lean practices within the company." DG1.R2 highlighted.

4.4 Quantitative Analysis

A set of questions were included to determine the nature and the background of the participants / organizations, in order to determine their perception of the implementation process and the significance of barriers hindering the implementation.

A reliability analysis was performed on the 244 responses using Cronbach's Alpha, results in section 4.4.1. Then a descriptive analysis was conducted on the data set in section 4.4.2. The inferential statistics in section 4.4.3 includes an analysis of variations using One-way ANOVA and t-test for parametric variables. A factor analysis was conducted in section 4.4.4.. After the analysis of variations, the authors have used a regression analysis to characterize the relation between the level of awareness and the barriers using a probability distribution. A summary of the results obtained is provided below.

4.4.1 Reliability Analysis

Scale reliability and internal consistency were tested using the Cronbach's Alpha coefficient of reliability as shown below.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.804	0.800	30

Table 11: Reliability Analysis

Cronbach's Alpha for the 21 variables was used to evaluate the awareness about the implementation and the barriers facing it which yielded 80.4% demonstrating a good reliability since it is above 70% (Yusoff, Rahim, Aziz, R, MeyJa'afar, & Esa, (2011)).

4.4.2 Descriptive Statistics

4.4.2.1 Company Characteristics

4.4.2.1.1 Year of establishment of the company

The year the company was established was collected in question 1 of the questionnaire and was represented by an ordinal variable. This question was included as it provides a tool for distinguishing between the responses according to the year their company was established.

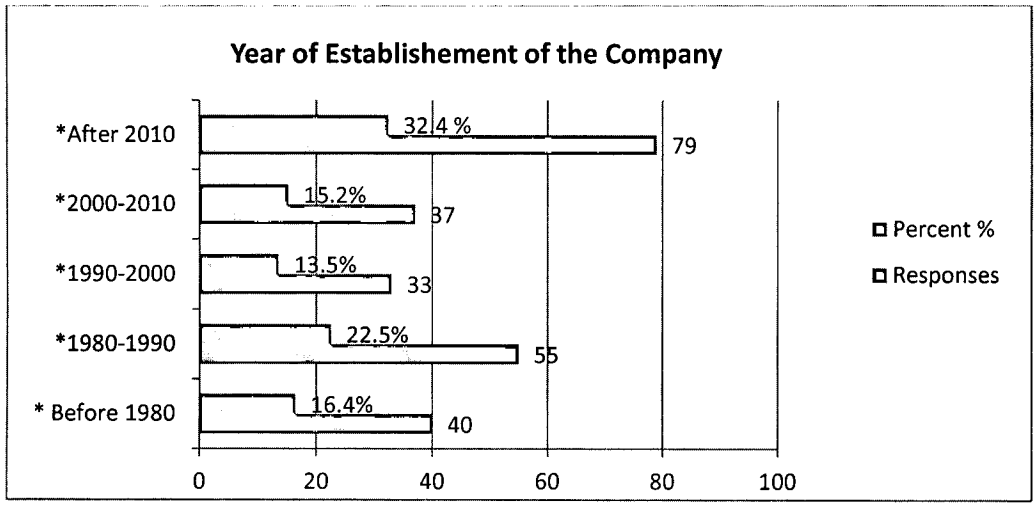

Figure 3: Descriptive Analysis – Year of the company's establishment

As can be seen from figure 3 above, the highest proportion of participants were those who work in companies that were established after 2010 and represent almost 32.4% of all respondents. 22.5% of respondents belong to companies established between 1980 and 1990, respondents working in companies established before 1980 came third (410 respondents almost 16.4%), and then respondents belonging to companies established between 2000 and 2010 which represents 15.2% of the data set. finally 13.5% of the respondents work in companies established between 1990-2000. This question will be later used to identify whether the year of establishment of the company affects the Lean awareness.

4.4.2.1.2 Number of employees

The Number of employees within the participant' s organizations was collected in question 2 of the questionnaire and was represented as an ordinal variable having six different groups of responses.

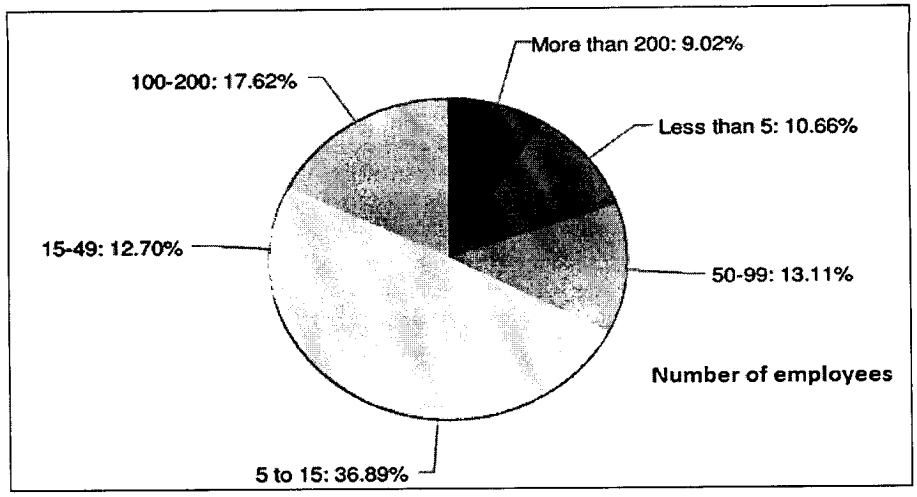

Figure 4: Descriptive Analysis – Number of employees in the organization

As can be seen in figure 4 above, 90 of the respondents (36.89%) belonged to organizations which have five to 15employees. The second group consisted of 40 respondents who belonged to organizations having 100 to 200 employees and represented 17.62% of all respondents; 32 respondents belonged to companies having 50 to 99 employees and representing 13.11% of the respondents, and 31 respondents belonged to companies having 15 to 49 employees for a total of 12.7% of the data set; while only about 10% and 9% of the respondents belonged to organizations which have respectively less than 5 employees and more than 200 employees.
The responses received from this question have evidently shown the diversity of respondents from small to large organization based on the number of employees.
However, it is seen that the majority of the respondents belonged to medium sized enterprises.

4.4.2.1.3 Yearly Gross Income

The yearly gross income of the organization was collected in question 3 of the questionnaire and was represented as an ordinal variable having six different brackets of responses.

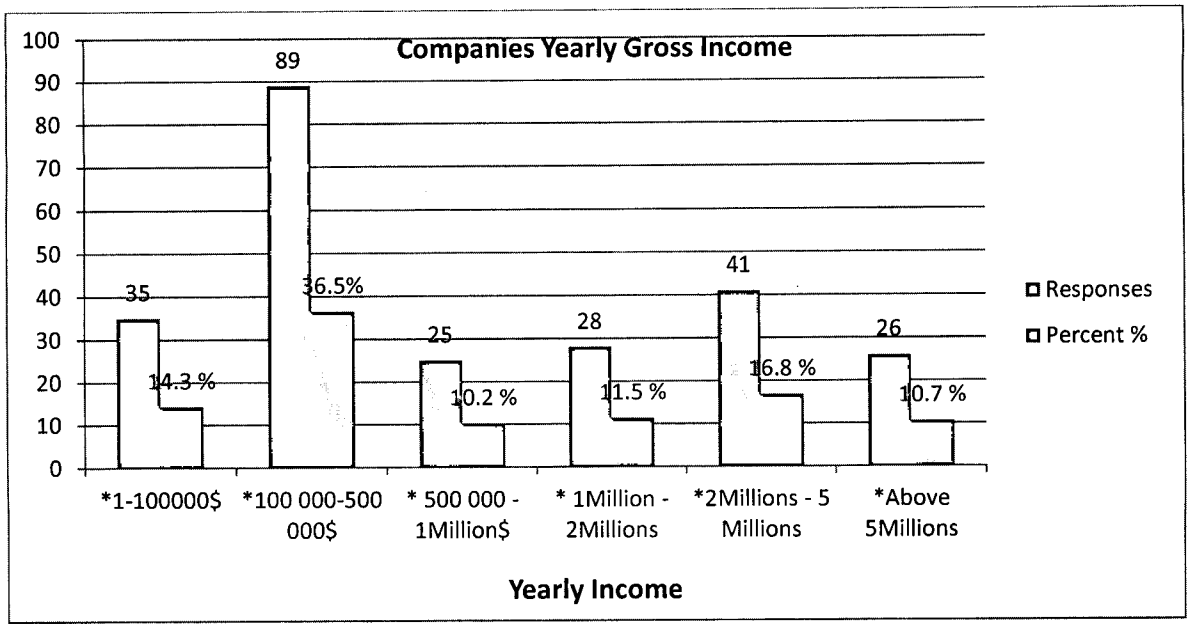

Figure 5: Descriptive Analysis – Yearly Gross Income

The results shown in figure 5 illustrated that the research was successfully able to capture a well distributed mixture of organizations based on their yearly gross income.

This study included most of the medium construction organizations in Lebanon. . Almost (36.5%) of the responses received represented organizations with a yearly gross income (YGI) ranging between 100 000$ and 500 000 $. Alternatively about 16.8 % of the responses represented organizations having YGI between 2 and 5 millions dollars.14.3% of the responses were from organizations with YGI below 100,000 dollars, whereas 10.7% represented companies with high gross income that lies above 5 Million and 10.2 % represented companies with an income that lies between 0.5 and 1 million dollar.

4.4.2.1.4 Number of countries

The number of countries the companies are operating in was collected in question 4 of the questionnaire in appendix C and was represented by an ordinal variable (Sum of countries). The selection included: Lebanon, KSA, UAE, Qatar, Africa, European countries and a box for other options to ensure flexibility. All companies must be working in Lebanon first so an answer of 1 meant that the company operates only in Lebanon, two mean that the company was operating in Lebanon and in another country.

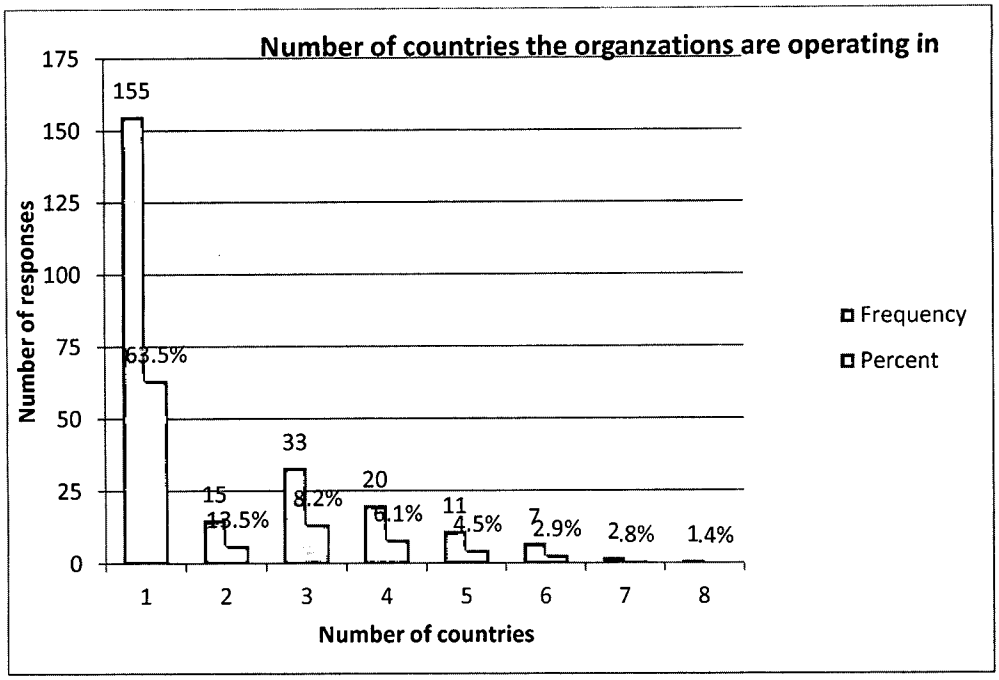

Figure 6: Descriptive Analysis – Number of countries operating in

Number of countries operating in	Responses	Percent %
1.00	155	63.5
2.00	15	6.1
3.00	33	13.5
4.00	20	8.2
5.00	11	4.5
6.00	7	2.9
7.00	2	.8
8.00	1	.4

Table 12: Descriptive Analysis – Number of countries operating in

This question aimed to identify the number of countries the organizations are operating in. As can be seen from table 12, 155 respondents (63.5%) were operating only in the Lebanese industry, 15 respondents stated that their organizations have projects in two countries with a percentage score of nearly 6.1% of all respondents. Twenty six percent of the organizations were operating in 3 to 5 countries and only 4.1 companies operated in six countries or more. Among those countries, we can find Qatar, UAE, KSA, Libya, Africa, Nigeria, France, and Peru. KSA seems to have the highest frequency, followed by UAE, and then Africa.

4.4.2.1.5 Implementation of Lean construction Management

Question 5 addressed the existence of a formal implementation of LCM within the company and was represented by a dichotomous nominal variable having as values of yes or no only.

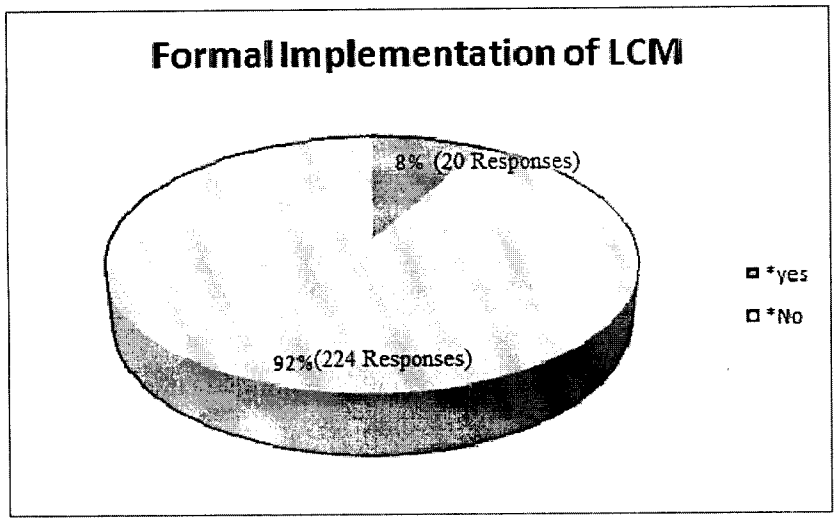

Figure 7: Descriptive Analysis – Formal Implementation of LCM

As it can be seen on figure 7, only 8% of the respondents stated that their company was applying LCM, whereas 92 % said that there was no formal implementation in their firms. The results were logical since it is well known that there are very few construction companies in Lebanon which are having extensive implementation of LCM. The results correspond with the qualitative study where we have discussed the presence of only one firm which has an extensive formal implementation of lean principles and tools.

4.4.2.2 *Respondents characteristics*

4.4.2.2.1 Gender

The gender of the respondents was collected in question 6 in the respondents' characteristics part of the questionnaire and was represented by a dichotomous nominal variable (GENDER) having as values male or female.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	*Male	192	78.7	78.7	78.7
	*Female	52	21.3	21.3	100.0
	Total	244	100.0	100.0	

Table 13: Descriptive Statistics – Gender

In the data set, the majority of the responses were collected from males. In fact, 192 of the people who responded to the questionnaire were males, which account for 78.7% and 52 respondents were females, which account for 21.3%. Even though we didn't have a normal distribution between the percentages of males and females answering the questionnaire, the sample represented the population since in the construction industry and especially on sites we usually encounter more males than females due to the nature of the work.

4.4.2.2.2 Age

The age of the respondents was collected in question 7 of the questionnaire and was represented by an ordinal variable (AGE) having as values seven age groups as illustrated in the following figure.

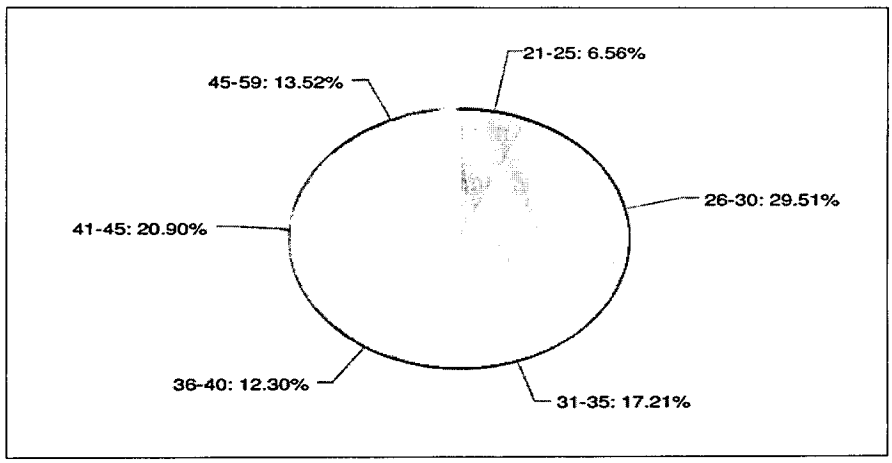

Figure 8: Descriptive Analysis - Age

The majority of respondents (29.5%) were aged between 26 and 30 corresponding to 72 respondents. Followed by 51 people aged between 41 and 45, which consist of 20.9%, then 42 respondents are between 31 and 35 years representing 17.2% of the data set. The smaller groups were between 36 and 40, and above 45 years being respectively 33 responses at 13.5%, and 30 responses at 12.3%. The young people that age between 21 and 25 are 16 respondents whom represent 6.6% of the total population. The above shows that the sample included all the age brackets almost equally distributed.

4.4.2.2.3 Educational level

The education of the respondent was collected in question 8 of the questionnaire represented by an ordinal variable (EDUCATION). This question was placed to identify the qualification set of the participants.

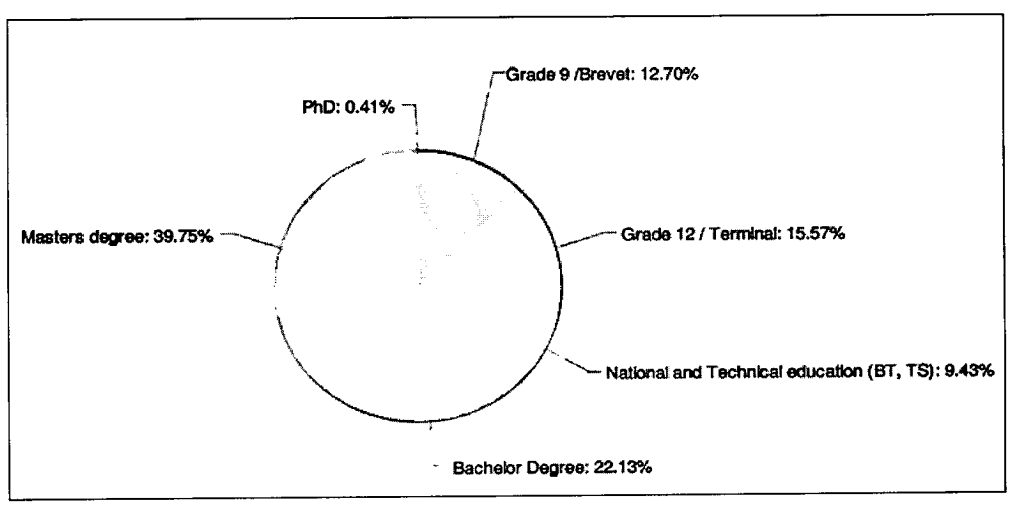

Figure 9: Descriptive Analysis – Educational level

While checking the education of the respondents, the majority held a masters degree with 97 responses at 39.8%, followed by 55 bachelor degree holds at 22.5% and 38 with a terminal (Grade12) level at 15.6% and 30 with Brevet (Grade 9) Level at 12.3%. The minority of 23 respondents had national and technical school (BT, TS) at 9.4% or holds a Ph.D. or doctorate degree with only 1 respondents representing 0.4%. The educational level of respondents included all the possible categories for employees in construction companies in Lebanon, even the ones having the highest degrees such as Ph.D. or Doctorate. The results from figure 9

above demonstrated that the research captured a well rounded mixture of professionals, based on their highest level of qualification. Another important observation obtained from the results of this question is the large percentage of participants holding postgraduate qualifications, i.e. masters degree.

4.4.2.2.4 Position in the company

This question was included to determine the current role of the participants. The results from this question are also shown in Table 14 below. The position of the respondents was collected in question 9 of the questionnaire and was represented by an ordinal variable (Position).

Position	**Frequency**	**Percent %**
Foreman	90	36.9
Project Manager	60	24.6
Engineer	46	18.9
General Manager	22	9
Top manager	15	6.1
Quality manager	6	2.5
Regional manager	3	1.2
Contract manager	2	0.8
Total	244	100

Table 14: Descriptive Statistics – Position

As noticeable, the largest proportion of the participants (90 respondents) was for site foreman at 36.9%, 60 respondents are on site project managers representing 24.6%. 46 respondents stated that they work as engineers in construction companies representing 18.9%; 22 of them are General Managers at 9%, 15 are Top managers at 6.1%. The minority of the respondents were respectively 6 quality managers at 2.5 %, 3 regional managers at 1.2%, and 2 contract mangers at 0.8%. As it can be concluded, the survey has targeted respondents from different positions in the Lebanese sector ranking from top mangers to foreman. This might be correlated with the results of figure 9, where we concluded that most of the people who hold a masters degree are working as site engineers, where as people who don't have a diploma are working as foreman in the organization. As noticeable, the responses obtained from this question have undoubtedly shown the wide diversity of the participants' current roles.

4.4.2.2.5 Years of experience in the current company

The duration for which the respondents have been working in their current companies was addressed in question 10 and was represented by an ordinal variable (Years in the current company.

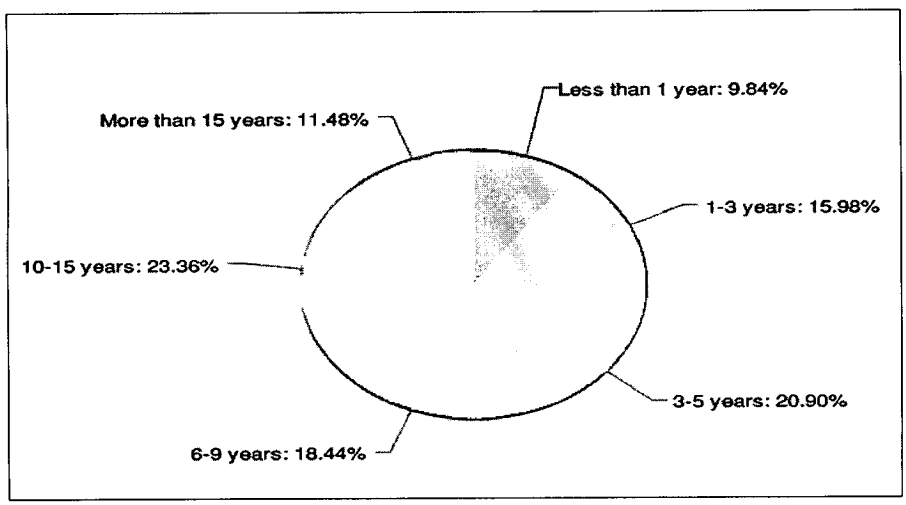

Figure 10: Descriptive Analysis – Number of years in their current company

The majority of respondents (23.36%) have worked in their current company fo10 to 15 years corresponding to 57 respondents. Followed by 51 people who worked for 3 to 5 years, which consist of 20.9%, then 45 respondents worked between 6to9 years representing 18.44% of the data set. 39 respondents have worked in their company for 1 to 3 years which consists of 16% of the total data set. The smaller groups have worked less than 1 year and more than 15 years being respectively 24 responses at 9.8%, and 28 responses at 11.5%. The above showed that the questionnaire have reached several groups of people with an equally distributed number of years spent in their current company.

4.4.2.2.6 Total years of experience

The total number of years of experience was collected in question 11 and was represented by an ordinal variable (Years in the current company). This question was included as it provides a tool for distinguishing between the participants according to their years of experience.

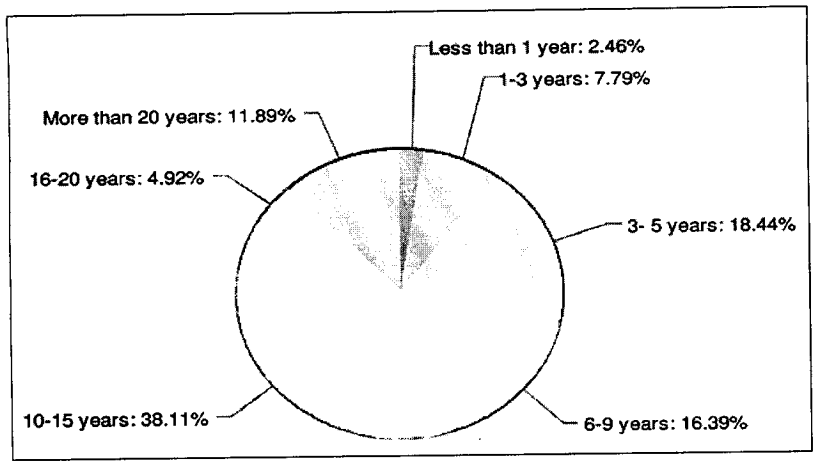

Figure 11: Descriptive Analysis – Total years of work experience

As can be seen from figure 11 above, the highest proportion of participants (38.1%) were those who have work experience of 10 to 15 years corresponding to 93 respondents. Followed by 44 people who are being in the field for 3 to 5 years, which consist of 18.0%, then 39 respondents worked between 6 to 9 years representing 16% of the data set. 29 respondents have a total work experience of more than 20 years, 20 respondents have 1 to 3 years of experience which consists 8.2% of the respondents, and 13 respondents have 16 to 20 years of experience at 5.3%. The minority (six respondents) had less than 1 year of and represents 25% of the data set. As it can be seen most of the respondents have a good work experience that allows them to have a clearer idea about the barriers that might face the implementation of Lean construction management. It is obvious from the results of figure11 that more than half (54.9%) of the responses received were from professionals with more than 10 years of experience holding senior positions at a managerial level. This definitely, enhanced the validity of the sampling approach adopted (Trochim, 2006), and thus, increased the reliability of the results achieved. It has also reflected a good base of personal experience in the sample. Thus, it is rational to infer that the respondents have a reasonable knowledge of Lean construction and that their response can be relied upon to some extent.

4.4.2.3 Awareness about LCM

These questions were introduced to see if the respondents are aware of the full picture of Lean & its potential benefits on the organization, and whether there is a holistic view of Lean within construction organizations or not.

The awareness about LCM was assessed using four proxies; awareness about the concept, awareness about the fun fundamental principles, awareness about the tools, and awareness about the benefits captured from the implementation evaluated respectively in question 12 to 15 in the questionnaire, these variables are measured on a scale of 0 to 10, 0 being the lowest value and 10 the highest, and were treated as metric variables. Descriptive statistics of the awareness variables are shown in the table 15.

Statistics

	Awareness about the idea of Going Lean	Awareness about Lean principles	Awareness about Lean tools	Awareness about Lean benefits
Mean	5.00	4.32	4.37	4.74
Std. Deviation	2.179	2.246	2.101	2.384
Variance	4.749	5.043	4.415	5.682
Skewness	.022	-.008	.169	.117
Kurtosis	-1.248	-1.252	-1.333	-1.460
Minimum	1	1	1	1
Maximum	10	9	10	10

Table 15: Descriptive Statistics – Lean Awareness Variables

The above table shows the descriptive statistics of the awareness factors, the average mean of the awareness about the concept is 4.6. It can be noticed that the means of all the factors are homogeneous on the lower end.

4.4.2.3.1 Awareness about the Concept in General

The awareness about the general idea of going Lean and the concept itself was collected in

Question 12 of the questionnaire and was represented by a metric variable. The following figure illustrates awareness about the general concept that was rated by respondents on a scale

of 0 to 10 where 0 meant that the employee did not have any clue about Lean construction management and 10 meant that the respondent had a very high awareness level about the concepts of Lean in a construction project.

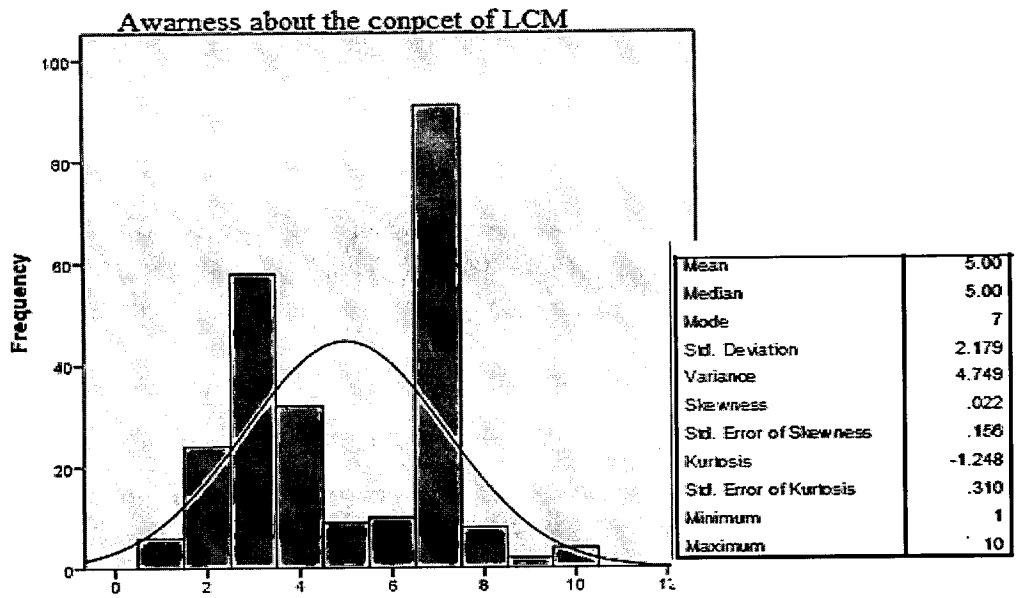

Figure 12*: Descriptive Statistics – Awareness about the concept of LCM*

The awareness about the general concept of Lean construction management presented a normal distribution with a mean of 5, a standard deviation of 2.179 and a kurtosis is –1.248 which is between -2 and 2 supporting the homogeneity of the sample (Gravetter and Wallnau, 2014).

The distribution of the awareness about the concept suggested that people had heterogeneous opinions in relation to this variable, since all the possible responses between 1 and 10 had a minimum frequency of 5 and a maximum frequency of 90. Looking at the mean of this distribution, we concluded that on average, people have a neutral judgment for general awareness (mean = 5.00). It can be noticed that we had for the scale of 3(mode= 58) and the scale of 7(mode=90). It can be concluded that respondents either considered that they moderately did not know the Lean concepts or moderately considered that they knew about it. Although the average is 5 but the distribution is saying zero.

4.4.2.3.2 Awareness about Lean Fundamental Principles

The following figure illustrated the awareness about Lean fundamental principles that was rated by respondents on a scale of 1 to 10. The awareness about the principles was collected in question 13 of the questionnaire.

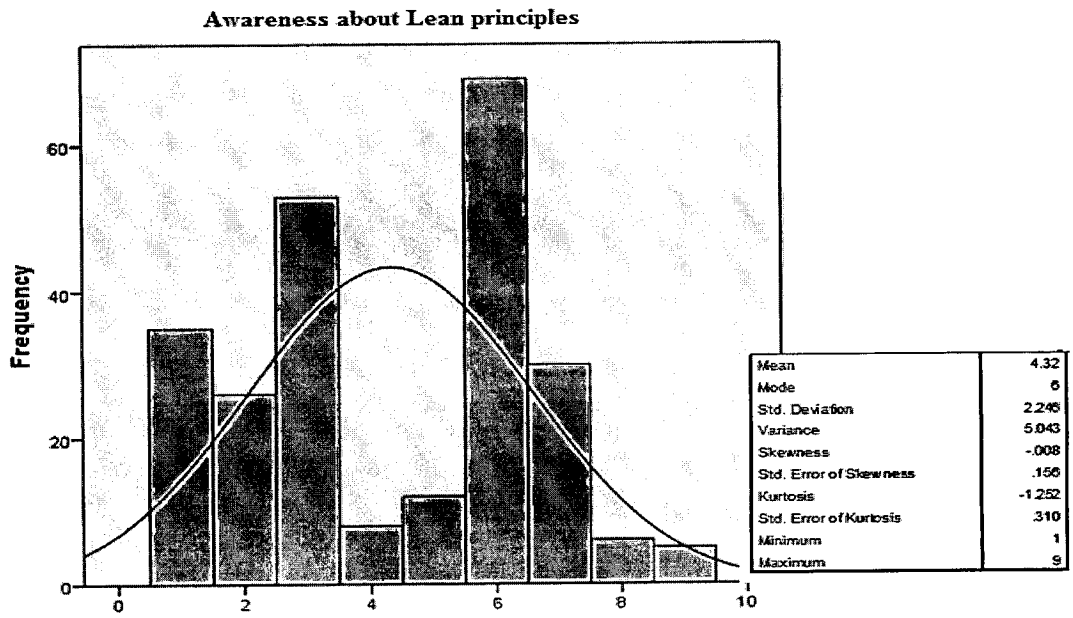

Figure 13: Descriptive Statistics – Awareness about the Principles of Lean

A normal distribution was noticed for the awareness about the principles with a mean of 4.32, a variance of 5.043, and a standard deviation of 2.248 and a kurtosis of 1.252. The mode of this variable was 6, meaning that when asked about the level of awareness about the five principles: Value, Value stream, Flow, Pull and Perfection, the answers having the highest frequency was 6 which mean that few respondents have a good background about the principles. The mean value of 4.32 reflected a moderate ranking of this awareness showing that it is slightly below the passing level.

4.4.2.3.3 Awareness about LCM tools

The awareness about LCM tools and techniques was measured on a scale of 0 to 10 as well. Description of these tools is illustrated in the figure 14.

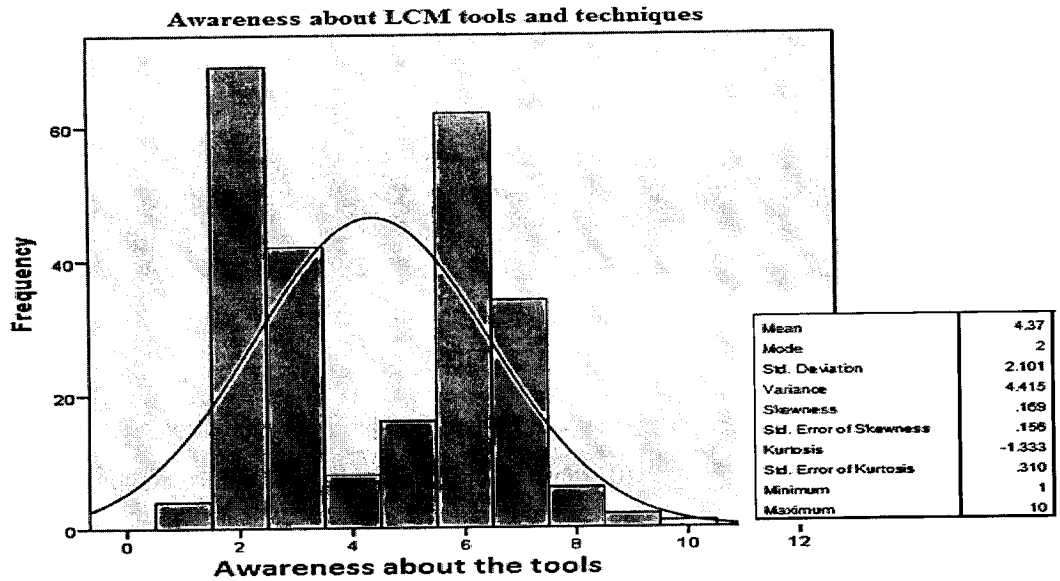

Figure 14: Descriptive Statistics – Awareness about the Principles of Lean

The respondents' perception about awareness of the tools have presented a normal distribution with a mean of 4.37, a standard deviation of 2.101 and kurtosis is -1.333, which is between -2 and 2 supporting the homogeneity of the sample. The highest frequency was for the value 2 followed by 6, 3 and 7. The distribution suggested that people had heterogeneous opinions in relation to this variable. Looking at the mean of this distribution, we concluded that on average, people have a moderate judgment for the awareness about the tools and techniques used in LCM.

4.4.2.3.4 Awareness about the benefits of LCM

An extensive literature review was conducted to understand the expected benefits from LC. Based on that, this question was designed to assess the participants' realization of the benefits of applying Lean principles to construction. The awareness about benefits was collected in question 12 of the questionnaire and was represented by a metric variable. The following figure illustrates awareness of the benefits that was rated by respondents on a scale of 0 to 10 where 0 meant that the employee does not have any clue about Lean construction

management benefits and 10 meant that the respondent has a very well awareness about the paybacks.

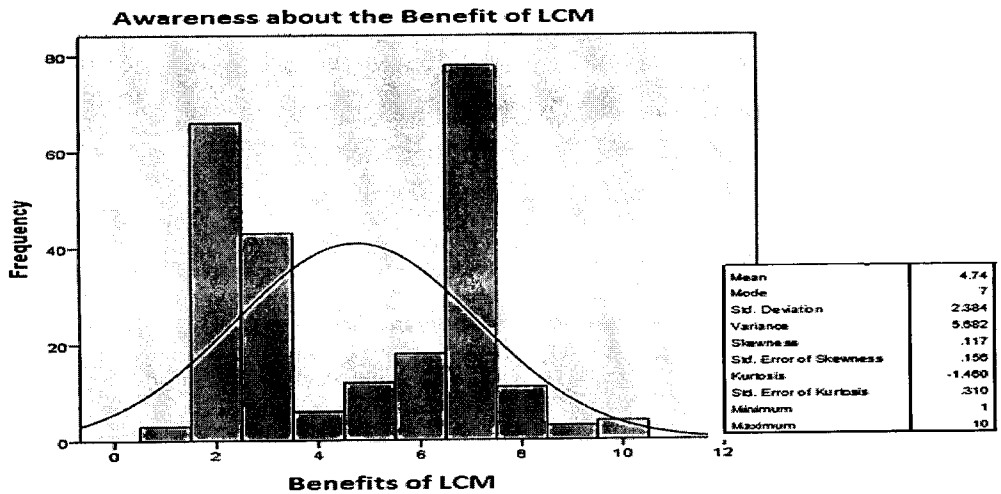

Figure 15*: Descriptive Statistics – Awareness about the Principles of Lean*

A normal distribution was noticed for the awareness about the benefits of LCM with a mean of 4.47, a variance of 5.682, and a standard deviation of 2.384 and a kurtosis of -1.460. The mode of this variable was 7, meaning that when asked about the level of awareness about the benefits, the answers having the highest frequency were 7 and the minimum frequency was 1 and 9 which mean that most of respondents have a good idea about the benefits captured from the implementation The mean value of 4.47 might reflect a moderate ranking of this benefits awareness.

4.4.2.4 Barriers of the implementation

Question 13 was introduced to see if the local companies agree with the authors' identification of the key barriers to LC; also, to prioritize the barriers identified, and evaluate their effect on the successful implementation of LC. As can be seen from Table 17 the respondents were asked to rate each barrier on a 10 point metric scale to indicate the level of influence of that factor on the potential implementation.

If the mean value scores a value of "six" or above to a particular barrier, then it would be classified as a somehow important barrier. Regarding the reliability test, the coefficient had a value of 0.828. Since this value is greater than 0.7, it is considered to be acceptable (Rahman et al., 2011).

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.828	.836	25

Table 16: Reliability Analysis for the barriers

The results of the frequency analysis are shown in Table 17.

	Lack of Top management	Lack of empowerment	Resistance to change	Dichotomy between design	Insufficient knowledge of	Multilayer sub-contracting	Tolerance for Untidy	Avoid taking responsibility
Valid N	244	244	244	244	244	244	244	244
Mean	7.82	7.51	7.77	6.04	8.16	6.15	5.05	5.61
Median	8.00	7.00	8.00	6.00	8.00	6.00	4.00	5.00
Mode	6	6	8	6	8	6	3	5
Std. Deviation	2.060	1.713	1.870	1.095	1.340	1.657	2.371	2.065
Variance	4.242	2.934	3.497	1.200	1.795	2.746	5.623	4.262
Skewness	-.280	-.103	-1.050	1.225	-1.126	-.271	.323	.629
Kurtosis	-.306	-.030	.365	4.970	3.602	.509	-1.246	-.304
Minimum	1	1	2	2	2	1	1	1
Maximum	11	11	11	11	11	11	11	11

Table 17: Descriptive Analysis – Barriers

	Using relationships to conceal	Lack of support from government	Lack of perseverance	Lack of consultants and trainers	Cultural behavior	Poor Cross functional teams	Lack of resources & planning
N Valid	244	244	244	244	244	244	244
Mean	8.79	5.52	5.02	6.08	7.96	6.05	8.48
Median	9.00	6.00	4.00	6.00	8.00	6.00	9.00
Mode	8	7	9	7	8	6	9
Std. Deviation	1.618	2.543	3.003	1.697	1.523	1.668	2.292
Variance	2.619	6.465	9.016	2.879	2.319	2.783	5.255
Skewness	-1.026	.059	.319	.000	-1.791	.054	-1.735
Kurtosis	3.930	-1.075	-1.318	.251	6.219	1.056	2.522
Minimum	1	1	1	2	1	1	1
Maximum	11	11	11	11	11	11	11

Table 18: Descriptive Analysis – Barriers

	Slow response to market	Lack of communication	Absence of Lean culture in the partners	Lack of logistic support	Lack of long term philosophy
N Valid	244	244	244	244	244
Mean	4.42	7.34	6.07	6.55	6.44
Median	3.50	8.00	6.00	7.00	7.00
Mode	3	9	6	9	7
Std. Deviation	1.926	2.114	2.281	2.025	1.600
Variance	3.710	4.471	5.201	4.100	2.560
Skewness	.717	-.720	.243	-.114	-.036
Kurtosis	.214	-.404	-1.010	-1.042	.689
Minimum	1	1	1	1	2
Maximum	11	11	11	11	11

Table 18: Descriptive Analysis – Barriers (continued)

	Absence of Lean culture and long term philosophy	Inability to measure performance	Lack of a defined process	Lack of leadership skills	Limited use of offsite construction techniques
N Valid	244	244	244	244	244
Mean	7.23	6.38	7.00	5.98	3.88
Median	7.00	6.00	8.00	6.00	3.00
Mode	8	6	8	4	3
Std. Deviation	1.634	1.721	1.889	2.313	1.623
Variance	2.671	2.960	3.568	5.349	2.635
Skewness	-.540	.208	-.652	.209	1.754
Kurtosis	.172	-.263	-.362	-.663	4.427
Minimum	2	2	1	1	1
Maximum	11	11	11	11	11

Descriptive Statistics

	Mean	Std. Deviation	Analysis N	Ranking
Using relationships to conceal mistakes	8.79	1.618	244	1
Lack of resources and planning	8.48	2.292	244	2
Unawareness about Lean	8.16	1.34	244	3
Cultural behavior issues	7.96	1.523	244	4
Top management resistance /Lack of mgt support	7.82	2.06	244	5
Resistance to change	7.77	1.87	244	6
Lack of empowerment of employees	7.51	1.713	244	7
Lack of communication between all parties	7.34	2.114	244	8
Absence of long term philosophy	7.23	1.634	244	9
Lack of a defined process	7	1.889	244	10
Lack of logistic support and logistical planning	6.55	2.025	244	11
Lack of long term philosophy	6.44	1.6	244	12
Inability to measure performance	6.38	1.721	244	13
Multilayer subcontracting	6.15	1.657	244	14
Lack of consultants/ trainers	6.08	1.697	244	15
Absence of Lean culture in the partners	6.07	2.281	244	16
Poor Cross functional teams	6.05	1.668	244	17
Dichotomy between design and construction	6.04	1.095	244	18
Lack of leadership skills	5.98	2.313	244	19
Lack of support from government	5.52	2.543	244	20
Avoid making decisions and taking responsibility	5.61	2.065	244	21
Tolerance for Untidy work place/ absence of 5s	5.05	2.371	244	22
Lack of perseverance	5.02	3.003	244	23
Slow response to market	4.42	1.926	244	24
Limited use of offsite construction techniques	3.88	1.623	244	25

Table 19: Ranking of the barriers

Table 19 presented the mean and standard deviation for a series of barriers as perceived by the respondents. It is to be noted that the higher the mean, the greater the importance of the hindrance. The listed hindrances received an average mean value 6.532.

An extensive literature review was conducted to understand the possible barriers to the successful implementation of LC. Based on a thorough analysis of these barriers, they were

merged and classified by the author into 25 different categories. The findings of this study has shown that only few of the barriers seven out of these twenty five were considered as not strong barriers to the successful implementation of LC (having a mean less than 6), mostly limited use of offsite technique, slow response to market. The barriers were then prioritized with the aim of evaluating their effect on the successful implementation of LC.

Overall, these items were perceived to have somewhat hindered the implementation of Lean practices. Specifically, the most significant barriers that can be ascertained from the ranking are:

- Using relationships to conceal mistakes (mean=8.79)
- Lack of resources and planning (mean=8.48)
- Unawareness about Lean concept (mean=8.16)
- Cultural behavior issues (mean=7.96)
- Top management resistance/Lack of management support (mean=7.82)

These five items appear to be of central concern to Lebanese construction employees and need to be addressed at the organizational level. Using relationships to conceal mistakes and cultural issues are of paramount importance for firms embarking on the Lean journey. Without a stable Lean culture, Lean initiatives will remain empty promises. In the Lebanese construction industry, the ranking suggested that, overall, the respondents recognized the importance of not using relationships to conceal mistakes concerning the delays in a project , yet it appears to be still lacking in practice. Furthermore, lack of resources was placed among the top three most significant barriers. This phenomenon is not uncommon in the Lebanese construction industry, where all people in the fields are interconnected. As a result, practitioners and suppliers are not afraid to lose their job if they are late, or the work is delayed since they are relying on their relationships to get the next job. This suggests that it might be a challenge to implement Lean practices, unless stakeholders are communicating professionally.

Unawareness about the details of what it takes to adopt Lean is another important barrier; workers were not able to identify the process, tools and benefits raised from such an implementation. If they are unaware about the implementation process, the implementation would not reach the expected benefits.

Moreover, the lack of top management commitment and management resistance to change– were also cited as significant hindrances to implementation which is in agreement with (Bhasin, 2012) findings that insufficient management skills is one of the greatest barriers to

Lean implementation. This also implied that management attributes such as leadership skills, problem-solving skills and others would help to facilitate the implementation of Lean.

On the other hand, respondents rated limited use of off-site construction technique as a relatively insignificant hindrance. Arguably, Lean practices such as JIT and build-in quality could be more adaptable to the prefabricated environment when construction work is undertaken in a factory environment, which shares much similarity with the manufacturing setting. In countries such as Singapore and Japan where tremendous efforts have been made to promoting the greater use of off-site fabrication, construction sites have increasingly become places where the various parts of buildings are being assembled (Sarahan, 2010). However, the low ranking of this hindrance implied that a majority of the construction projects in Lebanon still appear to operate in a conventional way, and that off-site fabrication techniques have not yet been commonly adopted. Perhaps the respondents may not be aware of the relationship between the use of off-site construction techniques and the deployment of Lean.

4.4.3 Factor Analysis

Factor analysis is considered the method of choice for interpreting self-reporting questionnaires which is used for reducing a large number of variables into a smaller set of variables (also referred to as factors). Factor analysis was applied to this study to group variables under different themes. A factor analysis was deemed necessary to be used in this study, due to the relatively large number of dependent variables (i.e. twenty four barriers). It was useful for finding the components of related variables and thus, suitable for reducing a large number of variables into a more understandable framework (Norussis, 2000). Tables 20 to 22 and Figure 16 provided the details of the results. Prior to the factor analysis, a Kaiser–Meyer–Olkin (KMO) test was conducted to help assess the factorability of the data. KMO, Measure of Sampling Adequacy test, is used to assess the suitability of the respondents' data for factor analysis. This was done prior to the extraction of the factors (Bartlett, 1950). The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis. The Bartlett's Test of sphericity should be significant (p-value<.05) for the factor analysis to be suitable.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.728
Bartlett's Test of Sphericity	Approx. Chi-Square	4849.004
	df	300
	Sig.	.000

Table 20: KMO and Bartlett test

The result of the KMO test in this study was 0.728, suggesting that the variables are adequate for factor analysis. This KMO test measures the adequacy of a sample in terms of the distribution of values for the execution of factor analysis. The significance (p-value) for the test is 0.0 which indicates that the variables are significantly correlated.

Conditions for applying factor analysis are present in the data:

1- KMO = 0.728 > 0.5

2- The determinant is 0.0004, which is higher than the cut-off of 0.00001 (for testing multicolinearity and singularity)

3- Sphericity =0.000 Indicating high correlation between variables.

The purpose of the factor analysis was to reduce the number of variables into smaller number of significant components that have an Eigen value less than1. The extraction method used in this study is principal components analysis (PCA) with Varimax rotation to determine the underlying structure of the barriers to Lean implementation. The concept of rotation is to maximize high item loadings and minimize low item loadings, in order to produce a more interpretable and simplified solution. Orthogonal Varimax rotation is the most common rotational technique used in factor analysis and is capable of producing factor structures that are uncorrelated (Costello and Osborne, 2005). It aimed is to provide easier interpretation of results. Prior to principal component analysis, the communalities involved were first established. Communality explains the total amount an original variable shares with all other variables included in the analysis and it is very useful in deciding which variables to finally extract and in determining the adequacy of the sample size (Field, 2005). Anti- image was checked to make sure that all variable have a value of 0.5 and above. Communalities were checked as well to make sure that the values exceed 0.5.

After extraction of all variables, the average communality value was above 0.6 which suggested that the sample size is adequate (MacCallum, 1999). A correlation matrix of 20 variables from the research survey data was calculated and presented in Table23. The correlation matrix shows that the barriers identified share some common fundamental relationships and that groups do exist. Table23 presents the factor structure matrix for the given barriers to Lean implementation in Lebanese construction firms. Correlation coefficients of each variable should have at least one factor that is above 0.30 (Pallant, 2001). All variables had correlation coefficients of more than 0.30.

Extraction Method: Principal Component Analysis.

	Initial	Extraction
Top management resistance /Lack of management support	1.000	.741
Lack of empowerment of employees	1.000	.800
Resistance to change	1.000	.804
Dichotomy between design and construction	1.000	.600
Insufficient knowledge of Lean /Unawareness about Lean benefits	1.000	.662
Multilayer subcontracting /hierarchies in the structure	1.000	.730
Tolerance for Untidy work place/ absence of 5s	1.000	.812
Avoid making decisions and taking responsibility	1.000	.818
Using relationships to conceal mistakes /a culture that accepts delays	1.000	.741
Lack of support from government	1.000	.800
Lack of perseverance	1.000	.828
Lack of consultants/ trainers	1.000	.677
Cultural behavior issues	1.000	.667
Poor Cross functional teams	1.000	.682
Lack of resources and planning/ time and commercial pressure	1.000	.753
Slow response to market	1.000	.773
Lack of communication and cooperation between all parties	1.000	.841
Absence of Lean culture in the partners	1.000	.707
Lack of logistic support and logistical planning	1.000	.735
Lack of long term philosophy	1.000	.782
Absence of long term philosophy	1.000	.830
Inability to measure performance	1.000	.813
Lack of a defined process	1.000	.827
Lack of leadership skills	1.000	.742
Limited use of offsite construction techniques	1.000	.549

Table 21: communalities

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.039	25.195	25.195	5.039	25.195	25.195	4.070	20.350	20.350
2	3.658	18.289	43.484	3.658	18.289	43.484	3.471	17.353	37.703
3	2.536	12.678	56.162	2.536	12.678	56.162	2.553	12.765	50.469
4	1.672	8.358	64.520	1.672	8.358	64.520	2.385	11.927	62.396
5	1.631	8.157	72.677	1.631	8.157	72.677	2.056	10.281	72.677
6	.864	4.318	76.996						
7	.734	3.671	80.667						
8	.700	3.500	84.167						
9	.629	3.146	87.313						
10	.452	2.262	89.574						
11	.389	1.947	91.521						
12	.360	1.799	93.320						
13	.294	1.472	94.792						
14	.238	1.192	95.984						
15	.203	1.015	96.999						
16	.195	.974	97.973						
17	.130	.650	98.623						
18	.104	.521	99.144						
19	.097	.486	99.630						
20	.074	.370	100.000						

Table 22: Percent Variance Explained

The total variances explained by each component extracted in Table 22 are: component 1 (25.195%), component 2 (18.289%), component 3 (12.678%), component 4 (8.358%), component 5(8.157%). Thus, the final statistics of the principal component analysis and the components extracted accounted for 72.667%.which meant that 72.667% of the reality is explained by the above components.

	Top management resistance	Lack of empowerment of e employees	Resistance to change	Dichotomy between design and construction	Insufficient k knowledge of lean	Multilayer subcontracting	ToleranceforUntidyworkplaceabsenceof5s	Avoid making decisions	Using relationships to conceal mistakes	Lack of support from government	Lack of perseverance	Lack of consultants	Cultural issues	Poor cross functional teams	Lack of resources	Slow response to market	Lack of communication	Absence of Lean culture	Lack of logistics support	Lack of long term philosophy	Inability to measure performance	Lack of a defined process	Lack of leadership skills
Top management resistance	1.000	.699	-.089	.082	.345	.136	-.584	.263	.527	-.245	-.550	-.202	.179	.103	.354	-.214	.118	-.114	-.114	.219	.259	.134	.353
Lack of empowerment	.699	1.000	-.172	.313	.303	.337	-.571	.308	.460	.017	-.441	-.045	.156	.359	.370	-.074	.058	-.031	-.100	.222	.323	.176	.639
Resistance to change	-.089	-.172	1.000	.103	.110	-.083	.147	-.491	.231	-.490	.061	-.171	.397	.044	-.312	-.320	.226	.004	-.271	.001	-.372	-.285	-.394
Dichotomy between design and construction	.082	.313	.103	1.000	.097	.400	.143	.011	.172	.100	.059	.242	-.058	.454	.241	.253	.328	.374	.062	.241	.029	-.062	.155
Insufficient knowledge of lean and its benefits	.346	.303	.110	.097	1.000	.099	-.114	.273	.205	-.004	-.117	.074	.467	.127	.033	.069	.101	.146	.153	.271	.451	.447	.311
Multilayer sub contracting	.136	.337	-.083	.400	.099	1.000	.115	.323	.099	.064	.033	.095	-.071	.578	.120	.288	.083	.277	.126	.029	.417	.186	.318

Tolerance for Untidy work place	-.584	-.571	.147	.143	-.114	.115	1.000	-.007	-.407	.384	.781	.369	-.055	.007	-.112	.488	.182	.459	.389	.063	-.026	.055	-.310	.212
Avoid making decisions	.263	.308	-.491	.011	.273	.323	-.007	1.000	-.113	.569	.075	.370	-.046	.119	.153	.471	-.215	.120	.472	.104	.684	.648	.643	.444
Using relationships to conceal mistakes	.527	.460	.231	.172	.205	.099	-.407	-.113	1.000	-.312	-.307	-.056	.222	.324	.401	-.238	.473	.040	-.113	.196	.024	-.019	.050	-.104
Lack of support from government	-.245	.017	-.490	.100	-.004	.064	.384	.569	-.312	1.000	.592	.580	-.139	.028	.226	.660	-.066	.304	.645	.254	.398	.479	.353	.226
Lack of perseverance	-.550	-.441	.061	.059	-.117	.033	.781	.075	-.307	.592	1.000	.619	-.011	.030	.002	.579	.261	.487	.490	.168	.077	.239	-.181	.141
Lack of consultants and trainers	-.202	-.046	-.171	.242	.074	.095	.369	.370	-.056	.580	.619	1.000	-.131	.096	.259	.482	.293	.438	.409	.228	.293	.417	.181	.151
Cultural issues	.179	.156	.397	-.058	.467	-.071	-.055	-.046	.222	-.139	-.011	-.131	1.000	.093	-.077	-.084	.081	-.131	-.006	.234	.125	.207	.018	.003
Poor Cross functional team	.103	.359	.044	.454	.127	.578	.007	.119	.324	.028	.030	.096	.093	1.000	.145	.352	.347	.361	.142	.320	.251	.081	.338	.138
Lack of resources and planning	.354	.370	-.312	.241	.033	.120	-.112	.153	.401	.226	.002	.259	-.077	.145	1.000	.083	.520	.279	.220	.338	.132	.131	.130	-.156
Slow response to market	-.214	-.074	-.320	.253	.069	.288	.488	.471	-.238	.660	.579	.482	-.084	.352	.083	1.000	.165	.583	.681	.347	.448	.447	.181	.346
Lack of communication	.118	.058	.226	.328	.101	.083	.182	-.215	.473	-.066	.251	.293	.081	.347	.520	.165	1.000	.554	.223	.425	-.163	-.026	-.186	-.140

Absence of lean culture	-.114	-.031	.004	.374	.146	.277	.459	.120	.040	.304	.487	.438	-.131	.361	.279	.583	.554	1.000	.558	.401	.160	.325	-.062	.022
Lack of logistic support	-.114	-.100	-.271	.062	.153	.126	.389	.472	-.113	.645	.490	.409	-.006	.142	.220	.681	.223	.558	1.000	.380	.465	.643	.064	.232
Lack of long term philosophy	.219	.222	.001	.241	.271	.029	.063	.104	.196	.254	.168	.228	234	.320	.338	.347	.425	.401	.380	1.000	.167	.161	.263	.053
Inability to measure performance	.259	.323	-.372	.029	.451	.417	-.026	.684	.024	.398	.077	.293	.125	.251	.132	.448	-.163	.180	.465	.167	1.000	.764	.540	.459
Lack of a defined process	.134	.176	-.285	-.062	.447	.186	.055	.648	-.019	.479	.239	.417	.207	.081	.131	.447	-.026	.325	.643	.161	.764	1.000	.385	.251
Lack of leadership skills	.353	.639	-.394	.155	.311	.318	-.310	.643	.050	.353	-.181	.181	.018	.338	.130	.181	-.186	-.062	.064	.263	.540	.385	1.000	.287
Limited use of offsite construction techniques	.042	.037	.003	.193	.120	.351	.212	.444	-.104	.226	.141	.151	.003	.138	-.156	.346	-.140	.022	.232	.053	.459	.251	.287	1.000

Table 23: Correlation matrix

	Component				
	1	2	3	4	5
Avoid making decisions and taking responsibility	.861				
Lack of a defined process	.836				
Inability to measure performance	.794				
Lack of support from government	.761				
Lack of logistic support and logistical planning	.683				
Lack of formal training	.572				
Tolerance of Untidy work place		.877			
To management resistance		-.822			
Lack of perseverance		.812			
Lack of empowerment of employees		-.772			
Multilayer subcontracting/ hierarchies			.813		
Poor Cross functional teams			.772		
Dichotomy between design and construction			.715		
Limited use of offsite construction techniques			.448		
Lack of communication				.816	
lack of resources and planning				.760	
Absence of Lean culture in the partners				.583	
Cultural behavior issues					.784
Insufficient knowledge of Lean / benefits					.748
Absence of Lean culture and long term philosophy					.652

Table 24: Rotated Component matrix of the barriers

The component matrix of the principal component matrix was presented .The Eigen value and factor loading were set at conventional high values of 1.0 and 0.4 respectively (see Ahadzie, 2007). As shown in Figure 16, five components with an Eigen values greater than 1.0 were extracted using the factor loading of 0.40 as the cut-off point. The scree plot (Figure 16) also presents the five components. The components can be thought of measuring scales for barriers factors during the implementation of LC.

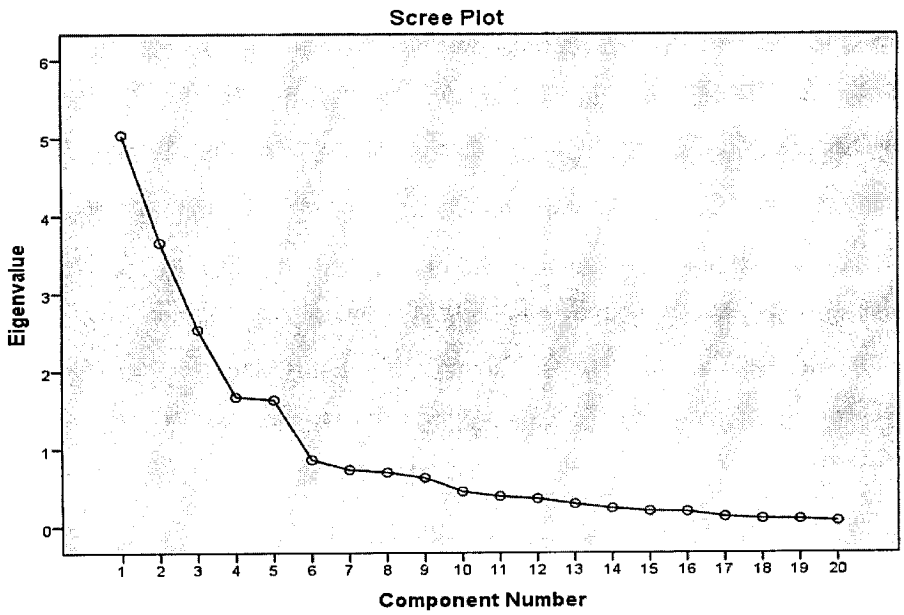

Figure 16*: Scree plot of the barriers*

Based on the examination of the fundamental relationships among the variables under each component, the following interpretation has been presented;

Component 1 is termed "Organizational support and Process" barrier

Component 2 is termed "Managerial" barrier

Component 3 is termed "Partnering and coordination" barrier

Component 4 is termed "Resources and communication" barrier

Component 5 is termed "Cultural" barrier

Factor 1: "Organizational and Process" barriers – the first of the five factors covers six barriers to Lean adoption. There appear to be two themes running through this factor: Lack of a defined process, lack of formal training, and inability to measure performance, and avoid

taking decisions; these four are under the theme of the knowledge of method /process used to implement Lean and gather its effect on the project cycle. Whereas lack of logistics support, support from movement reflect the organizational need for external support to implement the process.
This barrier group could appropriately be given the heading of "Organizational support and Process barriers". It accounts for 25.195 per cent of the total variance. It reflects how the lack of a practice method and external supports can be perceived as a major barrier.

Factor 2: "Managerial" barriers – the second factor accounts for 18.289 per cent of the total variance and conceptually links four hindering factors, namely Top management resistance , Lack of perseverance , Lack of empowerment , tolerance of untidy workplace. A closer examination reveals that these factors indicate lack in managerial commitment that prevents the firm from successfully implementing Lean. This factor accounts for the importance of management support to the implementation and its perseverance in empowering employees to implement Lean.

Factor 3: "Partnering and coordination " barriers – the third factor accounted for 12.678 per cent of the total variance, and is loaded with four factors that highlight the barriers related to having several stakeholders who need to coordinate which each other in order to reach a successful implementation and to convey smooth and rapid flow of the information : Multilayer subcontracting, poor cross functional teams , dichotomy between design and construction ad limited use of offsite techniques.

Factor 4: "Resources and communication" barrier - this factor combines the last three barriers: Lack of resources and planning, Lack of communication, Lack of Lean culture in the partners. This factor emphasizes the importance of having resources in order to integrate Lean, in addition to having a clear communication with the stakeholders and the need for the partners to at least understand what is Lean in order to be able to clearly communicate together in a way that leads to having a project that meets the critical success factors. This factor accounts for 8.358 per cent of the total variance.

Factor 5: "Cultural barriers" is the heading of the fifth group. It accounts for 8.157 per cent of the total variance, and is loaded with three factors, including Cultural behavior issues, absence of a Lean culture and long term philosophy and insufficient knowledge of Lean. All of the

three factors emphases on the importance of having an organizational Lean culture in order to successfully integrate the philosophy. It reflects how the lack of proper knowledge of Lean as a philosophy, among employees and partners, can be perceived as a major barrier.

In summary, the interpretation of the barriers factors through the use of the factor analysis was based on a close examination of variables under the five components derived.
This study clearly shows that the implementation of Lean practices by Lebanese construction firms is associated with many potential barriers. Factor analysis was used to examine the complex interrelationship between the barriers with the use of correlation matrix which is a systematic grid layout of correlations between all possible pairs of item to identify the fundamental common factors. All variables had correlation coefficients of more than 0.30. Additionally, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy value was 0.8728 (well above 0.50) and the Barlett's test of sphericity value was significant (p=0.0000). Therefore, the use of factor analysis was deemed suitable. Data was analyzed using a principal component for factor extractions, and five factors were identified to group the variables.

4.4.4 Inferential statistics

In this section, we performed inferential statistics on the data set collected from the quantitative method in order to confirm or to not accept the previously stated hypotheses in chapter 3. The random sample was representative of the population as discussed in the descriptive analysis in this chapter. Also since we have used a metric scale of 0 to 10 for the degree of awareness and significance of the barriers variables and the sample was homogeneous for having all of the factors kurtosis ranging between -2 and 2, it was acceptable to use parametric tests on the variables of these constructs.

4.4.4.1 Analysis of Variations

In order to evaluate if there was a difference in the perception of respondents on the awareness about Lean between different groups, Independent Samples t-test was performed on the dichotomous variables, and one-way ANOVA test on the variables having more than two groups. When ANOVA showed significant variations among the groups, further Independent Samples t-test were conducted in between the groups to verify the significance of each variation. The results of the tests are explored in the sections below.

4.4.4.1.1 Organizational Variation

4.4.4.1.1.1 Company establishment Variations

The following table suggested a significant difference in mean between the years of the company establishment groups in their awareness about Lean (p-value=0.01 <0.05). Therefore, the t-test was performed between each couple of groups in order to shed the light on the groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	114.509	4	28.627	6.839	.000
Within Groups	1000.363	239	4.186		
Total	1114.872	243			

Table 25: One-way ANOVA Test – Year of establishment

Table 26 describes the statistics of each year of establishment group in relation to awareness/implementation factor.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
* Before 1980	40	3.61	2.322	.367	3.87	5.36
*1980-1990	55	4.50	1.999	.269	2.96	4.04
*1990-2000	33	4.29	1.896	.330	3.62	4.96
*2000-2010	37	5.61	2.156	.354	4.59	6.03
*After 2010	79	5.98	1.935	.218	4.75	5.61
Total	244	4.71	2.142	.137	4.34	4.88

Table 26: Age Variations Statistics

The below table summarizes the statistically relevant difference among these groups, all other groups showed a p-value >0.05, and were considered non significant for t test comparison.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Before 1980 & after 2010	-4.865	132	.000	-1.676	.344
Before 1980 & 2000- 2010	-4.118	90	.000	-1.806	.439

Table 27: Independent Sample Test – Year of establishment

The independent sample test for the year of the company establishment and awareness attributes showed that there is a significant difference in the level of awareness between companies that were established before 1980 and companies that were established after 2000.Those which were established before 1980 have a mean awareness of 3.61 but it increases significantly for new companies to reach 5.61 for those established between 2000 and 2010 and mean5.98 for those who are newly established. This might be correlated to the reason that new companies have younger CEOs who might be aware about the benefits of the Implementation and is willing to adopt a Lean culture.

4.4.4.1.1.2 Number of employees Variations

The following table suggested a significant difference in mean between companies with different number of employees and their awareness about Lean (p-value=0.01 <0.05). Therefore, the t-test was performed between each couple of groups in order to identify the groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	175.599	5	35.120	8.899	.000
Within Groups	939.273	238	3.947		
Total	1114.872	243			

Table 28: One-way ANOVA Test – Number of employees

Table 29 describes the statistics of each Number of employees group in relation to awareness/implementation factor. It is important to note that all other groups that were not included in the table had a p-value >0.05, and were considered not significant for the comparison.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
* Less than 5	26	3.01	1.807	.354	3.08	4.54
* 5-14	92	3.19	2.143	.223	4.29	5.18
*15-49	31	4.48	2.033	.365	3.74	5.23
*50-99	32	4.80	1.641	.290	5.79	6.97
*100-200	41	4.74	1.623	.253	2.93	3.96
*More than 200	22	6.38	2.456	.524	3.71	5.88
Total	244	4.43	2.142	.137	4.34	4.88

Table 29: Number of employees Variations Statistics

Table 30 summarizes the statistically relevant difference among these groups:

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Less than 5 & More than 200	-3.963	122	.000	-1.649	.425
Between 5-15 & more than 200	-5.679	56	.000	-2.575	.453

Table 30: Independent Sample Test – Number of employees

The independent sample test showed that there is a significant difference in the level of awareness between large organizations with more than 200 employees (mean=6.38) and small organizations with less than five employees and 5 to 15 employees respectively (mean =30.1, mean =3.19). It seems that organization size makes a very considerable difference to the awareness of Lean. This might be due to the capability of large organizations to spend more in training their employees on new tools and techniques to be used in the implementation compared to others small companies that have few employees and does the strict minimum. Large organizations typically have a formal structure for continuous improvement which goes with the Lean culture.

4.4.4.1.1.3 Net gross Income Variations

The following table suggested a significant difference in mean between income groups in their awareness about Lean (p-value <0.05). Therefore, the t-test was performed between each couple of groups in order to shed the light on the groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	122.316	5	24.463	5.866	.000
Within Groups	992.556	238	4.170		
Total	1114.872	243			

Table 31: One-way ANOVA Test – Income

Table 32 describes the statistics of each Income group in relation to awareness/implementation factor.

Descriptive				
	N	Mean	Std. Deviation	Std. Error
*1-100000$	35	4.36	2.018	.341
*100 000-500 000$	89	4.03	2.062	.219
* 500 000 - 1Million$	25	5.09	1.673	.335
* 1Million - 2Millions	28	5.01	2.020	.382
*2Millions - 5 Millions	41	6.11	2.033	.317
*Above 5Millions	26	6.17	2.342	.459
Total	244	5.12	2.142	.137

Table 32: Income Variations Statistics

Table 33 summarizes the statistically relevant difference among these groups:

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
*100 000-500 000$ and *2Millions - 5 Millions	-3.514	58	.001	-1.733	.493
*100 000-500 000$ and * Above 5 Millions	-3.626	56.629	.001	-1.733	.478

Table 33: Independent Sample Test – Income

The independent sample test showed that there is a significant difference in the level of awareness between organizations with net income between 100 and 500 thousand dollars (mean=4.03), organizations with income between two and five millions (6.11), and organizations with net gross income above five million dollars (mean=6.17). It seems that organization income makes a very considerable difference in the level of awareness of Lean. This might be due to the flexibility of large organizations, their entrepreneurial spirit and their innovation capabilities which allows them being more productive and efficient through the implementation of Lean. Small companies with moderate income might be not confident of

the cost of its implementation and the tangibility of the results and benefits they may achieve. Most of these companies might fear that implementing lean manufacturing is costly and time consuming Compared to larger firms, small firms have fewer resources and often less access to capital, resulting in lower levels of adoption of cost intensive packages and new philosophies. Large organizations have the capacity to spend part of their income on training their employees on new tools and techniques. Those organizations typically have a formal structure for continuous improvement which goes with the Lean culture.

4.4.4.1.1.4 Countries operating in Variations

Groups in this question were divided into two categories for the analysis: Operating only in Lebanon and Operating inside and outside Lebanon. Since percentages of Local companies to International companies are not are not equally distributed, The Mann-Whitney test was used for the analysis. The results showed a significant variation between the perceptions of the two groups for the level of awareness about Lean.

	N	Mean	Std. Deviation	Minimum	Maximum
International	244	4.61	2.142	1	10
Local companies	244	1.41	.493	1	2

Table 34: Operation countries Variations Statistics

	AWARENESS
Mann-Whitney U	5939.000
Wilcoxon W	16379.000
Z	-2.341
Asymp. Sig. (2-tailed)	.019

Table 35: Mann-Whitney test – countries of operation

The results showed that companies who are working internationally (4.61) are more aware about the implementation of Lean than other companies who are working locally (1.41). International companies are dealing with people from different culture, different location and different work conditions that s why they might be aware about Lean in order to be able to standardize the work flow regardless of the conditions that apply in each and every project.

4.4.4.1.1.5 Lean formal implementation Variations

Since the answer to this question were either "yes, there is a formal implementation of the principles" or "No, there is not", and since percentages of companies that are implementing the process and those who were not are not equally distributed, The Mann-Whitney test was used for this analysis. The existence of a formal implementation showed a significant variation between the perceptions of the two groups for the level of awareness about Lean.

	N	Mean	Std. Deviation	Minimum	Maximum
AVERAGEAWARENESS	244	4.61	2.142	1	10
Formal implementation of Lean	244	1.92	.275	1	2

Table 36: Formal implementation Variations Statistics

	AVERAGEAWARENESS
Mann-Whitney U	1046.000
Wilcoxon W	26246.000
Z	-3.974
Asymp. Sig. (2-tailed)	.000

Table 37: Mann-Whitney test – Formal Implementation

The results are acceptable, since employees working in companies which have a formal implementation of LCM (mean=4.61)are expected to be aware about the process tools, techniques, and benefits more than those who are working in companies who are not integrating this philosophy in their organization(mean=1.92).

The results suggested that participants belonging to companies that are integrating a formal implementation of Lean philosophy have a greater awareness about the components of Lean than participants belonging to companies where Lean is not integrated. The results make sense, since companies who are integrating Lean philosophy in their organizational culture will encourage their employees and familiarize them with the constituent of concept and its benefits and decrease the amount of confusion on how Lean construction is best implemented.

One of the reasons of the lack of awareness is lack of understanding on Toyota's culture and the critical issues of Lean implementation. Some companies have failed in incorporating the Toyota example due to the fact that they are ignorant towards the internal culture of Toyota (Spear & Bowen, 1999). This is due to the lack of understanding about the Lean system as a management system since most of them view it as purely manufacturing system. More importantly, most of those companies have failed because they couldn't understand the values and respect of people as Toyota does.

4.4.4.1.2 Respondents Variation

4.4.4.1.2.1 Gender Variations

Since the percentage of males and females are not equally distributed, Mann-Whitney test was used for gender analysis. The results showed no significant variation between males and females for the level of awareness about Lean. Even though there is a difference in the means but the p-value = 0.209>0.05. Thus, no significant variation exists between the perceptions of the two groups.

	N	Mean	Std. Deviation
AWARENESS	244	4.61	2.142
Gender	244	1.21	.410

Table 38: Gender Variations Statistics

	AWARENESS
Mann-Whitney U	4428.500
Wilcoxon W	22956.500
Z	-1.256
Asymp. Sig. (2-tailed)	.209

Table 39: Mann-Whitney test - Gender

4.4.4.1.2.2 Age Variations

The following table suggested a significant difference in mean between the different age groups in their awareness about Lean (p-value=0.01 <0.05). Therefore, the t-test was performed between each couple of groups in order to shed the light on the groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	94.976	5	18.995	4.433	.001
Within Groups	1019.896	238	4.285		
Total	1114.872	243			

Table 40: One-way ANOVA Test – Age

Table 41 describes the statistics of each age group in relation to awareness/implementation factor.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
*21-25	16	4.13	2.585	.646	3.75	6.50	1	9
*26-30	72	4.85	2.222	.262	4.33	5.37	1	10
*31-35	42	4.43	1.784	.275	2.87	3.98	2	8
*36-40	30	5.24	2.213	.404	3.42	5.07	2	9
*41-45	51	5.89	1.877	.263	4.77	5.82	2	8
*45-59	33	7.01	1.941	.338	3.92	5.29	2	7
Total	244	5.81	2.142	.137	4.34	4.88	1	10

Table 41: Age Variations Statistics

Table 42 summarizes the statistically relevant difference among age groups, all other age groups do not show a significant effect on the results since they are having a p-value >0.05.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Awareness (21-25 and 45-49)	2.844	56	.006	1.696	.596
Awareness (26-30 and 45-49)	3.534	112	.001	1.422	.402

Table 42: Independent Sample Test – Age

The independent sample t-test for the age and awareness attributes showed that there is a significant difference in the level of awareness between respondents with age bracket (21-25) (mean = 4.13), age bracket 26 to 30 (mean 4.85) and those who are above 45(mean=7.01).

The finding suggested that people who are at the age of 45 or above are more aware about the idea of going Lean than young people aged less than 30. This might be correlated to their managerial role in tackling philosophies such as Lean and make decisions on their adoption. Younger people, on the other hand, work at an entry level position which does not put them in a situation where they can decide on potential initiatives/philosophies to be adopted. This variation was previously discussed in the literature. In fact, it was found that young entries should have regular training in order be able to perceive to the successful implementation. The findings related to employees' age confirm previous studies in the construction industry indicating that the age bracket has a positive correlation with the implementation of the concept (liker, 2004, Trochim, 2006). The variation analysis was not significant between respondents from other age brackets.

4.4.4.1.2.2 Education Variations

The following table suggested a significant difference in mean between the different education groups in their awareness about Lean (p-value=0.01 <0.05). Therefore, the t-test was performed between each couple of groups in order to shed the light on the groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	490.589	5	98.118	37.406	.000
Within Groups	624.283	238	2.623		
Total	1114.872	243			

Table 43: One-way ANOVA Test – Education

Table 44 describes the statistics of each education level group in relation to awareness/implementation factor.

Descriptive				
	N	Mean	Std. Deviation	Std. Error
*Brevet	30	2.73	.594	.108
* Terminal / BT	38	2.84	1.201	.195
* Bachelor Degree	55	6.11	1.984	.268
* Maters degree	97	5.46	1.865	.189
* PH.D	1	4.25		
Total	244	4.61	2.142	.137

Table 44: Education Variations Statistics

The below table summarizes the statistically relevant difference among age groups:

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Brevet - Bachelor	-9.077	83	.000	-3.376	.372
Brevet - Masters	-7.862	125	.000	-2.725	.347
Terminal- Bachelor	-9.077	91	.000	-3.274	.361
terminal - Masters	-8.032	133	.000	-2.623	.327

Table 45: Independent Sample Test - Education

The independent sample test for the education awareness attributes showed that there is a significant difference in the level of awareness/ easy implementation between respondents with a brevet or Terminal educational level (mean = 2.73 and 2.8) and the ones having a university undergrad (mean = 6.11) or master's degree (mean = 5.46), difference of 2.68 with school) with a significance p-value < 5%. The previous findings suggested that people who

pursue a university degree or above are more aware about the implementation of Lean then other workers. Variation analysis was not significant between respondents having a school education and PhD holders, maybe due to the small size of the latter group.

It is logical that early entry to markets should take into consideration the educational background of workers if considering the integration of the Lean program (Ballard, 2007). This was addressed in previous literature where inadequate training, poor understanding and awareness, illiteracy and computer illiteracy were considered barriers to the implementation. (Jorgensen et al., 2004; Olatunji, 2008; Abdullah et al., 2009; Mossman, 2009). As well, workers with school education level need to have some training in order to be able to perceive and attribute to the successful implementation of Lean. This Lean mmanagement training will expose them to the concepts and principles of Lean mmanagement to help them optimize processes, increase quality and drive maximum. Workers with school level should learn to create more value with the available resources, reduce unwanted activities and adopt continuous process improvement, where small changes are implemented systematically. The training will guide them in implementing Lean tools, techniques and metrics in their companies.

4.4.3.1.3 Position in the company

The following table suggested a significant difference in mean between respondents having different job roles/ position in their awareness about Lean (p-value=0.01 <0.05), which means that the null hypothesis of having equal level of awareness between groups having different positions in the company is rejected. Therefore, the t-test was performed between each couple of groups in order to investigate more on the groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	566.441	7	80.920	34.821	.000
Within Groups	548.431	236	2.324		
Total	1114.872	243			

Table 46: One-way ANOVA Test – Position in the company

Table 47 describes the statistics of each group in relation to awareness/implementation factor.

	N	Mean	Std. Deviation	Std. Error
Foreman	90	2.78	.853	.090
Engineer	46	4.65	2.159	.318
Project Manager	60	6.01	1.464	.189
quality manager	6	5.04	3.418	1.396
contract manager	2	7.00	.707	.500
regional manager	3	5.83	3.126	1.805
General Manager	22	6.20	1.769	.377
Top manager	15	6.82	.486	.126
Total	244	5.5	2.142	.137

Table 47: Position Variations Statistics

Table 48 summarizes the statistically relevant difference among age groups:

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Foreman - Engineer	-7.216	134	.000	-1.872	.259
Foremen -Project manager	-17.066	148	.000	-3.233	.189
Foreman - General manger	-13.241	110	.000	-3.430	.259
Foreman -Top mangers	-17.828	103	.000	-4.042	.227
Engineer - Project managers	-3.864	104	.000	-1.362	.352
Engineer - General managers	-2.942	66	.004	-1.558	.530
Engineer - Top managers	-.3841	59	0.000	-2.170	0.565

Table 48: Independent Sample Test – Position in the company

The independent sample test for the role position awareness attributes showed that there is a significant difference in the level of awareness (easiness of the implementation) between respondents with Working as foreman (mean = 2.78), engineers (mean = 4.65), project managers (mean = 6.01), general managers (mean 6.2), and top managers (mean 6.82

difference of 4.04 with foreman, and 2.17 with engineers) .The finding suggested that people who are at a managerial position are more aware about the implementation of Lean then other workers who are at lower positions in the company which means that they perceive awareness differently if they are at a managerial position. This might be due to their managerial role in undertaking ways of thinking within the organization such as Lean. People with lower level position do not decided on potential initiatives to be adopted and are only concerned with finishing their technical work. The top management should take active interest in introducing innovative practices in the organization and identify and how much information the workers absorbed. Management has to input more into efforts to increase workers awareness about Lean management implementation. The commitment of the top management for implementation of the principles and tools may be the most important factor in successful implementation.

Variation analysis was not significant between respondents working as contract managers and quality managers maybe because of the small size of the later groups. In summary, values show a noticeable variation as senior managers' show an optimistic evaluation declining steadily as the managerial position decreases.

4.4.3.1.3 Total years of experience

The following table suggested a significant difference in mean between respondents having different years of experience in their awareness about Lean (p-value=0.01 <0.05), which means that the null hypothesis of having equal level of awareness between groups having different years of experience is rejected. Therefore, the t-test was performed between each couple of groups in order to distinguish between groups having different means.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	135.391	6	22.565	5.460	.000
Within Groups	979.481	237	4.133		
Total	1114.872	243			

Table 49: One-way ANOVA Test – Years of experience

Table 50 describes the statistics of each group in relation to awareness/implementation factor.

	N	Mean	Std. Deviation	Std. Error
LESS THAN 1	6	3.63	2.386	.974
1-3 YEARS	20	4.24	2.070	.463
3-5 years	44	3.73	2.261	.341
6-9 years	39	4.40	2.311	.370
10-15 years	93	5.03	1.952	.202
16-20 years	13	6.94	.410	.114
more than 20	29	4.28	1.836	.341
Total	244	4.61	2.142	.137

Table 50: Experience Variations Statistics

Table 51 summarizes the statistically relevant difference among age groups:

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Less than 1 - 16 to 20 years	-5.019	17	0.00	-3.317	0.661
1 to 3 – 16 to 20 years	-4.627	31	0.00	-2.705	0.585

Table 51: Independent Sample Test –Year of experience

The independent sample test for the Years of experience and awareness attributes showed that there is a significant difference in the level of awareness between respondents with less than one year of experience (mean = 4.24), between one and three years of experience (mean 3.73) and those who have16 to 20 years of experience(mean = 6.94).The results suggested that new market entries to are not aware about the implementation as much as other employees who have already spend 16 years in the industry have. The reason for that might be that experienced people have already captured the needed skills and the knowledge about the technical work which allows them to 'be workplace-ready', build useful skills that cannot be taught in the classroom, and gives themselves an edge to push for the most sought to differentiate themselves. In other words, they have the time to think and search for new philosophies that enhance the quality of the work. Whereas, new entries are worrying about learning the basic technical skills needed for the job and are not interested in other incentives.

4.4.4.2 Regression Analysis

Regression analysis is used to understand the impact of the independent variables on the dependent variable, and to explore the nature of that relationship. In order to perform a regression analysis, we considered that the dependent variable is the mean of awareness about Lean. As mentioned in the methodology section, Lean implementation of the process was measured by yes or no, and since 92% of the respondents consider that their companies are not implementing Lean, the researchers decided to rely on Lean awareness to conduct the regression. It is important to note that awareness is a pre-disposition to Lean adoption. In fact, spreading awareness about Lean is the very first step when organizations are considering embarking in the journey of Lean implementation. Thus, the researchers decided to investigate the level of awareness in order to understand whether the company is exploring the implementation of Lean. To evaluate the level of Lean awareness at a given company, a set of commonly applied Lean elements were identified from previous research (Kirby & Greene 2003; Czabke et al., 2008, Liker, 2003).

This new variable was labeled AVERAGE AWARENESS.
AVERAGE_AWARENESS = (Awareness of the idea + Awareness of the principles + Awareness of the tools + Awareness of the benefits) / 4.

4.4.4.2.1 Regression between all barriers and the awareness

The independent variables are the set of all of the 25 barriers; the model summary of the linear regression is represented in the following table

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.879[a]	.773	.747	1.078

Table 52: Model Summary - Linear Regression of all barriers

As per the above table, The R value represents the simple correlation and it is 0.879 which indicates a high degree of correlation in this study. The R^2 value 0.773 indicates how much of the total variation in the level of awareness about Lean, can be explained by the list of the barriers presented. The difference between R^2 and $R^{2\ adjusted}$ is 2.9% which is less than 10% indicating no noise in the data. The adjusted R-squared has been adjusted for the number of predictors in the model (sample size=244 participants). In this case, awareness explains 74.7%

of the variation in the significance of the barriers. The rest (25.3%) are not explained by the barriers, it might b explained by other factors such as leadership skills, and willingness to implement Lean.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	861.754	25	34.470	29.688	.000[b]
Residual	253.118	218	1.161		
Total	1114.872	243			

Table 53: ANOVA model for all barriers

The above table indicates that the regression model predicts the awareness about Lean variable significantly. This is indicated by the statistical significance of the regression model that was run (p-value <0.05).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	8.288	.807		10.267	.000
Top management resistance	-.138	.070	-.133	-1.964	.051
Lack of empowerment of employees	.078	.099	.063	.793	.428
Resistance to change	.213	.068	.186	3.124	.002
Dichotomy between design and construction	.016	.095	.008	.164	.870
Insufficient knowledge of Lean /Unawareness about Lean benefits	-.547	.079	-.342	-6.935	.000
Multilayer subcontracting	-.406	.068	-.314	-5.960	.000
Tolerance for Untidy work place	.237	.068	.263	3.507	.001
Avoid making decisions	.027	.081	.026	.337	.737
Using relationships to conceal mistakes /a culture that accepts delays	-.080	.071	-.061	-1.127	.261
Lack of support from government	-.291	.075	-.346	-3.861	.000
Lack of perseverance	.251	.062	.351	4.038	.000
Lack of consultants/ trainers	.036	.079	.029	.463	.644
Cultural behavior issues	-.083	.072	-.059	-1.154	.250
Poor Cross functional teams	-.215	.074	-.167	-2.920	.004
Lack of resources and planning	-.003	.053	-.003	-.054	.957
Slow response to market	.067	.079	.060	.848	.398
Lack of communication and cooperation between all parties	.373	.071	.368	5.273	.000
Absence of Lean culture in the partners	-.076	.061	-.081	-1.245	.214
Lack of logistic support and logistical planning	.124	.081	.118	1.542	.125
Lack of Lean culture	-.377	.081	-.281	-4.641	.000
Absence of long term philosophy	.025	.077	.019	.322	.748
Inability to measure performance	.684	.096	.549	7.149	.000
Lack of a defined process	-.223	.089	-.196	-2.517	.013
Lack of leadership skills	-.041	.073	-.044	-.566	.572
Limited use of offsite techniques	-.054	.062	-.041	-.876	.382

Table 54: Regression Coefficients of all barriers

The Coefficients table provides us with the necessary information to predict awareness from barriers, as well as determine whether the level of awareness contributes statistically significantly to the model. As it can be seen some of the barriers Top management support , dichotomy between design and construction , avoid making decisions , lack of consultants, lack of resources, lack of long term philosophy, and lack of leadership skills are not significant of the analysis having a p-value greater than 0.05 . Thus, they will be disregarded.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	7.726	.787		9.811	.000
Resistance to change	.234	.066	.204	3.558	.000
Insufficient knowledge of Lean	-.542	.081	-.339	-6.688	.000
Multilayer subcontracting	-.364	.064	-.282	-5.656	.000
Tolerance for Untidy work place	.351	.061	.389	5.725	.000
Using relationships to conceal mistakes /a culture accepts delays	-.078	.069	-.059	-1.128	.261
Lack of support from government	-.329	.056	-.391	-5.838	.000
Lack of perseverance	.264	.056	.370	4.744	.000
Cultural behavior issues	-.161	.069	-.115	-2.353	.019
Poor Cross functional teams	-.171	.065	-.133	-2.635	.009
Lack of communication and cooperation between all parties	.260	.059	.257	4.378	.000
Absence of Lean culture in the partners	-.094	.059	-.100	-1.608	.109
Lack of logistic support	.126	.069	.119	1.829	.069
Absence of Lean culture in the organization	-.200	.062	-.152	-3.220	.001
Inability to measure performance	.642	.096	.516	6.691	.000
Lack of defined process	-.146	.085	-.129	-1.721	.087
Limited use of offsite techniques	-.087	.059	-.066	-1.487	.138

Table 55: Regression Coefficients of the significant barriers

The "Sig." column provides the p-value for the slope coefficient of all the factors. In our study, we kept variables with p-value of less than.05. According to the table above, the top

barriers are insufficient knowledge of Lean (-0.542), Inability to measure performance (0.642), and multilayer subcontracting (-0.364). Multilayer subcontracting had a slope coefficient of -0.364 for the Multilayer subcontracting variable. This meant that for every point increase in the Multi-layering variable, results in a 0.364 point decrease in the awareness scale, thus, decrease in the easiness in the implementation process. This tells us that the relationship between the two variables is negative. In other words, the more the company is hiring additional subcontractors to help complete its project, the less the employees will be aware about the implementation process and the harder the implementation will be. The more the ability to measure performance, the easier the implementation will be. The more the employees are unaware of Lean and its benefits, the harder the implementation will be.

4.4.4.2.1 Regression between factors of the barriers and the awareness

The independent variables are the components of the barriers extracted from factor analysis. The model summary of the linear regression is represented in the following table

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.712[a]	.507	.497	1.519

Table 56: Model Summary - Linear Regression of the factors

As per the above table, The R value represents the simple correlation and is 0.712 which indicates a high degree of correlation in this study. The value 0.507 indicates how much of the total variation in the level of awareness about Lean, can be explained by the barriers factors. R2 adjusted takes the sample size into consideration All of the barriers explain 49.7% of the variation in significant level of awareness and the easiness of Lean implementation, the rest is not explained by the above barriers, it might be due to other factors such as personal desire to adopt Lean or the existence of an internal resources that is acquainted with Lean .the difference between R^2 and $R^{2\,adjusted}$ is less than 10% indicating no noise in the data.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	565.491	5	113.098	48.996	.000[b]
	Residual	549.381	238	2.308		
	Total	1114.872	243			

Table 57: ANOVA

The table 57 indicates that the regression model predicts the awareness about Lean variable significantly well. This is indicated by the statistical significance of the regression model that was run. Here, p- value is less than 0.05, pointing out that; overall, the regression model significantly predicts the outcome variable.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.609	.097		47.382	.000
REGR factor score 1	-.210	.097	-.098	-2.158	.032
REGR factor score 2	1.397	.097	.652	14.333	.000
REGR factor score 3	-.378	.097	-.176	-3.876	.000
REGR factor score 4	.217	.097	.101	2.226	.027
REGR factor score 5	-.377	.097	-.176	-3.863	.000

Table 57: Regression Coefficients

The Coefficients table provides us with the necessary information to predict awareness from barriers. From this table the regression equation can be represented by:

AVERAGE_AWARENESS = 4.609 + -0.21(Organizational and process)

+1.397(Managerial)-0.378(Partnering & coordination)

+ 0.217(Resources and communication) - 0.377(Cultural)

This formula shows that factors with positive signs are the enablers of the Implementation ; i.e, Managerial factors are the biggest enabler of the implementation (1.397), and Resources san communication are the second enablers with a load of 0.217. Concerning the barriers it shows that the biggest barriers are partnering and coordination, and Cultural barriers almost at the same level (0.378 and 0.377 respectively), and then comes the organizational process barriers with lower effect.

Moreover, this table provides the regression statistics. Example -0.21 is the slope coefficient for the organizational and process variable. This means that, for every point increase in the organizational and process ambiguity results in a 0.21 point decrease in the awareness scale. This tells us that the relationship between the two variables is negative. The bigger the lack in the defined process of the implementation is and the more the company is shortening in setting the steps that leads the team towards its goals, thus, the less the awareness about Lean and the less the probability of having an easy implementation will be. For factor 2, the more the management supports the employees and the implementation, the more practitioners are aware about Lean concept and the easier the implementation will be.

In our study, the p-value is .0032 for factor 1, 0 for factor 2, 0.00 for factor 3, 0.027 for factor 4 and 0.000 for factor 5, which are less than a standard alpha of .05, suggesting that all of the factors are significant and should be kept in the regression. In other words, we can reject the null hypothesis that there is no relationship between the two variables and accept the alternative hypothesis that the identified barriers have an impact on the awareness about Lean and by consequent its potential implementation.

4.5 Main Results

4.5.1 Qualitative assessment results

The company has established a team of operation engineers to map the current processes critique them and identify adequate operational improvements to implement on construction sites. The team found the need for a desired system that involve every employee in active planning, and create a culture of making and meeting promises. That's why they have implemented the LPS. The framework used in this implementation is a conceptual and practical one because of the developments of the manuals that targets the role, responsibilities and ways of implementation for each position. The implementation process starts with a pilot project, and then expands

through the whole company, similar to the process presented by Anvari et al. (2011). It has common points with the framework proposed by Jadga et al. (2013) in terms of a bottom up approach since this case study is implementing Lean through the LPS which starts from the shop floor employees going up to managers. The framework implemented by the company answers the questions of whom and why to implement Lean practices as Anand and Kodali (2009) have proposed in their framework. As concluded from the results presented above, the framework used in the implementation targeted by this case study in Lebanon is a mixed framework that doesn't fit to one of the frameworks presented in the literature review; it has bits and pieces of different frameworks.

That last planner was a successful tool since it has led to the desired benefits of increasing safety, increasing the PPC of every week, and increasing the approval inspection rate of the project. The results are aligned with the conclusions of Anand and Kodali (2009) stating that LPS techniques is being used as a first step by around 53% of all the construction organizations \ for improving their internal/external collaborative relationships.
The important part of it is that it includes all the parties from different departments. The planning process now is a collaborative work between the planning department, and the construction department and the workers; this has increased the efficiency of the planning by making it more reliable and more realistic.

In addition to the last planner, visual controls were also implemented in the integration like the one proposed by Rose et al. (2010). One additional implementation tool was used "the huddle meeting "that was not lunched in any of the proposed frameworks, but has shown its efficiency in talking and tracking the constraints and the causes of the delays instantly in order to solve them before the next meeting.

This implementation has ensured a continual communication and increased the transparency between the teams. Moreover, it has improved the quality of the work and increased the number of approved inspections as was shown in figure 1.

The barriers found in this company: resistance to change, cultural behavior and unawareness about Lean benefits identified in literature are confirmed by the industry practitioners. The results are similar to the findings of Ogunbi (2013) concerning the top barriers hindering the implementation. People in this company continuously work to overcome those barriers in order to achieve better results. The implementation of the new concepts was facilitated by the

support of the top management which is an important factor when going towards something new, as mentioned in by Ogunbiyi (2014). Management has to show the workers that it trusts them and supports them financially by different means for them to embark in the change. Moreover, management has to empower employees, address them the responsibilities, and give them a small space of freedom in the work. All these should be done in an environment where good communication is the basic stone in order for parties to be able to meet, discuss, and resolve problems.

4.5.2 Quantitative assessment Results

The results of the study suggested that the following items were perceived to be the top barriers to the implementation of Lean practices: Using relationships to conceal mistakes as it is the common trait in the Lebanese construction organizations culture, where people sometimes give unfulfilled promises and low work quality and rely on relationships to conceal mistakes and to disregards or ignore their pitfalls. Lack of resources and planning is another important barriers were companies are suffering from low resources due to the stagnation of the GDP and the economy which makes them hesitating to invest more resources on new philosophies. Moreover, lack of managerial support is reported as one of the most challenging factors in Lean implementation. In fact, without a visible and active support from management, Lean implementation is unlikely to succeed. Consequently, when considering applying Lean to an organization, the management team must understand the managerial effort required, the needed amount of time spent and the adequate funding covering the needed action.

The ranking of the barriers confirms previous theories concerning the ones that ranked from 2 to 5 (Gursory, 2010; Abbasimehr et al., 2012; Verbraken et al., 2014); however, its signaling singularities in the Lebanese sector concerning identifying a new barrier, namely the relationships to conceal mistakes which was not found of high ranking in the literature. It was found in the literature of common et al. (2000) that cultural barriers, lack of commitment from top management and difficulties in understanding the concept were the main factors hindering the implementation of the LC concept in their construction industries (Abdullah *et al.*, 2009; Alinaitwe, 2009).

The results illustrated that the mean of respondents' perception on the average level of awareness/understanding of some fundamental Lean concepts and practices is approximately

equal to 4.61. These results obtained are consistent with the findings of studies conducted by Common et al. (2000) and Johansen & Porter (2003). These two studies revealed that there is a considerable lack of understanding to the fundamental concepts and application of Lean within construction companies.

It was observed from the variance analyses that the gender of the employees and the number of years the employees have been working in their current company do not make a difference to the level of awareness/understanding of Lean concept; while it was found that the organizations size (number of employees), age (year of establishment), net gross income, number of countries operating in, and the formal implementation existence lead to a singincant difference to the level of awareness about the concepts and affect the easiness and the speed of the implementation process. Moreover, it was found that the employees' age, education, position, and experience make a difference in the perception of the awareness level.

The findings of the positive correlations are similar to the findings of Shang and Pheng (2014) and very close to the conclusions of Sarhan (2010) concerning the perceptions of different Respondents/organizational characteristics to the awareness of Lean.

The results showed that newly established companies are the most aware amongst all, as they obtained much higher scores (5.98) than other older companies. The study also revealed that smaller companies (less than five employees) have a lower level of Lean awareness and implementation status, as they obtained much lower scores (3.01) than other larger companies.

In terms of the income, companies with a huge income of more than five millions were found to be the most aware about the philosophy. Finally organizations that are operating internationally are more aware about Lean than local companies. Moreover, findings indicated that a majority of employees who are above 45 years old and have more than 15 years of experience are respectively more aware about the Lean model (7.01, 6.94) than younger employees. In addition, people with a minimal education have barely heard about the Lean thinking, whereas the group of employees with the highest Lean awareness and Lean implementation status were engineers. Moreover, the findings showed that foreman were rarely aware of what Lean constituents of compared to mangers. This might be correlated to their managerial role in tackling philosophies such as Lean and making decisions on their adoption. Younger people, on the other hand, work at an entry level position which does not put them in a situation where they can decide on potential initiatives/philosophies to be

adopted. We can deduce that young users should have regular training in order to be able to perceive the benefits of the implementation of Lean.

The study revealed that, construction firms in Lebanon have not been affected by Lean practices to a large extent. This study offered a thorough overview of the barriers to implementing Lean practices in various contexts, with a focus on construction.

Realizing the full potential of Lean practices in the Lebanese construction industry requires that building professionals overcome the barriers in the following areas respectively : "Organizational support and Process "barriers, "Managerial" barriers", "Partnering and coordination" barrier, "Resources and communication" barriers, and "Cultural" barriers. This is considered 80% close to the findings of Shang& Sheng (2014).The barriers identified in this study can be used to help guide building professionals to conduct self-audits of their current implementation of Lean initiatives, if any, and to assist in the development of action plans designed to overcome such barriers.

The linear regression model generated in section 4.4.4.2.1 was able to explain half of the awareness (easiness of the implementation), this outcome is acceptable since as previously found in the literature, the barriers do not fully explain what drives companies to adopt Lean; some of it might be explained by personal desires to adopt lean, or the existence of internal resources that is acquainted with lean. Factor with positive sign are considered enablers of the Implementation, whereas the one with negative sign are considered barriers of the implementation

After combining the results of the qualitative and quantitative analysis, we can conclude that there is a strong positive relation between employees' awareness about the implementation process and the significance of the barriers. This strong association can be due to the lack of training and incentives to overcome the barriers and lack of knowledge about the importance of establishing a Lean culture within the construction industry. There is a distinct lack of understanding of the fundamental constituents for a Lean culture to exist within Lebanon.

4.6 Conclusion

This chapter started with a brief overview of the main sections, followed by the definition of the analysis framework of this research. Then we have analyzed the qualitative interviews and mentioned the major highlights. After that, the quantitative data was explored using reliability analysis, descriptive statistics, regression analysis and factor analysis. Since we are adopting a

mixed methodology in this paper, the last section of this chapter includes the main results after crosschecking the outcome of the qualitative and quantitative methods.

In the next chapter, we will provide a summary of the research aim and main findings; we will also link the research questions with the methodology and findings. Validity of this paper will be demonstrated, along with the research limitations and implications

Chapter 5

CONCLUSION AND REMCOMMENDATIONS

5.1 Introduction

This chapter will present the conclusion of this thesis that aims at evaluating the relation between barriers and the successful implementation of Lean construction management in the Lebanese market. The main findings will be summarized along with the respective research questions, methodology and tests used. Then we will tackle the validity of this paper, followed by its limitations and suggestions for future research. Finally, we will discuss the theoretical and managerial implications of this paper.

5.2 Summary of the Main Findings

In the pursuit of staying in a competitive business environment, companies have sought to eliminate waste through implementation of Lean management tools. While there are great deals of Lean success stories, this research study discusses the level of awareness of Lebanese practitioners in the construction industry about Lean, to identify the major barriers to reach a successful adoption in Lebanon, and to capture the variation in the perceptions of stakeholders to the awareness about the new philosophy. Moreover, it is important to be aware of the requirement of Lean systems by knowing the constituents and the importance of the key driving forces of creating the desired culture. That's why enablers were also discussed in this study.

According to the results of company X, the use of only one framework was not applied systematically. In fact, the choice of framework was based on their need for the "how "to implement and not only for matching a conceptual framework. Moreover, the implementation had started in a pilot project with the integration of shop floor employees in applying the new concept using the LPS which has showed great results in the implementation. The bottom-up strategy for LC implementation on construction sites described in this paper is effective because it stimulates the engagement of the workers to make improvements on their own processes. This is made possible through training to enable them to find and eliminate wastes in their daily work. In conclusion, this study has been able to identify three main barriers to the implementation of LC in Lebanon which are: resistance to change, cultural behavior, and

unawareness about the benefits of the new system, these are in order of importance to company X in the Lebanese industry. The study, therefore, provides an understanding of the Lebanese construction industry and its challenges that should be resolved in order to move the industry forward. The solution to some of the barriers (cultural behavior and resistance to change) could be to have a cultural change where 'no blame' environment dominates. The importance of such an environment lies on helping the team to learn from failures and to continuously improve. Participants must trust each other to start exercising reliable promises Therefore; companies must focus on changing the behaviors of people rather than just focusing on implementing some of the tools. For the other barriers, constraints should be identified beforehand in order to be able to get rid of them before the execution. The findings of the qualitative study are in agreement with previous authors (Ansell, Holmes, Evans, Pasquire, & Price, 2007; Johansen & Porter, 2003; Omran & Abdulrahim, 2015). Last Planner, Daily Huddle Meetings and visual control have become recognized Lean construction techniques that play the same role that Ohno's practices played in manufacturing. According to what has been discussed above, the framework used in this case study is a conceptual and an implementation framework at the same time. The common barriers that hinder Lean transformation in Lebanon are always the issues emerging at "shop floor employees" such as: cultural behavior, resistance to change, and unawareness about Lean benefits. This is consistent with what was found in the literature review, as the same conditions apply in Lebanon. Lean is characterized as a people-oriented system and "Employee involvement" is one of the most critical elements to make a Lean transformation program a success story, in addition to top management support, and effective communication between parties. The improvements that were mostly noticed were increased visualization, and improved quality. The last wouldn't be present without the encouragement of top management in empowering the employees. Moreover, the company has discovered the importance of a proper safe environment, since the lack of it is considered as a type of waste. It is, however, recommended that training programs about Lean construction be provided to industry professionals as these programs will help to upgrade their knowledge, skills, techniques and processes in order to overcome the barriers to LCM.

The quantitative study revealed that the level of awareness of Lean principles amongst construction organizations is low, and there is a significant lack of understanding of how to successfully apply these principles to construction processes and activities.

It was also interesting to discover that recently established organizations with a big number of employees, and high gross income, have higher level of awareness than other organizations. Moreover, educated employees who have high positions in the organization and have a considerable experience have a good level of awareness compared to others. The overall results pointed out that there is a strong relation between employees' awareness about the implementation process and the identified barriers. Evidence from the results review shows five vital factors that companies must pay attention to: management support, external support, knowledge of the process, multilayer's subcontractors, and resources and culture. Toyota and other companies who have implemented Lean successfully were found to be strong in these areas.

Companies ought to comprehensively understand the Lean system before its implementation. More importantly, a conducive environment must be created within an organization by employing the right people with a clear vision in order to achieve the expected outcomes from Lean. Both studies conclude that culture is found to be an important factor, which needs to be integrated in an appropriate manner. It was found that organizations can't succeed in Lean unless they have a healthy culture, an awareness of the processes and the buy-in from the top management.

5.3 Validity of the research

In this section, we will discuss the validity of this paper that can be defined as the best estimate of truth when drawing conclusions or inferences (Trochim and Donelly, 2001). In particular, we will prove the external, construct and internal validity of this research.

5.3.1 External Validity

Two populations were targeted in this research. In the qualitative method, we have chosen managers and foreman, concerned with Lean implementation. Taking into consideration their wide experience in this field and the difference in their education background, exposing their point-of-view should not be a threat the external validity. The interviews coding was done by three raters to make sure the outcome is homogeneous; this inter-rater reliability strengthened the findings' validity of the qualitative method.

In the quantitative method, external validity was strengthened by adopting a random sampling of the population representing the Lebanese construction industry and by the sample size, which yielded a 95% confidence level with 5% interval of error and reliability Cronbach's Alpha of 80.4%. Also the sample was, to the best of our knowledge, representative of the population; taking into account the gender distribution, age brackets, education levels, and years of experience.

As per the above, we had a strong external validity for using random sampling procedure on a statistically significant and representative sample size, thus, conclusions and inferences can be generalized to the whole population, especially since most of the outcome resonate with previous papers and theories (Frambach, Van der Vleuten, & Durning, 2013).

5.3.2 Construct Validity

The construct validity, which refers to the degree at which the factors used for awareness and barriers, can reflect these theoretical construct. This validity is mainly related to the quantitative method (Trochim & Donelly, 2001). In this research we consider that we had robust construct validity since the factors explaining the barriers hindering the implementation and the perception of the awareness were first deduced from the previous studies, then, the facilitating qualitative technique allowed us to confirm these variables and their adaptability in particular in the Lebanese market.

5.3.3 Internal Validity

The internal validity represents the most appropriate estimation of the truth when trying to confirm or reject causal associations (Trochim & Donelly, 2001). In this study, the qualitative method was only exploratory and inter-rater validity was respected. Moreover, the sample represented the company which was the first and the only company implementing Lean in construction engineering, interviews were conducted with managers having a wide experience and a high educational background, in addition to foreman who are relying on their experience to answer the questions.

In the quantitative analysis, we were able to prove strong causal relationship between awareness and barriers with R-square value (0.747) of 74.7%, which indicates that this paper had an adequate internal validity for having a significant and representative sample of the population (Frambach et al., 2013).

5.4 Limitations of the study

The purpose of this research was to identify and prioritize the enablers and barriers and offer an example of the framework and strategies used to implementing Lean Construction within the Lebanese construction industry. To contextualize the findings of the literature review within the Lebanese industry, this study collected the opinions of experts and professionals in the sector to identify the enablers, barriers and benefits of the implementation of LCM. The descriptive and quantitative analysis methods were utilized to present the results of the survey findings. This study focused on conducting an exhaustive analysis of the awareness, enablers, barriers and the implementation framework used in the Lebanese industry. It was within the scope of this research to conduct an in-depth study of the barriers but not seeking to provide the solutions or the overcoming strategies. This research was limited to gathering the perception of a small sample size in the qualitative assessment.

The other limitation is related to prolonged observations. Due to time and funding constraints, the research was limited in time. Broader data collection procedures, such as observations on several projects, would provide greater insight into Lean acceptance at each company. It would also provide greater insight into potential failures and barriers. The author did not have a chance to discuss and demonstrate many other findings from the quantitative analysis with the population of the qualitative analysis due to time constraints; however, investigating the triangulated analysis is highly recommended for future studies, as mentioned previously.

Also, only a limited amount of interviews were conducted, when compared to the size of the sample, due to availability limitations.

5.5 Recommendations and future research

The study recommends providing intensive training about the implementation of Lean construction management to professionals; as these programs will help to upgrade their knowledge, skills, techniques and processes in order to improve on the barriers for prioritizing Lean construction in construction industry. The research recommends a bond or link between Lean and its practitioners in a way to make them conscious about the suitability of various practices of the implementation in the resource allocation.

In addition, practitioners are to be equipped with the capability to think about their problems at work and find out the root causes of the problems prior to Lean applications. Lean should not be deemed as only a set of tools, but an endless journey to create a community of practitioners who are able to continuously improve, initiate and create solutions to solve daily problems. In order to consider the critical success factors of the implementation, several actions are to be taken concerning quality, safety and cost. Involving the client representative in the process of tracking the quality management indices, would be of better results involving the task hazard analysis in the LPS. Developing a risk assessment manual might help to decrease the number of injuries on site. Moreover, improving the involvement of the subcontractors in the cost/productivity monitoring process might help in decreasing the cost of the whole project. This study further recommends that for project stakeholders in the construction sector to address some of the challenges facing construction productivity. The process starts with setting the target for achieving a higher return, followed by educating the team on the Lean methods, and continuously supporting it.

Organizations need to devote effort and resources to set principles of LCM in order to achieve pull scheduling, which implies that if the resources are inadequate, it may not be possible to achieve a Lean implementation. In addition, the introduction of new planning methods such as location based management is recommended to be used in order to reduce the waiting time and the tasks conflicts.

For future studies the author recommends using the same questionnaire for conducting similar studies in different countries as it would help to identify the strengths and weaknesses of

different construction organizations. Moreover, referring to the secondary analysis, which consisted of six different classifications of the barriers, and carrying out further investigation, is strongly recommended. Each classification could be treated as a specific case study. Future work can conduct in-depth analysis to evaluate strategies to overcome the barriers faced in this industry for a better and more effective implementation of the principles. Research should focus on how the proposed framework in structural engineering fits mixed scenarios where the projects might be in other fields such as transportation, environmental, geotechnical or even other phases of the construction industry. In order to stimulate the bottom-up approach, future research might focus on the capability that should be built-in among the shop floor employees to move towards the Lean objectives of their organization. .

5.6 Research Implications

The implications of this research can be categorized into theoretical and managerial or professional implications.

5.6.1 Theoretical Implications

The definition of the barriers adopted by previous scholars as being a set of activities that prevent the successful implementation of Lean was validated in the construction industry in Lebanon. It can be inferred from this research that there are five factors of barriers that could be used as a model to understand the failure in implementing lean. Moreover, the managerial barrier factor has more impact on hindering the implementation than any other barriers. There exists a Study of the Lebanese construction industry that focuses on the main enablers and barriers of Lean implementation. More research can be done to investigate more about these points.

5.6.2 Managerial Implications

Managers in the Lebanese industry need to fight variability in work performance (due to irregularity of labor, equipment, information, changes, or logistics) and embrace a steady and uniform work flow in the system without interruptions. Managers can use buffers (cost, time, capacity, space, etc.) to absorb work flow variability (i.e. use Theory of Constraints guidelines). These can be used to synchronize the start and finish of tasks in order to avoid delays and rework. As recommend by Leach (2006), risk management techniques could be used to reduce the vulnerability to special causes of variation while buffers could be used to

manage the common causes of variability. Moreover, managers need to set up the layout of the work site to achieve a seamless work-flow and clean up and organize the work site daily using 5S techniques.

The research exposes a company's experience with the first extensive implementation of Lean construction in Lebanon and offers guidance in reducing the rework and modifications in the existing frameworks. It also educates about the strengths and weaknesses of each framework. It has been shown from this research that the successful implementation requires Lean champions who understand the principles to be fully engaged with the system and to take part in implementation by motivating people to adopt Lean principles.

Managers should be able to balance work resources based on work flow, rely on smaller teams, and adjust relations and the logic of work tasks accordingly. The objective is to be fully ready before the release of each task in the work package.

-Companies should put the enablers in place before the implementation and think about the plans to overcome those barriers before venturing LCM.

5.7 Originality of the study

This study is the first in investigating the framework used in Lebanon to implement Lean practices; in addition this study has presented the main enablers and barriers for the first extensive implementation of Lean techniques in Lebanon. In addition to presenting a successful framework used in the implementation that fits the Lebanese conditions of the industry, this study contributes in helping companies who are considering the implementation of Lean as their next step for business improvement to benefit from the experience of a different company working in the same country. Other companies have the chance of learning from previous lessons learned to have an idea about the barriers that they might face during the implementation to think about ways to overcome them ahead of time. Future attempts should be more effective than the first, since the system is better defined and elaborated before its initial introduction.

Twenty four factors were identified as critical in the literature and carried forward to the main study, but seven of these returned results of being non critical when subjected to statistical tests on the gathered data. Therefore, this work has identified seventeen factors which appear to be critical to successfully implementing Lean interventions in the construction industry.

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Appendices

Appendix A: Coding

Coding	
Frameworks	The structure designed to support the implementation, including the type or approach of the implementation, the ways to implement it, and the process used.
Benefits	The advantages of implementing Lean principles and techniques in Construction.
Barriers	The barriers and obstacles faced during the implementation that didn't make it as simple as it should be.
Enablers	The enablers and drivers that have helped the implementation to be successful.

Appendix B: Interview layout

It is understood and agreed to that the Discloser and the Recipient would like to exchange certain information that may be considered confidential. To ensure the protection of such information and in consideration of the agreement to exchange said information, the parties agree as follows the information can be presented in the research project without mentioning the name of the participants.

The aim of this study is to explore Lebanese construction companies that are applying Lean principles in construction, and to analyze the framework used in order to come up with the enablers and barriers faced in such a framework, in order to reach the ideal framework. For any question, you contact the researchers affiliated with Notre Dame University – Louaize:

Mira Thoumy (09-208339; mthoumy@ndu.edu.lb)

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Questions:

1- What is your Approach of Lean implementation?, i.e. top-down or bottom-up

2- How did you implement Lean construction in your project sites? Elaborate about the sequences used in your implementation.
   Last planner:

3- What are the Lean principles, tools, and practices adopted in your company? (Just in time, 5s, Last planner, huddle meeting, Multi-skilled workers) and how are you using them?

4- In which part of your turnkey projects were the Lean tools and techniques applied? (Lean in design? Lean in assembly? Lean in supply, Lean in construction?)

5- "Who "are targeted to use or apply the Lean principles that were proposed in your frameworks? Does the current Lean framework emphasize on the involvement of shop floor employees? How?

6- Does the framework provide practitioners with a clear picture of how to implement Lean along the journey and what is the next step for them to do? How

7- Are you applying Lean within the internal stakeholders only? Or does it include also external stakeholders (example: Personnel in the supply chain, subcontractors.)

8- What is the aim of your framework? And why are you implementing Lean tools, and techniques in each of the phases?

9- Does it focus on the capability of practitioners to Carry out problem solving and continuous improvement and equip the practitioners with capability in building up their own way towards Lean?

10- Can your framework be considered as a reference for waste identification? How?

11- Does your implementation of the framework have led to the benefits described in the literature in terms of project success?

12- What are the main benefits you have gained from applying Lean construction on your sites?

13- What is the ideal framework you are looking for?

14- Did you use agile engineering? Pilot project? Generalize?

15- Describe the whole process and barriers you faced in implementing Lean.

16- How did you overcome some of the barriers?

17- Why other companies are not applying Lean construction in your opinion.

18- Do you consider your experience with Lean as a successful one?