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Lean Framework for Assessing Construction Logistics in Jordan

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Abstract

Construction plays a significant role in forming civilisations as it has an impact that spurs societies worldwide to construct their own unique building identities. The structure of the construction industry is arguably considered to be fragmented and not well organised. So, effective construction logistics management is crucial to the success of construction projects that rely on extended supplier networks and delivery processes. As the construction sector is one of the vital sectors in the Jordanian development process, the construction logistics process is considered a significant problem confronting Jordanian construction and needs to be altered (Sweis et al., 2008; Momani, 2000). My investigation of a variety of databases has discovered no indication of implementation of lean thinking or lean practices within the Jordanian construction industry. The purpose of this study is firstly to examine the challenges facing construction logistics in Jordan, and then explore to what extent the Jordanian construction stakeholders are using lean planning tools and practices throughout their construction logistics process, which determines whether Jordanian construction is conventional or toward lean. Thus, this subject appears to be a substantial area to examine within the Jordanian construction industry.

The research aim is to develop models for assessing the adoption of lean logistics in Jordanian construction organisations. To achieve this aim, five objectives were prepared. In the literature review, a background of lean production and construction are illustrated; methods and approaches of lean construction along with the benefits and barriers of lean are also critically reviewed. However, the literature did not show any signs of lean practices in Jordan. In addition, supply chain and logistics, in a global sense, are clarified along with the differences between traditional and lean logistics. Most importantly, the literature review shows the challenges affecting logistics in the construction industry including the health and safety regulation factor; inventory factor; material preservation factor; labour performance and material handling factor (performance factor); planning factor; transportation factor; continuous improvement factor; and transparency and information exchange factor.

In terms of the research methodology used in this study, the researcher adopted the research-onion model (Saunders et al., 2009). The research tended towards positivism, realism and value-free stances in terms of philosophy, and the search approach used was a combination of inductive and deductive. The strategy of research first included a case study (semi-structured interview), and secondly a survey which considers the choice of this research as a mixed method. Firstly, semi-structured interviews were administered among nine experts in the Jordanian construction industry. This qualitative data investigated the current status of construction logistics in Jordan, factors affecting Jordanian construction logistics and the benefits and barriers of implementing lean practices. Secondly, the results of the semi-structured interviews and the literature review were utilised in the second data collection (questionnaire) in a wider section where 150 stakeholders participated. The descriptive outcomes and factor analysis show that planning is the leading factor (challenges) affecting construction logistics in Jordan. This is followed by the transportation factor, transparency and information exchange factor, continuous improvement factor, material preservation factor, inventory factor and finally the material handling factor. Moreover, the outcomes also show that the awareness and implementation of lean planning tools and practices are still underestimated. Furthermore, the Kruskal-Wallis test and logistics regression were used to find the different views among stakeholders (consultant, contractor and supplier) in regards to factors (challenges) affecting construction logistics, lean planning tools and practices. ISM (Interpretive Structural Modelling) was exploited to build final models, explain all the relationships between variables and level them in different stages from bottom (greatest influence) to top (lowest influence). The models included factors affecting construction logistics (ISM-1), lean planning tools (ISM-2) and lean practices (ISM-3).

Fulfilling the aim of this research offers both academics and practitioners contributions to the study of lean logistics. For example, academics will be able to use this research to identify initial indicators and tools for further in-depth studies related to lean logistics within developed and developing countries, whereas managers from different Jordanian construction companies (consultant, contractor, or supplier) will gain added insight into and guidance on lean logistics challenges and use of lean planning tools and practices. This will ultimately help managers assess, reframe and prioritise their managerial practices.

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Chapter One: Introduction

1.1 Overview of the Research Topic

Construction plays a significant role in forming civilisations. Construction impacts society worldwide, spurring cultures to construct their own unique building identity. The construction industry is deemed one of the largest global industries and acts as both a vital and major source of social and economic development (Winch, 2010).

However, the construction industry structure is arguably fragmented and poorly organized. Fragmentation increases as the number of small firms or organizations increases, along with a simultaneously decreases of their average size (Alashwal et al, 2011). Subsequently, this leads to the unclear role of learning within the construction industry, as construction fragmentation limits innovative solutions by reducing mutual information capturing and sharing. Consequently, the construction industry suffers from many problems related to time, cost, and quality because of the peculiar nature of the industry. Added to which is the fact that construction projects require a plethora of stakeholders (ibid).

However, this view has been significantly challenged. The unique peculiarities of the construction industry can be attenuated by applying several actions, such as the standardization of components, the utilization of modularization, prefabrication and the use of enduring teams etc. (Ballard and Howell, 1998). Furthermore, construction industry peculiarities can be minimized by simplifying site construction to final assembly and testing (ibid).

Much research and reports have been published to enhance construction industry performance, collaboration, and partnerships. For example, previous UK reports such as Latham (1994), Egan (1998), and the Strategic Forum for construction (2002) have drawn attention to construction industry supply chain and logistics problems, calling for greater integration of key processes for improved efficiency and quality of construction industry services and products. Such reports aim to reinforce the impetus for change and to make the industry more response to customer needs. However, change has been slow to materialise (ibid).

Since the construction industry strives for high quality whilst reducing cost and time, effective logistics management is crucial to the success of construction projects where extended supplier networks and delivery processes are relied upon (Sullivan et al, 2011). Logistics intention is to maximise profit and quality and to reduce time and waste, and is defined as the process of strategically managing the procurement, movement, loading, unloading, and storage of material, parts, and finished inventory, along with the related information flow through organizations (Christopher, 2012).

Within the context of the construction and building industry, supply chain logistics remains an area insufficiently reviewed and studied. Many point have not been adequately covered (Vidalakis and Sommerville, 2013). For instance, suboptimal conditions of construction negatively affect productivity, i.e. due to weather conditions, lack of space, and on-going activities that will inevitably damage materials; the construction site is the worse place to store materials (Koskela, 1999).

In the past, there have been initiatives to enhance several aspects of logistics. For example, Johnson (1982) created a schedule for materials control which included the materials description and the proper way of handling, storing and protecting each type of material, aiming to minimise loss or waste. However, Vidalakis et al (2011) highlighted a significant need for a variety of research to consider the structure and the nature of the construction industry supply chain and logistics. Similarly, the adoption of logistics necessitates examination of all logistical connections, cutting across organizational and constructional boundaries. Additionally, improving the logistics process provides opportunities for all stakeholders to achieve higher profits, lower costs, and better value for construction clients (ibid).

Accordingly, to survive in today's competitive market there is an urgency for construction companies to find new and different practices to improve the effectiveness and quality of their work, and to reduce waste and cost (Al-Aomar, 2012). Under the current economic recession and financial crises, this becomes particularly more pressing (ibid).

Therefore, the practice of lean construction principles, heavily influenced by the Toyota Production System (Womack et al., 1990), aims to solve managerial problems, develop the logistics system, and improve construction processes primarily through minimizing waste and maximizing value (Bryde and Schulmeister, 2012). As a means of improving supply chain performance, lean was initially adopted by numerous manufacturing companies, and afterwards widely in the construction sector (Ballard and Howell, 2003).

Several studies and research projects have concentrated on setting up and assessing the potential of lean to deliver claimed benefits, such as improved collaboration amongst parties, improved productivity, and output enhancement in various project contexts (Bryde and Schulmeister, 2012). For example, Dhandapanietal (2007) stated that an Indian steel company in India has shown significant benefits after applying lean thinking and lean practices. Furthermore, as well as Chen et al (2012) strongly affirmed the application of lean practices by the UK's Highways Agency resulting in saving cost, saving time and improving quality. Further on, both of these examples will be discussed later on in- detail through the literature review.

As discussed, the problems of logistics have greatly impeded construction sector performance. Moreover, applying lean thinking and lean practices will provide rational and practical solutions to resolve the major logistics problems (Chen and Xu, 2011).

1.2 Jordan (Geography, Economy and Construction Industry)

Formally known as the Hashemite Kingdom of Jordan, Jordan has a range of geographic features, from the Jordan valley in the west to the desert plateau in the east, connected by a range of small hills stretching in between (Ali and Al Nsairat, 2009). The Hashemite Kingdom of Jordan was officially formed in 1946. It is bounded to the north by Syria, to the north-east by Iraq, to the east and south by the Kingdom of Saudi Arabia, and to the west by Palestine and Israel, as shown in Figure 1.1. Jordan comprises a total area of 91,880 km^2 and has a population of 5,370,000. In addition, Jordan's geopolitical location gives it vital importance and significant impact on the political stability of the region (Alsayeed and Sweeden, 2010).

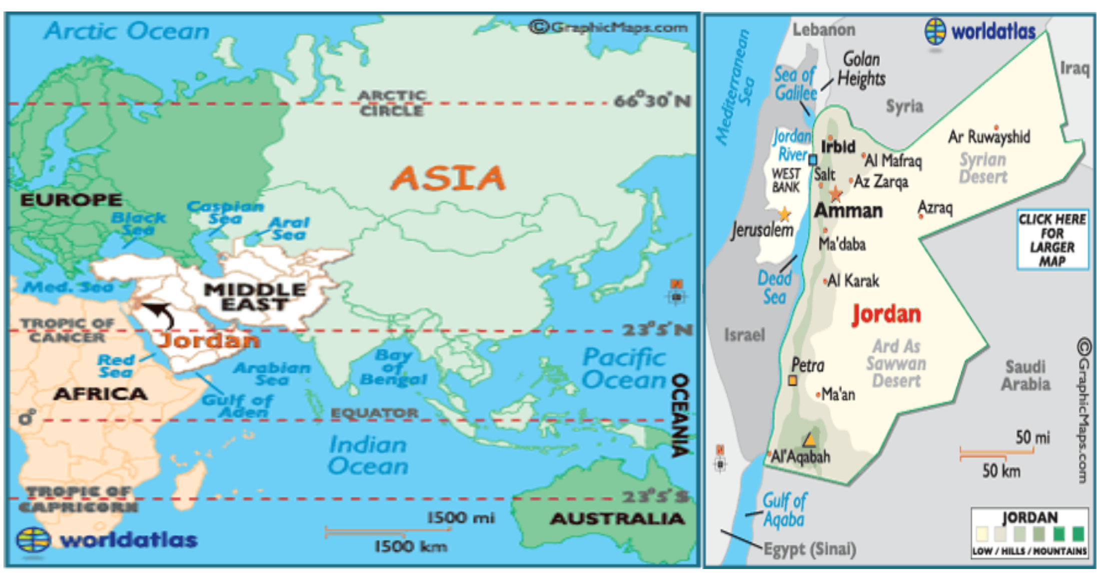

Figure: 1.1 Jordan Map

Jordan's economy has been characterized as a rentier and secondary-oil economy because of its high dependence on remittances from nationals working in oil producing Arab countries, unconditional grants the country has received due to its strategic geopolitical location, and exports to the Arab region (Majluf et al., 2012). The fate of the Jordanian economy has been tied to developments in the world oil market and to political events in a highly volatile region (ibid). The construction sector is a vital sector in the developmental process of Jordan and is considered to play a fundamental part in the social and economic growth of every country. Construction industry innovation plays a key role in delivering solutions with which to provide improved value for money and increased sustainability, for both clients and wider society. Although, Limitations still remain in the Jordanian construction industry which must be addressed before the most desirable development can be attained (Momani, 2000). The Jordanian government and construction industry specialists demand to commit resources to a focused industry-wide approach. Nevertheless, this kind of approach requires long-term initiatives (Alkilani et al., 2012). Furthermore, the Jordanian government is one government amongst many to discover that improvements of the various and far-reaching aspects of supply chain and logistics offer a valuable means by which to improve national economy (Shwawreh, 2006). Economic development will not be achieved without new ways of thinking and practices.

1.3 Defining Problem and Research Justification

It is worth simplifying the topic by providing a short description of *lean* and *logistics*. Lean is a group of managerial practices along with a new philosophy which aim to minimizing waste and maximizing value throughout each process, including planning and operation processes. Besides, according to this research, logistics is defined as a flow of material including transportation and delivery from the initial point (i.e. the supplier) to the construction site. Lifting and handling methods, along with the storage stages are an inclusive part of the logistics process. So, lean logistics can be identified as the application of lean tools and lean practices to construction logistics throughout all processes (Chen et al., 2012). The next chapter (literature review) illustrates the meaning of both lean and logistics in terms of the construction industry, providing comprehensive clarification regarding the area of lean logistics.

As discussed in the previous section, a necessity to develop the construction sector exists and a vital aspect to that is the improvement of logistics. Furthermore, research into the Jordanian construction industry has been conducted to investigate causes of delay, excessive costs, and disputes. Altogether, 130 projects were examined in the study which included the building of schools, medical centres, communication facilities and administration buildings. The results showed 81.5 % of the projects failed to achieve their goals within the contract time limit and the agreed cost (Momani, 2000). In accordance with this research study, delivery of materials, site conditions and disputes between parties (supplier and contractor) are considered significant causes of the problems within the Jordanian construction industry (ibid). These managerial problems are attributed to the logistics process. Developing logistics would significantly help construction parties to establish an adequate and mutually beneficial system (Shwawreh, 2006).

According to Sweis et al. (2008), a case study conducted across 13 Jordanian construction projects shows that in Jordan, by comparison to the UK and USA, more time is spent uploading, offloading, moving and storing than is spent on similar activities in the developed countries. As a consequence (ibid):

1. More work-hours are spent unloading because of the unplanned introduction of advanced work methods of construction,
2. There is inefficient temporary placement of materials near the delivery points as a result of a lack of advanced storage planning, and
3. There is additional manual handling to move materials from the storage to the work areas, even if advanced tools and equipment for this purpose exist on the project site.

Therefore, logistics methods and material delivery process used in Jordan tend to be far less sophisticated than those used in the USA and the UK. This demonstrates a need for advanced construction methods which require proper implementation to solve improper planning and execution, and so increase the level of productivity (ibid). In light of the revealed necessity for improving Jordanian logistics, the role of lean thinking and practices comes to the fore, where the implementation of techniques and tools can be used to overcome the fragmentation problems of traditional functional businesses (Sarhan and Fox, 2013).

Thorough research of a variety of databases has revealed no evidence regarding the practical implementation of lean thinking or lean practices within the Jordanian construction industry.

Therefore, this research will be the first application of lean that intends to assess and then evolve the current logistics situation, and to establish a basis for development of research into the area of lean logistics within the context of Jordanian construction industry.

1.4 Questions of the Research

Two main questions can be asked with regards to the topic:

1. What are the roots causes of the ineffectiveness of construction logistics in Jordan?
2. How can lean logistics in the Jordanian construction sector be assessed?

1.5 Aim and Objectives

The aim: The aim of the research is to develop models for assessing the adoption of lean logistics in Jordanian construction organizations.

Objectives:

1. To review the challenges (factors) affecting construction logistics throughout the worldwide construction industry, as well as within Jordanian construction.

2. To explore both the successful features and the difficulties of implementing lean practices throughout the global construction industry, as well as within Jordanian construction.

3. To explore the differences amongst Jordanian stakeholders' views with regards to factors (challenges) affecting construction logistics, lean planning tools and practices.

4. To develop an approach for the adoption of lean logistics in order to assess existing logistics processes within Jordanian construction.

5. To validate the developed approach and assessment models.

1.6 Research Methodology

Following a mixed method approach, two data collection phases were executed. The first phase was a case study (semi-structured interviews) involving nine experts. The semi-structured interviews were analysed using content analysis. Furthermore, the second phase was a survey (questionnaire), which resulted in 150 completed forms. Firstly, the second phase analysis commenced with descriptive data, with all data illustrated by percentage and based on the level of agreement. Secondly, inferential data was utilized as follows: factor analysis was used within the challenges affecting construction logistics in Jordan; then Kruskal Wallis and logistics regression tests were applied to discover the differences between the main construction logistics stakeholders (consultant/designer, contractor and supplier).

To validate the mixed method used throughout the data collection phases a focus group interview was conducted which included nine construction professionals, mainly from the logistics field. For this reason, ISM (Interpretive Structural Modelling) was used to confirm the outcome derived from the data collection and analysis. ISM methodology includes a Structural Self-Interaction Matrix (SSIM) to determine the relations among variables, then a Reachability Matrix accompanied by driving and dependent power. After that, constructing the reachability set, antecedents set, and intersection set, as well as iterations to reveal the differences in levels among variables results in the subsequent building of the final model.

Additionally, the targeted populations in both data collection phases and the validation section were professionals involved in the construction sector and included engineers (architect/designers), project managers, clients, academics, skilled labour (foremen), contractors and supply managers.

1.7 Scope of the Study

The construction logistics process and the subject of lean encompass many practices. Thus, it is beyond the remit of this research study to consider in detail the entire expansive area. Therefore, in an attempt to provide a context compatible with achieving the research aim and objectives, the scope of this study is tailored to explore the points illustrated below:

1. Logistics and the lean subject can be applied in a wide variety of industries (e.g. the automotive industry), however this research focuses on the construction field and particularly the cycle of materials from the supplier to the construction site storage.

2. The research was limited to mostly private sector, large and upper-intermediate sized organizations; so lower-intermediate and small sized organizations are not included.
3. Data used for strategy development was collected through survey (questionnaire) and case study (interviews), as to apply alternative methods (e.g. ethnography) to gain significant results would be impractical due to the time limit of the research study.
4. Various roles are linked with the logistics and lean subject. Due to the time limit of the study, as well as the result of data collection, this research addresses only the dominant pillars of the construction sector that includes the consultant (designer/architect), contractor, and supplier.

1.8 Expected Research Contributions

The research is likely to provide academic and practical contributions, as shown below:

1. This research reviews, synthesizes, and critically assesses the knowledge and evidences gained throughout different studies, particularly in the construction field, with regards to lean production and construction, supply chain management, and logistics.

2. This research is the first academic initiative concerned with both the purpose and application of construction logistics and lean construction in the Jordanian construction industry. Through this, the efficiency of managerial practices in Jordan can significantly develop. In terms of developing the Jordanian construction sector, the outcome of this research meets with Jordanian government ambitions, as studies regarding construction management are scarce.

3. Subsequently, this research study has provided a basis for the development of research in the area of construction logistics and lean (lean logistics) within the Jordanian construction industry.

4. Academics can exploit the outcome of this research to expand knowledge in regards to this subject. Furthermore, international academics are enthused to contribute further studies and explanations aiming to highlight the terms of lean and logistics. Thus, this research provides beneficial evidence, as research regarding lean logistics is scarce, particularly concerning developing countries.

5. Practitioners will gain further perceptions and guides regarding lean logistics. The research determines construction logistics challenges, and the level of applying lean planning tools and lean practices for each stakeholder. These findings provide each stakeholder with the knowledge required to better understand his or her position within the construction logistics process and to assess their individual attitude, leading to further development.

1.9 Methods Implemented in the Research

Table 1.1: Research implemented methods (P: Primary data, S: Secondary data)

Objectives	Research questions	Literature review	Interviews	Questionnaire	ISM
To review the challenges (factors) affecting construction logistics throughout the worldwide construction industry, as well as within Jordanian construction.	What are the roots causes of ineffectiveness of logistics in Jordanian construction?	S	P		
To explore both the successful features and the difficulties of implementing lean practices throughout the global construction industry, as well as within Jordanian construction.		S	P		
To explore the differences amongst Jordanian stakeholders' views with regards to factors affecting construction logistics, lean planning tools and practices.				P	
To develop an approach for the adoption of lean logistics in order to assess existing logistics processes within Jordanian construction.	How can lean logistics in the Jordanian construction sector be assessed?			P	P
To validate the developed approach and assessment models.					P

1.10 Structure of The Research

The thesis consists of seven chapters. The compositional aspects of each chapter are highlighted as follows:

1. Introduction Chapter:

The introduction opens with an overview of the subject and then identifies a background regarding the Jordanian construction sector. Exploring the research justification then takes a place in the first chapter, followed by research questions, aim and objectives. After which, the research methodology, scope of study, expected contribution, and sample are clarified. Finally, methods for the fulfillment of the research objectives are assigned through a table.

2. Literature Review Chapter:

In this chapter, two pillars have been critically discussed. The first pillar explains the significance of lean culture and practices, and clarifies lean production, lean construction, the difficulties and benefits of implementing lean, and the occurrence of types of waste. The second pillar depicts supply chain management, logistics, factors affecting logistics in construction, and also highlights the distinction between lean logistics and conventional logistics, along with considering successful lean logistics case studies. The researcher gained further knowledge and understanding of the topic through the significant theoretical background provided in this chapter. Moreover, chapter two considerably aided the development of questions in the data collection chapters.

3. Methodology Chapter:

This chapter contains the entire procedures regarding methods used to answer research questions and meet the research objectives. The methodology is based on the onion model. Here all philosophies, approaches, strategies, choices, the time horizon, and data collection and analysis procedures are all significantly justified. As the research launches depending upon secondary data gained through critical literature review, the chapter then explains in detail the data collection and analysis processes which were then advanced by utilizing primary data collection through two phases (semi-structured interviews and questionnaire). The reliability and validity methods used are also considered.

4. Initial Data Collection Chapter:

The research uses mixed methods to collect data in two phases. Chapter four contains the first phase where qualitative data was exploited by holding semi-structured interviews, in which nine experts from different positions and various type of organizations participated. The interviews focused on exploration of the current status of Jordanian construction logistics, as well as related challenges currently being faced. The chapter then discussed the drivers and barriers related to the implementation of new practices such as lean. The outcome of chapter four not only increases the importance of the research scope, but also gains further justification for the research. Added to which, the outcome of this chapter was used in the second data collection phase (questionnaire), in a wider sample to descriptively and statistically test construction stakeholders including contractor, engineer (architect/designer) and supplier.

5. Second Data Collection Chapter (Analysis and Discussion):

Chapter five discusses the outcome of the quantitative data (questionnaire), which originated throughout literature review and interviews. Seventh themes are thoroughly illustrated; the first theme provides a background for the respondents. The second theme analysed the current situation of construction logistics in Jordan. The third theme clarifies the challenges affecting construction logistics in Jordan. The fourth and the fifth themes explain the use of lean construction planning and practices in Jordanian construction. The sixth and seventh themes respectively consider drivers and barriers to the implementation of lean in Jordanian construction logistics. In this chapter, stakeholders' viewpoints are presented. Each stakeholder was affected differently by the themes, which included challenges affecting logistics, lean planning tools, and lean practices. Subsequently, the chapter mainly investigates the challenges of Jordanian construction logistics; and then explores significant supporting evidence for the application of lean practices and lean tools in considerably mitigating the disadvantageous influence of the challenges.

6. Validation Chapter:

As the research aims to develop models for assessing the adoption of lean logistics in Jordanian construction organizations, chapter six gained the research significant validation regarding the collected and analyzed data. The research objectives demand definition and assessment of the challenges of construction logistics in Jordan, and also assessment of the level of use and awareness of lean planning and practices. Subsequently, the chapter vindicates the research results concerning challenges in Jordanian construction logistics and lean planning tools. Furthermore, lean practices also have been assessed and validated by using ISM (Interpretive Structural Modelling) through a focus group interview. The methodology of ISM including SSIM, reachability matrix, reachability matrix with dependent and independent power, iterations to classify levels and launching the model and MICMAC (Cross-Impact Matrix Multiplication Applied to Classification) have been thoroughly clarified to build the final three models as an answer to the research gap.

7. Conclusion Chapter:

As the name suggests, the conclusion chapter is the last chapter of this research study. It concludes and summarises the overall points beginning with the research overview, moving on to the research objectives revised section, which includes a comprehensive explanation with regards to each objective and the method used in the accomplishment of that objective. Next, the research contribution has been highlighted and fully reviewed. Finally, research limitation and recommendations for further research are mentioned. This research can be considered unprecedented and provides a sound basis for continued exploration of this subject through various aspects in the Jordanian construction industry.

Consequently, Figure 1.2 below shows the sequence of the research chapters from introduction to conclusion and presents the main points of each chapter.

1.11 Introduction Outcome

The introduction chapter forms the research core and delineates the outline of this subject. The chapter comprises an overview of the topic and information about Jordan in terms of geography, economy, and the construction industry. Additionally, the construction industry problems are defined and the research justified. Research questions, the research aim and objectives, the scope of the research, the expected research contribution, the research sample, methods implemented, and the research structure, are all facets of the subject contained within this chapter. Figure 1.3 offers a comprehensive vision regarding the research plan from the first point to the last point.

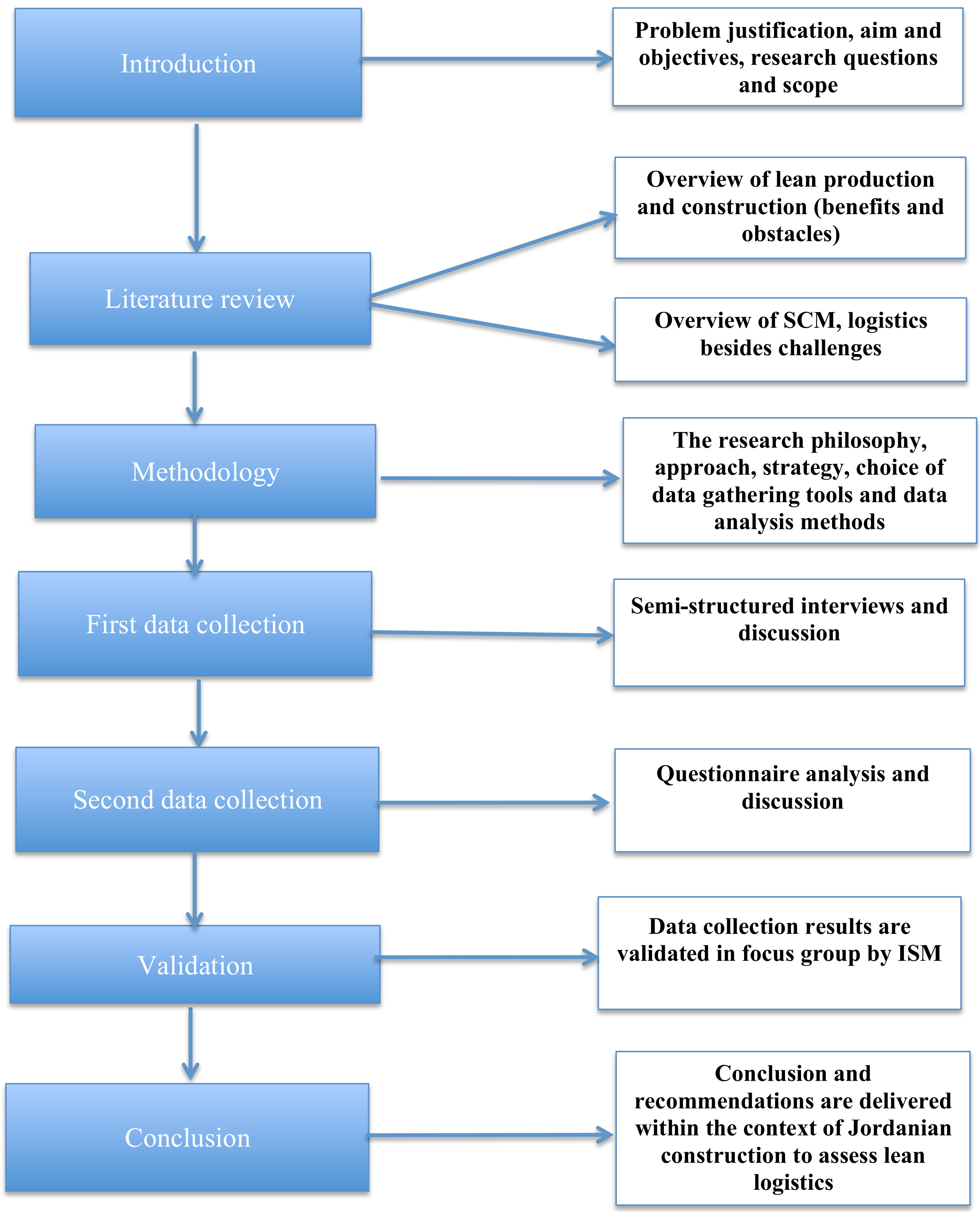

Figure 1.2: Research steps with corresponding chapters

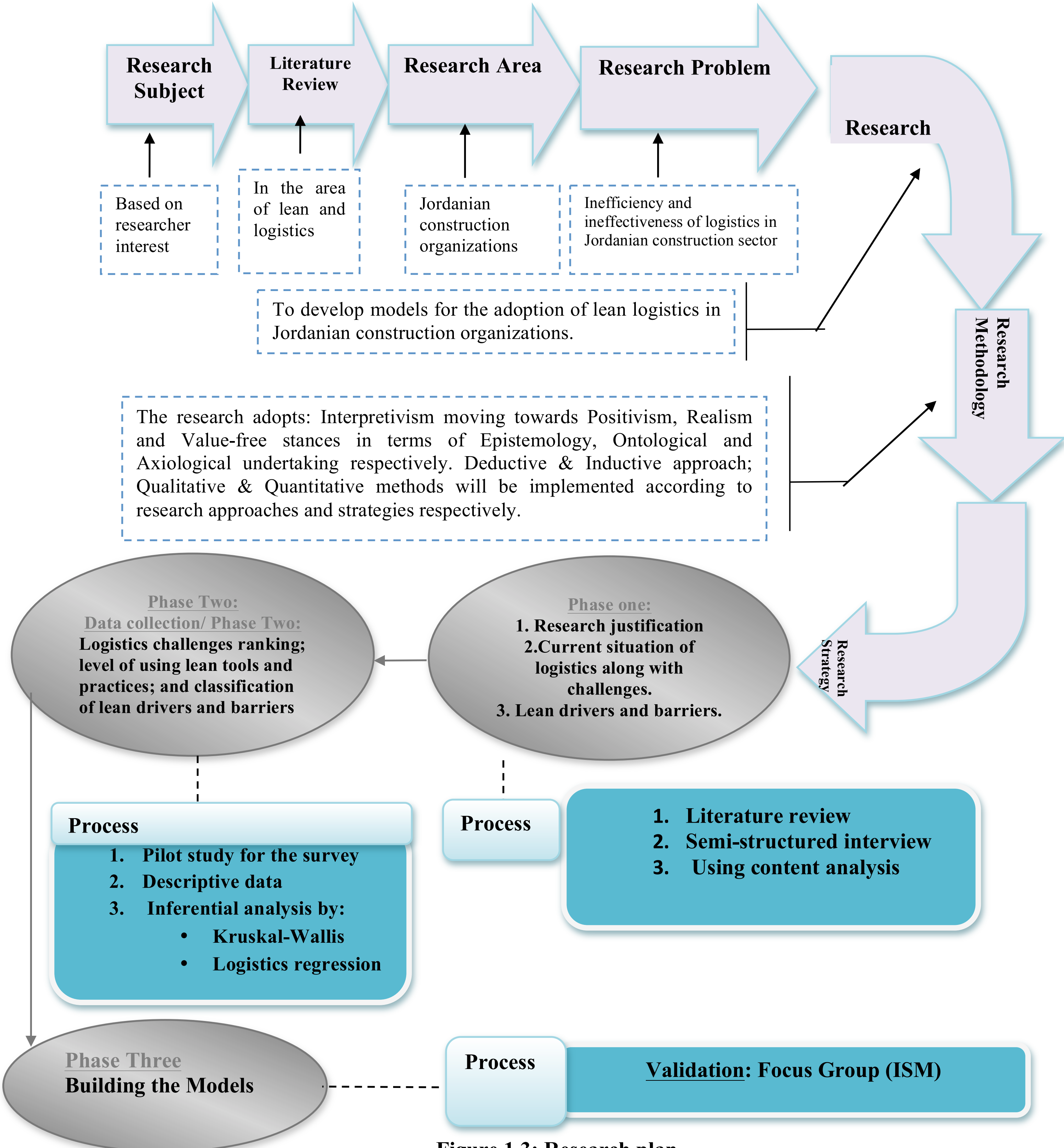

Figure 1.3: Research plan

Chapter two: Literature Review

2.1 Introduction

This chapter highlights the theoretical background regarding the research subject, as the aim of the research is to develop models for assessing the adoption of lean logistics in Jordanian construction organizations. Simplify the topic into two pillars was essential. Thus, the Literature Review chapter commenced in underlining these two pillars: the first critically reviewed lean production and construction; and the second comprehensively discussed supply chain and logistics. Next, lean logistics occupies a valuable place in the Literature Review chapter. Consequently, the critical knowledge derived from this chapter significantly assisted in building the data collection phases (the semi-structured interviews and the questionnaire).

The literature review commenced with the solution part, which is lean part before explaining the dilemma part, which is the construction logistics. The reason for that because lean has rooted terminologies; concepts; and approaches overlapped with supply chain management and logistics process and need to be comprehended prior introducing the logistics part. Understanding the lean part permitted the research to simply demonstrate the problem of construction logistics and subsequently leaded to provide a full picture of lean logistics at the end.

2.2 Overview of Lean

The application of lean thinking in the construction sector is one of the vital approaches for overcoming the challenges that face the construction industry. Nowadays, lean provides a holistic technique covering construction activities from conception to completion. Furthermore, lean technique has not been limited exclusively to single company members' work, but has been a mechanism of connection between different stakeholders and supply chains. Lean practices are spreading internationally throughout first-world countries; and some third-world countries have even established lean systems to cope with universal development, which indicates the significance of lean construction approaches.

2.2 Production and Lean Thinking

Lean thinking originated via the production sector, which critically highlights the relationship between the originality of lean thinking and production, particularly in Toyota.

The investment in development and research in the production sector is greater than in the construction sector, which means that the manufacturing industry is a significant driver for practical innovation in the construction industry (Forbes and Ahmad, 2009). Therefore, this development has made manufacturing approaches more effective and advanced in comparison to construction (Manley, 2008). Development and invention in manufacturing have been verified practically and effectively via the associated knowledge streams and the integration of project stakeholders with the customer throughout the period of the project.

2.2.1 An Overview of Production

The production sector plays a significant role in extending the benefits of lean throughout a variety of sectors, the construction industry is one of them.

According to Lanigan (1992), modern manufacturing is defined as "the application of technology to wealth creation by providing cost-effective solutions to human needs and problems". Throughout the twentieth century many experiments have been conducted concentrated on adopting and developing new production techniques. The American manufacturing revolution has led the world to the standardization approach (Boyer et al., 1997). Ford had a huge reputation globally at the beginning of the last century but many variations have occurred since that time. For example, the Fordism method of the assembly line has been applied to raise standardization efficiently (Lanigan, 1992).

Ford aligned assembly stages and steps as processes within the entire process sequence using custom-built machines for this purpose, which considerably supported the assembly of automobiles in a short period of time. Furthermore, the Taylorism approach treated labourers as machines that needed to perform the small share of tasks allocated to them (ibid).

American organizations focused on offering labourers suitable salaries to buy what they manufactured throughout the economic growth of that time. So, the American way of production did well in order to achieve mass production with huge consumption (Santos et al., 2006). On the other hand, these production companies failed to pay attention to the main customer needs and also to supply and demand (push system). Furthermore, Wilson (2009) noted that quality was not the priority of conventional production procedures. The philosophy of traditional production did not concentrate on the transforming perception of production and did not pay attention to value and flow. Accordingly, the new production philosophy focused on finding solutions for the problems of the traditional approaches. Moreover, high cost, waste, and customer satisfaction took priority. Lanigan (1992), Koskela (1993), and Grieves (2005) summarized three focal types which are identified in the modern production system: transformation, flow, and value concepts (TFV). These concepts are working as one concept in manufacturing at this time. The modern concepts of production are explained in some detail below (ibid):

1. Transformation Concept

This aims to transform the inputs to outputs by dividing up the process into smaller, more controllable activities. Moreover, the activities will also be further divided into sub-manageable activities. The main benefit of this concept is to increase independence because small duties will be managed more easily and efficiently which as a result will reduce time, cost, and waste. On the other hand, in some cases, this concept has a negative consequence on the effectiveness of production because some tasks are too complicated to split, or are not deemed as transformation activities.

2. Flow Concept

This concept outlines the foundation of lean production practices and the Just-in-Time (JIT) method. Furthermore, it takes into consideration those phases overlooked by the transformation concept which are considered non-transformation tasks. For instance, in terms of transportation and inspection, time is considered a significant input of the production procedures within the transformation and non-transformation phases. The mechanism of the concept is to reduce the overall time and improve the delivery of the production within the limited time.

3. Value Concept

   This concept concentrates on producing value for the consumers by combining their needs and requirements in the production procedures. Therefore, the value concept seeks to accomplish customer satisfaction.

2.2.2 The New Production Philosophy

New production philosophy has offered a new way of thinking. Through a different managerial philosophy, each aspect of the workplace can be improved.

According to Koufteros et al. (1998), conventional production concentrated fully on the processing methods, converting inputs to outputs, and not depending on the new technologies to enhance the processes. Moreover, standardization was a significant factor in the old system but it did not robustly consider the quality and the variety of the final product. The quality was identified in the classical production theory by inspection at the final stage, which was carried out for each completed product. Moreover, as an example, any product that had not matched the specification was remanufactured or scrapped, which drove up massive waste levels and extra cost.

However, the modern production philosophy has handled these shortages by implementing value and flow in each process as an encapsulated concept (Samson and Terziovski, 1999). The new production system managed to define the gaps in the production processes by splitting the activities into ‘value adding’ and ‘non-value adding’, which led to minimizing waste and enhancing productivity (ibid). Modern production has also produced many types of product; thus, the variety of products will meet customers’ needs and consequently achieve customer satisfaction (Womack, 2003). Furthermore, using an anticipation principle to measure quality is the mechanism of the new production system which assists in finding defects before they occur.

The innovations and techniques of the new production philosophy were founded in 1930 by the Japanese. The approaches have been used since the second war (Jones and Womack, 2007). Moreover, production in Japan commenced with sequential evolutionary steps, beginning with steady production along with veracity in production, and then moved gradually into higher production levels than the Western countries. Japanese culture played a significant role in this revolution. According to Womack et al. (2007), Toyota and Ohno are the originators of the techniques and philosophies of modern production, such as lean manufacturing and JIT (Just-in-Time). Ohno and Toyoda’s philosophies have spread to other scholarships and have enthused many researchers and academics, leading to the establishment of new concepts such as Total Quality Management (TQM) and Statistical Quality Control (SQC).

2.2.3 The Principles of the New Production Philosophy

The main principle of the new production philosophy is minimizing non-value added activities. This is the central difference between the new production philosophy and the conventional philosophy. Furthermore, Lanigan (1992) and Santos et al. (2006) summarized the new production philosophy as shown below:

- Incorporate the requirement of the customer in the input of the production procedure to add value to its output.
- Work as much as possible to diminish the variability in individual activities during the production process.
- Reduce the life cycle of the product to provide faster times to customers in order to avoid disruptive events in the process which could occur because of changing orders. Consequently, this enables better control of the forecast analysis for future products.
- Divide complex processes into simpler sub-processes and tasks. This can be done via three points: reducing the changeovers, and minimizing both the components produced and steps achieved with every task. As a result, this will enhance reliability, assist workers' training and reduce total outlay.
- Increase the transparency of the whole production processes among the workers by improving the visibility of errors in the processes. In this way flow and better control will be improved.
-Sustain the dynamic and continue improvements in the process, especially by operating repeated tasks.
- Use benchmarks against other processes inside and outside the company; this is a significant factor to enable continuous improvement during reconfiguration of the process.

2.2.4 Lean Thinking

The entrance of lean thinking is considered the starting point for changing conventional thinking toward lean.

According to Womack et al. (2007) the spirit of the new production theory transfigured the foundation of lean thinking, where this concept was coined in Japan and is established on numerous fundamentals derived from the Toyota Production System (TPS). Lean production was originated by Womack in 1990; he mentioned the new practice in *The Machine That Changed the World* (ibid).

The conceptualization of lean production has enhanced the manufacturing process by reducing the overall resources, such as materials, time, space, and labour. Supply chain is one of the significant factors that has been improved remarkably in the manufacturing process, in that production now occurs upon the customer's demand. The new pull system used in production, instead of the push system, is also crucial in production control and the level of inventory. "Muda" means waste in the Japanese language; Womack et al. (2007) identified this waste as non-value-added activities. For example, waste includes errors that need adjustment; uninteresting products which have low demand; superfluous steps; unnecessary effort and movement of labours; retransfer of products; and long waiting times.

2.2.5 Toyota Production System (TPS)

Toyota House and its "lean components" philosophy is represented by the Toyota Production System (TPS), as shown in Figure 2.1. According to Liker (2003), Toyota evolved the lean model in order to reduce waste and deliver higher quality within the shortest time and at the lowest cost. The Toyota Production System is established on two columns: the first one is JIT which represents the lean approaches and techniques; the other column is the Jidoka, which describes the machine with its own self-monitoring device. When an error occurs, the device is responsible for stopping the machine and that helps workers to achieve more value-generating work instead of observing the machine. The continuous improvement sustains the stability of the system significantly by implementing Heijunka (levelling of production), Kaizan (sustaining continuous improvement), and standardization of work (LEI, 2009).

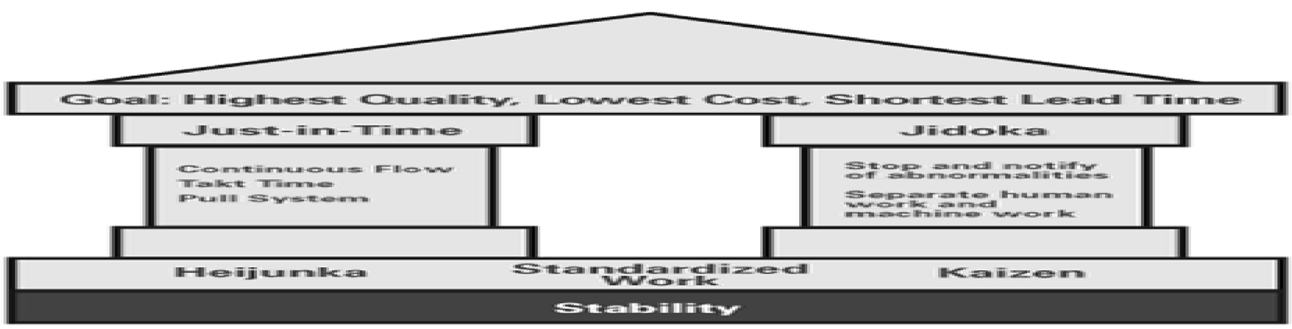

Figure 2.1: "Toyota House" (LEI, 2009)

Nowadays, lean perception, realization, and philosophies are playing significant parts in the top management of all sectors – not only in the manufacturing sector – as a consequence of its global success (Jones and Womack, 2007).

2.2.6 Lean Principles

Lean principles require a deep understanding of the philosophy of lean in order to be implemented in an appropriate way. Implementation requires controlled procedures working in continual, planned, and well-ordered settings which encapsulate all workers, customers, and the top management within one system (Shah and Ward, 2003). The principles have been clarified by Womack et al. (2007), as shown below (Figure 2.2):

1. Use the view of the customer to identify the value.
2. Specify the value stream for every product type, as well as reducing non-value-added procedures.
3. Make value-creating stages take place constantly and flexibly in the production flow from input to output.
4. Build a pull system, and use it between all production flow stages towards the end user.
5. Seek perfection by applying the above steps systematically, thoroughly, and constantly until a state where ideal values are produced with no waste and as a result the implementation of lean principles will be successful.

Figure 2.2: Principles of lean (LEI, 2009)

2.2.7 Techniques of Lean Manufacturing

Manufacturing techniques use the operational tools to accomplish lean thinking goals. However, these techniques have recently been utilized by a variety of industries, mainly the construction industry.

According to Moore (2007), one of the greatest features of lean techniques is the ability for them to be implemented concurrently. Traditionally, these methods have been taken from the production sector particularly, and later on have spread over to other sectors such as the construction industry. Companies generally use these methods in order to reach their own needs, circumstances, and requirements. The most familiar techniques of lean are discussed below (McLachlin, 1997; Choi and Eboch, 1998; Cua et al., 2001; Peter et al., 2004).

1. Just-in-Time (JIT)

When there is no order the inventory needs to be zero, so JIT aims to provide an inventory when demanded. It helps to reduce operation time, lot patches, queues, and production expansion. As a result, this will increase the repetitive procedures and gradually provide revisions, eradicate waste, and reduce the overall cost.

In the Japanese language, Kanban means "the sign card" and it is considered the essential tool of Just-in-Time (JIT). It is a signalling technique used in the pulled system to provide good management and monitoring for the materials flow. Moreover, the Kanban depends on the production plan where material will be produced when the signal is received by the downstream team. The customer is the most significant part of these processes, where Kanban is produced upon his order quantity and production plan. In addition, it assists the exposure of the processes that generate faulty products and avoids shortages of materials and equipment.

2. 5S

5S is a practice comprising five aspects: sort, order, shine, standardize, and sustain in order to generate a well-organized, clean besides disciplined work environment (Chapman, 2005). This assists with improving productivity and minimizing waste by implementing a systematic environment and visual management practices to gain consistent outcomes. 5S is a practice used mainly in site operation, in construction industry a contractor seems to have an ability to use this practice as it is 5S concern to maximize value and minimize waste. Sowards (2004) noted that the contractor is using 5S more regularly when compared with 1998. The level of implementing lean practices, and particularly 5S, are increasing dramatically through time.

3. Kaizen

This concerns how to apply supplemental amendments continually and frequently over time in order to make considerable developments. It is intended to work collaboratively in the organization by bringing together employees from different levels and various roles to deal with problems and recover processes.

4. Hiejunka

This refers to a balanced production schedule and capacity for both type and quantity of products. This helps to decrease changeover delays between processes, thus maintaining a continuous flow, having more control over inventory levels, and eliminating waste.

5. Five Whys

This is a technique for identifying the root causes of a problem by constantly asking the question "why?". "The basis of Toyota's scientific approach is to ask *why* five times whenever they find a problem. Furthermore, by repeating *why* five times, the nature of the problem and its resolution becomes clear" (Ohno, 1989).

6. A3 Report (Daily Report)

This was developed originally in Toyota. The name has been derived from the A3 size, the largest size that can fit through a fax machine. It is a problem solving tools typically have the scientific hypotheses as one common attribute. It appears in three types: Firstly, the problem-solving A3 report; secondly, the proposal A3 report; and thirdly, the status A3 report (Bassuk and Washington, 2013). Furthermore, due to his position on the construction site, the contractor's concern seems to be about further details in onsite planning, aiming to report all daily productivity in terms of proving his claim (Kumaraswamy and Yogeswaram, 2003). So, the contractor has his own method of performing the work on the construction site, as unforeseen events may occur and demand that vital changes to ordering priorities are made according to any such unexpected changes, and without any adverse effect in master planning (Bertelsen, 2004).

7. Integrated Project Delivery

Kent and Gerber (2010) noted "Integrated Project Delivery (IPD) seeks to improve project outcomes through a collaborative approach of aligning the incentives and goals of the project team through shared risk and reward, early involvement of all parties, and a multi-party agreement."

8. Relational Contracting-Partnering

Relational Contracting is identified as a contracting mechanism or transaction that aims to search for clear recognition of the relationships in commercial business among stakeholders (Colledge, 2005). Essentially, benefits and responsibilities are apportioned reasonably, fairly, and transparently. Furthermore, it includes a method for reliable delivery that focuses on trust and partnership, which helps to improve working relationships among all construction parties and so increase effectiveness and efficiency in all processes as well as enhancing the financial return.

9. Gemba

According to Womack (2011), Gemba (Japanese word) means "the real place", where a person needs to go by himself and see with his eyes, and ask about a concern, looking for solution opportunities as well as showing a high level of respect for others. Furthermore, a person who practises Gemba needs to observe the actual work being done to create value and achieve some organisational purpose, focus on a particular process (value stream), and start at one end and walk to the other, as well as engage people involved in the process. Russ (2006) noted that the engineering company is the major party caring for customer satisfaction, particularly in the traditional method. So, the consultant (engineer office) would apply “Go to Gemba” by regularly going to the construction site, leaving his office to see the actions through their eyes.

10. Accountability

    A daily accountability process is a significant element of the lean management system. It provides the steering wheel, directing which improvement will be worked on. The accountability meeting leader makes task assignments first to understand the cause of the problem captured on a visual control, and then to eliminate waste (Mann, 2009).

2.2.8 Waste in Lean Production

Waste is the most important aspect to be considered. Proper definition and understanding of 'waste' could deliver extremely beneficial development.

According to Conner (2006) and Matyusz (2011), lean production concentrates on eliminating waste, since the performance in the production progressions depends on the level of waste processed. The model of waste is extended by many concepts and is not exclusive only to the physical concept. It comprises any type of activities that utilize resources and cause non-value adding. Womack categorized the waste in lean production:

1. Time lateness,
2. Redundant movement and excessive transportation,
3. Excess inventories and overproduction,
4. Extra processing, and
5. Making unpopular products which do not meet the customers’ needs.

The reduction of the points above assists in value adding throughout the whole production processes, especially by involving the entire supply chain in the progression up to delivery.

2.3 Outline of Lean Construction

Regardless of the differences between production and construction, the significance of lean thinking in the production sector provided an admirable reputation and encouraged other industries, such as construction, to apply lean thinking and lean techniques in order to acquire the same benefits.

Koskela (1992) has presented the methods of lean production to the construction sector. He underlined the importance of the production processes flow as a significant support to productivity in construction and the elimination of waste. Koskela clarified that production in the construction sector needs to be perceived as a flow, where value will be generated all the way through the whole processes and especially in the sub-tasks and sub-processes. Moreover, this new practice needs to be addressed according to time, cost, and value, which are not measured by the conventional construction practices and methods.

2.3.1 Lean Construction Theoretical Background

The transfer of new thinking and philosophy from the production industry to the construction industry offers unique theories and approaches, enriching the construction industry workplace through new managerial practices.

According to Howell (1999), lean construction is considered as a philosophy based on the theories of lean manufacturing to improve construction processes in order to achieve the requirements of the client (customer) in a profitable and successful way. By utilizing the principles of lean manufacturing in construction, most of the classical challenges will be overcome. In addition, through emphasizing two main factors of production value adding and non-value adding, the entire productivity will be increased as well as the waste being diminished. The main focus is not only on the material waste, as in the conventional construction practice, but extends to time, workforces, machineries, and equipment. Substantially, it includes all consuming-resources activities along with the activities that interrupt the processes. However, Howell (1999) noted that many researchers, academics, and engineers believe that many practices of lean production in the manufacturing sector are not suitable to be used in construction due to the different environment. Construction projects are unique, complex, and include high levels of uncertainty, as well as most of the projects being unrepeatable. On the other hand, the waste in both areas arises from the same perspective: while lean production encourages the production of zero waste, lean construction initiatives seek to minimize the high level of waste (Salem et al., 2005).

2.3.2 Flow-Based Concepts for the Construction Process

Koskela (1992) has proposed a flow model to be applied in the construction processes. The model includes information and materials over four levels, as shown in Figure 2.3. The levels are:

- moving: in reference to transportation;
- delay: in reference to waiting time;
- conversion: in reference to processing; and
- inspection: in reference to the approval procedures carried out by a consultant.

The main point of the Koskela model is showing the construction process as a production flow as well as designating the non-value added (waiting, moving and inspection) and, on the other hand, the value-added, which is the processing activities. By minimising non-value added, the construction progression will be improved consistently (Koskela, 1993).

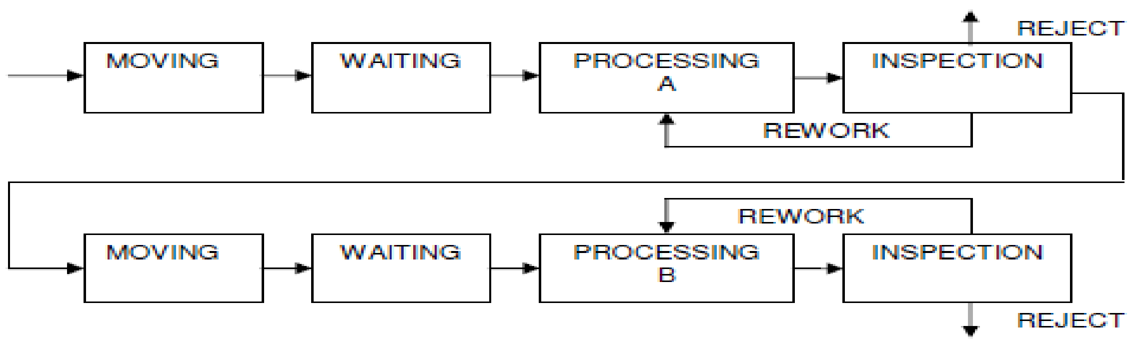

Figure 2.3: Koskela's flow-based model for the construction process (Koskela, 1992)

Thereafter, Serpell et al. (1995) proposed a systematic flow model for construction processes which is associated with the surrounding work environment. The work environment contains two categories of tasks and activities: controllable and uncontrollable. The details of these tasks and activities are shown below:

1. Flows: directed by the supervision and management (controllable), where the decisions that described the performance level will be made.
2. Conversion flows: are the processing of the resources and information (input) to the final product (output) and is divided into:

a) Internal flows: which are generally controllable: for instance, staff activities.

b) External flows: which are usually uncontrollable, are mainly for design plans, suppliers and materials delivery.

3. Conversion activities: which are the transformations from conversion flows into the completed product. The scale of productivity and the level of performance are governed by the management decisions and conversion flows.
4. Finished product: which is considered as the final result of the conversions activities.

Therefore, Serpell et al. (1995) showed that a low amount of waste and high productivity will be achieved by enhancing the controlled activities throughout the conversion flows and activities, as well as the decisions and actions of management. However, the uncontrollable flows also need to be addressed in an appropriate and anticipatory manner in order to improve the entire supply chain and consequently complete the project efficiently.

2.3.3 Methods of Lean Construction

Lean construction methods play a significant role in improving the construction industry. Below, Table 2.1 illustrates the main and popular methods of lean utilized in the construction industry.

Table 2.1: Shows lean construction methods with definitions

Lean Construction methods	Definition
Daily Group Meetings	According to Ballard (2000a), providing meetings between management and workers will simplify the communication between them and ease the discussion of project barriers and progress, as well as boosting the involvement of employees in the project.
First Run Studies	According to Forbes and Ahmad (2009), first run studies focus on non-value added by carrying out the PDCA (four-steps cycle). Moreover, by implementing this method via the management, engineers, foremen and supervisors, along with reasonable visual wherewithal, the non-value added will be reviewed and specified. Additionally, Rother (2009) added and explained these points as below: - Plan: hypothesis or prediction by defining what you expect to do and what will happen. - Do: test these hypotheses, run the process according to the plan. It is usually prepared on a minor scale initially. - Check (study): this is the comparison between the actual outcomes against the expected outcome. - Act (what next): stabilize and standardize what works or initiate the PDCA cycle again.
Kanban Cards	This is the same Kanban cards technique as in manufacturing and has the same use in the construction sector. Salem et al. (2006)

	added that using Kanban cards will assist the team to avoid distrust in the flow of the on-site process.
Concurrent Engineering	This technique is applied by multi-disciplinary members of employees the purpose of which is to incorporate design and all processes in order to enhance quality to meet customer requirements (Forbes and Ahmad, 2009). So, concurrent engineering requires all parties to coordinate together throughout the processes (Ngowi, 2000).
Visualization	According to Forbesand Ahmad (2009), increasing the visualization technique is used to develop transparency between employees. It includes and covers many areas, such as quality, safety, and timetable (a customized sign for safety and milestone of the project), which will help workers to simply understand anything that is presented.
Failsafe For Quality	According to Ballard (2000a), this method focuses on safety and quality matters and the improvement of these factors in continuous and constant routine through the whole lifecycle of the construction.

However, at this point, it is essential to state that mentioned production techniques could also be employed with significant effect in construction industry.

2.3.4 Implementation Approaches of Lean Construction

2.3.4.1 Lean Project Delivery System (LPDS)

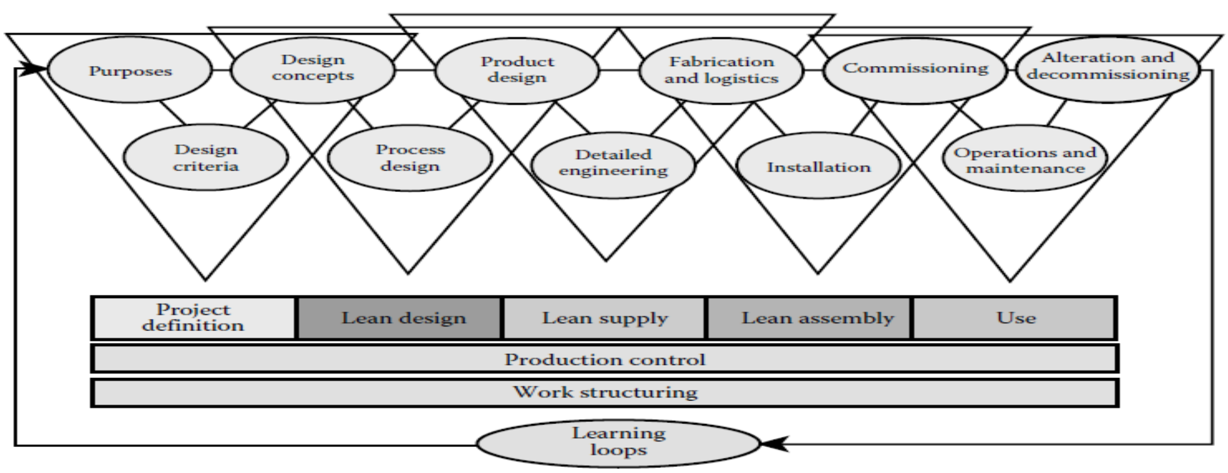

Figure 2.4: Work structuring in the Lean Project Delivery System (Ballard and Howell, 2003)

This is the first approach to implement lean construction. Ballard (2000b) noted that LPDS provides the wherewithal of addressing the faults and lack of the conventional construction system and enhancing the design and the construction process. Furthermore, in order to achieve Koskela's concept of lean construction, which is maximizing value and minimizing waste and focusing on consumer-oriented product delivery, this approach concentrates on the separation among designers and constructs throughout, considering them as a continuum for the management of the construction project.

According to Ballard (2008), there are five stages in LPDS which are similar to the classical construction stages; the difference between them is that LPDS applies the manufacturing-system methods to enhance the delivery of the project from pre-design to the accomplishment stage. As illustrated in Figure 2.4, these stages in the model are: lean design, lean supply, lean assembly, and completion (use). Furthermore, the model is represented as a sequence of overlapping triangles, where each level impacts the other, and shows that discussion and conversation is essential among stakeholders. In addition, Ballard and Howell (2003) noted that production is supported by work structuring, which provides the base for the overall construction process. Work structuring divides work into parts of different shapes to allow variation in production and to motivate flow. As a result, the LPDS model re-identified the construction process from its classical reactive to be a continuous and proactive type.

2.3.4.2 Last Planner System (LPS)

LPS is considered the most popular and well-known approach within the construction industry. The Last Planner System (LPS) was invented by Ballard in 2000.

The system was made to gain the highest productivity of labour resources and materials; it is a control system that addresses the inconsistency of projects and facilitates workflow (Ballard, 2000a). LPS can work separately or as an entire system under the LPDS. Ballard and Reiser (2004) showed that fewer than fifty percent of the tasks in the conventional construction projects are achieved according to plan. Project managers in the classical approach usually apply the push system, allocating work plans beyond the ability of the labourers and using corrective actions based on a time baseline and cost deviations. Production activities are influenced by the construction-flow variability, where established time frames in the work plan do not take into account the capability of achieving those activities. Ballard (2000a) noted that the LPS system utilizes the methods of lean construction to match labourers' capabilities and materials according to the planning scheme to complete tasks in response to downstream demand. Essentially, LPS authorizes the employees to work as the last planner, which means it decentralizes the decision making. Therefore, LPS provides a pull-driven planning-and-control system which will lead to improved flow reliability. The methods can be applied separately or combined depending on the necessity of using these methods for each project. Furthermore, the Last Planner System tool is a system for collaboratively managing a relationships network along with changes required for programme coordination, production, planning, and project delivery. LPS has five major components, as follows (Ballard and Howell, 2003; Mossman, 2009):

1. *Master plan*: This provides a collaborative creation to follow the production sequence. The aim is to bring all major parties into the early stage of the process. Therefore, critical independencies can be disputed, suppositions can be tested, and the most appropriate practice will be agreed on. The main goal of the master plan is to develop and display execution strategies to show the feasibility of achieving the project within the required time. The most important part of the master plan is the critical path analysis which needs to be considered as a high concern (ibid).
2. *Phase planning:* This is about breaking down the master plan into various phases, aiming to develop more detailed work plans and provide goals that can be considered targets for the project team. Furthermore, phase planning seeks to present specific targets in each phase and then work backwards to accomplish them. The reason for doing this is because a construction project moves through various phases. The significance of phase planning lies in producing the most excellent potential plan through engaging all stakeholders (contractors, subcontractors, clients, consultants, suppliers, etc.) and representatives of all the supply chain organisations who work in the same phase, and developing more detailed information about that phase for each of the parties involved in it (ibid).
3. *Weekly work planning:* This is the collaborative agreement between parties regarding production tasks for the next day or week through weekly meeting. It aims to plan a work schedule which will be carried out during the next period, keeping in mind the work that is currently under process as well as gathering all the information and knowledge needed for the work that will be done. This assists in exploring any interdependencies among

resources, access, and equipment, which consequently keeps the project plan reliable according to time limits and based on the capability and the possibility of doing the planned work (ibid).

4. *Look ahead planning:* According to Henrich and Koskela (2005), look ahead planning is about making goals ready when the right time comes. It is normally used in the construction industry to focus the management's attention on what is assumed will happen at an exact time in the future. Furthermore, it encourages people to take action in the present towards accomplishing the desired future goal. Look ahead planning is used to reduce the uncertainty over abstract constraints regarding the fulfilment of the project's targets in the look ahead period. This period is variable from 4 to 8 weeks to ensure that all targets are set for production when required. Consequently, waste relating to equipment, material and time will be decreased rapidly, material delivery will be improved, and the chance of material damage will be diminished.
5. *Percent Plan Complete (PPC) and analysis of reasoning for incomplete assignments:* PPC is used to improve project planning and production; it is applied to measure productivity. On the other hand, look ahead planning helps to enhance PPC as well as avoiding time and cost overrun (Ballard, 1997). PPC is a measure of the proportion of promises that are achieved on time. Firstly, the percentage of planned completion needs to be computed by the number of activities that are completed as planned, divided by the total number of planned activities, and presented as a percentage. Secondly, all reasons for incomplete assignments involving all stakeholders are identified. Thirdly, tracing reasons that are related to root causes mean they can be eliminated and repetitions prevented. In addition, PPC will be improved through applying the technique of tracking the reasons. This aids in identifying the reasons why tasks were uncompleted or late delivery occurred, which assists in avoiding these problems in the future (Ballard and Howell, 2003).

Subsequently and according to Myer et al. (2015), there is an urgent need for constructing a new and advanced planning method through an organized collaboration to reach to an agreement between all parties in construction on procurement plans derived after the master plan. So, this research reviews the current usage of these planning tools besides exploring missing tools in

Jordanian construction logistics to deliver a comprehensive explanation regarding the requirements needed to develop planning status.

Consequently, Table 2.2 shows lean approaches in construction industry as follow:

Table 2.2: Illustrates lean construction approaches and characteristics

Lean construction approaches	Characteristics
Lean Project Delivery System (LPDS)	Project definition; lean design; lean supply; lean assembly and use.
	Production control
	Work structuring
	Learning loops
Last planner system (LPS)	Master plan (MP)
	Phase planning
	Weekly work planning
	Look ahead planning
	Percent Plan Complete (PPC)

2.3.5 The Waste of Materials and Advantages of Implementing Lean

The definition of 'waste' within the construction industry is an important matter and requires further attention by staff. Thus, the implementation of lean practices can significantly assist in mitigating the effect of waste.

According to Formoso et al. (2002), material waste (physical) is one of the significant points in the construction industry; this is contrary to the manufacturing sector, where waste is usually well managed. The reason for this is that in the construction industry the levels of waste generated are higher than in the planning scheme. Furthermore, the lack of transparency of performance in construction companies has occurred constantly, which affects estimation of the actual amount of material waste produced. Additionally, many research studies have been conducted and have discovered that imperfect flow generates high levels of material waste, such as in transportation and handling (ibid).

As mentioned above, lean construction methods prioritize minimising non-value adding activities which consume time, material and labourers without any obvious productivity. In addition, physical waste raises the amount of non-value added activities. There were some attempts in the conventional construction field to minimize physical waste (material) by prefabrication of material and mortar, but these attempts were not enough to fulfil the desired result (Ballard and Reiser, 2004). The reason for that is because material waste is essential in the flow process and is not connected directly to the adopted technologies for its mitigation; it is related to a combination of aspects encompassing lack of efficiencies in the planning and management system as well as insufficient training of labourers. Hence, lean construction methods are providing a unique strategy to address these aspects by improving material procurement; combining design and construction stages; and offering sufficient delivery and employment (ibid).

Ciarniene and Vienazindiene (2012) noted that the main advantages of implementing lean practices are as follows: Firstly, productivity is increased because of the focused improvements made to processes with the intent of eliminating waste. Secondly, customer satisfaction is increased by reducing waste; the final product is delivered to the customer with value. Thirdly, implementing lean practices usually produces a significant change in an organisation's attitude, which can be very challenging if an organisation is not well suited to deal with the changes. Fourthly, as a result of process improvement initiatives, the overall quality and profit are also improved in the process as well as time being saved. Finally, another fundamental element of lean practices is Just-in-Time production, which is the idea that an excess inventory will not be maintained in order to fulfil customer orders. Subsequently, delivery time is improved (ibid).

Forza (1996) noted that lean practices implementation is actually considered in order to distinguish an LP (lean practices) organisation's reputation from other non-LP organisations. This result attests to the fact that the two groups of organisations are considered to differ from each other as far as lean practices are concerned. Therefore, implementing lean practices will highly enhance a company's reputation.

A significant finding through the housing industry sector in the US shows that lean practices do appear to have some positive effects on occupational safety and health administration (OSHA) incidence rates, which suggests that lean may be beneficial not only for process improvement and waste reduction but also for improving safety in the construction industry (Nahmens and Ikuma, 2009).

According to Nahmens and Ikuma (2011), several case studies have been done to illustrate the effects of lean on the triple bottom line of sustainability (economic, environmental, and social) in modular homebuilding. Each case study highlights one dimension of sustainability. Lean construction has resulted in a significant environmental effect through reducing material waste by 64 percent and lessened social effect by 31 percent through decreasing working hours as well as eliminating or reducing key safety hazards. Consequently, lean construction is a viable and effective strategy to improve sustainability in building.

Some features such as effective communication, transparency, feedback, reputation, training, education, and the behaviours of the management are fundamental in ensuring that lean practices are successfully implemented in service sector enterprises (Bruce, 2010).

2.3.6 The Challenges of Applying Lean Methods

Challenges may occur when applying lean methods. Construction parties need to take into consideration these challenges in order to gain the maximum benefits offered by lean practices.

Implementing lean methods and principles in the construction industry is not a simple task, particularly because it is positioned on the establishment of a link between conventional practices and the philosophy of lean (Salem et al., 2006). The approaches of lean construction cover the entire processes in construction in many areas within the activities of the workforce, its management and the benchmarks against other corporations. Therefore, the application of lean interferes in each stage in the process, where the progression of work needs to be handled as a sequence of sub-processes and tasks that form a customer and flow-oriented entire process. Furthermore, the attitude and culture changes are significant factors in lean practices, as well as giving an indication of the validity of these practices in any construction environment (Salem et al., 2005). The contemporary construction has intended to use lean practices because of lack of commitment and planning of the whole organization. Increasing awareness, reliability, learning and training of staff about lean construction methods are significant factors and should be commenced with senior managers, as a full understanding of the lean scope needs to be gained. Afterwards, learning and training of the workforce should take place and they should be involved in the entire view of the processes (decentralized management and planning of activities). Additionally, it is important to encourage the culture for environmental change as well as the enhancement needed in various actions and measures instead of depending only on the existing capabilities. Besides, this mechanism can be applied by defining and speeding up the flow processes, backing the information flows and inducing short-term achievement. Consequently, non-value adding activities will be identified and minimized and most of the problems will be revealed (ibid).

Moreover, Ciarniene and Vienazindiene (2012) mentioned some significant points relating to lean implementation risks as follows: Firstly, customer dissatisfaction problems: lean processes are so dependent on supplier efficiency that any disruption in the supply chain and therefore in production can be a problem that adversely affects customers. Delivery delays can cause long-lasting marketing problems. Secondly, productivity cost: in order to achieve such productivity, there is a significant upfront investment in achieving a level of standardised processing which can be a disadvantage during the implementation process. Thirdly, lack of acceptance by employees: lean practices require constant employee input on quality control, which some employees may feel disinclined or unqualified to do. There may also be some difficulty finding managers with sufficient leadership and persuasion skills to overcome this. Fourthly, high cost of implementation: lean practices often require completely dismantling previous physical plant setups and systems. The purchase of efficient machinery and training employees can add considerably to companies' payroll expenses (ibid).

However, lean construction has been criticized by Green and May (2003), who stated "lean construction notably ignores the extensive literature that addresses the extent to which lean methods are applicable beyond the unique Japanese institutional context". On the other hand, many researchers have opposite views; Mann (2010) noted that any culture can be developed by having all the stakeholders involved in the processes and sharing the outcome. He laid out the components of lean management and explained their way of working together and how to implement the tools in the processes. Therefore, creating courses and guidelines for leaders which guided them over the cultural minefields to lean conventions. For that reason, the aim of the research is to address the gap in literature between the two views, as well as to introduce lean techniques in a new environment and culture (Jordan), and will indicate to what extent the validity of implementing lean construction practices and lean planning tools will be usable in Jordanian construction logistics.

2.4 Supply Chain and Logistics

2.4.1 Supply Chain

Supply chain and logistics were discussed in this section (pillar two). The section began with supply chain and moved on to the logistics process, where differences between the two processes are clarified. After that, construction logistics challenges; the differences between traditional and lean logistics; case studies; the challenges of lean logistics; and lean logistics in Jordanian construction are all critically reviewed.

According to the OGC (2005), "a supply chain is the combination of all parties both inside and outside the organization, involved in delivering the inputs, outputs or outcomes that will meet a specified public sector requirement". For example, supply chain includes external suppliers; partner organizations; or internal corporate-service units. Furthermore, 'supply chain' is defined as the term used to describe the linkage of companies that turns a series of basic materials, products, or services into a finished product for the client (Constructing Excellence Supply Chain Management, 2004).

Supply chain teams include many stakeholders (OGC, 2005): clients, shareholders, financers, users, contractors, subcontractors, suppliers, project developers, advisors, architects, quantity surveyors, engineers, and government.

Nowadays, organizations are obliged to increase their global market share in order to carry on, and some of them need to support their local market against global competitors. These organizations need to expand their global supply chain and distribution networks in order to ship products to customers through sophisticated networks at the required time, along with controlling the inventories (Handfield et al., 2002).

2.4.2 Supply-Chain Management

The SCM concept appeared for first time in the literature in the mid-1980s but the original assumptions which include managing inter-organizational operations can be traced back to 1960 (Cooper et al., 1997). According to Shingo (1988), SCM was invented and developed in the manufacturing sector. The Just-in-Time (JIT) delivery system was the initial sign of SCM in the Toyota Production System. In 1950, Deming recommended that working with the same suppliers as partners in the long term would build robust relationships and could enhance the overall supply chain along with reducing cost and time (Deming, 1982). As early as the 1980s, the term supply-chain management (SCM) was developed to express the need to incorporate the key business processes, from end consumer through to original suppliers. However, the construction industry has improved in partnering and collaboration work, especially after some significant studies and researches such as Latham's report in 1994 and Eagan's report in 1998. Figure 2.5 illustrates the material flow and information flow among the entire supply chain instead of showing just the next level or part. Its intention is to increase alignment and the transparency of the supply chain configuration and coordination in spite of any boundaries (Cooper and Ellram, 1993).

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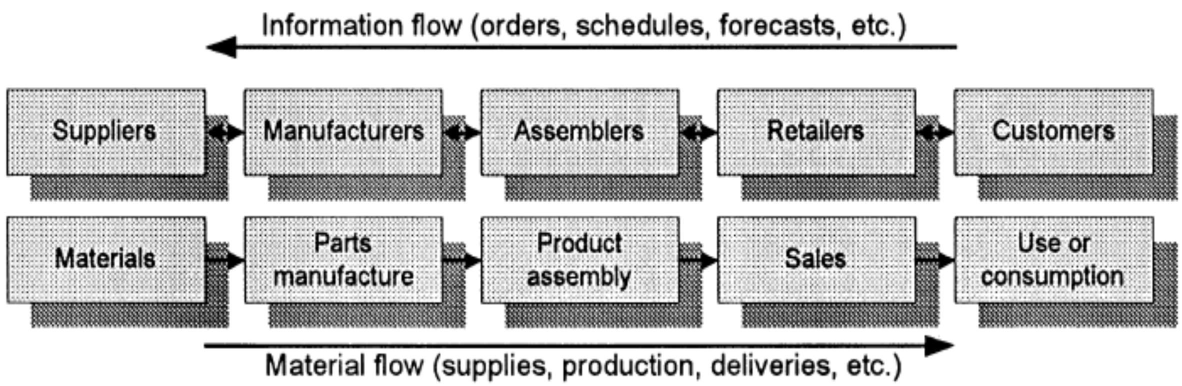


Figure 2.5: Generic configuration of supply chain in manufacturing (Cooper and Ellram, 1993).

According to O'Brien (2008), over the last few decades many of the manufacturing corporations admitted SCM as a new-fangled trend of doing business. Over time, the development of technology, internet, globalization and varieties of customer needs and qualities play significant roles in changing the manufacturing environment, where the competition is transferring from company to company and from supply chain to supply chain. SCM is a consistent management perception and offers an integrated philosophy for managing organizations' purchasing and distribution processes based on a marketing perspective (Bolumole, 2000). Moreover, the overall objective of SCM is to contribute to improvements in the company's baseline or revenues. It contains cost reduction through reducing the inventory and raises profitability through seeking to meet customer requirements. Additionally, this philosophy requires the extension of certain behaviour to external partners, such as suppliers and customers, mutual sharing of information between the members of the supply chain, risk and reward sharing among the members, and cooperation. Furthermore, the philosophy involves integrating the processes, establishing the same goals – especially regarding customer demand – and building up long-term relationships. The importance of integrated SCM is supply chain planning and control. It has three essential aspects: Firstly, functional integration, which comprises decisions about purchasing, manufacturing and distributions activities through the firm, as well as among the firm and its suppliers and customers. Secondly, geographical integration of these functions throughout physical facilities located in one location or several locations (sometimes overseas locations). Thirdly, inter-temporal integration of strategic and operational supply chain decisions (Shapiro, 2001). Therefore, it aims to increase the efficiencies and effectiveness, avoiding fragmentation and building a capable delivery system.

2.4.3 Supply Chain Management in Construction and Procurements

Supply chain management has spread to the construction industry. The uniqueness of the construction industry sector depicts supply chains in construction according to three factors: Firstly, is a converging supply chain pointing the entire material to the construction field, where items are assembled from incoming materials. Secondly, the one-off construction projects make SCM unstable and fragmented. Thirdly, supply chains in construction are typically made-to-order, especially in that each project creates a new prototype or projects, mostly with a low level of repetition (Vrijhoef and Koskela, 2000). Furthermore, the supply chains in construction can be improved by four practical initiatives: improving the interface between site activities and supply chain; improving the supply chain itself; transferring activities from the site to the supply chain; and finally integrating the site and supply chain as a modern option (ibid).

At this stage, it is important to state the procurements contracts used by stakeholders in the construction industry throughout the world. The procurement method fully determines cost, time required, quality needed, relationship, responsibility and liability among construction parties. According to Constructing Excellence (2015), procurement strategies are explained as follows:

- Traditional procurement process or design-bid-build: time and cost developed by an architect hired by a client. Although, this type of procurement is considered a sequential and subsequently slow process. Furthermore, it is also not suitable for fast track projects. Tenders have two stages, where the second one includes a contractor’s intervention; thus overall cost and less accurate completion date are likely to occur.

According to Gransberg and Windel (2008), in traditional design-bid-build contracts, the customer (owner) hires the designer (architect) to generate an efficient documents comprising master plan besides its critical path analysis. Moreover, engineering company commonly takes the planning job separately in the traditional planning method, Moreover, Ballard et al. (2001) noted that the designer (architect) in the traditional method appears to be responsible for the planning phase, insufficient design combined with design-bid-build procurement may leave contractor no option except to depend on design faults and omissions to produce beneficial contract. So, the consultant somewhat has sole connection with the client, in contrast to other contraction parties who do not have this privilege in traditional construction procurement. So, the engineering company devotes time for the clients' sake by applying on-going improvement and seeks further development over time. This provides further work for the company in the future with the same client, due to client satisfaction. Akintan and Morledge (2013) stated that in the past traditional procurement used to be the core method in the UK, then the method failed to accomplish client satisfaction because of the lack of the construction parties' participation through planning and coordination, besides self-interests. The supplier's company ought to take its part in the planning phase to develop the construction logistic process efficiency.

- Design-build procurement process: cost certainty and speed are core parts in this procurement, where the main contractor plays a significant role in coordinate amongst parties. This procurement process provides the client a single point of the contract. Nevertheless, the client commits to construction cost and design cost in early when compared with traditional procurement. On the other hand, risk is mainly shifted to main contractor, thus it is vital that design responsibility is perfectly maintained to insure the risk. Furthermore, changes by the client through design are usually costly, due to their effect on the entire design-build contract, rather than only the design side cost.
- Management contracting or construction management: this approach is suitable for sharing risks, fast tracking, complex buildings, as well as developing brief for the project. Furthermore, the client allocates the designer and the contractor (known as management contractor) and pays the contractor a fee in terms of managing work on the construction site. The point is the early involvement of the contractor to the work together with the design team to build a full programme for construction design and operations. Then, the management contractor competitively gives the work in packages to proper subcontractors, suppliers, and specialists. The procurement is based on selection of the project team, the business solution used by contractor management, then captured

learning within post project review.

- Nowadays, a contemporary method known as IPD (integrated project delivery) has begun to be applied in the construction industry. It is a project delivery approach that integrates all persons, business structures, systems, and practices into a process which collaboratively employ the insights as well as talents of all contributors in order to optimize project outcome, diminish waste, and increase value to the client, besides maximizing the efficiency throughout all phases commencing from pre-design, design, fabrication then the construction phase (Guide, A. I. A., 2007). IPD values can be implemented to a variety of contractual arrangement and an IPD team has the ability to involve participants (such as main suppliers and other specialists) well beyond the basic triad of client, architect, and contractor. Integrated projects in all cases are uniquely distinguished through extremely effective collaboration between client, prime designer (architect) and contractor, beginning in early design and is ongoing throughout project delivery (ibid).

Design-bid-build contract is considered the most prevalent procurement in Jordanian construction (Odeh and Battaineh, 2002). There is a need for adopting other procurements (contracts) in Jordanian construction such as design-build and construction management. Such contracts reduce delays by improving the design stage, improving the contractual relations between construction stakeholders (ibid). Thus, the type of procurement can play a significant role towards the integration of all stakeholders in a systematic approach.

Accordingly, this research justifies in details the most common procurement contract used in the Jordanian construction industry, as well as provides recommendations and implications for future procurements methods.

2.4.4 Logistics and Supply Chain Management

By 1986, the Council of Logistics Management (CLM) had defined logistics as “the process of planning efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information flow from point of origin to point of consumption for the purpose of conforming to customer requirements” (CLM, 1986).

However, to better understand the approach, Halldorsson and Larson (2000), report that the term ‘logistics’ is a common expression used in relation to supply chain. SCM is relative to logistics and is viewed in four manners, as shown in Figure 2.6. Moreover, the main reason for these different perspectives is because there is no unified definition of this expression.

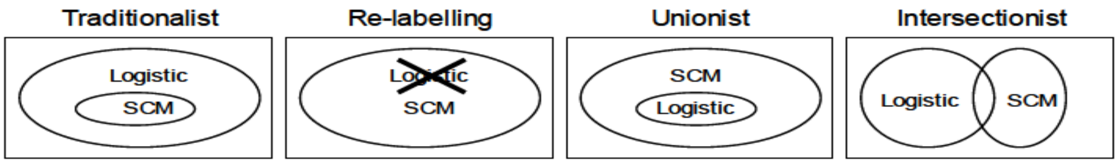


Figure 2.6: Perspectives of supply chains and logistics (Halldorsson and Larson, 2000)

The traditionalist view shows that logistics hires supply chain analysts to focus on cross-functional and inter-organizational issues. However, some researchers do not make a distinction between SCM and logistics. The unionist approach shows supply chain management to be more than simply logistics: it includes operations, purchasing, and marketing. Meanwhile, the interventionists describe it as a staff function of internal consultants (ibid).

On the other hand, Cooper et al. (1997) agreed with the prevailing view by academia which says that there is a need for some level of coordination of processes and activities within and among the organizations in a supply chain that extends beyond the term logistics. Therefore, 'logistics' is not a synonym of SCM and this means that SCM partnerships will probably engage more processes and functions (such as business operations) than integrated logistics partnerships; thus, SCM transcends firms, functions, and business processes. Figure 2.7 illustrates a framework of conceptualization of supply chain management which includes three aspects: management components, structure of the chain, and business processes (ibid). Furthermore, Figure 2.7 depicts the supply chain across the top, the process cuts across the functions within the organization and also across to other organizations within the supply chain. In addition to the management components which are recorded at the end of the framework.

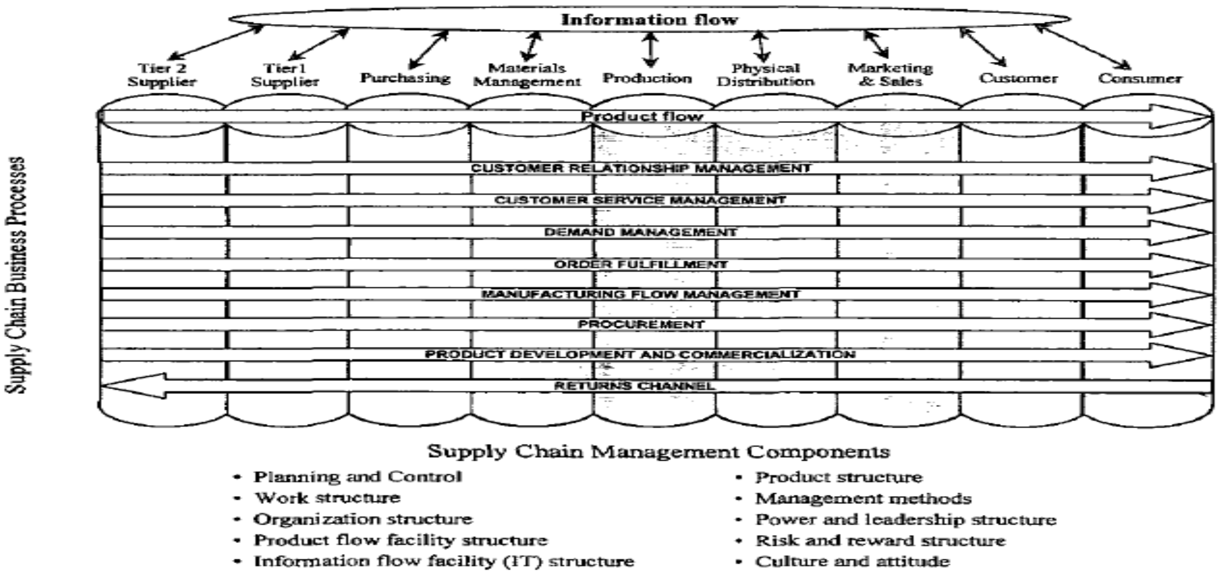


Figure 2.7: Framework of supply-chain management (Cooper et al., 1997)

On the other hand, two main aspects mainly characterize logistics in the construction industry: movement and capacity. Capacity is defined as the possibility of the value-added system permitting physical materials, services, goods and information to be transferred and stored within and between facilities. The movement is defined as the flow of physical services, materials and/or information within and amongst facilities (Novack, 1993). Therefore, construction logistics in this context is defined as physical distribution (with/without information) and transportation jointly evolved into the discipline (ibid). In addition, suppliers' logistics costs could vary between 2 percent and 18 percent of the material purchase value, confirming that construction costs can be significantly influenced by the indirect costs related with suppliers' logistics efficiency (Vidalakis and Sommerville, 2013). A previous study by Soderman (1985) noted that up to 40 percent of the material cost is assigned to acquisition cost related to the suppliers' activity (Vidalakis and Sommerville, 2013). The shortage of materials could result in time exceeding and could strongly effect the cost and quality of the building; this accounts for 40 to 50 percent of the overall construction costs. Furthermore, depending on evidence from construction industries, there is a considerable possibility of saving 10 to 30 percent by improving logistics throughout the supply chain (CPA, 2005). The movement of logistics from the original point to the site of assembly is very important to evaluate the overall performance; these sequences of movements comprise ordering, loading, transportation, unloading and storage and return (Johnston, 1981).

In construction logistics, comprehension of the concept of 'flow' is essential. The management of flow and storage of materials and related information across SCs is the fundamental feature of logistics management (CLM, 1998). Effective logistics should encompass component and materials management by integrating materials supply; storage; processing and handling; manpower supply and schedule control; site infrastructure and equipment location; physical site flow management; and information management (Agapiou et al., 1998).

As mentioned above, management of flow is crucial in empowering the logistics process, which helps to reduce non-value adding and increase value adding (Koskela, 1992). The flows are usually uncoordinated because most construction materials suppliers have their own dedicated vehicles and delivery schedules, and deliver ad hoc to various locations locally and nationally (Muya et al.,2008). Rother (2009) stated that organisations need to calculate their Takt time, aiming to find the exact time needed for certain demands as well as knowing the number of labourers required in each process. He added that if any problem appears through the flow of materials and information in any stage, the rest of the team who work in the next stages will be notified rapidly because the flow will be clearly affected, and they will cooperate to solve the problem together, which eventually reduces the time buffers. Furthermore, flow can be affected by different issues. First of all, most materials are usually demanded rather late, which affects the supplier because of having to have a large materials buffer; uncertain demand too can affect the service level, or too early demand leads to site buffering (Vrihoef and Koskela, 2000). Delivery processes have many restrictions that require providing short-term plans for tasks depending on the constraint analysis of project resources. Moreover, two requirements are needed for analysis of the material constraints. Firstly, there must be transparency of material availability for site inventories and other phases of the construction SC. Secondly, a short timespan for planning demands short response times along the construction SC (Ala-Risku et al., 2004).

Further details concerning flow are added in the next part it overlaps with different logistics factors (challenges). So, the following subsection critically discusses the main challenges (factors) affecting construction logistics including all information (sub-factors) in accordance to their main factors (challenges).

2.4.5 Factors (Challenges) Facing Logistics in Construction

- **Health and Safety Factor Regulations**

Health and safety is one of the main concerns in the construction industry but executes inadequately and poorly in occupational health and safety. Regardless of the initiatives and conferences, the numbers of incidents show that the situation is still misjudged, as many construction workers continue to be killed, injured, or suffer long-term illness at the construction field every year (Lingard and Rowlinson, 2005). Firstly, research study in supply chain logistics showed that the roads transportation structure has led to insufficient health and safety. The design and quality of roads can generate substantial threats and hazards for all logistics stakeholders, and additionally, negatively affect the road-travelling public (Rawling and Kainet, 2012). Secondly, at several stages in the UK, and according to the Health and Safety Executive (2011), "In 2009/10 there were 42 fatal injuries giving a rate of 2.2 per 100,000 workers. This is the third highest rate of fatal injuries, behind agriculture and extractive industries. Construction accounted for 35% (276 cases) of all reported injuries involving high falls and 24.8% (89) involving electricity. The incidence rate of reportable non-fatal injury was 1,300 per 100,000 workers (1.3%) in 2008/09 (three-year average). This was statistically significantly higher than the average across all industries. In 2009/10 3.3 million working days (full-day equivalent) were lost in this industry due to workplace injury and work-related ill health.". Lehaney (2012) has studied the health and safety factors affecting SC performance, and he concluded that complex legislation was the second main challenge after the lack of resources, particularly in small and medium sized enterprises. These percentages are considered more than the average in different industries. Furthermore, environmental rule is a part of the health and safety topic and is mainly based on government rules. It depends on standards, codes, and rating systems that are set by international and local environmental organisations and need to be implemented by those involved in building projects, such as clients, contractors, subcontractors, and suppliers (UNEP, 2010). However, many developing countries depend on voluntary standards and assessments for materials and buildings, which are less effective than applicable rules (UNEP, 2007). Aronsson and Brodin (2006) noted that there has been extra consideration given to environmental matters in logistics systems generally over the previous decade. There are two main levels of different factors, which can be applied for accomplishing environmental enhancements; the first one is at the macro level, which is the actions that can be received by governments' bodies and legislative authorities; and the second is at the micro level which includes the actions that are received by construction companies. Furthermore, the main challenge for today's logistics managers lies in integrating environmental management practices into their work on a daily basis through the decision making process (ibid). Lastly, difficulties in customs regulations to release products can cause considerable delay in the logistics system, Ali et al. (2008) highlighted that problems related to trade and customs facilitation is one of the major issues that has been outlined by the Association of Southeast Asian Nations (ASEAN) concerning the integration of the logistics service sector. This issue can also affect health and safety particularly when drivers do extra load and over speed due to lateness.

Within Jordanian construction, there are numerous obstacles regarding the health and safety system (Ali and Nsairat, 2008). Furthermore, developing a contemporary system is becoming essential to solving the existing construction difficulties and limiting environmental impact, besides producing healthy workplaces and additional productive benefits from this issue (ibid). Consequently, in this research, participants are requested to indicate their view in regards of health and safety regulations through two data collection parts (quantitative and qualitative), thus the importance of this factor are illustrated at the end of the discussion.

- **Inventory Factor**

Inventory is expressed as materials, products, and material stored by a company to back production procedures, as well as defined as buffering phases throughout supply chain process (Rother, 2009). A large inventory is seen as an impediment during logistics process mapping. The majority of projects still have excessive inventory that causes low-speed operation throughout the logistics process (ibid). JIT is one of the main practices to reduce inventory level as previously clarified. Regardless of few research that still consider that JIT is risky (Fearne and Fowler, 2006). Most research shows effectiveness and efficiency in regards of time, cost and quality added through bringing materials when needed (Novack, 1993; Cahn et al., 2009; Bryde and Schulmeister, 2012; Vidalakis and Sommerville, 2013). Most research agrees that bringing materials by using Just-in-Time is one of the main aspects to enhance inventory level, in addition to differentiation amongst new construction methods and traditional construction methods (Patty and Denton, 2010). According to Polat and Arditi (2005), in traditional procurement the contractor seeks to receive and save material at an early time (Walsh et al., 2004). In developing countries, contractors have a huge tendency to buy material to protect themselves. Norris (1994) mentioned that JIT comprises risk of motivating in inflation when there are material shortages, the supplier tends to raise costs, so he chooses to keep materials and send them when needed. On the other hand, contractor for the earlier cause is attempting to possess inventory to prevent delays or shortages of material (Abdelhalim and Duff, 1991; Ofori, 1994). Additionally, a study in Turkey (a developing country) shows that full collaboration by construction parties with suppliers are the most substantial foundation with which to apply JIT because late deliveries are considered a primary cause for non-application of JIT (Oral, 2003). So, there is a necessity to integrate the entire supply chain, including the supplier, in long-term relations to assure quality and stability, along with straightforward interaction with the client. However, stability in demand needs to be ruled through government regulations (ibid).

In Jordan, which is considered one of the developing countries, participants who contributed to the data collection part of the research clarify their views regarding the inventory challenge, in addition to the applicability and usage of JIT in Jordanian construction.

- **Material Preservation Factor (Preserving Quality)**

Material quality is paid proper attention in terms of the logistics process efficiency and effectiveness. One of the main cores of the logistics process is keeping sufficient focus on right quality, accurate time, accurate place, accurate quantity, and cost (Lundesjö, 2015). The guarantee of quality of material as well as understanding the dynamics of logistics and the SC process generate numerous consequences on the overall performance (ibid). It seems that quality of material is overlapped with other factors, but it can be reviewed as an individual factor due to its importance, as quality is considered to be one of the main pillars of the construction industry as well as the construction logistics process. Furthermore, Kaare and Koppel (2012) noted that construction stakeholders undervalue streets and main roads within the construction SC. That is, regular road servicing and sufficient standardizations along with the ability of drivers, could significantly contribute towards the avoidance of breaking the material. These circumstances appear to be critical and yet not properly taken into consideration by construction parties. Lundesjö (2015) added that challenging occurred due to the nature of construction, whereas disruptions throughout the construction process along with increasing the material waiting time results in considerable damage and defects. In other words, when material moving throughout several points starting from supplier and ending at the construction store, there is a high possibility of decreasing the material quality required. Consequently, there is a substantial need to urge construction stakeholders to comprehend all the previous information when planning the construction logistics process. In Jordanian construction, these points are examined throughout data collections phases (mixed methods) and then evaluated to check whether Jordanian construction logistics suffers in terms of this factor.

- **Labour's Performance and Material Handling Factor (Performance Factor)**

Performance is defined as "the execution of a certain task measured against current known standards of completeness, accurateness, time, cost and quality" (Business Dictionary, 2013). Performance in a contract is considered to be the accomplishment of obligation in the way that discharges the performer from all the responsibilities and liabilities under the contract. In the construction field, performance has been considered as a significant factor that needs to be improved, and many studies have developed frameworks for measuring the supply chain (SC) performance. Wegelius-Lehtonen (2001) developed a framework for measuring the SC performance. However, the materials delivery parts as well as on-site logistics have not been focused upon sufficiently. Firstly, Vrijhoef and Koskela (2000) explained how poor performance would decrease productivity and quality, which eventually cause time and cost overruns. Some significant reports such as Latham (1994) and Ethan (1998) mentioned that many of the dilemmas in the construction industry were related to poor performance, such as reworks and defects, which increase waste and negatively affect material quality as well as productivity. So, it seems that labours' performance has overlapped connections with substantial factors, whereas within the logistics process it is mainly concerns of material handling that is discussed next.

Material handling is defined as the methods of loading and unloading the material by using machines, labourers or both together (Josephson, 2013). Developing efficiency of these methods offers greater benefits on material control. According to Johnson (1981) efficiency in loading and unloading of materials is the most vital factor to success in keeping control of materials. Furthermore, during assembly time, workers need to be well organised and skilful so that they finish at the planned time and avoid delay (Josephon, 2013). Furthermore, Brag (2011) mentioned that there is a necessity to build a framework to include the best techniques that demand to be considered during logistics process, where material handling is one of the main themes of this framework. Additionally, Lundesjö (2015) noted that material handling can add additional expenditure when materials are moved throughout different places, particularly when using equipment and machines. Some experts critically discuss the preference of whether to use labourers or machines during material handling. As Josephson and Saukkoriipi (2007) stated, material handling deducts around 14% of labourers' time, and besides, handling can produce rework, interruptions and long waiting times. So, machinery delivers a better development if properly taken into consideration. On the hand, there is no best way of doing the handling; the proper physical environment has to be considered in the planning to discover the most suitable way (Brag, 2011). Consequently, the situation in Jordanian construction logistics is still ambiguous as there is no information regarding this factor. Thus the previous points are clarified during the data collection stages in order to elucidate and then analyse the current situation in Jordan for the purpose of establishing a proper solution for improvement.

- **Planning Factor**

Planning is one of a vital part of construction projects. Many studies have been done on planning to emphasise how sufficient planning leads to a successful project outcome. Planning can be divided into two main levels: pre-construction and on-site planning (Johansen and Wilson 2006). The first is tactical and strategic, and most importantly includes choosing the whole construction team, such as consultant, contractor, subcontractor, and supplier, as well as selecting and purchasing the materials. In contrast, on-site planning is about managing the operational processes and delivery of materials from the supplier to the construction site, in addition to guaranteeing that the intended tasks will be achieved according to the master-plan schedule (ibid).

Many factors can affect the logistics process in terms of planning. Firstly, Vrijhoef and Koskela (2000) explained that at the beginning and the end of each sub-process in the logistics system considerable time buffers occur, especially because of the inventory and delays, which indicates long waiting times. Furthermore, lack of coordination in planning is considered to be one of the major obstacles causing the time buffers (ibid). Ballard and Howell (2003) noted that independency needs to be fulfilled to decrease the waste in terms of waiting time. Consequently, activities and tasks will be avoided and any kind of adjournment as well as resources will be adequately used. Secondly, Koskela and Howell (2002) showed that uncertainty significantly affects the supply and demand of the flow of materials, which makes the master plan (general plan) appear unreliable due to this variability. So, reliance on the master plan leads to poor short-term planning and most importantly increases the complexity of planning (ibid). Thirdly, lack of understanding of the role of planning increases cost and time, and consequently leads to large deficiencies in planning (Gidado, 2004). Fourthly, interactions in construction projects are not free relationships and need to be governed by a specific procurement type, which in addition includes the contract type, responsibilities, and risk sharing among parties (Telford, 1998). Fifthly, Rahman (2006) noted that lack of training is one of the main factors affecting the construction SC as well as preventing improvement. In his study, which he conducted in Australia, he mentioned that logistics managers are least satisfied with the education and training aspect where quality is affected negatively by this factor. Furthermore, corporate culture (40 percent), and training and education of the employee (40 percent) were the most important factors in the study; however, lack of training was more severe in the case of logistics firms. Finally, Johansen and Wilson (2006) stated that on-site planning delivers well-organized management in operational processes, particularly delivery speed besides fast responsiveness which commences from supplier to the construction store.

Thus, the result of having effective flow leads due to sufficient planning can enhance overall customer service, which includes the speed of the delivery, fast responsiveness, and fulfilment of orders (Vicker et al., 2003; SCOR, 2010). As a result, it becomes evident that there are many significant arguments related to the planning factor in pre-construction and throughout constructions as stated above, and grants this factor a unique and special status of critical importance. In Jordan, each argument is discussed within the data collection chapters (qualitative and quantitative methods) to explore levels of these arguments through the logistics system, as no evidence indicates the current situation of planning in Jordanian construction logistics.

- **Transportation Factor**

Transportation is an essential part in the logistics process; all movement of material depends on this factor. It is mainly identified as transporting material from the initial point (supplier) to the finish point (construction site) in the storage area by choosing the most suitable and adequate transport (Baudin ,2004). Furthermore, transportation accounts for between 10 to 20 percent of overall construction costs (SACTRA, 1999), and so is considered one of the main factors for increasing outlay. In addition, transportation is divided into two parts: inside site and outside site (Baudin, 2004). Significant improvements can be achieved by reducing trips instead of reducing distances. Furthermore, some of the common problems lie in sites using the wrong vehicles, as well as in insufficient site security (ibid). WRAP (2013) noted that deliveries need to be scheduled manually, taking many factors into account: site access; order size and vehicle utilisation; size of transportation; and the number of fleet vehicles required. Besides, Vidalakis and Sommerville (2013) noted seven transportation drivers: distance, weight, density, stowability, liability, and market factors. They also added that appropriate transportation means a positive influencing over cost-efficiency. Moreover, Shigute and Nasirian (2014) soundly stated that the contemporary logistics process needs to involve appropriate sharing of transportation within the logistics system. Sharing transportation is proved by Cruijssen and Salomon (2004), they determined in their research that 5 to 15 percent cost reduction could be made by implementing order sharing among organizations. So, it could be said that this way of sharing between parties can confer significant benefits to the logistics process.

Additionally, many features need to be taken into consideration when planning the delivery process: transport type, transport size, the technique of transport use, and the quantities of vehicles needed (WRAP, 2013). Vidalia and Sommerville (2013) emphasized that applicable transportation leads to beneficially effects on cost effectiveness. Subsequently, it seems that the type of vehicles used in transportation is required to perfectly fulfil customer requirements. Furthermore, accurate and effective movement of the transportation must be given due consideration. Matyusz (2011) stated that excessive transportation and unnecessary vehicle movement are considerable causes for extra waste. Additionally, fluctuations in materials can have an adverse effect on transportation. Vrihoef and Koskela (2000) noted that volatile market demands need to be controlled through development of a framework for an agile paradigm, through using market information and practicable collaboration to exploit positive chances within the market. Market condition has a huge impact on a country's economy, and gradually affects the construction industry. Furthermore, uncertainty in product demand also needs to be considered, justified by the market's volatility which is often present in the current business context (Sonia et al., 2013). In logistics, Bowersox et al. (2007) noted that high levels of fluctuation in the demand for building materials can result in a sporadic delivery services which can defeat the entire effort to integrate transport capability into a logistical system. The volatility of markets has created a huge pressure to build SC tools to address uncertainty, namely at the demand level. Market fluctuation leads to fewer transportation runs carrying smaller loads, increasing inefficiency due to the quantity of lorry movements (Fearne and Fowler, 2006). So, the market status has an essential link with the logistics process and in particular the inevitable influence on the transportation aspect. Vickery et al. (2003) stated that integrating SC could improve the market situation. However, Power (2005) illustrated that the reduction of the bullwhip effect can influence the market condition and significantly improves the SC. Logistic category management methods can be implemented whenever different product categories require different production and logistic approaches in addition to different marketing policies (Cigolini, 2004). The beliefs behind business process redesign can be extended to an SC environment, as their aim lies in connecting the marketplace (ibid). Having a well-developed market for building materials and services, centralising, and outsourcing the project supply logistics, can be considered as the best cost-efficient resolution to aid control of the project (Sobotka et al., 2005). Therefore, an agile SC reacts to fast-changing global markets dynamically and flexibly through organisations (Sukati et al., 2012). Moreover, the volatile marketplace can be mitigated by developing construction SCs within the framework of the agile paradigm by using market knowledge and a virtual corporation to exploit profitable opportunities in this market (Vrihoef and Koskela, 2000). To achieve cost reduction, production needs to adjust to changes in market demand flexibly and promptly in order to avoid time wasting (Dias et al., 2009). Furthermore, Eng (2004) suggested that electronic marketplaces (e-marketplaces) have a strong influence on the way in which companies deal with their SCs. Many supporters of the e-marketplace conception propose that web-based trading systems would enable organisations to more efficiently buy, sell, and handle their SC processes on a global level. Consistently, SCs have to be responsive in order to follow fickle market trends (Cigolini, 2004). Moreover, effective supply chain management (SCM) is an important determinant to building and sustaining competitive benefits in the marketplace (Sukati et al., 2012). So, clearly, market status needs to be taken into account when creating the logistics process, as well as due attention being paid to the direct impact of the transportation logistics factor, as mentioned above.

Finally, government regulations have a considerable influence on the overall logistics process (Oral, 2003; Aronsson and Brodin, 2006; Lehaney, 2012; Kaare and Koppel, 2012), allowable weight and customs regulations lie within the governmental arena. The Jordanian government has a serious intention to improve its supply chain and logistics processes (Shwawreh, 2006). Thus, using mixed methods (quantitative and qualitative) of data collection, this study highlights that point and provides clear information about the level of government awareness required to improve the construction logistics processes. Similarly, all other previous points: market condition, unnecessary movement, sharing transportation, and suitability of vehicle types will be reviewed throughout the two data collection phases. Consequently, providing a full picture in terms of the transportation factor.

- **Continuous Improvement Factor (CI)**

Continuous improvement is deemed an important pivot point between the transition from conventional construction to lean construction.

According to Imai (1997), continuous improvement is an on-going effort to improve products, services, and processes. These efforts seek to improve incrementally over time. When applied in the workplace, this shows that continuous improvement involves the entire team of managers, engineers, and workers alike. The improvement techniques used by companies provides an indication as to what extent the level of improvement can attain. Furthermore, the Japanese word 'Kaizen' means "continuous improvement of working practices" or "personal efficiency", and originated from the Toyota Production System (ibid). Hence, this factor concerns obstacles which are preventing improvement to the logistics process. Developing culture plays a significant role in this factor. Creating a sufficient culture has to be a priority for companies in order to advance their processes to attain significant benefits, as well as reducing costs and time. The companies need to apply new practices and views and consider developing themselves consistently through incorporating all managers and workers into one centre. Continuous improvement is not just for Japanese people, because many companies throughout the world have constructed their organizational culture successfully (Rother, 2009). The first step requires commencing on-going feedback and shared learned lessons throughout the project, as well as the finished project. Chang et al. (2010) highlighted that temporary SC is considered to be an existing problem, and proposed a framework based on applying feedback and learning lessons from previous projects so as to gain considerable benefits from better managed SCs. Lack of feedback along with not learning from previous experience will not help to improve the logistics process in the next project or level. Improvement needs to focus primarily on customer satisfaction, so all stakeholders are required to keep this fact in mind, particularly the supplier as his participation through one project is regularly less than others. According to Kabirifar and Ghafourian (2014), it seems many consultants in the construction industry have a passion to add quality implications from Toyota particularly the PDCA (Plan-Do-Check-Act) cycle, and repetitive cycle. Frodell et al. (2008) highlighted that suppliers need to change their manners and, regardless of incomes and transient sales, set customer satisfaction amongst their top needs, as this will help to produce continuous improvement and provide a substantial return in the long run. So, customer satisfaction requires prioritizing in the development of continuous improvement in the Jordanian construction logistics process. Consequently, continuous improvement is an approach that seeks change for the better through focusing on continuous incremental enhancement, which can be done by decreasing waste and creating more value (Imai, 1997).

All points mentioned in regards of the continuous improvement factor are discussed in the two data collection phases where all participants' replies concerning this factor are reviewed in order to establish a comprehensive notion about the matter. Regardless of having specific CI (Japanese practice) within lean practices along with its specific cycle, the Continuous improvement factor is extended across a wider range based on the previous information, all aforementioned points related to CI are reviewed in the data collection part to indicate the level of CI used in Jordanian construction with a view to improvement of the logistics process.

- **Transparency and Information Exchange Factor**

Transparency is the visibility of processes that are defined as methods of controlling and visualising the activities of a company. It is the perception of responsibilities, status, problems, understanding, interdependencies, and the facilitation of system performance (Klotz et al., 2008). Logistics is defined as managing the SCs, the latter being a network of organisations linked by materials and information exchange and bounded with a product (project) life cycle which extends from the procurement of raw materials to the final place (Sobotka, 2005). Furthermore, the logistics definition also considers the connections among SC members to be a vital factor in managing and controlling all processes including ordering, reception, transport, and storage (ibid). Diverse aspects of transparency between the SCs can be discussed. First of all, swapping information needs to be controlled through appropriate transparency. For example, RFID (radio frequency identification) is a sufficient technology that can be exploited to enhance visibility throughout the entire logistics process, with traceability of material then generating accelerated and consistent operational processes including tracking, shipping, checkout, as well as process counting. The consequence is additional knowledge and information besides less inventory flow. Alodeh (2010) mentioned the GPS (Global Positioning System) performing as a good technological tool to assists tracking material information, and simplifying relationships amongst parties. Moreover, lack of sharing and distribution of information, shortage of information (due to lack of information-gathering), lack of coordination amongst parties, as well as poor relations with both suppliers and customers, are considered to be crucial factors affecting the supply chain relationships (Love and Edward, 2004; Lambert and Cooper, 2000). So, a poor relation amongst stakeholders, particularly between supplier and client, is deemed to be an area of concern in regards to the logistics process. Johansen and Wilson (2006) revealed that these problems arise an insufficient number of meetings and a lack of commitment. They emphasised that weekly meetings are extremely important for addressing problems in the early stages, and averting conflicts before they arise. Upgrading transparency in the construction industry could help to improve relations considerably.

Additionally, monitoring and controlling tracking system are not used frequently for all products and material. Dias (2009) noted that consistent application of developed approaches and superior technologies with regard to controlling and tracking, offers competitive benefits to the whole supply chain and logistics process. It seems that transparency is reliant on technological methods used throughout the construction logistics process.

Furthermore, trust is generally underestimated in the construction industry, regardless of having the most suitable contracts between construction parties. Trust can play a significant role with the chosen contract to improve the work, reduce time, reduce cost, and improve quality. Akintoye et al. (2000) noted that trust among members is an essential feature for efficient SCM implementation. Kwon and Suh (2006) explained that trust is built on two pillars. The first pillar is social exchange variables (perceived satisfaction, partner's reputation, and perceived conflict). The second pillar is transaction cost variables (asset specificity, behavioural uncertainty, and information sharing). So, the presence of trust measurably enhances the chance of successful SC performance. Colledge (2005) reports that construction stakeholders must focus on constructing appropriate approaches for consistent delivery that concentrate on partnership and trust so as to aid improvement of working relationships between all construction stakeholders, thus raising the efficiency and effectiveness of the entire process and so developing financial return. So, it could be stated that trust appears to be a hidden aspect that is not taken seriously between construction parties.

Additionally, in the context of information exchange, there are several frequent procedures that need to be perfectly done in order to avoid delays. For example, ordering step considers a vital one, it is the method of communication used to order a product via the telephone, face to face, or through the internet (Johnston and Clark, 2005). Furthermore, storage (inventory), transportation, as well as handling and reception factors also require proper information exchange between construction parties.

Similarly, differences in meanings and interactions between a diversity of cultures leads to increases in misunderstanding and causes excessive reworks and mistakes, eventually reducing the efficiency of the supply chain (Rother, 2009; Menches, 2008). Moreover, from the supplier's or subcontractor's perspective there is disinterest because the client and his team, including the contractor, usually do not take the supplier's/subcontractor's opinions into consideration during the work. As a result, not only is a lack of partnering promoted (Bagballe et al. 2010), but also the competence of decisions is reduced, as significant members are left out of the decision-making process (Pan et al, 2010; Koskela and Vrijhoef, 2000). Long or short-term contractual relationships are very important. Most partnering builds on long-term contractual relationships between parties and needs all parties to be involved in the logistics decision process (ibid). Consequently, it is very clear how information exchange and transparency between parties plays a significant role in the logistics processes.

After reviewing the factors (challenges) affecting construction logistics, this research addresses all eight factors (challenges) later on in the data collection and discussion chapters, where all of them, along with their sub-factors, are critically discussed in terms of Jordanian construction logistics. The implications of lean practices are also justified for each factor in order to find a solution for the advancement of the logistics process in terms of the Jordan case.

Finally, Table 2.3 highlights the main factors (challenges) affecting construction logistics derived from literature review. These factors helped build the semi-structured interviews and the questionnaire, where respondents were asked about each challenge in relation to construction logistics in the Jordanian construction industry. Further explanations are provided in the following chapters.

Table 2.3: Shows factors (challenges) affecting construction logistics

Construction Logistics Factors
Health and safety regulation factor
Inventory factor
Material preservation factor (preserving quality)
Labour's Performance and Material Handling Factor (Performance Factor)
Planning factor
Transportation factor
Continuous improvement factor
Transparency and Information Exchange Factor

2.4.6 Traditional Logistics Versus Lean Logistics

There is plenty of evidence to illustrate the inadequacy of traditional logistics in the construction process. For example, partially loaded lorries while moving, waiting time for unloading, lack of information flow, large stores of inventories, multiple handling, and extra waste in construction sites when compared with manufacturing sectors. In addition, there is little formal training for staff related to logistics (CPA, 2005).

Ali-Risko and Karkkainen (2004) strongly stated that the traditional method of construction needs to be improved by implementing new interactive management methods, where the following phase in the construction project will be defined based on the current phase. Furthermore, out-dated and predefined traditional planning will be overcome through flexible project management methods, where lean is considered to be the best of such approaches, especially via the Last Planner System (LPS).

On the other hand, lean logistics is considered a new way of thinking (lean thinking) about supply chains and provides a significant framework based on the fundamental philosophy of Toyota Production System and lean practices from raw materials to customers (final consumer).

The lean logistics approach offers a development method to overcome the fragmentation of traditional logistics and business thinking. Value, value stream, flow and, pull system are addressed within lean logistics (Jones et al., 1997). For example, conventional logistics uses traditional flow where buffers are located among the processing stages. The buffers separate the processes' steps from each other and make sure that the steps can continue functioning even if another process step breaks down (Slack et al., 2004). On the other hand, JIT emphasizes that buffers should be zero, and in case of breakdown occurrence all processes will be aware of the problem, with everyone working together to solve the problem instead of leaving the stuff associated with step work alone (Rother, 2010). In addition, the quality of work will increase because of using the experiences of everyone to face any circumstances. Furthermore, the materials will not become old or damaged (Slack et al., 2004). This will also reflect positively on costs because companies do not have to spend money on storage (12 manage, 2008). This statement will be supported and proved further with significant examples under Section 2.4.7 "Implementation of Lean in Logistics".

2.4.7 Implementation of Lean in Logistics

1. Case Study: Indian Steel Plant (Dhandapanietal., 2007)

This case study is about a steel company in India. The company is one of the main producers of reinforcement bars and rolling mills and is based in the Trichy city, Tamil. The capacity of the rolling mills before thinking of lean practices equals 57,300 tonnes annually, with sales of approximately 54,000 tonnes, and production of 32,000 tonnes of crude steel annually. The company has one day off per week and has received the ISO 9002 award. In this case study, by applying lean thinking, various stages have been implemented, as shown below:

1. Defining the value stream: the priority is to define value according to customers' needs. The requirements could be summarized as cost, quality, availability, customer service, and on-time deliveries. Given the nature of the product, availability and cost are still amongst the most significant features.
2. Identifying the value stream: by process-activity mapping that also captures all sources of waste, the value stream can be identified.
3. Eliminating waste and enabling flow: improper heating; insufficient cuts in the section by increasing the length of the billets by a few centimetres; and high cost of maintenance because of the malleability of the metal whilst rolling – all these points were discovered and considered waste in the processes. By using the "five whys" analysis, the outsourced billets were found to be the main cause of loss in the production processes. Changing the cross section reduces the demand of outsourced billets by 1800 tonnes. Furthermore, use of imported scrap can save 2.2 % of the turnover annually in the cost purchasing outsourced billets. In addition, energy savings in the charging process can be made by reducing the life-cycle time, and decreasing the inventory level.
4. Moving to pull: as mentioned above, the use of imported scrap enhances the yield from the furnace and also reduces the process time by around one-third. So, having implemented the changes outlined above, the process time would be 368 seconds, which is very close to the calculated Takt time (374). Changing the manning arrangement helps to enable a pull system, along with implementing Kanban cards amongst the supply chain. The result of these actions gives a reduction in the finished goods stock by 50 percent, and saves 200,000 pounds of capital.
5. Striving for perfection: the current change should not be considered the only enhancement. At each stage a continuous improvement philosophy needs to be presented because inventories and lead times must still be effectively reduced. Working collaboratively with the team, and searching for more improvements is the way to seek perfection.

As a result, there is an annual cost saving of 8 percent, a release of capital equivalent to 3.5 percent of turnover through the removal of inventory, and a lead-time reduction of around 50 percent. The implementation of lean thinking has proved significant and crucial to the Indian steel company for the delivery of process improvement and cost benefits.

2. Case Study: Highways Agency in the UK (Chen et al., 2012)

The Highways Agency is an administrative agency for the UK department for transport. It executes the operation, maintenance and development of the 7000 km of strategic road network that encompasses English highways and trunk roads. The maintenance of the network involves twelve managing agent contractors; different design, build, finance and operation companies; and IT contractors. The agency has spent 1 billion pounds on capital projects, and 1.5 billion pounds on others. In 2010-2011, the agency planned to save 114 million pounds to reduce costs and improve value, accomplishing “more for less”. This has been achieved by applying lean practices in various projects throughout the country, most notably by saving 4.7 million pounds on the M6 extension from Carlisle to Guards Mill. On the M6. It has been recognized that lean implementation has significant benefits in terms of cost, time and quality delivery.

Moreover, lean practices grant the staff (logistics) tools to improve practices in a systematic way. A 'highways agency lean maturity assessment toolkit' was made as a set of metrics to assess every supplier’s approach against lean and continuous improvement. The successful point in this project depended on creating a continuous supply chain and robust logistics (continuous improvement for the supply chain), which included: use of multiple-batching within close proximity of the site; night maintenance with alerts for any incidents occurring to prevent plant breakdown; changes in working pattern, such as cutting pavement joints in the previous evening to avoid morning delay; increasing the times of delivery to create continuous supply from 7am to 5pm, as well as using another road (an old tank road through Catterick military base) instead of the motorway (A684). On the M53 Bidston Moss Viaduct strengthening project, over 1 million pounds of savings have been attributed to lean deployment on the plan. A culture of continuous improvement was evolved throughout the project by: collaborating on planning in design and construction; integrated project meetings (daily for construction, and weekly for design); employing a lean visualization board “fishbone” diagram; using the five whys; and placing targets along with defined barriers. Commitment and reliability in construction has been improved from 78 to 90 % by applying lean practices, as shown in Figure 2.8.

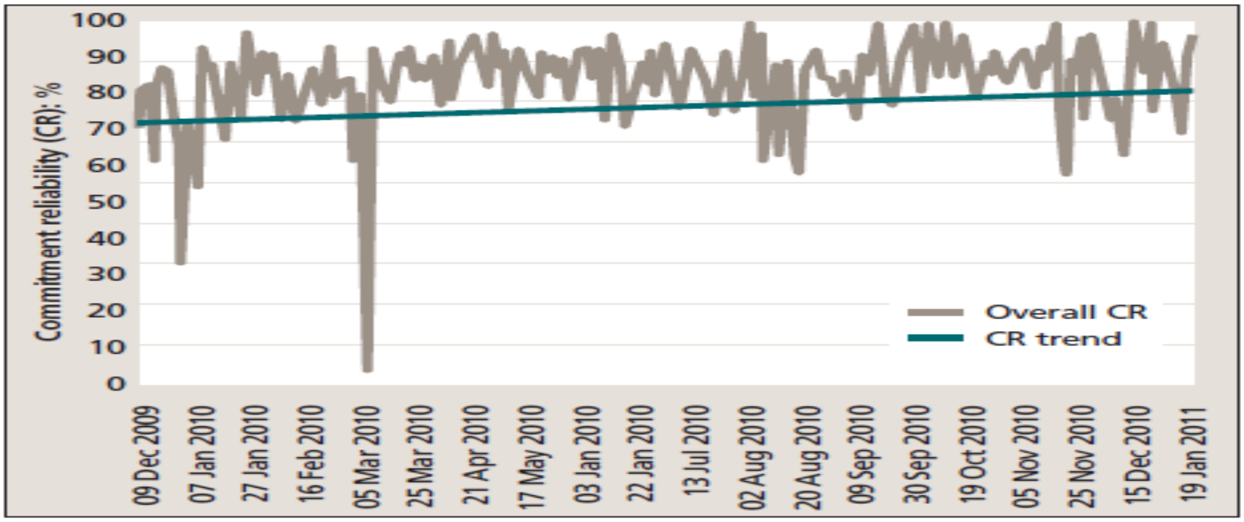


Figure 2.8: The improvement of commitment reliability by applying lean (Chen et al., 2012)

2.4.8 Challenges of Lean Logistics

Implementation challenges for lean have been mentioned in Section 2.3.6, and factors affecting construction logistics have been explained in Section 2.4.5. Most of the lean logistics challenges are analogous and comparable to lean implementation challenges and factors affecting logistics, as previously illustrated. Moreover, Eriksson (2010) stated “The field of lean construction is relatively immature and occasionally criticized for having an overriding positive bias based on enthusiastic arguments in management books rather than on scrutinizing unbiased theoretical reasoning in peer reviewed journals”. For that reason, significant amounts of research have been recently published investigating lean construction implementation and how it affects logistics.

This research intends to prove the capability of lean logistics throughout the construction phases. Furthermore, the particularity of lean logistics in construction lies in the movement (materials, information) and the capacity, specifically in the transportation part, which is based on JIT (Novak, 1993). Many research and case studies have illustrated the efficiency and effectiveness regarding time and cost gained by implementing lean practices especially the JIT technique (Novack, 1993; Cahn et al., 2009; Bryde and Schulmeister, 2012; Vidalakis and Sommerville, 2013). However, some papers criticize JIT implementation. Fearne and Fowler (2006) noted that fewer and fuller loads via transportation and appropriate co-ordination saves time (waiting time, distance travelled) and cost, yet in the same context inefficiency will be raised through increasing the amount of lorry movements. Besides, JIT is considered a high-risk strategy with a limited upside given relatively high levels of delivery unpredictability (ibid). The research will address and highlight the significance of JIT emerging through understanding and introducing of lean thinking and approaches in Jordanian construction, which will subsequently assist in strengthening or weakening the technique.

2.4.9 Lean Logistics in Jordan

This following subsection is illustrated in two parts. The first part concerns logistics and supply chain in Jordan, and the second part will explain the current situation of lean in the Jordanian construction field. First of all, the Jordanian government is one of the governments that found out that one of the main ways to develop its economy is to improve logistics and supply-chain management (Shwawreh, 2006). According to the government (2006), most of the development has been made by depending soley on the technology, such as in the health care sector. This means they have not included a new way of thinking or changing peoples' minds to become leaner. Moreover, the Jordanian government was the main leader in developing SCM. However, due to the shortage of research studies conducted with regards to logistics and supply-chain management in the Jordanian area, making significant improvements proved difficult. Secondly, according to lean practices, several organizations have implemented lean practices throughout the world to achieve beneficial results at various levels in different countries. However, there is no evidence to show lean thinking and lean practices in the practical construction field in Jordan. Therefore, this research will be the first of its type to apply lean practices in the Jordanian construction logistics, aiming to assess; providing a basis; and then improving the construction logistics amongst parties. Subsequently, offering a basis for the development of research in the area of lean and logistics in the kingdom of Jordan.

2.5 Literature Review Outcome

Two main pillars have been illustrated in the literature review chapter. The first pillar depicts the importance of the lean part and the second pillar demonstrates the logistics part. Furthermore, with regards to the two pillars, the literature review chapter gained the researcher significant understanding. Firstly, the vital understanding of the role of lean construction which necessitated the researcher to review the original meaning of the lean concept, including the idea behind this terminology, as well as providing an overview of lean thinking. Next, the base of lean in the production sector was illuminated, particularly the new production theory and related practice developed by Toyota (the Toyota Production System). Furthermore, the production tools and techniques of lean manufacturing were illustrated. The sequential movements of lean through the production sector to the construction sector were understood. Then, the chapter enlightened a theoretical background about lean, mainly the flow-based concept for the construction process. The methods of lean construction have been demonstrated, where the methods of the construction sector have been essentially derived from the production sector. Furthermore, lean construction approaches including the Lean Project Delivery System (LPDS) and the Last Planner System (LPS), the challenges of implementing lean construction practices, as well as the benefits of lean construction practices have been illustrated in this chapter. The aforementioned points significantly assisted the researcher in building the data collection phases (semi-structured interviews and questionnaire), as follows:

1. Research of lean production and construction methods provided the information needed to build the lean planning tools and lean construction practices questions in the survey, so as to explore the level of lean employed in Jordanian construction logistics.

   Additionally, in order to understand the benefits gained through lean application, the researcher commenced the literature review by studying the root of lean, and also tracked the history of lean from the production industry to construction industry, in order to increase awareness of the lean aim. The literature review also provided a significant explanation about lean planning tools and lean practices, and how to use them. In the second data collection (questionnaire), the lean planning tools and lean practices derived from literature review have been listed and then ranked according to the participants' level of agreement in using the tools and practices. At the end of the second data collection, a conclusion regarding the position of Jordanian construction in accordance with using lean is delivered in percentages.

2. Research of both lean challenges and lean benefits from literature review provided the researcher with the information needed to formulate questions relating to the drivers and barriers of implementing lean construction in Jordanian construction logistics. The questions were then asked through semi-structured interviews and questionnaire (the data collection phases).

   Literature review revealed drivers and barriers of implementing lean throughout the construction industry and so offered a clearer vision of how to examine the Jordanian case study, as all respondents in first data collection phase (semi-structured interview) exposed their drivers and barriers to implementing lean. Next, the drivers and barriers extracted from literature review and through the first data collection phase were listed, and were then ranked in the second data collection (questionnaire), according to stakeholders' level of agreement, which affirmed the most important drivers and barriers with regards to Jordanian construction logistics.

The second pillar of the literature review was related to construction logistics. For the comprehension of the subject, the researcher found importance in initially understanding the term *logistics*, and then understanding the difference between logistics and the supply chain in general. Furthermore, comprehension of logistics and the supply chain have been further extended into the context of construction.

First and foremost, in this part, are the factors (challenges) affecting construction logistics. The construction logistics challenges outcome in the literature review was expanded as background information providing a robust base for the interview and questionnaire (the data collection phases).

According to literature review, factors (challenges) affecting construction logistics including planning; transportation; transparency and information exchange; continuous improvement; health and safety; material preservation (preserving quality); inventory; and material handling. All of them with their sub-factors have considerably highlighted and justified in the previous discussion in this chapter. After that, participants throughout first data collection (semi-structured interviews) listed their construction logistics challenges as well. Consequently, all factors (challenges) points derived from literature review and semi–structured interviews have been divided into 35 questions to cover all points in the second data collection (questionnaire), where 150 respondents have stated their level of agreement for each one of them and allow the researcher to understand the effect of those factors (challenges) on the Jordanian construction logistics due to the holistic literature review provided in this area.

The outcome also offered the researcher an opportunity to add statistical tests, such as Kruskal Wallis and logistics regression tests, to facilitate the discovery of any differences amongst participants' (stakeholders') views based on their position (supplier, contractor, consultant). The results of differences among stakeholders' opinions were then critically compared with the substantial information gained by literature review, and a reliable conclusion shaped accordingly.

As the lean concept is vague for a few researchers, lean logistics shares the same concern, thus it was important to distinguish lean logistics from traditional logistics. This point contributes further information to this study, as the researcher then prioritized investigation regarding whether Jordanian construction logistics is lean logistics or traditional logistics. The outcome of this point determined the approaches of the overall research. Case studies regarding lean implementation in construction logistics also helped to prove to the extent to which lean could improve the construction logistics process.

Thus, information previously gained through literature review facilitated the building and analysis of the questions related to Jordanian lean logistics; and to indicate whether Jordanian construction logistics remains conventional, or not.

Consequently, the outcomes of the literature review and data collection phases were later used to build the final model by ISM.

Therefore, as the research is predominantly related to Jordanian construction industry, it was important to state the current position of lean logistics in Jordan. Regarding this point, the literature review outcome was inadequate, giving further justification to commence research within this field. Thus, the first and the second phases of data collection aimed to explore in-depth the current state of construction logistics in Jordan. So, this chapter strongly supported the formulation and development of questions in the data collection phases. Finally, this chapter clearly fulfilled the theoretical parts of the first and the second objectives including reviewing challenges (factors) affecting construction logistics within the construction industry; and success factors and difficulties of implementing lean tools and practices in global construction industry.

Chapter Three: Methodology

3.1 Introduction

In the first chapter the research background and gap were identified. The research aim, objectives, and the questions were also highlighted and explained. This chapter discusses the methodology adopted to achieve the aim and objectives. This research methodology adopts the research-onion model (Figure 3.1), which has been noted by Saunders et al. (2009). There are various layers in the model are clearly demonstrated in this chapter. The first layer signifies the research philosophy; the second represents the research approach; and the third embodies the strategy. Moreover, the fourth layer comprises research choices; the fifth layer concerns the time horizon; with the final layer representing data collection and analysis which are critically explained through this chapter. This chosen method by using research-onion model assists the researcher to understand, classify, and develop the research in a proper manner.

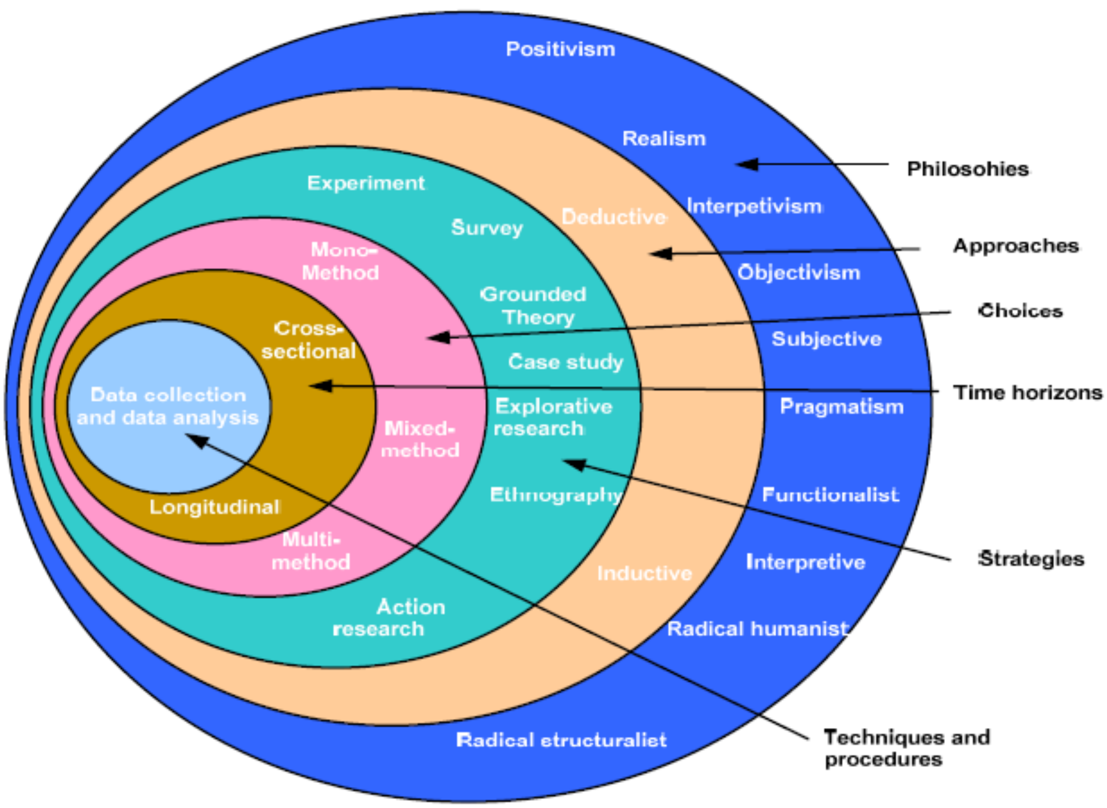


Figure 3.1: Research-Onion Model (Saunders et al., 2009).

Firstly, according to Cavalier (1990), the word "philosophy" is derived from Greek words meaning "the love of wisdom". The essence of philosophy is encapsulated by wisdom. It includes regarding questions, trying ideas, making interpretations, thinking about the workability of concepts, and thinking of possible arguments for positive and negative sides (Ruona, 2000). Furthermore, Honderich (1995) added that philosophy provides a framework of thinking, assists to develop capacities of thinking, and improves an arrangement between thinkable practices and practicable action. In the depths of philosophy meaning, Root (1993) noted that philosophy is a systematic checking of assumptions and common wisdom that emphasizes thought and action. According to Bohm (1994), in order to realize the possible usefulness of philosophy, a system of thought and action needs to be addressed. This philosophical knowledge claims to perform a set of essential assumptions related to the world, the individual's place in it, and relationships between the researcher and the world.

3.2 Research Philosophy

There is a minimum of three reasons for understanding the significance of philosophical matters for any research (Easterby-Smith et al., 2002). Firstly, it assists in shaping research designs. Secondly, knowledge of philosophy helps the researcher to distinguish which design is appropriate to implement. Thirdly, this knowledge helps the researcher to identify, and sometimes to create, a design previously unfeatured in researchers' experiences (ibid). Philosophy of research consists of three assumptions: epistemology, ontology, and axiology as shown in Table 3.1 (Sexton, 2003).

Table 3.1: Assumptions of research philosophy (Easterby-Smith et al., 2002).

Epistemology (The how?)	General set of assumptions about how we acquire and accept Knowledge about the world.
Ontology (The what?)	Assumptions that we make about the nature of reality
Axiology (The Why?)	Assumptions about the nature of values and the foundation of value judgments

3.2.1 Epistemology

This includes two main parts: positivism and social constructionism (interpretivism). Positivists claim that the world occurs externally and that its properties ought to be computed more by objective measures than subjective measures (Easterby-Smith et al., 2002). It considers a deductive approach and a conception of scientific method, which is emphasized by a belief that only that which is based in the observable world can be deemed valid knowledge. Travers (2001) added that positivists think that sociology should be part of a science and should apply quantitative methods in making logical connections among variables in the natural science way. It is founded on numeral representations of observations for the reason of depicting and illustrating the events. Positivism roots were launched at the end of nineteenth century as a victory of rationalism and science. It embraces interpretations derived from observed data, and the systematic and transparent use of data collection and analysis methods (Patton, 2002). The power of the positivism paradigm appears through focus on insight and clarity of views measured by a rigorously structured methodology. On the other hand, the weakness of positivism becomes manifest through its association with doubtful concepts, whereas true objectivity could be assessed and represented, especially for complex social and behavioral phenomena.

On the other hand, social constructionists believe that reality is not objective and external, but rather is socially constructed with meanings provided by individuals (Easterby-Smith et al., 2002). It implements a qualitative approach and gives an explanation as to how individuals realize their own acts (Travers, 2001). Therefore, interpretivists reject the positivist notion of knowledge being grounded in the tangible and objective, and seek to understand social reality by the views of those being examined. Moreover, theoretical assumptions of the interpretive paradigm and qualitative research are interdependent based on the concept that social reality is constructed and sustained by means of the subjective experiences of individuals engaged in communication. So, clearly the interpretive method (social constructivism) grasps that reality is socially created and determined through persons rather than by objective external factors. Contrary to positivism, social constructivism does not deem the world to involve an objective reality, but instead centres on subjective perception given meaning by the individuals involved (Easterby-Smith et al., 2008). The comparisons between the two epistemological paradigms are illustrated below in Table 3.2 (Easterby-smith et al, 2002).

Table 3.2: Contrasting implications of positivism and social constructionism (Easterby-smith et al, 2002)

	Positivism	Interpretivism (Social Constructionism)
The observer	Must be self-governing	Is part of what is being observed
People's concerns	Should be unrelated	Are the main drivers of the science
Clarifications	Must explain the causality	Intend to raise general understanding of the circumstances
Research progress throughout	Assumptions and derivation	Collecting significant data from which ideas are provoked
Notions	Are required to be under operation, they can be measured	Have to fit in stakeholder needs
Divisions of analysis	Should be decreased to the simplest provisions	Could comprise the complexity of the whole situation
Generality throughout	Numerical likelihood	Hypothetical concept
Sampling requires	Significant numbers chosen accidentally	Small numbers of cases chosen for specific causes

In this research, a mixed approach including both qualitative and quantitative is used (later explained in detail in "The Research Choices" section), thus a transition from interpretive values towards a positivist view occurred through integrating complex phenomena into the context. Firstly, the interpretivist stage can be clearly noticed throughout the qualitative phase which is the first data collection through interviews. Here the research highlights various perceptions as well as deep explanations; meaning the study began with the assumption of constructivism. Secondly, the positivist stage is clearly attended in the second data collection phase which is the questionnaire through hypotheses formations, causal relations between factors, quantitative method use, independency of research, researcher's objective measures and value-free interpretations. So, within this context, although the beginning of the research involves interpretivist philosophy, the major part of the research depends on the second data collection phase (questionnaire); thus the overall research stance requires a need to examine the positivism philosophy. Additionally, the transition from interview to questionnaire method matches the shift in essential philosophical assumptions from an interpretivist view towards a positivist view. The qualitative method is less structured with features of the research process subject to change in response to either information or events. It is mainly concerned with explaining experiences; discovering as well as clarifying the nature of a subject. The confirmatory part of the positivist view is underlined through gathering and analyzing data to test hypothesis; determining typical rules that apply to whole populations rather that limited clusters and so segregating the effect of any variable to reach a more profound understanding of statistical relations. Objectivity can be attained if different examiners agree on what was examined. Consequently, it can be significantly stated that the quantitative method shifted the research towards a positivist perception where variables are descriptively and statistically measured.

On the other hand, it is inevitable that the arguments surrounding epistemology and ontology have had a competitive ring to them. The argument is regularly outlined in terms of a choice between either positivism or interpretivism philosophy. Subsequently, in practice, choosing between one position or the other is fairly impractical and unrealistic. So, if this view occurred, then it would be best to adopt the position of pragmatist (Tashakkori and Teddlie, 1998). Moreover, pragmatism claims that the most vital determinant of the research philosophy is the research question adopted. One approach might be better than the other for answering specific questions. Additionally, if the research question does not clearly propose that either a positivist or interpretivist philosophy is adopted, then this approves the pragmatist's view, meaning that it is absolutely feasible to work with both philosophies. As this research is considered interpretivist moving towards positivist, it is acceptable to undertake the pragmatist view.

3.2.2 Ontology

Ontological assumption, or assumptions made about the reality of nature, is another significant feature within research philosophy. Ontological assumptions include two aspects: realism and idealism. Idealism assumes that the external world does not have a predetermined nature or structure. In contrast, realism assumes that the external world has a predetermined nature or structure (Gummesson, 2000). Realist (nomothetic) methodologies build research on systematic techniques and protocols, whilst in the main testing hypothesis (Gill and Johnson, 2002). On the other hand, idealism (ideographic) methodologies emphasize analysis of subjective matters through participation in everyday activities. The differences between the two methodologies are shown in the table below.

Table 3.3: The distinctions among Realism and Idealism (Gill and Johnson, 2002)

Realism	**Idealism**
Deduction	Induction
Clarification by analysis of casual relations	Clarification of subject meaning systems and description through understanding
Quantitative data use	Qualitative data use
Use of various controls, statistical or physical, thus as to permit the testing of hypothesis	Commitment to research in daily sets, to allow access to and diminish reactivity between research subjects
Extremely structured research methodologies to confirm the above 1,2,3 and 4	Reduce structure research methodologies to ensure above 2,3 and 4

In this research, the development process of the model was based mainly upon the formulation of hypotheses that were then empirically verified throughout the research phases which were constructed mostly through the quantitative method and explained the casual relationships using a variety of tests. Also, a large sample of questionnaires were examined where the researcher could not be a part of the area being observed; thus inclining towards the realism approach rather than getting involved in everyday activities, where flow of perceptions and thoughts would be viewed as idealism. Furthermore, the large questionnaire sample provided better understanding regarding the construction logistics process and lean opportunities in Jordanian construction and is facilitated by positivism stance. Accordingly, based on the above reasons, it can be stated that for this research positivism and realism stances are preferable to interpretivism and idealism stances.

3.2.3 Axiology

This is the third feature of research philosophy that must be discussed. Axiology concerns an assumption about the value that the researcher appends to the knowledge. Positivist research, deductive, objective preferences and quantitative nature are dependent on formulating the research hypothesis and verifying it in an empirical manner on a particular set of data known as value-free research (Nachmias and Nachmias, 1996). Additionally, researchers' own values, biases and subjective preferences have no place in testing these hypotheses. Thus, researchers note the communication process as tangible and concrete as well as analysing it without involving actual individuals who participated in communication (Sapsford and Jupp, 2006). On the other hand, interpretivism (social constructionism) proposes research as value-laden, where there is a clear interrelationship between the researcher and the subject of exploration. Human interpretation plays a significant role in determining what exists in the human and social world (Healy and Perry, 2000). Consequently, if the research is determined by objective criteria, it will be a value-free research. Conversely, if the research is determined by subjective criteria, human beliefs, and experience, it will be a value-laden research (Easterby-Smith *et al*, 2002).

In terms of axiology this research adopts a value-free stance. This is due to the nature of the research requiring an empirical set of data where the researcher's own values, subjective preferences, and biases have no place in verifying research hypotheses; unlike a value-laden stance which relying upon individuals' thoughts and experience.

In summary of research philosophical considerations, according to all relevant aspects previously discussed along with the above evidence, it seems clear that this research tends towards positivism rather than interpretivism in terms of epistemology, realism in terms of ontology, and in terms of axiology adopts value-free stances.

3.3 Research Approach

Choosing the research approach is significantly important to meet the research aim and objectives. Inductive and deductive are the two major methodological approaches (Saunders et al., 2009). The deductive approach implies an inquiry into an identified problem based on testing a theory. It moves from theoretical base to empirical examination (ibid). Conversely, the inductive approach builds a theory starting from empirical examination (Yin, 2003). The differences between the approaches are as follows:

Table 3.4: Differences between deductive and inductive approaches (Saunders et al., 2009)

Deduction	Induction
Scientific principles	Gaining an understanding of the meanings humans assign to incidents
Starting from theory to data	A proper understanding of research background
The need to clarify fundamental relations between variables	Mostly, the collection of qualitative data
Mostly, the collection of quantitative data	Flexible structure to allow changes in research emphasis as the research proceeds

The application of controls to guarantee the validity of the data	A realization that the researcher is considered a part of research procedures
The operationalization of concepts to guarantee definition clearness	Less worry with the demand to generalize.
Highly structured approach	
Researcher is independent of what is being investigated	
The need to choose samples of adequate size to generalize a conclusion	

To entirely isolate inductive and deductive within a research project is not easy. Thus, Saunders et al. (2007) stated that a combination of research methods could be applicable to fulfil specific research goals. The nature of the research plays a significant role in choosing a suitable approach. It seems that mixing both approaches throughout the conducted research study leads to further benefits as most social research is considered both deductive and inductive (ibid). Subsequently, the nature of this particular research tends to combine both approaches. Additionally, Trochim (2006) explained that deductive research is linked with the positivist paradigm in what is called a top-down approach which descends from theory, hypothesis, observation, and then to confirmation. It is considered a fact-centred and confirmatory approach. Inductive research is associated with the interpretive paradigm in what is called the bottom-up approach which ascends from observation, pattern, tentative hypothesis, and then to final theory. It considers exploration of manners, thoughts and adopts an open-ended approach. Additionally, it is not controlled with a pre-determined group of hypotheses (ibid).

In this research, and based on the above information, both approaches were presented throughout the study. As deductive reasoning employs general principles to grasp specific conclusions, inductive reasoning observes specific observation, to gain a general principle. This research initially collected observations in regards to construction logistics and lean opportunities in the Jordanian construction industry (area of interest) to address hypothesis, which is considered an inductive approach. The area of interest was then extensively expanded and theories were established with regards to that area. Specific hypotheses were then developed by summarizing all logistics and lean research comprised from descriptive and statistical tests, reflecting a deductive approach. Consequently, the trends of inductive and deductive approaches throughout the research processes are clearly detectable.

Furthermore, reproductive (abductive) is meant to cover both practical reasoning and scientific inquiry, and can include characterizations in terms of inductive and deductive modes (Svennevig, 2001). As this research contains both inductive and deductive approaches, it can be stated that abductive (reproductive) also seems to be a proper depiction for the research approach.

3.4 The Research Choices

There are varieties of choices when collecting data. Saunders *et al*. (2009) mentioned two main choices that may be utilized. The first choice is the mono-method where research is obtained in a single data collection, either quantitatively or qualitatively. The second method combines both qualitative and quantitative methods. According to Saunders et al. (2009), multiple methods are divided into:

1. Mixed method: it uses both quantitative and qualitative data collection and analysis processes, either at the same time or sequentially. It is divided into mixed method research and mixed model research. The first type (mixed method) is when research applies quantitative and qualitative data collection techniques and analysis procedures either at the same time (parallel) or sequentially, but does not combine them. It means that quantitative data are analyzed quantitatively and qualitative data analyzed qualitatively. The second type (mixed-model research) combines quantitative and qualitative data collection techniques and analysis procedures as well as quantitative and qualitative data approaches from other phases of the research.
2. Multi-method: which is divided into multi-method quantitative studies and multi-methods qualitative studies. In this method more than one data sample is collected and then analyzed with the related analysis processes, restricted to either the quantitative or qualitative way. For instance, if researcher prefers selecting quantitative data using (multi-method quantitative study), interviews and questionnaire will be analyzed using quantitative procedures (statistical). Instead, if the researcher prefers selecting qualitative data using (multi-method qualitative study), so data will be analyzed using qualitative procedures (non-numerical).

There are significant benefits of using multiple methods, as follows (Tashakkorl and Teddlie 2003; Fellows and Liu, 2009; Powell *et al*., 2008):

1. There are suitable methods to properly fulfill the research gap, as well as gaining the research outcome a sufficient acceptance for drawing conclusion and recommendation.

2. Using more than one method (qualitative and quantitative) provides trust in the gained outcome and offers further confidence to the researcher with regards to addressing the research problem.

3. Adopting both quantitative and qualitative methods increases the advantages associated with both methods, as well as decreasing the disadvantages from both methods. Each disadvantage from the first method can be mitigated through adopting the second method. The two tables (3.5, 3.6) show the main advantages and disadvantages between qualitative and quantitative strategies, as well as the distinctions between qualitative and quantitative.

Table 3.5: Advantages and disadvantages of qualitative and quantitative strategies (Easterby-Smith et al., 2002)

	Quantitative strategy	Qualitative strategy
Advantages	Can offer wide coverage for a range of settings	Data collecting methods are perceived as natural rather than artificial
	Mainly economical and fast	Has an ability to express at the change process over time.
	Can be of significant relevance to policy decisions where statistics are combined from large samples	Ability to comprehend people's meaning
		Ability to amend to new ideas issues as they occur
		Subsidizes to theory generation
Disadvantages	They are not very applicable in understanding processes or the implication that people assign to any action	Data collection could be uninteresting and demand additional resources
	They are not very valuable in creating theories	Interpretation and analysis of the data may not be easy

	The methods used tend to be quite artificial and inflexible	Harder to control the pace, progress and end-points of the research process
		Policy-makers may offer low trustworthiness to outcome obtained through qualitative approach

3.4.1 The Adopted Research Choices

Based on the previous information, in order to satisfactorily address the research gap and to fulfill the research aim and objectives, adopting mixed methods appears to be the best research choice. Thus, in this case, the utilization of both qualitative and quantitative aspects was deemed the most suitable choice. Accordingly, semi-structured interviews (quantitative method) followed by content analysis (qualitative: non-numerical) served not only to enrich the research justification and evidence so providing further knowledge in regards to Jordanian construction logistics and the exploration of lean opportunities in Jordanian construction, but to then finally contribute to the formulation of the questionnaire form. Afterwards, the questionnaire (quantitative method) was widely distributed throughout the construction industry with main Jordanian logistics stakeholders (contractor, architect [designer], supplier) participating in this approach. Furthermore, descriptive and statistics analysis have been utilized to dig in-depth to answer all research questions and fulfilling the research aim. The next section discusses in further detail both the quantitative and qualitative methods (mixed methods).

3.5 Research Strategy

There are several research strategies that can be used in the primary research. The research can use either qualitative or quantitative strategies, or a mix of both (Saunders et al., 2009). This research employs a qualitative strategy in the first phase and a quantitative strategy in the second phase.

3.5.1 Qualitative

Qualitative methods are used to describe the phenomena about which little is known, to capture meaning. It is based on the individuals' thoughts, behaviours, feelings, etc. (Mayan, 2001).

3.5.1.1 Case Study

In order to provide a deep investigation or validation of the research subject this method uses observations, interviews, the focus group, documents, and records (Yin, 2003). According to Neville (2005), there are four types of research:

1. Exploratory research: used when the number of previous studies is inadequate, where hypotheses are found and can be tested to build a new knowledge.
2. Descriptive research: performed with the intention of identifying and classifying the aspects or features of the subject.
3. Analytical research: broadens the descriptive research and adds the questions of "why?" and "how?" something is happening. Analytical research tries to discover the causes of a situation.
4. Predictive research: close analysis of available evidence of cause and effect is undertaken for the purpose of predicting future probabilities of a situation.

In line with these definitions, it is noteworthy to state at this point that this research is considered exploratory research. As the definition of the exploratory research implies, this type of research generates when existing knowledge or practice is inadequate. Furthermore, Naoum (1998) noted that the explanatory case study deals with a theoretical approach to the problem by attempting to find the causality and the relationships between the objectives of the study.

According to Kitzinger (1995), the focus group is a form of group interview that capitalizes on communication between the researcher and other participants in order to produce data. It uses group interaction as a part of the method. Instead of asking each participant individually, a focus group study gathers the participating experts in one discussion, which considerably assists in sharing experiences and exploring and clarifying views so as to achieve the objective in the best way.

3.5.1.2 Action Research

An action research project is defined as “the method which aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by collaboration within a mutually acceptable ethical framework” (Jarvinen, 2007). Furthermore, action research projects are considered a design research approach, both have similar characteristics: the action researcher and the client are keen to engage in collaboration as they are mutually dependent on each other’s experiences, skills and competences to accomplish problem-solving and knowledge increase (ibid). Therefore, design research and action research provide alternative methods to improve the level of performance practically (Koskela, 2008). According to Gummesson (2000), an action research project gives a full understanding of the immediate circumstance by highlighting the complex nature of the projects, thus not approaching the situation with a vague view. Furthermore, it can use both quantitative and qualitative strategies (interviews, observation, and questionnaire) to assist in developing a holistic understanding about the project and providing the required improvement. Winter (1987) noted that in most research studies the investigator is separated and usually does not interfere with the subject being examined. In contrast, action research gives the investigator the ability to be thoroughly involved in process planning, work to introduce change and subsequently evaluate the result. The level of involvement can be controlled to determine the level of change, whether desirable or not. Therefore, the interference of the investigator in action research plays a significant role in this strategy. According to Hales and Chakravorty (2006), there are two fundamental benefits of action research:

1. It gains a substantial explanation about how and why the event occurred, otherwise difficult to explain by statistical models.
2. Action research projects analyse the problem in natural settings, which would be hard, costly, and unfeasible in a lab experiment.

It could be stated that action research requires the researcher to work for long periods of time and to deal with companies who align their attitude with research procedures - offering full access to needed data, encouraging managers, engineers, and workers to cooperate with the researcher. Although, most companies and organizations do not simply offer this service, particularly when the researcher is not a staff member.

3.5.1.3 Ethnography

According to Gilbert (2008), ethnographic research demands spending long periods of time amongst a group or organization, and places a certain emphasis on the group culture. Over a prolonged period the researcher engages him/herself with a specific group and asks questions, conducts interviews, observes manners, and understands and analyses discussion amongst employees (Bryman, 2008). So, quite obviously, ethnography is a strategy governed by the availability of a capable work group engaged in research over a prolonged period of time.

3.5.1.4 Grounded Theory

In this strategy, data is collected without any theoretical framework, no theoretical framework exists prior to the data collection procedure (Partington, 2000). Theories are therefore derived from the collected data, after which conclusions are formed before being tested. Action research and ethnography are different from grounded theory as they are deeply rooted in social science and allow the researcher to interfere in the research subject (Berg, 2004). Application of grounded theory within commercial organizations is not easy due to difficulty in gaining full access to data, unlike in health and educational systems where access is flexible. Grounded theory is thus better developed within those systems (Easter-Smith *et al,* 2008). Documents, observations, interviews, historical records, videotape, as well as any suitable method are used in grounded theory to fulfill the research gap (Bryman, 2008). Quite obviously, as mentioned above, application of this strategy requires lengthy periods of time and a specific work environment.

3.5.1.5 Content Analysis

According to Holsi (1969), content analysis is a technique for making inferences by objectively and systematically identifying specified characteristics of messages. Furthermore, objectively means that there must be transparency concerning the procedure used and personal biases should be minimised; whereas systematically means that the rules are applied in a consistent manner.

Earlier definitions of content analysis were associated with the component of quantification. Content analysis attempts to characterise meanings within a given body of discussion in an organised and quantitative fashion (Kaplan, 1943, p: 230, cited in Franzosi, 2004).

The Bureau of Justice Assistance (2006) offers another definition of content analysis as "a set of procedures for collecting and organising non-structured information into a standardised format, which facilitates the making of inferences about the characteristics and meaning of written or recorded material". Moreover, content analysis can be used to analyse qualitative or quantitative data. Visual and printed data such as field notes, interview transcripts, newspapers and media material can be analysed (Krippendorff, 2004). Nowadays, content analysis has become increasingly important in the analysis of qualitative data as researchers are able to analyse large amounts of textual information and systematically identify properties such as key word frequency and underlying concepts, arriving later at conclusions (ibid). Therefore, in this manner, content analysis is used to uncover and analyse a textual data set logically. Writing full scripts and establishing codes and categories with content analysis makes for a rich and meaningful tool, as coding is considered the heart of textual analysis. Additionally, texts are scrutinised for the existence of concepts or themes linked with each code (Stemler, 2001). The significance of coding relies not on proliferation but on reducing the data set; codes need to be manageable and of a reasonable number (Bernard, 2000). Furthermore, identifying an explicit concept is clear and straightforward; whereas capturing an implicit terms related to a concept must be carefully done as it could affect the reliability and validity of the data (Krippendorff, 2004). This kind of data analysis is suitable for much research, particularly exploratory or discovery research (Bernard, 2000). However, there is little information regarding categories. Krippendorff (2004) stated that establishing categories is defined as an art, and in that regard little is written. According to kulatunga et al. (2007) content analysis has five steps:

1. Researcher becomes familiar with the data set,
2. Initial coding,
3. Search for concepts/themes from the dataset,
4. Assign the codes, and
5. Review concepts/themes and codes.

With regards to the philosophy aspect, content analysis is considered a value-laden interpretivist stance (Krippendorff, 2004). Furthermore, coding can be divided into inductive and deductive coding (Bernard, 2000). Called pre-established code, deductive coding is derived from literature review and is suitable for conducting well-organised data analysis and for the confirmatory stage. On the other hand, inductive coding, called emerged code, is derived from the data set and the researcher's own experience during the study. Additionally, use of codes lies in inductive or deductive (ibid). However, some codes can be pre-established from literature and can also be found through text, this approach is called abductive (Miles and Huberman, 1994). Validity, reliability, and objectivity are criteria used to evaluate the quality of research in the conventional positivist research paradigm. As an interpretive method, qualitative content analysis differs from the positivist tradition in its fundamental assumptions. Recognising this gap, four criteria have been proposed for evaluating interpretive research work: credibility, transferability, dependability, and conformability (Zhang and Wildemuth, 2009). Furthermore, the quality of a study in each paradigm should be judged by its own paradigm's terms. For example, while the terms reliability and validity are essential criteria for quality in quantitative paradigms, in qualitative paradigms the terms credibility, neutrality or conformability, consistency or dependability, and applicability or transferability, are to be the essential criteria for quality and collectively called trustworthiness (Golafshani, 2003). Finally, content analysis is applied through phase one (interviews), and extensive information regarding content analysis is included in the data collection chapter which follows.

3.5.2 Quantitative

Quantitative methods identify the problem by testing the theory using numbers, and conduct analysis through statistical techniques (Fellow and Liu, 2008). The most common approaches for the quantitative strategy are surveys and experiments, as shown below:

3.5.2.1 Surveys

Surveys gather useful data about personal experiences, behaviour, values and attitudes. Questionnaires are one of the main methods used in surveys. In this research, a questionnaire will be implemented in phase two where all questions are based on a comprehensive literature review and phase one interviews. Questionnaire design is a critical and significant aspect of research due to the risk of misleading results if research is undertaken in an inappropriate way (Babbie, 1990). Furthermore, following a thorough literature review, a sequentially ordered set of apt questions must be formulated as part of the research to provide the required data for problem identification. Moreover, questions need to provide rigorous information that can be used to undertake suitable analysis (ibid). For that reason, a pilot study will be carried out on the first draft of the questionnaire (see appendix), in which university doctors, construction professionals, and experts in construction logistics will be participating in order to refine the questions. In addition, brainstorming sessions will be held with PhD students to gain the best possible result and consequently achieve the final refined questionnaire draft.

According to Oppenheim (2000), structured and unstructured questionnaires are the two most frequently used kinds of questionnaires. Structured questionnaires consist of pre-coded questions including well-defined skipping patterns to follow the sequence of questions. In carrying out structured questionnaires, management of the data is considered easier and answers are more consistent. Survey type questions have five main categories: open-ended, closed-ended, partial-open-ended, scaled, and ranking (Instructional Assessment Resources, 2007). This research has adopted closed-ended, partial-open-ended, and scaled questions due to the nature of the research scope. Therefore, the questionnaire is considered a structured questionnaire. However, it is worth mentioning that scaled type questions dominated the conducted questionnaire, as it seeks to determine the degree of a response/opinion.

The degree of response is very significant, as obtaining precise and accurate answers will lead to the building of a reliable strategy. Moreover, stakeholders (respondents) will be divided into consultant, contractor, or supplier. Each one of these stakeholders will be asked about his view regarding the current situation of the logistics process in Jordanian construction, his level of agreement about factors affecting Jordanian construction logistics, and lean implementation opportunities in Jordanian construction (see appendix). Furthermore, collection will be done on the same day and eliminates the need for a follow-up. The rate of response is a significant parameter in questionnaire-based data collection methods; higher response rates enhance the accuracy of the survey (Rea and Parker, 1997). Therefore, this point will be taken seriously when distributing the questionnaire. In addition, the refined questionnaire will be translated into an Arabic language to make it easy for all stakeholders to understand, which results in an increase in the accuracy of the answers. The analysis of the questionnaire answers was done by using the SPSS program (statistical analysis in social science).

3.5.2.2 Experiment

An experiment is conducted by taking a sample of the population within a controlled environment to examine whether there is a causal relationship between the variables under investigation (Fellow and Liu, 2008).

At this stage, after explaining the qualitative and quantitative strategies, it is suitable to reveal the linkage between the philosophical considerations and the research strategies in one scope. Sexton (2003), illustrates in Figure 3.2 how the research strategies can be positioned within the epistemological, ontological and axiological continuums. We can see how experiments, surveys, and relative case studies are governed by positivist, realist, and value-free stances; whereas action research and ethnographic approaches lean towards interpretivism, idealism and value-laden stances. As overall this research leans mostly towards positivist, realistic and value-free stances, so interviews and questionnaire appear to present the proper options to employ.

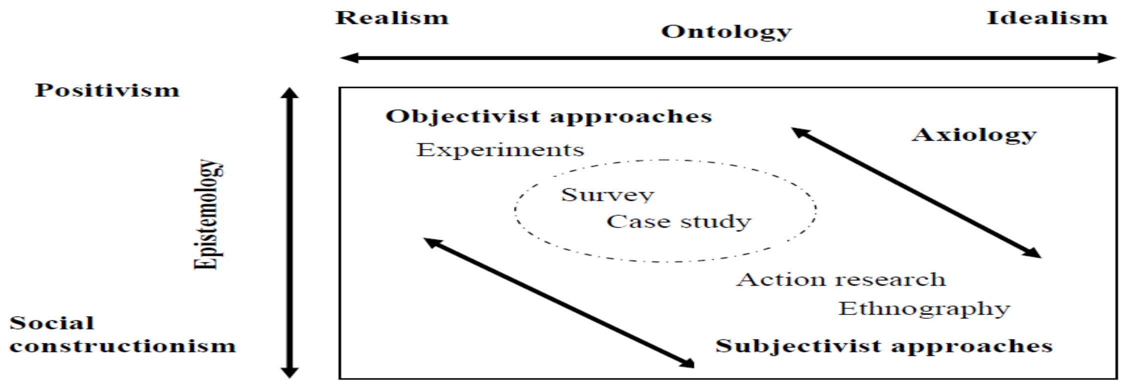


Figure 3.2: Continuum of research approaches (adopted from Sexton, 2003)

Subsequently, it is also appropriate at the instant to remark the differences between the qualitative and quantitative data, mentioned by Hair et al. (2009) as shown in Table 3.6.

Table 3.6: The differences among qualitative and quantitative data (Hair et al., 2009)

Qualitative data	Quantitative data
Centered on meanings conveyed by words	Centered on meaning originated from members
Collecting outcomes in non-standardized data demanding classification into categories	Collecting outcomes in standardized data and numerical
Analysis directed by conceptualization use	Analysis directed by statistics and diagram use

3.5.3 The Adopted Research Strategies

The associated advantages and disadvantages of the interview (a qualitative strategy) and questionnaire (a quantitative strategy) have been mentioned previously. In order to exploit the advantages and overcome the disadvantages of both the interview and questionnaire, combing both techniques becomes the obvious strategy choice, if research questions and aims are to be properly addressed and fulfilled.

Being defined as study 'in the field' and capturing social meaning, other strategies such as action research or ethnographic research are disqualified from suitability for this study. With these types of research the researcher must work every day, and be thoroughly involved in the settings, if not the activities to collect data comprise a systematic manner (Brewer, 2004). Furthermore, both of these latterly mentioned methods require considerable time periods (Burns, 2000), which renders them in this case inapplicable due to the strict time limit of this research.

3.6 Time horizon

For any research the time horizon can be either cross-sectional or longitudinal (Saunders et al., 2009). Due to the time limit of the PhD period, this research is considered a cross-sectional study.

3.7 Data Collection and Analysis

3.7.1 Data Types

In this research study, there are two main types of data. The first type is secondary data and the second is primary data.

1. Secondary data: is the previously gathered for reasons other than the problem at hand. Basically, secondary data is the data already completed by other researchers using different method. Secondary data is found mainly through journals, including e-journals, books (e-books), as well as official websites (Malhotra and Briks, 2007). So, secondary data forms the base of any research that a researcher needs to deliver a comprehensive understanding and awareness in regards to his subject. The research problems can be basically clarified through different faces and views by secondary data. Hollenson and Schmidt (2006), mentioned that the most positive points of secondary data are easy accessibility, quick obtainability, and inexpensiveness - especially for the researcher who may have free access to secondary data sources through a library (e-library). Secondary data is vital for the researcher to commence his research and helps in understanding the subject, producing hypothesis, building an answer (models) for the research problem, as well as answering research questions. In this research, all secondary data types have been utilized to enrich the research and include books, journals, official websites, previous case studies, and theses. Secondary data has been used in all chapters, but most significantly to build the literature review chapter, which includes lean and logistics theoretical sections, more particularly, factors (challenges) affecting the construction logistics process in Jordan which have been compared with the findings. Consequently, we could strongly

state that secondary data exerts positive effects in developing, assessing and refining both the logistics process in the Jordanian construction model and the lean planning and practices models.

2. Primary data: is defined as data invented by the researcher himself by exploiting certain methods to address the research gap (Malhotra and Birks, 2007). Primary data is indeed required to answer the research questions, accomplish the research aim and achieving all research objectives. As previously mention in the research strategies discussion, there are many ways to collect data. Each individual research study has a unique situation, and the researcher must find the best strategies for the research sake.

3.7.2 Types of Variables

Field (2013) stated that variables could be either dependent or independent variables. Two tests can be implemented either parametric or non-parametric test. Furthermore, according to Field, the measurement of variables is divided as follows:

- Categorical Variable:
  A. Binary variable that includes two categories, in other words, it just takes two values such as dead or alive, true or false, and so on.
  B. Nominal variable that includes more than two chooses without having natural order.
  C. An ordinal variable that has logical categorical order such as asking about the score on a scale of one to five, where one means the lowest and five means the highest score.

- Continuous Variables:
  A. Interval variable that includes equal interval or equal differences between choices.
  B. Ratio variable that is the same as the interval variable, but based on ratio form, although ratio variables must express logic when comparing with each other.

So, several types of variables can be used when forming a questionnaire.

In this research, variables are essentially categorical, and are firstly divided into dependent and independent variables. The researcher within the first part of the questionnaire manipulates independent variables that are stakeholders types: contractor, designer (consultant), or supplier.

In the third part of the questionnaire the dependent variables are questions. The last part of the questionnaire is measured on the 5 points Likert Scale and includes: the level of participants' agreement with regards to factors (challenges) affecting construction logistics in Jordan; the level of participants' agreement in exploiting lean planning tools and practices; and the level of participants' agreement regarding lean drivers and lean barriers. These questionnaire parts (the third to the last) are consider ordinal and non-parametric, due to the Likert Scale use (Field, 2013).

3.7.3 Data Collection and Analysis procedures

Commencement of the data collection began by applying a semi-structured interview to extensively identify and investigate construction logistics and lean opportunities within the context of Jordanian construction. Thus, further knowledge related to the topic was gained, and assisted in forming the questionnaire. Next, to confirm the first phase and to descriptively and statistically test the outcome, the questionnaire was distributed throughout a large sample. The validation was conducted using ISM (Interpretive Structural Modelling) through focus group meeting, where a group of experts were gathered. So, the variety of adopted research strategies provides sturdy, reliable and confident results. By using these diverse strategies, the outcomes can be seen from various angles and viewpoints. Each adopted strategy is discussed below in further detail.

1. <u>Semi-Structured Interviews:</u>

The semi-structured interview is one of the methods of data collection in which participants are chosen based on their knowledge and experience in relation to the discussed problem. In this instance, those participants gave their views in terms of Jordanian construction logistics and lean opportunities in Jordan. Each interview lasted for around an hour and a half, with time and location pinpointed in advance. Most interviews were recorded based on interviewees' approval, then information given was written up directly, after which all written forms were returned to each interviewee to check the accuracy of the information. For confidentiality and privacy purposes the interviewees were documented anonymous in the research. Moreover, some body language and reactions made through emphasizing or denying certain points were noted and added to the interview discussion. According to (Fellow and Liu, 2008), there are three types interview, the first is the structured interview, the second is the semi-structured interview, and the third is the unstructured interview. The main difference between them is based on the extent to which questions are designed beforehand, where structured interview are planned questions and unstructured interview are unplanned questions. The primary benefit of structured interviews is increased reliability and validity. Unstructured interviews do not have planned questions, and so the interviewer needs to exercise caution to avoid losing the discussion and time. However, any unpredicted point arising throughout an unstructured interview can be explored, shifting the discussion to a new and unprecedented area. To achieving the best outcome through this data collection phase, semi- structured interviews based on prepared questions were conducted to discuss each part separately, as well as allowing unexpected points to emerge and add much valuable information relative to the study. Subsequently, the semi-structured interview seems appropriate for this research and exploring in-depth all needed information.

A well-defined sampling strategy offers a sturdy and unbiased outcome. The research sample was properly chosen for the purpose of gaining valuable data and obtaining maximum value. Nine interviews were conducted in universities and a variety of organizations including contracting, engineering, and supplying companies. The nine interviewees in the first data collection (phase one) include all Jordanian construction stakeholders: client, contractor, sub-contractor, supplier, and academic. The variety of participating interviewees enriches the data collection (phase one) and garners a deep understanding regarding the subject. This phase also supports the rationale and significance of the logistics process in Jordan, as there are few studies or citations regarding this topic. The number of interviews was not determined beforehand, but rather the researcher decided to continue to hold interviews and dig in-depth until interviewees offered no further additional information of value. Each interviewee was given a consent form to sign, and they had the option to withdraw at any point during the interview. The interviews discussed four main pillars commencing with the current situation of logistics in Jordanian construction and reasons for improvements. The next subject for discussion was challenges (factors) affecting construction logistics in Jordan, followed by the topic of the drivers and barriers for implementing lean in Jordanian construction industry. Throughout the data collection and analysis of phase one (semi-structured interviews) the five previously mentioned steps of content analysis were implemented, and information provided within phase one was then utilized for design of the second phase (questionnaire).

2. <u>Questionnaire:</u>

The questionnaire as a quantitative method was used in this research for the second data collection (phase two). A broad range of participants with different experiences and positions from a variety of companies contributed through participation. Such diversity assisted in grouping all variables and ranking all factors (challenges) affecting logistics and lean variables. A self-administered questionnaire was used. Half the questionnaire forms were distributed via internet methods (emails, social media), whilst the remaining half were sent directly to companies to distribute to amongst staff, utilizing the snowball technique (Saunders et al., 2009). Oppenheim (2000), emphasised that the snowball technique is commonly applied when collecting quantitative data in social science surveys because it ensures accurate sampling, no interviewer bias, and is low cost. All completed forms are afterwards collected.

The questionnaire method is the method dominantly used in social science due to the low level of bias as well as the high response level (Oppenheim, 2000). The distributed questionnaire forms numbered two hundred. One hundred and fifty were completely filled by participants.

The questionnaire form was split into seven sections: respondent background, current situation of logistic process in Jordanian construction industry, factors (challenges) affecting construction logistics in Jordan, lean planning tools, lean practices, lean drivers, and finally lean barriers. The questionnaire questions were designed in clear and simple language, and attached to each English form was an official Arabic translated form.

The first section of the questionnaire related to general information about participants' experience, position, education, and their type of organization. All gathered information helped the researcher to understand the participating sample and connect answers to the research outcome. The second and third sections extensively discussed the dilemma situation (challenges affecting Jordanian construction logistics), where statements are ranked based on the contributors' assessments. Subsequently, the implications of implementing lean are derived through the last sections.

Participants' views and visions were measured using Likert Scale (five points: strongly disagree, disagree, neutral, agree, strongly agree). The Likert Scale uses statements through questionnaire accompanied by pre-coded categories, one of which is chosen by the participant to show their level of agreement or disagreement (Hair *et al*., 2009). Furthermore, it seems the five options of the Likert Scale are less threating for participants than declaring that they may not know something. This scale allowed the researcher to determine and evaluate logistics challenges, lean planning tools and practices usage, and opportunities for lean (drivers and barriers) in Jordanian construction logistics, all of which were previously identified through literature review and semi-structured interviews (phase one). The outcome of the questionnaire yielded the following: descriptive data for all questionnaire sections regarding construction logistics parts and lean parts, where all responses were represented by percentages; then factor analysis for challenges affecting construction logistics was applied to group sub-factors (statements) into main eight groups; the Kruskal–Wallis Test and logistics regression were then applied within the challenges affecting construction logistics (the eight group) and lean planning tools and practices in order to predict stakeholders affected by those features.

3. <u>ISM:</u>

Interpretive Structural Modelling (ISM) is an approach to identify, explore, and then summarize all correlations among factors (variables) where a research gap is identified throughout the ISM process (Sage, 1977). A focus group helps create a large amount of data in short time, particularly when participants discuss an issue concurrently (Green et al., 2003). Accordingly, holding a focus group of nine experts who are professionals in Jordanian construction logistics was applied to organize and classify all variables throughout ISM. The methodology of ISM is explained as follows: firstly, clarifying variables for the focus group; secondly, variables are arranged and listed; thirdly, a Structural Self-Interaction Matrix (SSIM) is used to create correlations between variables; fourthly, a reachability matrix is prepared by SSIM; finally, a reachability set, an antecedents set and an intersection set are constructed form the previous point, then ISM are drawn. In this research there are three ISM models to fulfill the aim and objectives. The first indicates the challenges affecting construction logistics; the second indicates lean planning tools, while the third indicates the lean practices model. Furthermore, ISM models were proposed to evaluate and validate the resultant outcome through the data collection phases. Further information with significant details relating to ISM and the associated methodology are extensively discussed in the validation chapter (chapter seven). Figure 3.3, placed towards the end of this chapter, shows the holistic research plan for this research.

3.7.4 Pilot Study

Pilot study is defined as a data collection technique implemented upon special participants prior to conducting the main study (Saunders et al., 2009). After forming the final draft of the questionnaire, based on literature review and interviews answers, the pilot study was applied prior to wider use for collecting data. Considered a pre-testing procedure, the pilot study is used mainly to indicate the strengths and weaknesses of the questions, besides helping remove any probable unclear points or ambiguity relating to the subject layout or the questions. So, the pilot study is a small-scale test made before implementing a wider scale test, and aims to eliminate in the early stages any potential difficulties in survey or interview prior to the main data collection (Saunders et al., 2007). For this research a pilot study was vital as the researcher adopted a self-completion questionnaire. Several participants from different universities including The University of Salford participated in the pilot study. The participant group comprised seven PhD students and three academic staff, all of whom are familiar with the topic at hand. Each of them was asked to signify their views regarding several themes mentioned by Bryman and Bill (2007) including clarity of instructions, the clarity of questions, superfluous questions, possible alteration of questions, and finally the time needed to complete the questionnaire. Consequently, the original questionnaire was simplified with valuable changes made in overall structure and to certain questions based on participants' feedback.

3.7.5 Ethical Issues

Collecting data is connected with ethical issues, particularly in relation to the rights of respondents participating in the research. Ethical issues are usually concerned with participants' voluntary and informed consent, confidentially and anonymity, as well as any risk associated with the research.

Firstly, an introduction about the research subject and purposes of the data collection parts (interviews or questionnaire) were explained to the participants. All research questions are related to the topic, and there were no personal or peculiar questions. In terms of voluntary disclosure, there was no pressure on any participant to contribute during the research data collection. Additionally, participants had the option to either continue throughout the data collection parts (interviews and questionnaire) or withdraw at any time. Thus, the researcher offered respondents full freedom of choice to either participate in the interview and questionnaire, or to leave without mandatory response. Furthermore, participants' privacy and anonymity (in interviews) was granted serious consideration, as the researcher kept participants' information and answers confidential and available only to those directly involved in the research. Also, participants could review the research outcome if desiring to avoid perceived future risk. However, in questionnaire part, participants’ identities were unknown even to the researcher. Consequently, prior to data collection phases, an ethical approval form was filled for sanction by a governance and ethics committee at The University of Salford (see appendix), thus the form has dealt with the ethical issues that explained above.

3.7.6 Validity and Reliability

Validity and reliability are significant elements of research development and grant necessary quality to the study. The perception of validity and reliability becomes necessary during the data collection and analysis stages. Reliability relates to data consistency and dependability, while validity is concerned with the accuracy and truthfulness of findings (Saunders and Lewis, 2012; Bryman and Bill, 2007). In this research, semi-structured interviews and then questionnaire were conducted to increase quality related to validity and reliability of the research study level.

3.7.6.1 Validity and Reliability (Qualitative Method)

Dependability: concentrates on the outcome being coherent with collected data (Patton, 2002). Thus, the outcome reflects the method of the research which other researcher can then assess in terms of how far they constitute trustworthy methods and practical decisions. Therefore, all methods are properly defined based on onion-model in further details, as shown in Figure 3.3.

Conformability: indicates to what extent the collected data considers bias. Collected data must be free from bias based on the researcher’s view (Denscombe, 1998). In this research, the variety of methods used provides a sturdy indication of the outcome conformability. Qualitative data was gathered through critical interviews conducted in a quiet environment without disruption. The outcome of this phase (interviews) was compared with the comprehensive literature review to confirm the findings. Still further confirmation was carried out for this research study by comparing the interviews’ outcome with the survey’s outcome.

Transferability: relates to the extent the outcome is transferable to other instances. Transferability considers the data generalizability, which means the researcher must implement several methods to ensure outcome transferability (Denscombe, 1998). In this research, several interviews were conducted with a variety of experts and stakeholders from different companies and universities, all whom have different construction industry experiences, particularly in construction logistics and supply chain management. Interview participants included the designer (consultant), contractor, supplier, and academics. Furthermore, all interviewees' outcome were compared not only with the literature review, but also compared with each other.

Credibility: reveals the level of accuracy within qualitative data, and is simply the truth of the outcome (Patton, 2002). In this research, sufficient interview samples in the first phase of data collection, as well as confirming interview outcome through the sizable sample of the second phase of data collection (questionnaire) have significantly enriched the outcome of data.

3.7.6.2 Validity in the Quantitative Method

According to Churchill (1991), validity is divided into three main parts:

1. Content validity: mainly from literature review and from experts.
2. Construct validity: concerns relating to the structure of questions, correlation among variables within the data collection method, tools used, and measuring procedures. In this research, the pilot study.
3. Criterion-related validity: concerned with the capability of a measuring tool to predict a variable that is designed as criterion.

Certainly, the adopted mixed-method including semi-structured interviews, the questionnaire, and ISM models was effective and successful in showing the findings (outcome), which helped to achieve the research aim.

3.7.6.3 Reliability in the Quantitative Method

Reliability is the level of stability of a measure, which relates to the truth of outcome supported by evidence. In quantitative data, sufficiency, supporting evidence, as well as rigorous data collection and analysis are required (Churchill and Iacobucci, 2002). In this research, valuable procedures were applied, such as: test and retest approaches, using different methods for data collection, proper sample sizing (150 participants in questionnaire), generalization and randomization. The rationale behind this number is because it has been used in previous studies (Sukati et al. 2011; Ondiek, and Kisombe, 2013; Devaki and Jayanthi,2014).).

Several analytical approaches were prepared where outcomes were compared to increase the level of reliability. In terms of quantitative reliability, the essential part using Cronbach's alpha which is a popular method for assessing the internal consistency and reliability in the quantitative method (questionnaire). A Cronbach's alpha value lies between 0 to 1, and in social science research the value must be over 0.7 to be acceptable and considers consistent (Field, 2013). All questionnaire sections in this research have been measured where all of them were over 0.7 values (chapter five). This indicates sufficient reliability between questionnaire components.

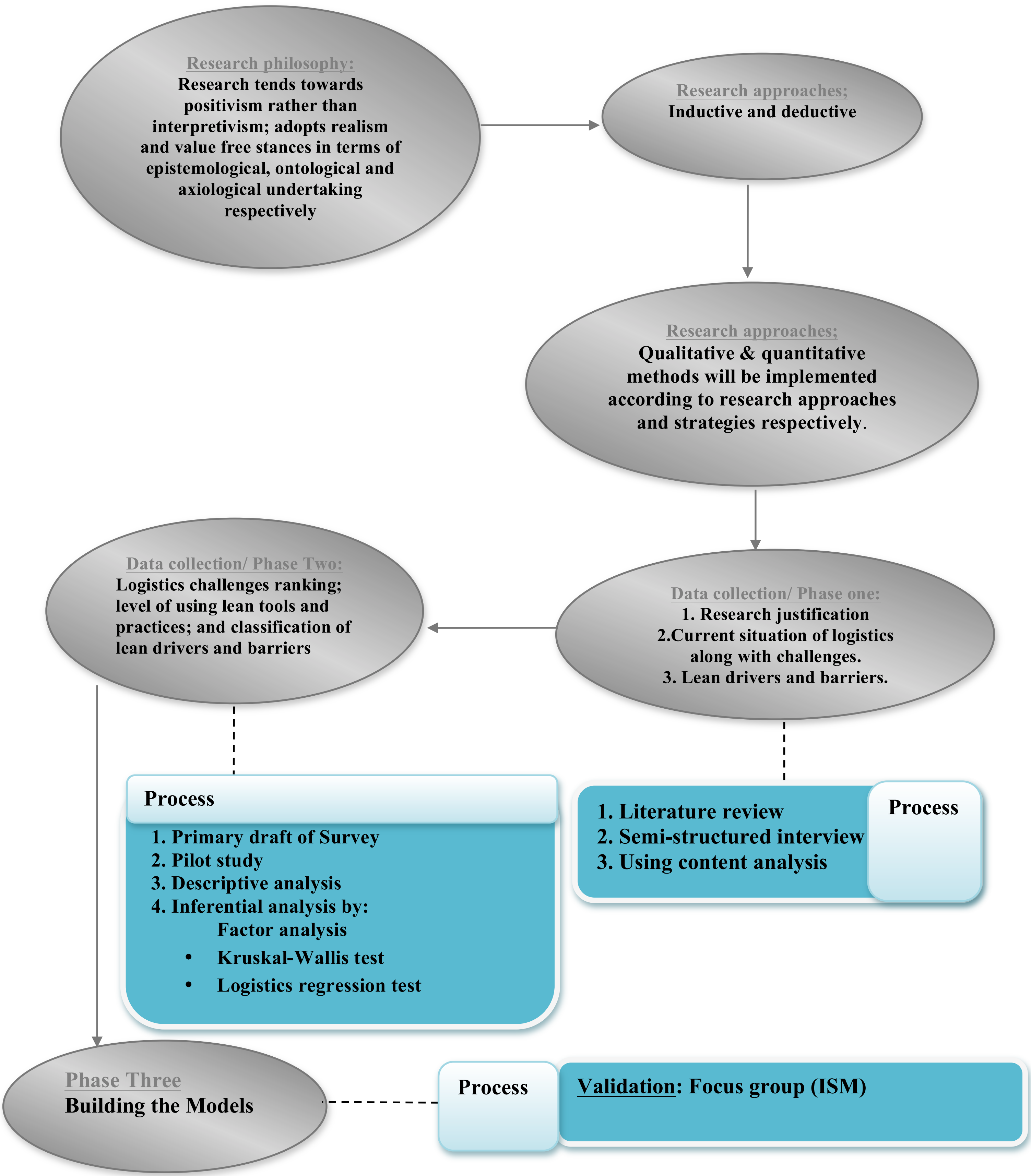


Figure 3.3: Research Methodology steps Based on Onion-Model

3.8 Conclusion of the Methodology Chapter

Throughout this chapter the entire methodological procedure and steps employed to answer research questions and meet the research objective have been critically explained and enlightened. The research methodology is based on the onion model, where philosophies, approaches, strategies, choices, the time horizon, and data collection and analysis procedures are significantly justified.

With regards to data collection procedures, the research commenced with reliance on secondary data through critical literature review, then progressed by exploiting primary data collection through two phases. The first phase comprised semi-structured interviews and the second phase involved a survey study (questionnaire). The first phase provided additional justification to the research regarding rationalization for research, delivered in-depth information, and presented better understanding in terms of construction logistics and lean opportunities. The second phase examined the outcome of literature review and semi-structured interviews in a wide sample using questionnaire, where the outcome was then descriptively and statistically tested.

The next chapter (chapter four) discusses and analyses the data generated through the first phase of data collection, which is the semi-structured interview. Chapter five is the data results chapter and relates to the second data collection phase, which is the questionnaire. Chapter six intensively discussed all outcomes, where information generated from literature review, semi-structured interviews, and the questionnaire are properly linked and overlapped in an inclusive context, as well as being critically analyzed to derive validation and then conclusion.

Chapter Four: Initial Data Collection

4.1 Introduction

This part of the research will include phase one (qualitative data), which has been pointed out in the previous chapter. Semi- structured interviews have been employed; the five steps of content analyses mentioned in the methodology will be conducted.

Firstly, the researcher is familiar with the data as he carries out all interviews, data recording, and formatting into written texts. Secondly, the initial codes have been employed prior to interviews. Thirdly, searching for themes relevant to the analysis from textual data has been manually undertaken. Fourthly, the codes were assigned. Fifthly, codes and themes are discussed and reviewed, with explanations summarised in tables (kulatunga et al., 2007).

Phase one comprises interviews with all stakeholders at the supply chain in Jordan, including client, contractor, sub-contractor, supplier, as well as academics. The aim of semi-structured interviews being to explore all factors (challenges) affecting the construction logistics process; problems and underlying reasons. Variety of interviewees has been applied so as to enrich the data collection and gaining deep understanding with regards to the subject. Furthermore, this phase also supports the justification of the research by increasing the reasoning, rationale, and the significance of the logistics process in Jordan, as there are not many studies or citations regarding this topic. Moreover, survey, which is the next phase, will be based on the literature review as well as data collection gathered by interviews. Interview questions consist of three main parts. The first part is very significant, it is about the current situation of the Jordanian logistics process, and most importantly asks about factors affecting logistics in Jordan. The researcher strives to find factors mentioned in the literature review in addition to digging deep so as to extract further factors that are not existent in the literature review, and add them to the second phase. The Second and third part of the interviews relate to drivers and barriers to improving the logistics process. Interviews have been utilised as a qualitative method and involved a semi-structured form, designed with a mixture of open-ended and closed questions (see appendix). Each interview lasted approximately an hour and a half.

First of all, Table 4.1 shows a profile of the interviewees and includes their details, their position, their code, and their experience:

Table 4.1: Interviewees' Background

Company	Job of Interviewees	Code	Experience	Back Ground information
University	Professor in civil engineering department	A	>15	Researcher in the construction management and has experience in a variety of projects in Jordan and USA.
Supplier	Manager of a supplier company	B	>20	Owner of a stone and block factory and has significant experience in material logistics.
Contractor	Project Manger	C	>30	Significant experience in gulf countries and Jordan form site. My experience: Bridges, pavement, reinforce concrete and steel.
Consultant	Project manager	D	24	Very good experience in infrastructure and has a Master degree, worked as a contractor and know as a consultant.
Client	Owner/Manager	E	8	Civil engineer and works as a consultant and he owns a residential company.
Contractor	Logistics manager	F	12	Good experience in SCM, construction regulations as well as expert in purchasing from abroad.
Sub-contractor	Head Forman	G	>10	Good experience in material purchasing, transportation and distribution.
University	PhD/ CM department	H	>18	Lecturer in project management department
Consultant	Project Engineer	I	> 8	Good experience in a variety of projects especially commercial buildings.

4.2 The first part explores the current situation of logistics in Jordan

i. The level of improvement in Jordanian construction (code 1)

First of all, according to the interview answers, it seems that the construction industry in Jordan is improving over time; Interviewee A said “There is substantial growth in Jordan because of the external investments that has come from the surrounding countries”. Interviewees B, C, E, F, G, H and I mentioned the same reason, i.e. investors from outside supporting the recent boom within the construction industry. All of the participants except Interviewee F mentioned the politics factor as an essential aspect reflecting the development in the construction industry. Interviewee A noted "Political situations in the region play an important part in improving the construction industry in Jordan". For example, migrations in 1948 and 1967, Iraq’s wars in 80 and 90, and during Arab spring”. Interviewee G and C stated that population has affected the construction industry. Interviewee G said “Natural growth of the population increases the demand. Jordan has a young generation, more than 50 per cent of the Jordanians are less than 14 years old and there are 200 thousand apartments sold annually. When you have growth that means you will have high demand and the result of the demand will require more improvements”. Furthermore, Interviewee E mentioned that the demand for residential apartments has increased because of the security in Jordan, where many refugees from abroad came because of the stable political situation, as well as citizens nowadays being unable to afford to buy a house, so that the residential sector is booming. Academic staff (A and H) emphasise the educational side, where Interviewee H said “Developing the education system has played a significant role in increasing the standardization level to some extent in Jordan, as well as enhancing to some extent the awareness of many points which were neglected in the past, such as health and safety". Furthermore, Interviewee D added "Nowadays, government is helping companies by giving them more permissions to build crushing and mixtures in different places, and assisting companies to buy their material from everywhere, which consequently increased the importance of international logistics". Also. enormous technological development has assisted all the stakeholders to straightforwardly achieve their tasks, as Interviewee I, F, and B claimed. Interviewee F said "It is much easier these days buying material from suppliers as online services significantly facilitate the ordering procedures, and any changes occurring can be readily informed to any member of the supply chain”. However, regardless of the overall significantly positive points, there are still some setbacks, as Interviewee C said “We don’t have many unique projects, and engineers in Jordan have limited experience because there is no variety in projects. Engineers who leave the country will have huge advantages in terms of knowledge and benefits". Interviewee B asserted "Current developing in construction has affected the small and medium factories as material and labour cost has considerably increased. This raised the competition among suppliers and consequently their profits have been declined". Accordingly, Table 4.2 illustrates the reasons for improvement along with their themes.

Table 4.2: Jordanian construction improvement reasons

	Improvement reasons (code 1)	
Themes	External investment	Young generation more educated
	Politics reasons and security	Technology improvement (online purchasing)
	Population growth	Improvement of Education system
	High demand	Unrestrained buying material from abroad

ii. <u>Factors (challenges) affecting logistics process in Jordanian construction (code 2)</u>

This part illustrates the main challenges facing Jordanian construction logistics based on interviewees' views. There are seven themes concerning this code, and each theme contains several valuable sub-themes (sub-points).

- **Continuous Improvement:**

The construction industry should use continuous improvement (Kaizen in Japanese language) whilst undertaking each process in the logistics system so as to gradually develop. The culture challenge factor will initially be illustrated, Interviewee A said " 60 years ago, Amman (capital of Jordan) was a forest and started to be a new city. Some parts of Amman were without electricity in the late of 70, and so this created a considerable gap between generations. The young generation believes in implementing new things to develop, and an old generation has difficulty in accept new things. In my opinion, this gap also appears in construction works among the two generations, which affects the understanding between them and reduces the development and improvement". Furthermore, Interviewee D agreed by saying "I think the generations gap plays a significant role in understanding and improving the construction industry". Interviewees

A and E contributed "Some people spend a lot of money for unreasonable things and fatigue their supplier and contractor just to show off in front of others. A surprisingly state of extravagance culture". Furthermore, Interviewees F and E stated "stakeholder mentalities are sometimes hard to believe". Interviewee F said “Mentalities and awareness of the leaders in Jordanian construction are sometimes not ready to improve the logistics.” This means that the logistics process in Jordan may face difficulty in improvement if the peoples' mentality is not considered. Interviewee F added "Culture change towards improvement is a decisive driver in continuous improvement procedures. I think educational culture plays a significant role to improve the overall situation in Jordan".

Sources as are very limited in Jordan and the only way of improvement is to enhance the institutional level of education and awareness. In addition, Interviewee C noted "Applying standardisation in a proper manner through the logistics process will positively impact on the improvement ability”.

Interviewee B, E and A mentioned a feedback point, with Interviewee B said "I see no learning loop or benchmarks, or at least proper guidance for staff in Jordanian construction” Furthermore, Interviewee A added “In the big projects, you could receive some feedback, but most of them aren't valuable and just paperwork. In the residential sector, there is no feedback at all because it fragmented”. In addition, Interviewee E noted "Logistics need to have systematic shared lessons among parties, especially in material control".

Finally, this part can be concluded by saying that continuous improvement should locate the customer satisfaction factor at the first stage. Additionally, Interviewee G stated "Customer service is not a priority especially for suppliers where most of them are just looking to have a high benefit regardless of anything else”. Interviewee B agreed with this point to an extent, but also criticised by saying “The supplier's first concern is not always client satisfaction, his business is more important. The client is also responsible for a some of the problem because he asks always for the cheapest price and wants highest quality. He needs more awareness and information of the current situation to make our price more competitive, our company (supplier) strives to reduce the cost of workmanship in the factory and in the construction site (through our workers who work there to fix the stones), and this will eventually hurt the business, and poses a threat to mutual benefit, so consequently the quality will considerably fall”. Thus, customer satisfaction necessitates being a priority in developing continuous improvement to the logistics process, and on the other hand customer needs to enhance his knowledge and information to diminish his ignorance.

After reviewing all previous sub-themes in terms of continuous improvement, it seems that the theme (CI) plays an essential role in assisting the development of Jordanian construction logistics. The evidence show that there is a need for urgent action in order to improve the current situation. However, in the next part, participants indicated that one of the drivers to implement lean practices is significantly enhancing continuous improvement.

- **Performance and Material Preservation:**

Talking about quality is primarily related to level of performance, where construction management is looking always for customer satisfaction, and achieving this service means better performance aiming for higher quality.

Interviewee A said “The logistics process is effected by lack of productivity and poor quality. Many parts of constriction suffer from same issues.” Interviewee G claimed “Poor performance, particularly by labourers in logistics process, has a serious negative effect on material quality through loading, unloading, transportation, storing, and installing”.

Nowadays, the cost of labour has dramatically grown. Interviewee B mentioned “Labour's cost has increased considerably, around three times within 10 years, which makes companies have to rely on non-skilled, or average-skilled, labour so as to reduce cost”. Furthermore, Interviewee D added "Most of the payments in infrastructure are related to mobilization". Interviewee B noted “Some performance problems come from unprofessional unloading or unloading, as well as the client or contractor sometimes asking the supplier to do something extra for free, which could waste his time and money. For example, unloading material at different places with different portions at one site, and supplier does this to keep his ties with them”. Interviewee D added “While unloading material there are specifications that need to be followed based on the type of material, proper handling can reduce waste notably”. However, material is still being damaged when unloading as Interviewee E mentioned “The main waste in material occurs in handling. The average waste on each block delivery is about 500/10000. Logistics people still depend on labour skills, or in better conditions, relying on machines when loading and unloading material”. Similarly, Interviewee C stated "There is a high likeliness of material being ruined or broken due to long waiting time between processes", where Interviewee F said

"The quality of material is vulnerable throughout logistics process, especially during the movement of material. Interviewee F also contributed to the previous thoughts “The damage of material happens in the construction site, especially for heavy tiles (finishing products) because it is done by manually. There is a need for using machines while loading and unloading to increase material quality and reduce time”. Interviewee G criticized, stating “The machinery rent is expensive, if you need it for one day in a far place, sometimes you need to rent it for three days”. As a result, it can be significantly note that the performance theme along with its sub-themes is considered to be a high demand in the logistic system; consequently, helping to save time, save money, and increase quality.

- **Health and Safety Regulations:**

Regulations and legislations by the Jordanian government have been dramatically changed. For example, Interviewee A said "Diesel was subsidized by the government in the last two years. Diesel has now become unsubsidized by government, this rule change increased the cost of materials and transportation and will eventually lower the level of health and safety as many drivers attempt to load over the permitted weight for their trucks". Interviewee D mentioned the same point "Government rules need to be developed especially regarding health and safety, as well as environmental impact. I need to see a real intention to change the current situation”. Furthermore, Interviewee E stated “The damage in block is thrown away near to the construction site and there is no way to return it, or to implement reverse logistics, which negatively effects the environment and health and safety levels. Government needs to make more effort about this point”. Health and safety regulations have been discussed extensively, where Interviewee D noted that the main barrier preventing improvement of the logistic process is lack of health and safety rules "The country needs to develop a proper system in health and safety regulations". This has been explained by Interviewee B saying "Overload carriage are considered a jeopardy in the logistics process. Drivers claimed that their vehicles and trailers can bear more than the permitted load, this can sometimes lead to increasing the profit margin, or sometimes can lose money. So, drivers have to move during the night to hide from the weight points, which are located on the side of the roads (hard-shoulders), because of this drivers need to wait for a long time, delaying the entire logistics process and other stakeholders".

So, after explaining the sub-themes related to the health and safety theme, it is revealed at this point to what extent health and safety regulations slow the logistics process, and reflects the poor situation of H & S in Jordanian construction.

- **Planning:**

Planning was mentioned by all participants as a key factor in the logistics process. Interviewee A said "Thinking of improving logistics is directly linked with enhancing the level of planning which will gain considerable benefits to all parties. Two things need to be taken into account, the complexity of a plan and deficiencies in planning."

Interviewee I concurred "The major failure, in my opinion, regarding the logistics process would be primarily related to the planning complexity or deficiency". Interviewee B stated "Lack of planning between the supplier and the site manager (PM) increases the amount of indirect work. Lack of planning usually starts in the pre-construction period, and then during construction work. The logistics order and deliveries are adversely affected, in addition to increasing the variation".

The engineering officer (consultant), in the DBB (Design-bid-built) method prepares the master plan regardless of the participation of other parties. However, the contractor has the opportunity to participate, especially in the construction phase, and again when variations or change in orders occur. Whereas the supplier is usually excluded of this process". Interviewee H agreed with this point, and mentioned that residential buildings in Jordan suffer from delays due to poor planning.

Surprisingly, Interviewee A also remarked "In the residential sector poor planning is the main reason for the delaying of most projects, particularly when the client does not have strict time to meet, aside from when planning is only managed by one party".

Interviewee F noted an interesting point in how planning can be affected by material coding. She said "Different codes make distinctions between the order party, supplier, the shipping line and the customs release in the port. I (contractor) create codes in the planning phase with the client which sometimes are not comparable with the factory code in a foreign country".

Interviewee B stated that planning considers the most vital issue "For example, the stone material is requested from my factory just two days before the actual work, which gives an idea about the poor planning occurring in construction projects". Furthermore, ordering material need to be changed, currently delivery periods are not committed due to the poor planning by both the supplier and contractor. The consultant can also influence slowing the schedule when he delays approval for no reason".

Furthermore, order changing by the client can considerably alter the planned process, Interviewee C stated "If you buy something from abroad and you ask the supplier to change the product then you could wait in a new queue and this will eventually cause massive time and cost overruns".. He further explained an example of this case by saying “Elevators from Japan had been approved to be used in the project, all the specifications and colours had been approved, advanced payment had been made to the supplier, and suddenly the client changed his mind. He wanted to change the lifts (different brands). The contractor (me) had to send a letter to him related to the new cost and time. After three months, the client said I will proceed with the first one, and there is no need for a change. When I returned to the previous supplier he said, you were in the production line before, now you need to queue again where you need to wait 8 months. However, the project time was only 22 months, so huge disturbance and efforts were made because of this uncertainty, just to reduce the delivery time from 8 months to 4 months”. So, he emphasized the necessity for the logistic planning process to have full integration among all parties: engineering office (consultant), contractor (main contractor and sub-contractor), and supplier to avoid extra cost and time.

Additionally, in the construction industry, contracts distribute the responsibilities and liabilities and bind all parties. Interviewee A commented "Contract needs to be complete and include all liabilities, jobs, and risk sharing with substantial details". The type of contract is an important aspect, Interviewee D noted “All procurements are Design-bid-Build in the infrastructure projects, this type is does not help the contractor to share ideas and thoughts with the designer". Interviewee C mentioned the same point, saying “Most of the projects are Design-bid-Build contracts which affect the relationships between the contractor, the consultant (architect), as well as client. Our company (contractor) spends much time explaining information to the consultant, which takes too long to be approved. In addition, supplier opinions are not shared and not taken into consideration”.

On the other hand, the supplier role is revealed by Interviewee C “The problem in Jordanian logistics lies in poor planning through delivery speed as well as responsiveness. Most suppliers don’t have the desire or ability to prepare these”. Interviewee F also noted that the supplier needs to have a proper mechanism to ensure delivery speeds are sufficient.

Demand size and delivery requirements are noted by Interviewee A “Construction logistics in Jordan suffers from mismanaging the demand needed and fulfilling the delivery needs. If new practices can manage these aspects, many companies will apply them”. Furthermore, Interviewee B emphasized “Fast delivery and responsiveness is strongly needed, where each supplier tries to learn and improve himself in order to achieve it. So, it is an aim to learn and implement new practices to increase the delivery responsiveness”.

The previous points lead to the importance of training, where Interviewee H noted “Lack of training in companies and universities obstructs people from implementing new practices in Jordanian construction. Trained people need to be qualified, not just certified, in order to help develop Jordanian construction knowledge, particularly if people are trained abroad". Interviewee A said "Value engineering and training sessions need to be implemented to continue the improvement processes, especially by analysing unnecessary work and movement, as well as thinking of new and better way to improve the current situation". In addition, Interviewee C noted "Applying standardisation in a proper manner through the logistics process will positively impact on the improvement capability". Interviewee B assumed that lack of training happened as Jordanian organisations have no well-defined scheme identifying and prioritizing areas in need of improvement.

All the participants agreed that Jordanian construction has to develop the planning system, particularly the sub-themes which previously discussed. Agreement was also reached in the shared belief that logistics stakeholders must follow new practices to solve the majority of problems.

- **Inventory:**

Large inventory is the primary obstruction within logistics flow, and represents the main difference between the conventional method and the new method within the construction industry. Interviewee E said “My main concern is the storage area because our projects depend on the space nearby for storing material. It is usually vey suitable, but sometimes we have to store material in the street, especially before casting the first floor, where we can later store material". Interviewee G emphasized this point stating "The main barrier to material flow is the large inventory size as well as unnecessary use of storage”. Interviewee F mentioned this problem "It is better to install at the same time of unloading to avoid large inventory and double handling", thus she suggested creation of a mediator logistics party. However, she additionally stated that

"Bringing materials Just-in-Time is still very difficult to apply in Jordan as many materials come from abroad”.

Furthermore, inventory control is derived through theory concept and best practices concept applied during the logistics process, explained extensively in the literature review. Interviewee H said "The Just-in-Time (JIT) technique could be a good solution to have a proper flow if it has been applied in as systematic manner, but it needs people in construction to understand the pull system concept". Interviewee G shared the same opinion “We have two problems, as you know most of the projects are residential buildings, most of them they store their materials such as gravel, sand, and blocks in the land next to the projects, if they were lucky to have free lands nearby. Furthermore, other materials are stored inside the buildings particularly after casting the first floor. In the case that there is no free land, where most of the projects have this situation, the storage area will surrounding the construction site and most of the material probably will cover half of the streets which causes material waste. Consequently, this amount of storage will add double handling, extra movement, and disturbing, thus JIT can be an ideal approach to avoid this problem". In regards to inventory, Interviewee C stated “As a contractor in Jordan, my main concern in logistics is the storage part, where I don’t usually have enough space in the store. Sometimes I have to store material near the road. In my opinion, new practices could be widely used if this problem can be solved". However, Interviewee D disagreed and said "Sometimes using JIT is reasonable if you don’t have space in your store and you want to avoid double handling, but in another sense JIT is strongly undesirable because the contractor gets paid (80 percent of the full cost) by the owner if he brings material and store them at an early time in the construction storage. Not only that, but some materials need to be brought from abroad, so you need to make sure you store them in advance to avoid any delay". Additionally, Interviewees B, A, and I agreed with this view, where Interviewee B commented "In a stone factory, JIT in ordering stone is unfavourable, the client or main contractor requests extra amount of stones to choose favourable stones and to return unfavourable ones (as stone is natural). Where he could find better way to do this, he would". Interviewee A stressed the same example by saying "To avoid receiving bad quality stones, the contractor requests from the stone factory supplier extra stone and more quantity than is demanded". Moreover, Interviewee I added “It is very difficult to convince the client to bring the material in time, they can’t bear waiting for material. They want to receive materials at an early time and store them”.

Consequently, later on in the discussion chapter all of the previous sub-themes are critically examined by extracting valued evidence through literature review, interviews, and survey (phase one, and two). A wider number of participants state their views in phase two (questionnaire), determining to what extent inventory is affecting construction logistics in Jordan, besides considering the applicability of JIT in Jordanian construction logistic.

- **Transportation:**

Transportation has been mentioned a few times in the literature review in different features. This theme is still undervalued within the Jordanian construction logistics process, so it needs to be taken seriously into account. Interviewee A said, “Developing logistics flow efficiency in Jordanian construction occurs when transportation improves. Many aspects need to be taken in to consideration, such as: the type of transport used, fuel type and cost, the number of trips to avoid unnecessary movement, the number of labourers needed per trip, trip time and duration, using strategy to implement shared transportation with other construction parties, as well as the type and situation of roads”. Furthermore, Interviewee B added “Choosing the right roads or streets, knowing the road status (diversion, damage) and the quality of the vehicle used are significant factors in the logistic process”. Consequently, some material can be damaged during the trip, Interviewee E stated “Block can significantly break at the bottom of the vehicle during transportation”. Interviewee G mentioned a similar point, but he noted that "Tile is considers the major waste, it has a big chance of be broken during transport".

Furthermore, Interviewee H said that "Transportation is underestimated in the logistics process and reasonable effort is not taken to prevent drivers sometimes remaining in one area for unreasonable causes". So, drivers’ ability also counts, where Interviewee F stated “There is some behaviour by drivers when material is checked, especially on the side road, they don’t properly close and cover the material again, as well as they need to know the status of the road.”

Additionally, Interviewee B mentioned a valuable point, in that "Government regulation is inconsequential, especially in permitted loads and customs rules. Considerable delays can occurred, which can consequently lead to project failure". Other participants talked about government regulation in terms of customs. Interviewee C noted, “Aqapa port (the only port in Jordan) is considered quite small, in addition to that the government procedures take too long. Material lateness needs to be solved by changing the rules”. Interviewee F explained this point by saying "It is very important to know the agreements between countries and Jordan, such as the agreement between Jordan and USA. Jordan customs doesn't mention this kind of information to the companies. Therefore, these companies need expert people of logistics who know this information beforehand. So, companies will save a huge amount of money, as they will pay just 10 percent of the custom plus the 16 percent tax. Otherwise, 55 percent will be paid if they don't know the agreements, or if there is no agreement with the country that produced the material. In addition, many agreements have been signed such as the Europe agreement, which also can eliminate 16 percent of the tax, and Arabic agreements reduce the tax paid as well. Some materials have exemption by government, and companies require knowing that for themselves. They need to follow the customs website regularly and update their information". Interviewee H emphasised point and added "Customs need to be more flexible, their procedures are very complex. In addition to that, regulations need to be improved. For instance, government once changed a rule and asked all companies to receive their material with packaging and add the producer country's name printed and stamped in each package. They got confused as they ordered some stuff that needed to be received after a few months, and they didn't tell their suppliers about it, which eventually cost them much at the end because some of shipments were returned".

Moreover, market condition influences transportation efficiency, undoubtedly Jordan has been affected with the worldwide situation regarding global market condition, as well as with specific conditions within the Middle East. Besides, limited resources in Jordan have gained market condition important consideration. So, transportation is mainly affected by market condition, as mentioned several times by participants. Interviewee A mentioned the increase fuel cost because of the economic crisis, he said "The economic crisis negatively affected the fuel price, and diesel is considered as a major component in transportation". This same point is mentioned by Interviewees G and B. Participant B added "Our job relies on receiving the stone material from a far place (the place of origin). I receive the big stone, cut and finalise it as required, then send it to the construction site. So, when the fuel cost was raised the overall processes changed as transportation is the main part". Furthermore, Interviewee G added "Many companies couldn't bear the considerable fuel price rise and eventually closed". Interviewee D "Best sight taken from the market, knowing material condition, fluctuation and availability mean effective transportation and subsequently successful logistics. On the other hand, fluctuation of material means several trips will carry half loads due to material shortage, which means additional trips are required, and this significantly increases the transportation cost in Jordanian construction logistics which consequently leads to failure throughout the logistic process".

So, it seems that the transportation theme along with its sub-themes is considered a key influence within the logistics process. Thus, further significant information in the discussion chapter critically integrates the literature review, interviews, and survey outcomes together in one scope in order to extract a valuable consequence in regards to this vital theme.

- **Transparency and Information Exchange:**

Basically logistics is a social interaction between different people, to cooperate and work together to achieve the proposed aim. "Logistics relationships are complex. Each project has its own kind of dealings among parties, sometimes in a small project the client manages the logistics relationships himself, a main contractor controls the logistics relationships in a medium-sized as well as a big project", stated Interviewee A. Interviewee B noted "Sharing information and increasing the motivation between the stakeholders is the key significant factor towards improving logistics to gain the expected benefits as well as reduce the overall cost". Interviewee C mentioned an interesting notion by saying "Enhancing the relationships and the cooperation among stakeholders, especially in the early stage, will assist in choosing and purchasing the most appropriate material for the project. But most of parties need to be more professional, especially the consultant, where his fearlessness from client loyalty makes his work bias and non-professional". Therefore, mutual information is very important between stakeholders for a successful logistics process. Furthermore, the client will have valuable information by interfacing with the supplier and the sub-contractor in the decision-making process. Interviewee B commented on this by saying "The client needs more information to increase his knowledge and awareness of the current situation regarding materials, then the supplier can fulfil his requirement if they can meet regularly".

Interviewee A mentions another point related to this theme " The construction industry in Jordan needs to keep up to pace through advanced technology, particularly to develop logistic process visualization". Though, Interviewee B believed that Jordanian logistic stakeholders undervalue the demand to advance their transparency, specially by exploiting advanced technology". He also said "There is a necessity to apply technology constantly along the logistic process to achieve the greatest values of transparency".

Additionally, several interviewees have cited the extent to which tracking systems as an advanced technology can further transparency by raising the levels of monitoring and control, whilst providing substantial details throughout the construction logistics flow. Hence, Interviewee A mentioned that tracking systems could be a good solution for the logistics system. However, Interviewee B criticised tracking systems by saying "It could add extra cost to the logistic process". However, this view was opposed by a variety of Interviewees as C and F argued "Tracking system need to be a vital part in increasing the efficiency of the logistic process, but the most difficult matter is that people in Jordanian construction would need to realize how to apply it in a proper manner".

Moreover, many of the participants complained about the current lack of coordination and communication between stakeholders in Jordanian construction logistics, Interviewee H said “The reason for the lack of coordination is because there are no regular meetings among SC parties”. Other participants A, B, and E claimed that increasing the level and means of communication and transparency could solve his problem. Interviewee E said “Communication needs to be improved to build up robust relationships involving all SC members. For example, some companies are still using only telephone for ordering and dealing with stakeholders. Not involving any of the more advanced technologies in the project makes the mistake margin quite considerate”. Furthermore, lack of communication and coordination between the supplier and the site manager (PM) has been mentioned by Interviewee B “Most of the ordering is done by telephone. However, we have experienced some extra cost because of wrong orders due to misunderstanding; different language; or even dialect. For instance, materials have been sent to the site and then returned back because ofors, and we have paid the transportation, loading, and unloading cost. People have to be taught the most transparent, suitable and reliable ways for coordination and communication to place orders; as well as using advanced technology to overcome errors. Developed communications need to be used instead of the traditional one”. "The benefits of developing the coordination and communication systems are uncountable" Interviewee I affirmed. He also added, “Sufficient coordination aids are needed to reduce time and effort. Sometimes you are working at something and then you're surprised that someone else in the same company is working at the same thing”. Furthermore, interviewee F emphasized “The procedures for getting approval from the manager and the general manger regarding the best cost is sometimes very hard. I really have difficulty getting an approval from my manager and other higher managers in my company, especially if he is abroad. We need to build a sufficient SC to solve this problem. The best thing is to make a group in a social media such as *What's App* to have faster agreement and communication". Interviewee G added "I ask all the members in the SC to put my name (CC) in each email to keep in touch for everything". Talking about this point can be concluded by Interviewee A, he stated "I think the communication part is underestimated by construction people in Jordan; the lack of communication hits the construction field badly. Improving communication helps to reduce errors of information exchange and increase cooperation, which helps to find problems in an early stage so solutions can be sought". Consequently, it appears that the previous sub-theme has gained the attention of most participants.

Furthermore, distrust plays a significant role in relationships, Interviewee C said "Dealing with the consultant or supplier is not easy in Jordan because of the distrust, each company needs to take into account the reputation of the other company and its history". Interviewee F added "There is huge distrust between supply chain parties, and most importantly there's a lack of truthfulness". While Interviewee E highlighted "The lack of trust leads to not building long relationship which is very important to develop the overall logistics process and consequently construction projects". Additionally, long relationships are an ambition for consultant, contractor and supplier. Interviewee B stated "The supplier usually agrees to do an extra job to show his loyalty and full commitment to building a long-standing future relationship with the customer. I think long relationship will guarantee my work, but most of the clients like to change their suppliers to have more quality and variety with lower prices". He also added "Long term relationship provides me many advantages; the credibility between my factory and client will provide a good deposit, as well as increase the standardisation which will eventually enhance the logistics process". Interviewee D argued that "In some part of construction, it is very difficult to have long-term relationship such as infrastructure projects, which is provided by government tendering. Moreover, Interviewee I mentioned "Short relationships often create problems, when many problems will be eliminated from one project to another by enhancing the mechanism for mutual information and providing weekly meeting among parties". Interviewee F also highlighted "Long term relationship need extensive work by building a trustworthy partnerships".

It seems that everyone in the SC is trying to build long relationship, but firstly barriers must be overcome.

Accordingly, after explaining the sub-themes related to the transparency and information exchange theme, the effect of this theme on the overall construction logistics process in Jordan are revealed. Subsequently, code 2 is considered deductive coding as each code is derived mainly from the literature review. Table 4.3 summaries factors (challenges) and sub-factors affecting Jordanian construction logistics based on the previous information acquired from the literature review and the semi-structured interviews.

Table 4.3: Shows Factors (Challenges) affecting construction logistics

Factors (challenges) affecting construction logistics (Code 2)				
Themes	***Factors***	***Sub-factors***	***Literature review***	***Stated by Interviewee***
	Planning	Deficiency and complicity	Koskela and Howell (2002)	A, B and I
		Interference and integration by contractor and supplier	Kent and Gerber (2010)	C and F
		Type of contract (procurement)	Telford (1998); Ruparathna and Hewage (2013)	A, C and D
		Delivery speed as well as responsiveness	Wegelius-Lehtonen (2001); Johansen and Wilson (2006)	A, B, C and F
		Trained staff	Gidado (2004); Rahman (2006); Mossman (2012)	A, B, F and H
		Overproduction within the construction logistics	Conner (2006); Matyusz (2011)	B
	Transportation	Types of vehicle used in transportation	Vidalia and Sommerville (2013); WRAP (2013)	A, B and F
		Government regulation regarding customs and allowable loads	Ta et al. (2000); Ali et al. (2008)	A, B, C, D, E and F
		Fluctuation of material in the market condition	Vrihoef and Koskela (2000); Vickery et al. (2003); Cigolini (2004); Eng (2004); Power (2005); Sobotka et al. (2005); Fearne and Fowler (2006);	B, D and G

			Bowersox et al. (2007); Dias et al. (2009); Sukati et al. (2012)	
		Unnecessary movement and excessive transportation	Womack et al. (2007); Conner (2006); Matyusz (2011)	A and G
		Shared transportation vehicles with other parties	Cruijssen and Salomon (2004); Shigute and Nasirian (2014)	A
	Inventory	Storage is desirable by contractor	Walsh et al. (2004); Polat and Arditi (2005)	B, D
		JIT is insufficient in Jordanian construction logistics	Novack, (1993); Fearne and Fowler (2006); Ala-Risku and Karkkaine (2006); Cahn et al. (2009); Patty and Denton (2010); Bryde and Schulmeister (2012); Vidalakis and Sommerville (2013)	F, D and G
		Excessive and unnecessary inventory	Abdelhalim and Duff (1991); Ofori (1994); Vrijhoef and Koskela (2000); Rother (2009); Ciarniene and Vienazindiene (2012)	E and G
		Mapping the material route	Rother, (2010); Tyagi et al. (2015); Klotz and Horman (2008)	(None)
	Health and Safety	Health and safety regulations are not taken into consideration	Lingard and Rowlinson (2005); Ali and Nsairat (2008); The Safety Executive (2011)	D and E
		Determining the most appropriate road is insufficient	Rawling and Kainet (2012)	A,B and F
	Performance and material preservation	Quality of the finished product is affected by construction logistics	Kaare and Koppel (2012) and Bowersox et al. (2000)	A
		Long waiting affects performance and quality	Lundesjö (2015)	C

		Lifting and handling by Machinery not preferable	Josephson and Saukkoriipi (2007)	F
		Lifting and handling by skilled labours	Johnson (1981); Brag (2011); Josephson (2013)	B and D
		Lifting by Machineries increases cost	Lundesjö (2015)	G
		Shortage of machinery and equipment	Josephson and Saukkoriipi (2007)	F
	Transparency and information exchange	Tracking system adds unnecessary cost	Dias et al.(2009); Alodeh (2010)	B, C and F
		Mutual information and instructions	Johansen and Wilson (2006); Love and Edward (2004); Lambert and Cooper (2000)	A, B, E, F, G and I
		Distrust among parties	Colledge (2005); Kwon and Suh (2006)	C, E and F
		Tracking systems are not using permanently	Dias et al. (2009)	A and B
		Different languages and sometimes dialects	(None)	B
		Advanced technology to increase communication and visualization	Ballard (2000a); Forbes and Ahmad (2009)	A
		Regular meeting between parties	Ballard (2000a); Ballard and Howell (2003); Johansen and Wilson (2006); Forbes and Ahmad (2009); Mossman, (2009)	A, B and E
		Interference in making decision by contractor or supplier	Ballard (2000a); Koskela and Vrijhoef (2000); Ballard and Howell (2003); Bagballe et al. (2010); Pan et al. (2010)	B and C
	Continuous improvement	Cultural challenges and behaviors	Womack et al. (2007); Rother (2009)	A, E, D and F
		Feedback or shared lessons among parties.	Chang et al. (2010)	A, B and E
		Customer-client service is not a top priority for suppliers	Frodell et al. (2008)	B and G

4.2 Lean opportunities

i. *Drivers of implementing lean techniques in Jordanian construction (Code 3)*

Participants have been asked about the drivers of implementing new practices such as lean construction practices, and what is the possibility of convincing people in construction to apply the new practices.

Firstly, reliability in cost, time and quality have taken significant places, where Interviewee I noted “Reliability in cost, time, quality and sustainability are the essences of developing the construction industry in Jordan. Thus, raising the reliability in these essences, particularly cost reliability (as this has the utmost importance in Jordan), by implementing lean techniques will eventually convince construction people to use them”.

Increasing profits is a factor too, as mentioned by several participants such as A, B, E, D, G, and F. Interviewee B said “Implementing new techniques depends on to what extent our profits will be grown”. However, Interviewee E mentioned “To get additional profits, I think the new practices need to be used by the whole SC”.

Reliability in time is mainly noted by Interviewees D, B, and I, where participant D commented “It is very important for any new practices to work on decreasing time. Contractor time is a vital issue and needs to be accounted for, sometimes we can finish in advance and move to another project”. Interviewee B added “Reducing time in the delivery process by new practices will enhance the flow of material, which will lead to improve the logistics process”. Others mentioned the quality theme as being significant to implementation of new practices, Interviewee C said “Quality of material is the main factor in logistics. If the quality is affected by the processes then the overall logistics process will have to be repeated.” Interviewee G added “Customers can’t deal with the same supplier if he sends undesirable quality”. On the same point, Interviewee F emphasised “The reason for buying a material from outside is to have better quality than the market can offer. If new practices will improve the quality needed, it definitely will be acceptable”. Interviewee F also mentioned that "Reducing the defects or rework factor not only helps to avoiding sending new material, but also increases logistics quality". Nevertheless, Interviewee H holds a different opinion, believing that reducing defects is a separate issue from having desirable quality, saying “Quality is related to the final product, but defects mainly appear in logistics through transportation in the loading and unloading processes". Consequently, Interviewee C determined the same point “Applying any practices should enhance the reliability in time and cost and especially quality".

Furthermore, Interviewee B mentioned the competition between companies theme, and clarified by saying “If my competitor implements new practices, I will definitely implement them". He also added “Following the competitive companies is very important to keep me robust in the market”. Interviewee D noted “Most construction companies are copying their competitor companies to maintain rivalry and keep themselves level with the competition”.

Additionally, the labour shortage theme was mentioned by Interviewee E, he declared “Labour shortage is a concern when it happens, if new practices can manage this concern my company will certainly implement them". However, Interviewee G said “Using new practices depends on to what extent these practices are capable of reducing your manpower”. Similarly, machineries was also mentioned, with Interviewee F stating “We are facing a machineries shortage or high machineries rent, new practices such as lean requires solving this issue to be a core driver".

Furthermore, huge demand for fast response by the supplier theme has been stated by Interviewees A and B. Participant A cited that "Construction logistics in Jordan suffers managing delivery requirement against demand needed. So, if there are new practices that aid in solving this problem, people will apply them". Interviewee B emphasized this point by saying "There is an urgent need for implementing new practices to develop fast delivery and responsiveness by the supplier".

Additionally, the catch problems early theme comes next. Interviewee A stated that "Most problems are discovered late, so new managerial practices need to have a strategy to catch problem early".

Besides, Interviewee C previously mentioned a vital theme with regards to storage by saying “As a contractor in Jordan, my main concern in logistics is the storage part. I usually don’t have enough space in the store, and sometimes I have to store material near the road. In my opinion, if this problem can be solved, then the new practices can be widely used”.

Furthermore, Interviewees A and H remarked on the safety theme. Participant A stated “Safety is still underestimated and not taken seriously; new practices need to concentrate on this factor”. Interviewee H added “Jordan is a developing country, most developing countries are not concerned with or do not properly apply safety regulations, and new managerial practices have to target this part to improve the logistics process".

Both of the previous interviewees (A and H) also stated the role of understanding the sustainability triangle (economical; social; and environmental dimensions) which supports Jordanian construction to take a big step forward.

Additionally, an interesting theme has been raised by Interviewee F saying “Creating value is missing in our logistics system in Jordan, I have worked with different companies as a logistics manager, but we have never taken steps to enhance the value chain, or focusing on customer satisfaction". The same Interviewee added “Customer focus necessitates being a priority when improving the chain”. Interviewee B concurred “Customer focus is to some extent neglected, where everyone just wants to gain profit. New practices require putting this point at the core”. However, Interviewee I claimed “Customer focus is a mission that needs to be applied by companies who are serving the client. On the other hand, the employee satisfaction factor is quite missing Jordan. Companies only ask the client exactly what he needs, and ask for feedback about the level of his satisfaction”. Interviewee G also emphasized “We are not using any tools to measure the level of client satisfaction”.

Moreover, Interviewee E passed comment on the conflict between parties theme “Problems always occur during construction, particularly in logistics. The construction industry in Jordan needs a system that helps to manage the conflicts”. So, new practices need to find problems early, as well as help to manage conflicts among parties.

Finally, Interviewees D and C wondered about to what extent new practices could improve a company’s reputation. Regarding this theme, Interviewee C noted “If implementing new managerial practices improves the level of reputation many companies will implement them to gain extra advantages”.

Consequently, through the previous discussion it becomes obvious there are significant drivers affecting the opportunities for the implementation of new practices such as lean practices in Jordan. All these drivers are critically discussed throughout the discussion chapter. Finally, code 3 is considered an inductive coding, Table 4.4 sum-ups lean drivers based on the previous information gained from the literature review and the semi-structured interviews.

Table 4.4: Drivers to implement new managerial practices (lean practices)

Drivers to implement Lean practices (code 3)			
Themes	***Drivers***	***Literature review***	***Stated by Interviewee***
	If your competitor use them	(Handfield et al., 2002)	B
	Labour reduction	(Ballard, 2000a; Rother, 2010)	G and E
	Huge demand and delivery requirements	(Henrich and Koskela, 2005; Ciarniene and Vienazindiene , 2012)	A
	Better reputation	(Forza‹1996)	C and D
	Increase safety	(Ballard, 2000a; Forbes and Ahmad, 2009)	A and H
	Sustainable development	(Nahmens and Ikuma ,2011)	I
	Solve storage problem	(Lundesjö, 2015)	C
	Need for fast delivery and responsiveness	(Ballard,2000b; Henrich and Koskela, 2005; Ciarniene and Vienazindiene, 2012)	B
	Reliability in cost	(Lanigan, 1992; Koskela, 1993; Grieves, 2005)	I
	Reliability in quality	(Slack et al., 2004; Chen et al., 2012; Dhandapanietal, 2007).	A and G
	Create value and customer focus	LEI, 2009; Shah and Ward, 2003; Womack et al. 2007; Womack, 2011)	F
	Employee satisfaction	(Ballard, 2000a; Forbes and Ahmad, 2009; Ciarniene andVienazindiene, 2012).	I
	Catch problem early	(Ohno, 1989; Rother, 2010; Bassuk and Washington, 2013).	A
	Helps manage conflicts	Johansen and Wilson (2006)	E
	Reliability in time	(Vrijhoef and Koskela, 2000; Ballard and Howell, 2003)	C

ii. Barriers of implementing lean practices in Jordanian construction (code 4)

Barriers and obstructions always occur in construction when applying new things. There are significant obstacles which have been pointed out throughout the interviews. Firstly, Interviewee B noted “Peoples' mentality does not easily accept applying new things, and in construction it is even worse because it's about profit and not loss”. Interviewee C contributed with "Foremost, people’s way of thinking needs to be changed in order to accept implementing new practices in their construction management”. Furthermore, as Interviewee A regarded previously “The gap between generations obstructs applying new techniques in construction, especially in logistics. Culture challenges are a main hurdle against improvement”.

Secondly, Interviewee F mentioned beforehand a significant point that is also considered as a barrier by saying “Lack of awareness and understanding whilst doing new things in construction is underestimated. People need to raise their knowledge to gain a sufficient level of benefit”.

Interviewee F added “Many companies hear about many new things such as lean, but they can’t implement them because of lack of technical manuals”. Moreover, Interviewee H added “University programs, training, and successful case studies examples are inadequate. Many students and construction experts complain about this issue”.

Therefore, it seems that there are some barriers related to knowledge which could obstruct the implementation of lean practices in Jordanian construction logistics.

Thirdly, Interviewee G mentioned an additional barrier “Responsibility and reliability need to be in at a sufficiently high level to achieve desirable development in Jordanian construction logistics”. Furthermore, Interviewee F also noted “Employees and managers have to be mandated and committed as implementing new practices require fulfilment of this part”.

Finally, the government support barrier has been noted as playing a significant part among participants A, C, E and F in Jordanian construction logistics. In addition, Interviewee A said “Government has to encourage institutions to increase published articles to help educate all stakeholders and lead towards eventually improvement”. Interviewee C added “Government support needs to develop its rules to meet stakeholder needs”. Interviewee E added a similar point, saying “Government need to establish a database system including all of the latest articles, so that all construction people and logistics experts have the opportunity to read them and implement all of the new techniques”. Finally, Interviewee F mentioned “Many companies hear about many new things such as lean, but they can’t implement them because of the lack of technical manuals”. Therefore, it seems that there are some barriers that could obstruct the implementation of lean practices in Jordanian construction logistics. Finally, code 4 is considered an inductive coding. Table 4.5 outlines the cited barriers in both the literature review and throughout the semi-structured questionnaire.

Table 4.5: Barriers to implement new managerial practices (Lean practices)

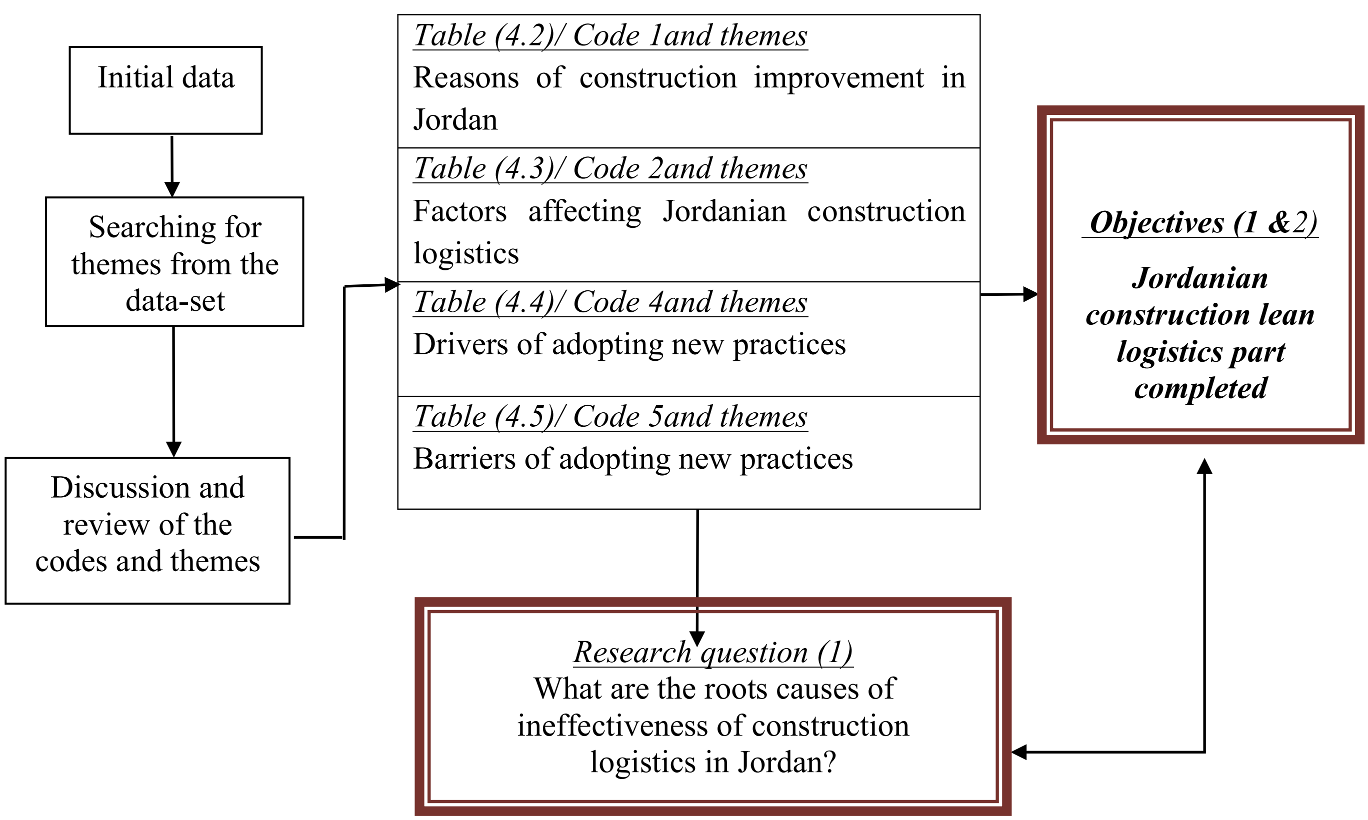
Barriers to implement lean practices (code 4)			
	Barriers	***Literature review***	***Stated by Interviewee***
Themes	Mindset issues	(Womack, 2007; Rother 2010; Mann, 2012).	A
	Lack of awareness and understanding	(Nordin et al., 2010; Salem et al., 2005)	F
	Lack of training and education	Mossman, 2012; Rahman, 2006)	H
	Lack of mandate and top management	(Ciarniene and Vienazindiene, 2012; Sarhan and Fox, 2013)	G and F
	No support from government	(Oral, 2003; Aronsson and Brodin, 2006; Shwawreh, 2006; Lehaney, 2012; Kaare and Koppel, 2012)	A, C, E and F

The outcome:

The systematic procedures of content analysis served to guide the breakdown of the data set into meaningful categories. The data was then condensed into analysable unities, with the data being finally organised to arrive at conclusions. Furthermore, this part of data collection comprises phase one of the research, which aims to explore the current situation of Jordanian construction logistics. Furthermore, interviews have been applied with Jordanian stakeholders (Table 4.1) to explore the reasons for construction improvement in Jordan (code 1), factors (challenges) affecting Jordanian construction logistics (code 2), drivers of implementing new practices such as lean (code 3), and finally barriers of implementing new practices such as lean (code 4). Throughout the interview discussions, themes have been scrutinised and extracted from the textual data. Results are illustrated by Table 4.2, Table 4.3, Table 4.4, and Table 4.5 where codes and their themes are summarised.

To conclude:

1. First of all, this part increases the significance of the research scope as well as gains the research further justification, as there are not many references regarding this subject.
2. Secondly, this data collection part (phase one) has fulfilled the Jordanian parts of the first and the second objectives within construction logistics, and the first research question as shown in Graph 4.1.
3. Thirdly, the outcome of this phase will be utilized in phase two (the questionnaire) in a wider section where all stakeholders will be classified based on their position, as follows: consultant (architect/design), contractor, and supplier. The outcomes of this phase are ranked and then statically analysed in the second phase (questionnaire), which is presented in the next chapter. Then, the final outcomes are critically illustrated and sturdily justified along with literature review to form the final models for this research.



Graph 4.1: Initial data collection outcome

Chapter Five: Analysis of the Results

5.1 Introduction

This chapter illustrates the results of the descriptive and statistical tests undertaken on the data collected in the Jordanian construction industry. These tests are the art, which can lead to drawing a proper conclusion from the collected data (Ross, 2004). The questionnaire has been designed to explore a variety of points related to the construction logistics and lean practices in Jordan; all responses are represented and discussed in this part.

The chapter firstly represents the reliability of the questionnaire, which describes the factors affecting construction logistics, lean planning tools, lean practices and lean drivers, lean barriers. Then, descriptive data illuminates respondents' backgrounds and the current situation of construction logistics in Jordan; factors (challenges) affecting construction logistics in Jordan; lean planning tools; lean practice; lean driver; and lastly lean barriers.

Finally, inferential statistics have been applied to the data using factor analysis to find the main latent factors within construction logistics sub-factors. Kruskal-Wallis and logistics regression are applied to explore the differences in stakeholders' views (i.e. consultant/designer; contractor; and supplier). Accordingly, all previous information in this chapter create significant results along with the literature review and previous interviews, which consequently assist in building the final model.

5.2 Questionnaire Reliability

According to Field (2011), reliability is defined as consistency among the respondents' answers on a given scale. It expresses the coherence of the answers. Reliability can be measured using Cronbach's alpha on a scale of 0-100%, with a higher value indicating more consistent answers, leading to greater reliability (ibid). Furthermore, the measurement must be over 0.7 to be reliable. Using SPSS, Cronbach's alpha is calculated for each section including factors affecting construction logistics in Jordan, lean planning tools used in Jordanian construction, lean drivers to lean barriers. Moreover, all the reliability measurements are over 0.7, which means that all sections are consistent and reliable. The reliability table (Table 5.1) along with the Cronbach's alpha for each section is shown below:

Table 5.1: Cronbach's alpha for questionnaire sections

Sections	Cronbach's alpha
Challenges (Factors) affecting construction logistics	0.833
Lena planning tools	0.786
Lean construction practices	0.707
Lean drivers	0.892
Lean barriers	0.718

5.3 Background of the Respondents

5.3.1 Field of Study

Figure 5.1 illustrates the professional background of all respondents: the majority (61.1%) were engineers; 12.8% were project managers; 8.1% were foremen; 6% were academic staff; 4% were skilled labours and 8% were others, the majority of which were material supply managers.

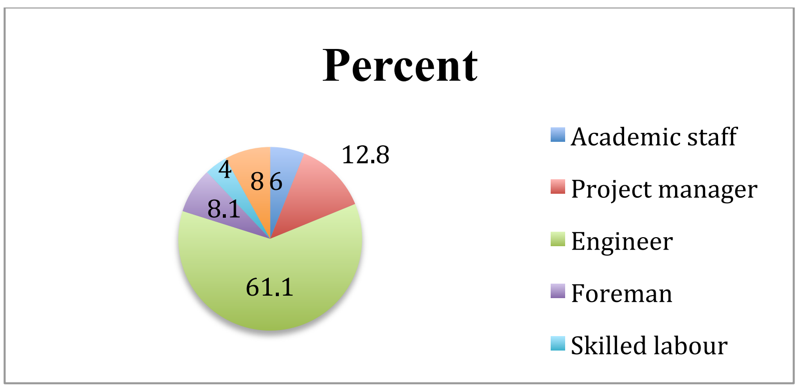


Figure 5.1: Shows the frequency of answers regarding respondents' background

5.3.2 Educational Level

As shown in Figure 5.2, the most frequently observed educational qualification level of the questionnaire participants was a bachelor's degree (62%), followed by a master's (15.3 %), a diploma (10.7%), a higher diploma (1.3%), a PhD (1.3%) and a qualification below diploma (9.3%).

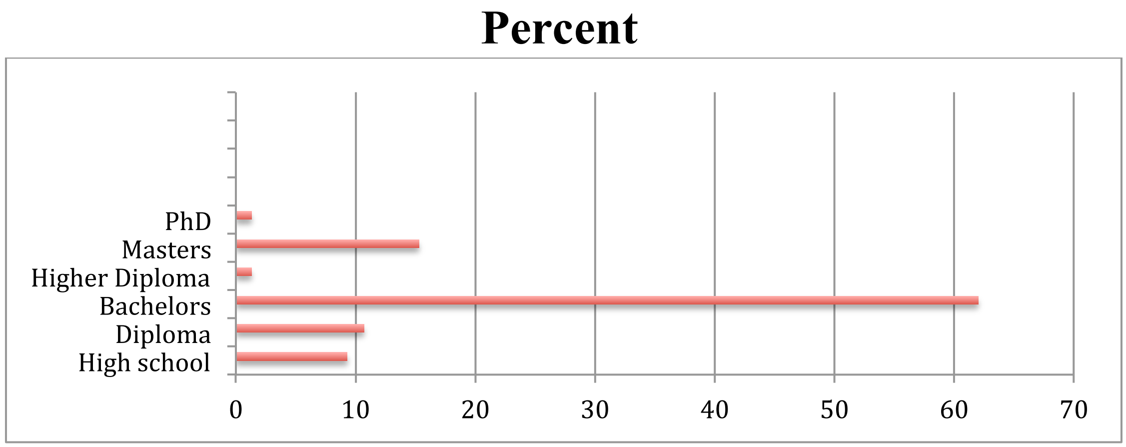


Figure 5.2: Shows the frequency of answers regarding level of education for respondents

5.3.3 Experience Gained

Figure 5.3 shows that the private sector significantly participated more that the government sector; over 80% of the participants were considered as a part of the private sector. However, 6.1% were considered as part of the government sector and 7.5% worked in both the private and government sectors.

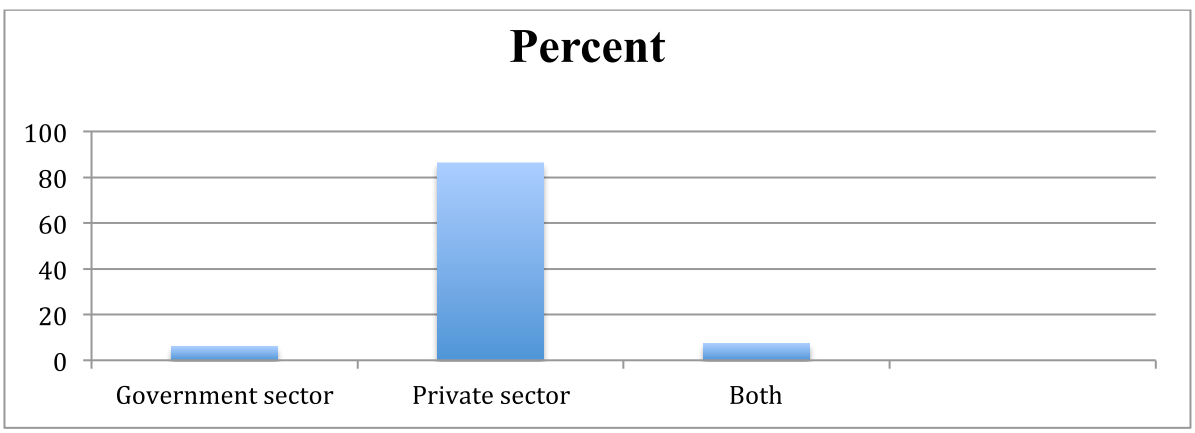


Figure 5.3: Demonstrates the frequency of answers in percentages in relation to experience gained for respondents

5.3.4 Experience Field

It seems that the majority of participants (43%) gained their experience in residential housing projects; 27% gained experience in commercial projects and 23% in infrastructure projects; 6% gained experience in universities and educational institutions (Figure 5.4).

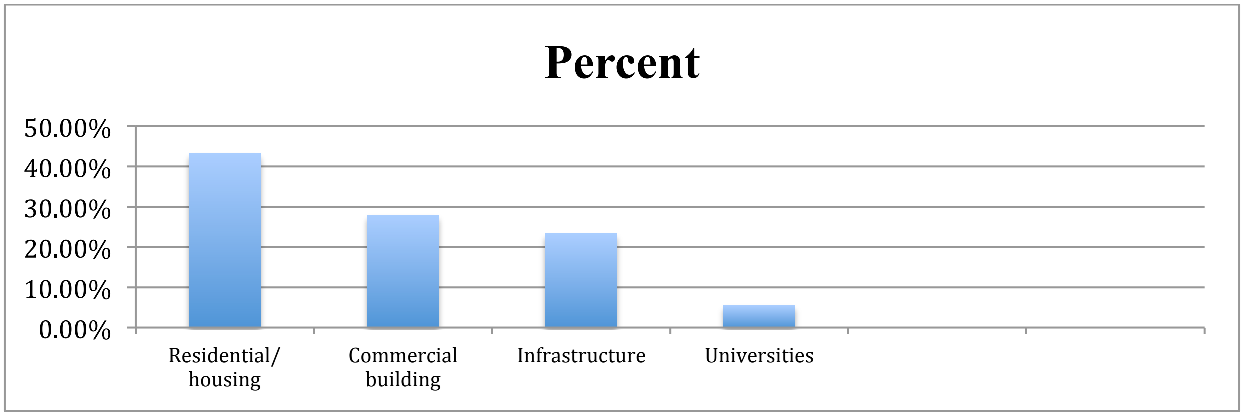


Figure 5.4: Shows the frequency of answers regarding experience field

5.3.5 Company Type

Figures 5.5 shows a variety of construction stakeholders who shared their views in this questionnaire: 27.6% were engineering and consultancy companies, 35.5% were contracting companies and 36.8% and were supplier companies.

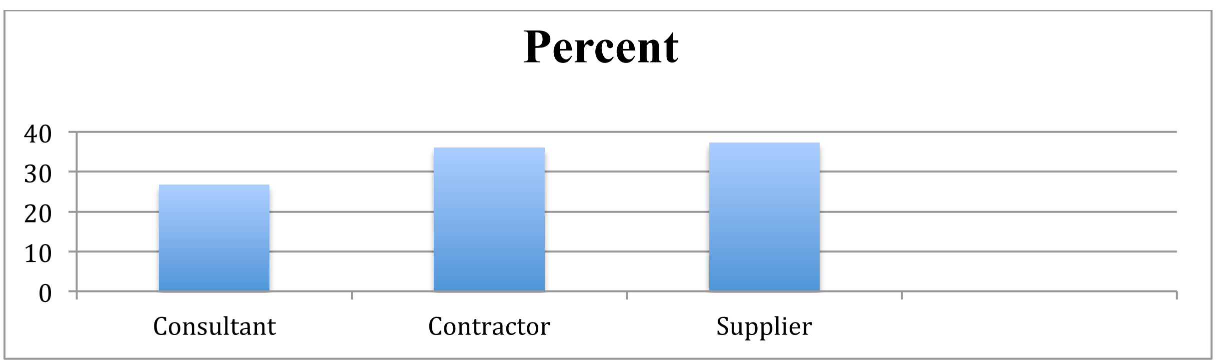


Figure 5.5: Shows the frequency of answers in percentages in relation to company type

5.3.6 Years of Experience

The experience of participants in this survey varied, as shown in Figure 5.6: 51.3% had experience of one to five years, followed by 32% who had experience of six to ten years, 13.3% had experience of eleven to fifteen years and 3.3% had experience of over 15 years (Figure 5.6).

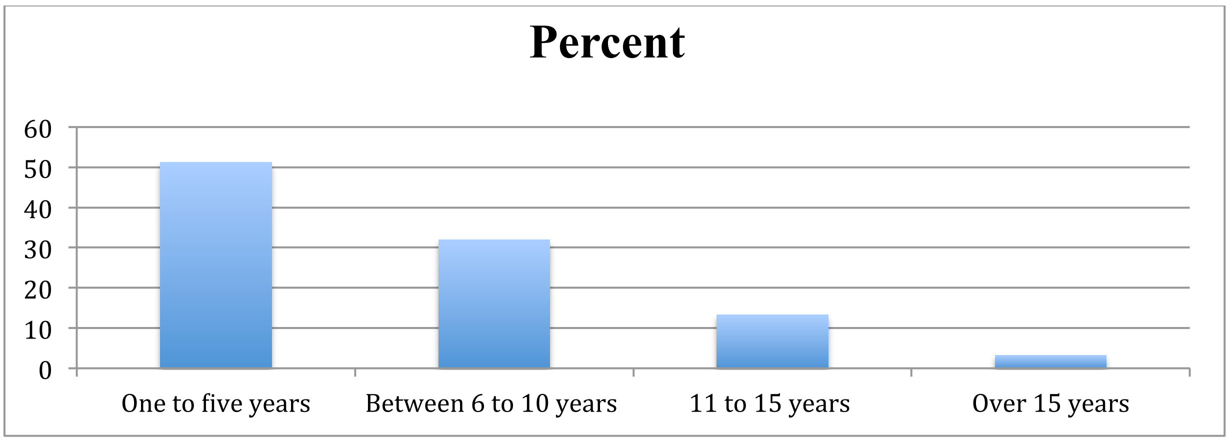


Figure 5.6: shows the frequency of answers in percentages regarding years of experience

5.4 Current Situation of Construction Logistics

5.4.1 The level of waste produced in construction logistics on time, cost and quality

5.4.1.1 Cost

The participants' opinions had higher agreement on cost as a major impact in producing waste in comparison to time and quality, with percentages showing 31% for effect and 25.7% for high effect (Figure 5.7).

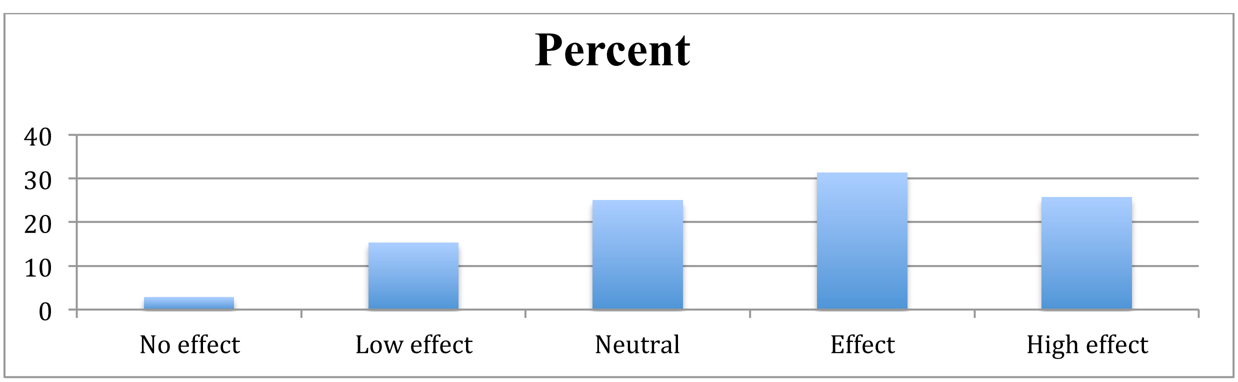


Figure 5.7: shows the frequency of answers in percentages regarding the level of waste

5.4.1.2 Time of waiting

The time of waiting came second, with the results showing 30.1% for effect and 16.1% for high effect (Figure 5.8).

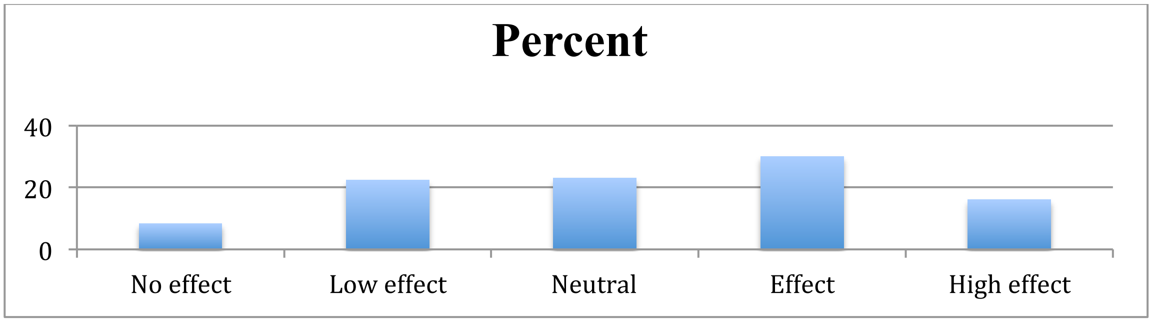


Figure 5.8: shows the frequency of answers in percentages regarding time of waiting

5.4.1.3 Quality

Finally, the respondents reported that quality had a 36.6% effect and a 9% high effect, regarding the level of waste produced in the Jordanian construction industry (Figure 5.9).

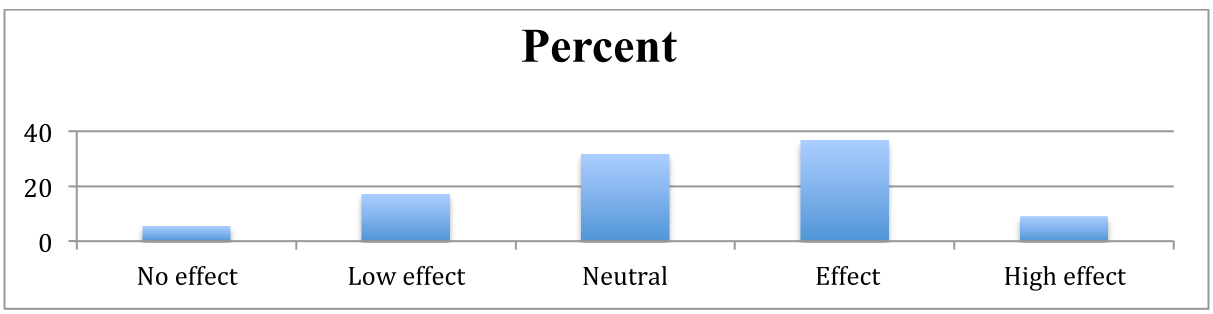


Figure 5.9: shows the frequency of answers in percentages regarding quality

5.4.2 Reverse construction logistic processes (the remaining/damaged material moves from the site to the production point)

Figure 5.10 shows that over 50% do not use reverse logistics, with just over 25% noting the use of reverse logistics and 20% having never heard of it.

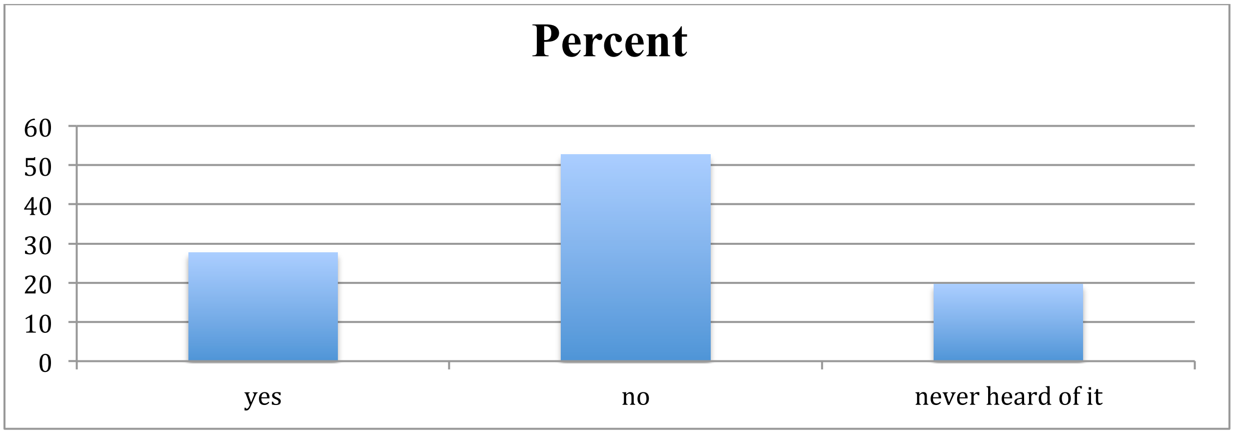


Figure 5.10: shows the frequency of answers in percentages regarding reverse logistics

5.4.3 Training sessions provided for your team

Figure 5.11 shows that over 83% did not provide training sessions for their team or company, and only 14% had training sessions in professional project management and building construction and project management modules.

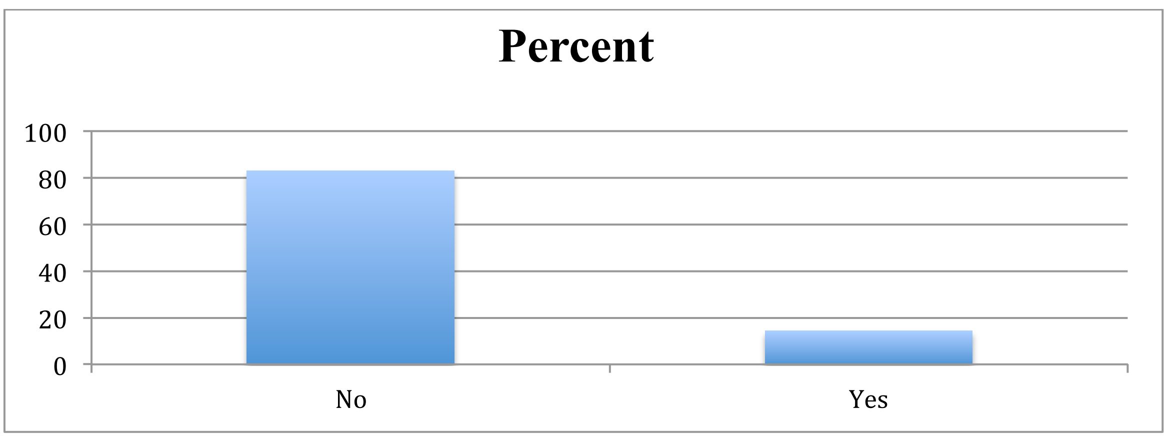


Figure 5.11: Shows the frequency of answers in percentages regarding training sessions

5.4.4 Type of contract (procurement) used

Just under 60% of the construction parties used traditional contracts, 25% used design and build, 13.6% used management contracting and 2% said that it depended on the project as shown in Figure 5.12.

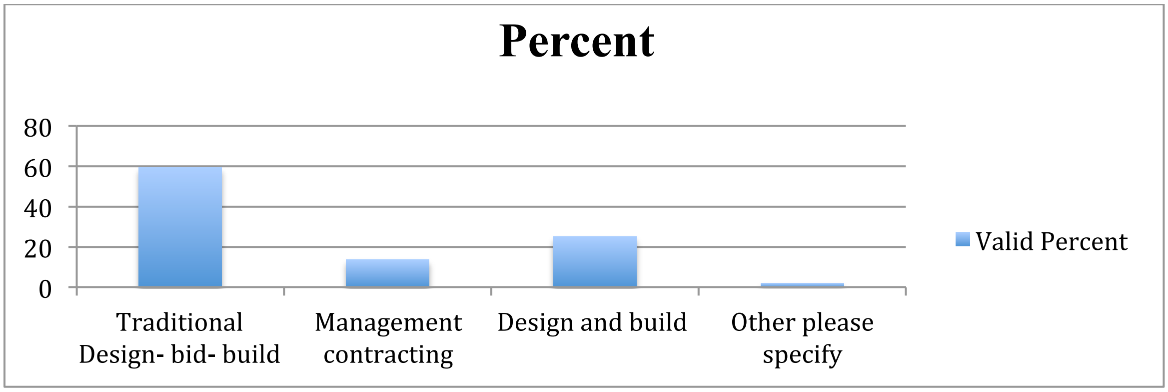


Figure 5.12: Shows the frequency of answers in percentages regarding type of contracts (procurement)

5.5 Factors (challenges) Affecting Construction Logistics with Ranking

The table below (Table 5.2) shows the frequency of the responses regarding each of the 35 factors affecting construction logistics in the Jordanian construction industry, using a Likert scale (strongly disagree, disagree, neutral, agree, strongly agree). The factors have been ranked (R), based on the highest to the lowest level of agreement. Furthermore, the table includes the level of agreement (L.A), the level of disagreement (L.D), as well as the mean of all factors. The factors have been ranked based on the highest to the lowest level of agreement, as the data is considered ordinal (Bertram, 2007).

Table 5.2: Shows the respondents' satisfaction regarding challenges affecting logistics

Factor	SD %	D %	N %	A %	SA %	Mean	L.D %	L.A %	Rank (R)
Mapping the material route from the original point to the construction site is insufficient in Jordanian construction logistics	0.7	2.8	14.8	47.2	34.5	4.12	3.5	81.7	1
Lack of trained staff significantly affects construction logistics in Jordan	2.8	7	12	52.1	26.1	3.915	9.8	78.2	2
Distrust among parties negatively affects the construction logistics process	2.8	7.7	14.7	44.8	30.1	3.916	10.5	74.9	3

Lack of meeting between construction parties negatively affects construction logistics in Jordan	1.4	7.1	18.4	48.9	24.1	3.87	8.5	73	4
Fluctuation in material negatively affects construction logistics in Jordan	2.8	4.9	20.8	42.4	29.2	3.90	7.7	71.6	5
Interference in decision making by the supplier is inadequate in the Jordanian construction logistics process	1.4	10.5	17.5	43.4	27.3	3.846	11.9	70.7	6
Determining the most appropriate road is insufficient in Jordanian construction logistics and particularly affects health and safety	4.2	10.5	15.4	46.9	23.1	3.74	14.7	70	7
Deficiency and complexity in planning negatively affects Jordanian construction logistics	3.4	10.3	16.6	50.3	19.3	3.72	13.7	69.6	8
Interference in decision making by contractors or subcontractors is insignificant in construction logistic	2.8	9.8	18.9	48.3	20.3	3.73	12.6	68.6	9
Lack of mutual information and instruction parties negatively affects construction logistics in Jordan.	0	10.7	22.1	43.6	23.6	3.8	10.7	67	10
Type of contract or procurement used between construction parties is not chosen properly in construction logistics	0.7	9.2	23.2	52.1	14.8	3.71	9.9	66.9	11
Shared transportation is inadequately used between construction parties.	4.9	11.9	17.5	45.5	20.3	3.64	16.8	65.8	12

Poor delivery speeds and responses from suppliers negatively affect construction logistic	0.7	7	27.3	53.8	11.2	3.68	7.7	65	13
Jordanian construction logistics has unnecessary and large inventories	0.7	15.9	18.6	46.2	18.6	3.66	16.6	64.8	14
Customer-client service is not a top priority for suppliers	2.1	10.5	23.1	43.4	21	3.70	12.6	64.4	15
Controlling and monitoring of the tracking system are not used permanently in Jordanian construction logistics	2.1	10.5	24.5	43.4	19.6	3.68	12.6	63	16
Storage material by contractors is desirable in Jordanian construction	2.1	14.2	23.4	52.5	7.8	3.49	16.3	60.3	17
Feedback and shared lessons are not essential among parties in Jordanian construction logistics'	3.5	10.6	26.8	45.1	14.1	3.556	14.1	59.2	18
Lifting and storing don't need skilled labours	2.8	14.6	23.6	41.7	17.4	3.56	17.4	59.1	19
Determining the most appropriate road is not usually negotiable between construction parties in Jordan	2.8	7.7	31	41.5	16.9	3.61	10.5	58.4	20
Advanced technology is insignificant in the construction logistics process	2.1	8.4	31.5	48.3	9.8	3.552	10.1	58.1	21
Jordanian construction does not consider long waiting throughout the process that affects the quality of the logistics process	0.7	11.2	30.1	45.5	12.6	3.58	11.9	58.1	22
Lifting and handling by machine increase the cost in Jordanian construction logistics processes	4.9	20.1	20.1	46.5	8.3	3.33	25	54.8	23

Types of vehicle used in transportation are insufficient in the construction logistics process	4.9	16.8	24.5	46.2	7.7	3.35	21.7	53.9	24
Health and safety are not given great consideration in Jordanian construction logistics processes.	2.8	18.1	25.7	37.5	16	3.46	20.9	53.5	25
Cultural challenges are a vital aspect in construction logistics in Jordan	3.5	11.2	32.2	41.3	11.9	3.47	14.7	53.2	26
Different languages and dialects negatively affects the construction logistics process	3.4	15.2	32.4	33.1	15.9	3.43	18.6	49	27
Government regulation regarding allowable loading and customs negatively affects construction logistics in Jordan’	3.5	13.3	35	37.1	11.2	3.39	16.8	48.3	28
Shortage of machinery and equipment negatively affects Jordanian construction logistics	2.8	24.3	26.4	38.9	7.6	3.243	27.1	46.5	29
Tracking systems add unnecessary cost in Jordanian construction logistics	7.1	30	17.1	32.9	12.9	3.14	37.1	45.8	30
Poor quality of finished goods occurs because of poor construction logistics	5.6	25.2	23.8	30.8	14.7	3.237	30.8	45.5	31
Jordanian construction logistics suffers from unnecessary movement and excessive transportation	2.8	16.1	38.5	39.9	2.8	3.237	18.9	42.7	32
Construction logistics suffers from overproduction in the construction logistics process	2.8	32.4	33.1	27.5	4.2	2.98	35.2	31.7	33

Lifting and handling by machines is undesirable to contractors and suppliers	11.9	33.6	27.3	21	6.3	2.76	45.5	27.3	34
Bringing material just in time is required by Jordanian construction logistics parties	23	38.1	25.9	10.8	2.2	2.3	61.1	13	35

5.6 Lean Planning Tools with Ranking

In this section, the Likert scale is divided into five choices as shown in Table 5.3: never used (N), rarely used (R), sometimes (S), mostly used (M) and always used (A). Additionally, the table includes the level of agreement in using planning tools (L.A), the level of agreement in none-using planning tools (L.N), as well as the mean of tools. The planning tools have been ranked based on the highest to the lowest level of use by participants.

Table 5.3: Demonstrates the participants' agreement with the use of Lean planning tools

Tools	N %	R %	S %	M %	A %	Mean	L.N %	L.A %	R
Daily progress report	0	3.3	29.3	49.3	18	3.82	3.3	67.3	1
Weekly plan	1.3	20.7	34	37.3	6.7	3.27	22	44	2
Master plan	26	17.3	12.7	32	12	2.87	43.3	44	3
Critical path method	26.7	19.3	17.3	29.3	7.3	2.71	46	36.6	4
Look ahead plans	20.7	28.7	26.7	22	2	2.56	49.4	24	5
Work breakdown structure	26	43.3	20	8.7	2	2.17	69.3	10.7	6
Planned completed percentages estimation	28	40	23.3	6.7	2	2.14	68	8.2	7

5.7 Lean practices with Ranking

In this section, the Likert scale is divided into five choices as shown in Table 5.4: never used (N), rarely used (R), sometimes (S), mostly used (M) and always used (A). Moreover, the table contains level of agreement in using lean practices (L.A), the level of agreement in none-using lean practices (L.N) as well as the mean of practices. Lean practices have also been ranked based on the highest to the lowest level of use by participants.

Table 5.4: Demonstrates the participants' agreement with the use of Lean practices

Practices	N %	R %	S %	M %	A %	Mean	L.N %	L.A %	R
Meeting with your team	11.3	28.9	31	15.5	13.4	2.9	40.2	28.9	1
Meeting with stakeholders	16.2	40.8	21.1	13.4	8.5	2.57	57	21.9	2
Root causes analysis (5 WHYS)	27.7	31.2	24.1	12.8	4.3	2.35	58.9	17.1	3
Gemba	37.2	29.2	18.2	10.2	5.1	2.17	66.4	15.3	4
First run study	38.8	39.3	9.2	8	4.7	?	78.1	12.7	5
5S	42.6	33.3	15.6	6.4	2.1	1.9	75.9	8.5	6
JIT/Just In Time	58.7	29.7	5.8	3.6	2.2	1.6	88.4	5.8	7
Value stream mapping	40.6	42	14	2.1	1.4	1.8	82.6	3.5	8
Last planner	71.2	20.9	5	1.4	1.4	1.4	92.1	2.8	9

5.8 Drivers with Ranking

In this section, Likert scale is divided into five choices (strongly disagree, disagree, neutral, agree, strongly agree) as shown in Table 5.5. The drivers have been ranked based on the highest to the lowest level of agreement. Furthermore, the table includes the level of agreement (L.A), the level of disagreement (L.D), as well as the mean of all drivers. However, the drivers have been ranked based on the highest to the lowest level of agreement due to the nature of data, which is considered ordinal.

Table 5.5: Shows the participants' agreement regarding lean drivers

Drivers	SD %	D %	N %	A %	SA %	Mean	L.D %	L.A %	R
Reliability in cost	0	3.7	24.4	54.1	17.8	3.86	3.7	71.9	1
Need for fast delivery speed and responsiveness	1.5	6	23.9	53	15.7	3.75	7.5	68.7	2
Better reputation	1.5	5.9	25.2	42.2	25.2	3.84	7.4	67.4	3
Reliability in time	0.7	10.3	24.3	48.5	16.2	3.69	11	64.7	4
Reliability in quality	2.2	5.2	28.1	53.3	11.1	3.66	7.4	64.4	5
Solve storage problem	1.5	8	27	46.7	16.8	3.69	9.5	63.5	6
Huge demand and delivery	2.9	6.6	27.2	50.7	12.5	3.63	9.5	63.2	7
Create value	5.1	8.1	23.5	54.4	8.8	3.54	13.2	63.2	8
Sustainable improvement	4.4	8.1	26.5	47.1	14	3.58	12.5	61.1	9
Increased safety	3	8.1	28.1	45.9	14.8	3.61	11.1	60.7	10
Catch problems early	0.7	9.5	29.2	44.5	16.1	3.66	10.2	60.6	11
If competitors use them	2.9	12.5	26.5	52.2	5.9	3.46	15.4	58.1	12
Help manage conflict	2.2	8.1	31.9	45.2	12.6	3.58	10.3	57.8	13
Labour shortage	6.7	11.9	28.1	44.4	8.9	3.37	18.6	53.3	14
Employee satisfaction	3.6	9.5	39.4	38.7	8.8	3,39	13.1	47.5	15

5.9 Barriers with Ranking

In this section, Likert scale is divided into five choices (strongly disagree, disagree, neutral, agree, strongly agree) as shown in Table 5.6. The barriers have been ranked based on highest to the lowest level of agreement. Furthermore, the table includes the level of agreement (L.A), the level of disagreement (L.D) as well as the mean of all barriers. Nevertheless, the barriers have been ranked based on the highest to the lowest level of agreement due to the nature of data, which is considered ordinal.

Table 5.6: Shows the participants' agreement regarding lean barriers

Barriers	SD %	D %	N %	A %	SA %	Mean	L.D %	L.A %	R
Mindset issues	0	2	10	60	28	4.1	2	88	1
Lack of awareness and understanding	2.9	3.6	10.2	62	21.2	3.95	6.5	83.2	2
Lack of training and education	3.7	0.7	16.9	51.5	27.2	3.98	4.4	78.7	3
Lack of mandate and top management	2.2	5.8	21	46.4	24.6	3.86	8	71	4
No support from government	3.6	9.4	23.2	38.4	25.4	3.72	13	63.8	5

5.11 Inferential Data

Firstly, it is very vital to identify the nature of data before proceeding with testing the hypothesis. As mentioned in the methodology, there are two types, parametric and non-parametric. Parametric data is mainly defined through normal distribution and has an interval scale. In contrast, non-parametric data it not justified by normal distribution and has an ordinal scale. In this study, a Likert scale with five points was used in the survey, which means that the data is assumed to be ordinal and, consequently, non-parametric; thus, suitable non-parametric tests have been employed on the data.

In this section, inferential statistics is used to support the descriptive findings and add significant results as well as further solid outcomes relating to the data collection. The inferential statistics have been utilised to: 1) apply factor analysis through the factors affecting construction logistics in Jordan (i.e. 35 questions) to perform grouping, ranking and to eliminate non-significant factors of which results have noteworthy main groups, each one of them with a group of sub-factors that have logical and reasonable relationships with each other; 2) one of the vital points of this study is to find if there are differences in effects among stakeholders regarding the factors affecting construction logistics lean planning tools, lean practices, drivers and barriers. Therefore, the Kruskal-Wallis test (i.e. non-parametric test) and logistics regression test were employed to fulfill this point.

5.11.1 Factor Analysis

Factor analysis identifies as the method of data reduction. It does this by pursuing fundamental latent variables that are reflected in the observed variables (Field, 2005). Using factor analysis throughout factors affecting logistics in Jordan (i.e. 35 questions) results in eight main groups. SPSS software assisted in grouping and ranking the 35 sub-factors and placed them in eight major groups. The dimension reduction (factor analysis) was run in SPSS several times to gain the best reasonable and appropriate main factors correlated to the data as well as using absolute value 0.5 and varimax rotation. Some of the sub-factors were eliminated and others were grouped with each other, as shown in Table 5.7. The findings of the factor analysis will be discussed in detail, as well as with the descriptive findings, to draw proper conclusions for the factors affecting Jordanian construction.

Table 5.7: Factor analysis regarding challenges affecting construction logistics in Jordan

Planning	Lack of training staff	.787							
	Deficiency and complexity in planning	.641							
	Type of contract procurement used between parties	.628							
	Poor delivery speed and responsiveness by supplier	.624							
Transportation	Using shared transportation vehicles with other parties		.685						
	Types of vehicle used in transportation are insufficient		.650						
	Construction logistics suffers from unnecessary movement and excessive transportation		.547						
	Government regulations regarding customs & allowable loads		.529						
	Fluctuation of material		.501						
Transparency and Information Exchange	Tracking system adds unnecessary cost			.774					
	Lack of mutual information and instructions			.697					
	Controlling and monitoring tracking system are not using permanently			.588					
	Distrust among parties			.517					

Continuous Improvement	Cultural challenges and behaviours				.745				
	Feedback or shared lessons among parties				.638				
	Customer-client service is not a top priority for suppliers				.580				
Health and Safety	H&S regulations are not given great consideration					.701			
	Determining the most appropriate road is insufficient					.656			
Material preservation (preserving quality)	Poor quality of the finished product because of logistics process						.717		
	Construction logistics process in Jordan not considering the long waiting time among the processes						.517		
Inventory	Storage in construction sites is desirable by contractors							.651	
	Bringing material JIT is required							.634	
	Jordanian construction logistics processes suffer unnecessary inventory							.513	
Material handling	Lifting and handling by machines considerably increases the cost								.731
	Lifting and handling by machines is undesirable								.675

5.11.2 Kruskal-Wallis

After grouping the sub-factors based on the factor analysis, it is very important to mention at this stage that the main factors (findings groups) were recoded and computed based on the sum (i.e. non-parametric data). Furthermore, computing the sum was recoded for the lean part also.

These sums were used in the Kruskal-Wallis test as well as in the next part of logistic regression. According to Field (2005), Kruskal-Wallis is a non-parametric test to measure the effect of an independent variable of more than two levels on the rest of the dependent variables (i.e. measured by ordinal scale). Kruskal- Wallis examines more than two independent variables, unlike Mann-Whitney U test (non-parametric test) which examines just two independent variables. So, as this research has three independent variables (consultant, contractor, supplier), Kruskal Wallis test is suitable to be used to find the effect of each of the stakeholders on the dependent factors. Furthermore, the significant difference among the independent variables is measured by alpha level (sig), which measures the opportunity of the outcomes being random and should be less than or equal to 5% to reflect a significant effect.

As discussed previously, this research considers non-parametric and ordinal. Furthermore, "the average (mean) of 'fair' and 'good is not ' fair and a half '; which is true even when one assigns integers to represent 'fair' and 'good'" (Jamieson, 2004). Thus, this explains to far extent that mean (average) considers unacceptable in the ordinal data. Ordinal data is using the median and the mode instead of the mean (Bertram, 2007). Consequently, the previous information justifies the use of median instead of mean in the following test (Kruskal Wallis test).

5.11.2.1 The Differences of the Level of Agreement among Stakeholders in Factors (challenges) Affecting Construction Logistics

Table 5.8 shows that there are significant differences among independent variables through the dependent variables (factors affecting construction logistics in Jordan). The difference between stakeholders means that the one with higher frequency (> median) has a greater effect than the others. Therefore, and based on the data results regarding the factors (challenges) affecting construction logistics in Jordan, two major factors have significant alpha. Firstly, planning factor (0.00 sig): the consultant has the higher effect, then the contractor and lastly the supplier. Secondly, transportation factor (.001 sig): the supplier has a higher level of agreement and effect, subsequently the contractor and finally the consultant.

Table 5.8: Shows the differences among stakeholders in logistics challenges

Frequencies				
		Size as		
		Consultant	Contractor	Supplier
Planning factor	> Median	28	28	12
	<= Median	12	26	44
Transportation efficiency factor	> Median	12	20	36
	<= Median	28	34	20
Transparency/ information exchange factor	> Median	21	28	18
	<= Median	19	26	38
Value adding factor (continuous improvement)	> Median	19	16	16
	<= Median	21	38	40
Health and safety (H & S) factor	> Median	21	27	24
	<= Median	19	27	32
Inventory level factor	> Median	20	29	24
	<= Median	20	25	32
Material handling factor	> Median	18	22	19
	<= Median	22	32	37
Material preservation	> Median	12	20	15
	<= Median	28	34	41

Test Statistics								
	Planning factor	Transportation efficiency factor	Transparency (visualisation) and information exchange factor	Value adding factor (Continuous improvement)	H&S	Inventory level factor	Material handling	Material preservation
N	150	150	150	150	150	150	150	150
Median	15.0000	18.0000	14.0000	11.0000	7.0000	9.0000	6.0000	7.0000
Chi-Square	23.659[b]	13.411[b]	5.675[c]	4.444[d]	1.004[e]	1.333[f]	1.269[g]	1.388[h]
df	2	2	2	2	2	2	2	2
Asymp. Sig.	.000	.001	.059	.108	.605	.513	.530	.500

5.11.2.2 The Differences in the Level of Agreement between Stakeholders in Lean Planning Tools

According to Table 5.9, it seems that the consultant has a greater effect (higher frequency) than others, then the contractor and lastly the supplier on the master plan (.000 sig), critical path analysis (.001 sig) and weekly plans (.000 sig). On the other hand, for look ahead plans (.000 sig) and daily progress reports (.002 sig), the contractor comes first with a higher frequency compared to the other stakeholders, followed by the consultant and then the supplier.

Table 5.9: Shows the differences between stakeholders in Lean planning tools

Frequencies				
		Size as		
		Consultant	Contractor	Supplier
Master plan	> Median	30	15	9
	<= Median	10	39	43
Critical path method	> Median	22	13	3
	<= Median	18	41	49
Look ahead plans	> Median	16	32	9
	<= Median	24	22	43
Weekly plans	> Median	27	32	13
	<= Median	13	22	39
Daily progress report	> Median	17	24	5
	<= Median	23	30	47
Planned completed percentages estimation (PCPE)	> Median	17	27	17
	<= Median	23	27	35

Work breakdown structure (WBS)	> Median	16	25	16
	<= Median	24	29	36

Test Statistics							
	Master plan	Critical path method	Look ahead plans	Weekly Plans	Daily progress report	PCPE	WBS
N	146	146	146	146	146	146	146
Median	4.00	4.00	3.00	3.00	4.00	2.00	2.00
Chi-Square	35.405	28.631	19.611	19.728	17.976	3.274	2.705
df	2	2	2	2	2	2	2
Asymp. Sig.	.000	.001	.000	.000	.002	.195	.259

5.11.2.3 The Differences in the Level of Agreement among Stakeholders in Lean Practices

The consultant has a higher frequency (> median), subsequently the contractor and finally the supplier on lean practices: ‘first run study’ (0.009 sig), ‘root cause analysis’ (0.12 sig), ‘Gemba’ (0.47 sig), ‘weekly meeting with your team’ (.000 sig) and ‘weekly meeting with stakeholders’ (.000 sig). However, the contractor has a higher frequency (> median) than the others on the ‘5S’ (0.12 sig), followed by the consultant and lastly the supplier (Table 5.10).

Table 5.10: Shows the differences between stakeholders in lean practices

Frequencies				
		Size as		
		Consultant	Contractor	Supplier
Value stream mapping	> Median	10	10	9
	<= Median	28	43	43
Last planner system	> Median	17	16	15
	<= Median	21	34	36
5s	> Median	13	23	9
	<= Median	24	29	43
First run study	> Median	14	12	5
	<= Median	24	41	46
JIT	> Median	19	19	24
	<= Median	18	32	27
Root cause analysis	> Median	24	20	17
	<= Median	14	33	34
Gemba	> Median	21	20	15
	<= Median	16	32	34
Weekly meeting with your team	> Median	23	15	4
	<= Median	15	38	48
Weekly meeting with stakeholders	> Median	25	15	6
	<= Median	13	38	46

Test Statistics									
	VSM	LPS	5s	First run study	JIT	Root cause analysis	Gemba	Weekly meeting with your team	Weekly meeting with stakeholders
N	143	139	141	142	139	142	138	143	143
Median	2.00	1.00	2.00	2.00	1.00	2.00	2.00	4.00	3.00
Chi-Square	1.206[b]	2.484[c]	8.913[d]	9.361[e]	1.921[f]	8.845[g]	6.131[h]	29.591[i]	30.191[j]
df	2	2	2	2	2	2	2	2	2
Asymp. Sig.	.547	.289	.012	.009	.383	.012	.047	.000	.000

5.11.3 Logistic Regression

Regression is considered a vital test to explain the predictive power of the variables; it is about fitting a predictive model to the data, and using the model to predict the values of the dependent variables (DVs), from one or more independent variables (IVs). Furthermore, single regression pursues predicting an outcome variable by using a single predictor variable, whereas multiple regression can predict an outcome variable by using more than one predictor. Logistic regression is a multiple regression but with an outcome variable that is a categorical dichotomy and a predictor variable that can be continuous or categorical (Field, 2011). In this research, logistic regression seems to be the best proper test as each dependent variable has binary values zero or one (e.g. consultant has two values: 0 = not consultant, 1 = consultant).

Furthermore, dependent variable in logistics regression has binary values zero or one (two values). Unlike linear regression, which accepts one value for independent variable. So, in this research logistics regression deems the best choice as each stakeholder has two values (i.e. not consultant=0, consultant=1).

Nine models were used in this study, using SPSS (regression, binary regression, logistic regression), three models for factors affecting Jordanian construction logistics, three models for lean planning tools and three models for lean practices. Each model seeks to predict each one of the stakeholders (consultant, contractor, supplier) individually by predictive variables.

According to Field (2011), logistic regression is rarely used and it is hard to find any solid guides about how to properly explain it. However, in this research, the significant points related to the study will be explained to support the previous findings and add more concrete answers for the fourth objective. As this part has nine models and each one includes four tables, it is essential to provide a proper explanation for the tables below. The first table (Omnibus tests of model coefficients) includes Chi- square distribution with k degree of freedom, which is the distribution of a sum of the squares of k independent standard normal random variables (Field, 2005). Furthermore, Chi-square distribution has degrees of freedom (df) equal to the number of parametrics in the new model minus the number of parametrics in the base model, which is always equal to one. The significant value is considered the main outcome of this table, where this value should be less than or equal 0.005 to build a significant model (ibid). The second table (model summary) includes: log-likelihood statistic, which sums up the probabilities related to the predicted and actual outcomes. This explains how much unexplained information there is after the model has been fitted (Tabachnick and Fidell, 2001). Furthermore, the table also includes the Cox and Snell R Square (Rcs) and the Nagelkerke R Square (Rn), which are used to provide a gauge of the substantive significance of the model; they represent the correlation among observed and predicted variables by the logistic regression model. Both R squares are identified as the percentage of variance of dependent variables that can be accounted for by independent variables to the create regression equation (Field, 2011). Rcs has a maximum value of 0.75 and Rn is an adjusted version of Rcs that enlarges the range to be zero to one, thus it is preferable to describe the results by Rn-value. If the Rn-value equals one, this means that the model ideally and perfectly predicts the observed data. Additionally, it is a measurement of how much variability in the outcome is accounted by the predictors (Fritz and Berger, 2015).

The third table (classification table) tells that the model is classifying a certain amount of cases, which means that, if this value increases, the model can predict higher percentages of the cases (a proper model has more than 60%). It indicates how the model can predict values through the observed data (Field, 2005). The last table (variables in the questions) represents the final model and mainly includes: B coefficient, which is the log of the odds ratio; this coefficient shows whether a positive value representing the dependent variable is predicted to be affected by independent variable (predictor) or a negative value, which means that the dependent variables are predicted not to be affected by the independent variable (predictor). Additionally, a higher value of B is associated with higher probabilities of predicting the dependent variable.

Standard error (SE) represents the measure of accuracy of predictions, Exp B, which represents the odds of an event that expresses the probability of an event occurring, divided by that event not occurring (Odds=P event / P no event). The interpretation of the Exp B means, if the value is more than one, when the predictor increases the odds of the outcome occurring increase too. On the other hand, if the value is less than one, as the predictor increases the odds of the outcome occurring inversely decrease (Field, 2005). In addition, the Wald statistic, which is an analogous statistic that has a special distribution known as chi-square distribution, tells about the b-coefficient and its standard error (Wald=b/SEb). It should be used carefully and precisely because the associated standard error is inflated and the coefficient b is quite large, which results in an underestimated outcome of the Wald test. This inflation of the standard error decreases the probability of accepting a predictor while the predictor is considered a significant and noteworthy contribution to the model. In simple terms, the Wald test shows that, if the coefficient is different from zero, the predictor is creating a significant contribution to predicting the outcome (Menard, 1995). Importantly, the significant value for each predictor must be less than or equal 0.005 to have a significant prediction.

5.11.4 Using Logistic Regression for Factors Affecting Construction Logistics (IVs) (after factor) Analysis to Predict Consultant, Contractor and Supplier (DVs)

Model 1: Predicting the consultant by factors affecting construction logistics

Table 5.11 (Omnibus tests of model coefficients) shows that the model is significant (0.000) with a chi- square value = 31.547. According to Table 5.12 (model summary), Rn is equal to 0.274, which means that the percentage of variance of the dependent variables that can be accounted for by the independent variable is around 28%. Moreover, it can be explained as a 28% variability of the model that could be predicted using the variables of the model. Table 5.13 (classification table) indicates that the model could predict 78.3% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.11: Shows Omnibus of model coefficient for Model 1

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	31.547	8	.000
	Block	31.547	8	.000
	Model	31.547	8	.000

Table 5.12: Shows model summary for Model 1

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	143.658[a]	.187	.274

Table 5.13: Shows classification table for Model 1

Classification Table					
	Observed		Predicted		
			Consultant		Percentage Correct
			null	yes	
Step 1	Consultant	null	103	9	92.0
		yes	24	16	40.0
	Overall Percentage				78.3

<u>The null hypothesis:</u>
H01: Factors affecting construction logistics in Jordan do not predict the consultant.

<u>The alternative hypothesis:</u>

H1: Factors affecting construction logistics in Jordan predict the consultant.

- The alternative sub-hypotheses are:

H1a: Planning factor predicts the consultant

H1b: Transportation factor predicts the consultant

H1c: Transparency factor predicts the consultant

H1d: Value adding factor predicts the consultant

H1e: Health and safety factor predicts the consultant

H1f: Inventory factor predicts the consultant

H1g: Material handling predicts the consultant

H1h: Material preservation predicts the consultant

Table 5.14: Shows variables in the equation for Model 1

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Planning	.440	.115	14.714	1	.000	1.553
	Transportation	-.274	.080	11.700	1	.001	.760
	Transparency	-.016	.077	.045	1	.833	.984
	Value adding	.008	.103	.006	1	.940	1.008
	H&S	.023	.131	.032	1	.858	1.024
	Inventory	-.204	.103	3.946	1	.047	.815
	Material handling	-.004	.121	.001	1	.974	.996
	Material preservation	.112	.161	.485	1	.486	1.119
	Constant	-1.920	.913	4.428	1	.035	.147

According to Table 5.14 (variables in equation), alternative sub-hypotheses H1a, H1b and H1f have been significantly accepted. Firstly, planning factor-H1a (independent variable) can predict (dependent variable) being a consultant (B=+0.44) with a significant value (0.00). Thus, an increase in the independent variable (planning factor-H1a) predicts an increase in the dependent variable (consultant). Secondly, transportation-H1b (independent variable) can predict (dependent variable) not being a consultant (B=-.274) with a significant value (0.001). Then, an increase in independent the variable (transportation-H1b) predicts a decrease in the dependent variable (consultant). Lastly, inventory-H1f (independent variable) can predict (dependent variable) not being a consultant (B=-0.204) with a significant value (0.047). Therefore, an increase in the independent variable (inventory-H1f) predicts a decrease in the dependent variable (consultant).

Model 2: Predicting the contractor by factors affecting construction logistics

Table 5.15 (Omnibus tests of model coefficients) shows that the model is significant (0.10) with a chi-square value = 20.190. According to Table 5.16 (model summary), Rn is equal to 0.171, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is 17.1%. Moreover, it can be explained as a 17.1 % variability of the model that could be predicted using the variables of the model. Table 5.17 (classification table) indicates that the model could predict 65.8% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.15: Shows Omnibus of model coefficient for Model 2

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	20.190	8	.010
	Block	20.190	8	.010
	Model	20.190	8	.010

Table 5.16: Shows model summary for Model 2

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	177.606[a]	.124	.171

Table 5.17: Shows classification table for Model 2

Classification Table					
	Observed		Predicted		
			Contractor		Percentage Correct
			null	yes	
Step 1	Contractor	null	86	12	87.8
		yes	40	14	25.9
	Overall Percentage				65.8

The null hypothesis is:

H02 Factors affecting construction logistic in Jordan don't predict the contractor.

The alternative hypothesis is:

H2 Factors affecting construction logistic in Jordan predict the contractor.

- The alternative sub-hypotheses are:

H2a Planning factor predicts the contractor.

H2b Transportation factor predict the contractor.

H2c Transparency factor predicts the consultant.

H2d Value adding factor predicts the contractor.

H2e Health and safety factor predicts the contractor.

H2f Inventory factor predicts the contractor.

H2g Material handling predicts the contractor.

H2h Material preservation predicts the contractor.

Table 5.18: Shows variables in the equation for Model 2

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1	Planning	.181	.084	4.618	1	.032	1.198
	Transportation	-.130	.067	3.748	1	.053	.878
	Transparency	-.003	.066	.001	1	.969	.997
	Value adding	-.084	.091	.854	1	.355	.919
	H&S	.081	.117	.483	1	.487	1.085
	Inventory	.224	.091	6.037	1	.014	1.251
	Material handling	.078	.107	.531	1	.466	1.081
	Material preservation	.013	.139	.008	1	.927	1.013
	Constant	-3.309	1.189	7.742	1	.005	.037

According to Table 5.18 (variables in equation), alternative sub-hypotheses H2a and H2f have been significantly accepted. Firstly, planning factor-H2a (independent variable) can predict (dependent variable) being a contractor (B=+0.181) with a significant value (0.032). Thus, increase in the independent variable (planning factor-H2a) predicts an increase in the dependent variable (contractor). Secondly, inventory-H2f (independent variable) can predict (dependent variable) being a contractor (B=+0.224) with a significant value (0.014). Therefore, an increase in the independent variable (inventory-H2f) predicts an increase in the dependent variable (contractor).

<u>Model 3: Predicting the supplier by factors affecting construction logistics</u>

Table 5.19 (Omnibus tests of model coefficients) shows that the model is significant (0.000) with a chi-square value = 72.674. According to Table 5.20 (model summary), Rn is equal to 0.519, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is around 52%. Moreover, it can be explained as around a 52% variability of the model that could be predicted using the variables of the model.

Table 5.21 (classification table) indicates that the model could predict 80.9% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.19: Shows Omnibus of model coefficient for Model 3

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	72.674	8	.000
	Block	72.674	8	.000
	Model	72.674	8	.000

Table 5.20: Shows model summary for Model 3

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	127.391[a]	.380	.519

Table 5.21: Shows classification table for Model 3

Classification Table					
	Observed		Predicted		
			Supplier		Percentage Correct
			null	yes	
Step 1	Supplier	null	84	12	87.5
		yes	17	39	69.6
	Overall Percentage				80.9

The null hypothesis:

H03: Factors affecting construction logistics in Jordan do not predict the supplier.

The alternative hypothesis:

H3: Factors affecting construction logistics in Jordan predict the supplier.

- The alternative sub-hypotheses are:

H3a: Planning factor predicts the supplier

H3b: Transportation factor predicts the supplier

H3c: Transparency factor predicts the supplier

H3d: Value adding factor predicts the supplier

H3e: Health and safety factor predicts the supplier

H3f: Inventory factor predicts the supplier

H3g: Material handling predicts the supplier

H3h: Material preservation predicts the supplier.

Table 5.22: Shows variables in the equation for Model 3

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Planning	-.759	.148	26.264	1	.000	.468
	Transportation	.591	.119	24.694	1	.000	1.806
	Transparency	-.023	.091	.066	1	.798	.977
	Value adding	.144	.137	1.113	1	.291	1.155
	H&S	-.008	.166	.003	1	.960	.992
	Inventory	-.138	.117	1.391	1	.238	.871
	Material handling	-.016	.137	.014	1	.906	.984
	Material preservation	-.085	.179	.226	1	.634	.919
	Constant	.691	.760	.828	1	.363	1.997

According to Table 5.22 (variables in equation), alternative sub-hypotheses H3a and H3b have been significantly accepted. Firstly, planning factor-H3a (independent variable) can predict (dependent variable) not being a supplier (B=-0.759) with a significant value (0.000). Thus, an increase in the independent variable (planning factor-H3a) predicts a decrease in the dependent variable (supplier). Secondly, transportation-H3b (independent variable) can predict (dependent variable) being a supplier (B=+0.591) with a significant value (0.000). Therefore, an increase in the independent variable (transportation-H3b) predicts an increase in the dependent variable (supplier).

5.11.5 Predicting Stakeholders by Lean Planning Tools

Model 4: Predicting the consultant by lean planning tools

Table 5.23 (Omnibus tests of model coefficients) shows that the model is significant (0.000) with a chi-square value = 46.453. According to Table 5.24 (model summary), Rn is equal to 0.394, which means that a percentage of the variance of the dependent variable that can be accounted for by the independent variable is around 40%. Additionally, it can be justified as around a 40% variability of the model that could be predicted using the variables of the model. Table 5.25 (classification table) indicates that the model could predict 83.6% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.23: Shows Omnibus of model coefficient for Model 4

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	46.453	7	.000
	Block	46.453	7	.000
	Model	46.453	7	.000

Table 5.24: Shows model summary for Model 4

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	125.000[a]	.273	.394

Table 5.25: Shows classification table for Model 4

Classification Table					
	Observed		Predicted		
			Consultant		Percentage Correct
			null	yes	
Step 1	Consultant	null	100	6	94.3
		yes	18	22	55.0
	Overall Percentage				83.6

<u>The null hypothesis:</u>

H04: Lean planning tools do not predict the consultant.

<u>The alternative hypothesis:</u>

H4: Lean planning tools predict the consultant.

- The alternative sub-hypotheses are:

H4a: Master plan tool predicts the consultant

H4b: Critical path analysis tool predicts the consultant

H4c: Look ahead plans tool predicts the consultant

H4d: Weekly plans tool predicts the consultant

H4e: Daily progress report tool predicts the consultant

H4f: Percentage planned completed tool predicts the consultant

H4g: Work breakdown structure tool predicts the consultant

Table 5.26: Shows variables in the equation for Model 4

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	Master plan	1.278	.382	11.199	1	.001	3.591
	CPA	.570	.285	3.996	1	.046	1.768
	Look ahead plans	-.529	.238	4.924	1	.026	.589
	Weekly plans	.527	.257	4.200	1	.040	1.693
	Daily progress report	-.159	.315	.253	1	.615	.853
	PPC	-.087	.233	.139	1	.709	.917
	WBS	-.207	.224	.855	1	.355	.813
	Constant	-7.541	1.931	15.244	1	.000	.001

According to Table 5.26 (variables in equation), alternative sub-hypotheses H4a and H4b, H4c and H4d have been significantly accepted. Firstly, master plan-H4a (independent variable) can predict (dependent variable) being a consultant (B= +1.278) with a significant value (0.001). Thus, an increase in the independent variable (master plan-H4a) predicts an increase in the dependent variable (consultant). Secondly, CPA-H4b (independent variable) can predict (dependent variable) being a consultant (B=+0.570) with a significant value (0.046). Therefore, an increase in the independent variable (CPA-H4b) predicts an increase in the dependent variable (consultant). Thirdly, look ahead plan-H4c (independent variable) can predict (dependent variable) not being a consultant (B=-0.529) with a significant value (0.026). Therefore, an increase in the independent variable (look ahead plan-H4c) predicts a decrease in the dependent variable (consultant). Lastly, weekly plans-H4d (independent variable) can predict (dependent variable) being a consultant (B=+0.527) with a significant value (0.04). Therefore, an increase in the independent variable (weekly plans-H4d) predicts an increase in the dependent variable (consultant).

Model 5: Predicting the contractor by lean planning tools

Table 5.27 (Omnibus tests of model coefficients) shows that the model is significant (0.001) with a chi-square value = 23.439. According to Table 5.28 (model summary), Rn is equal to 0.203, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is 20.3%. Additionally, it can be explained as a 20.3% variability of the model that could be predicted using the variables of the model. Table 5.29 (classification table) indicates that the model could predict 66.4% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.27: Shows Omnibus of model coefficient for Model 5

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	23.439	7	.001
	Block	23.439	7	.001
	Model	23.439	7	.001

Table 5.28: Shows model summary for Model 5

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	168.955[a]	.148	.203

Table 5.29: Shows classification table for Model 5

Classification Table					
	Observed		Predicted		
			Contractor		Percentage Correct
			null	yes	
Step 1	Contractor	Null	73	19	79.3
		Yes	30	24	44.4
	Overall Percentage				66.4

The null hypothesis:

H05: Lean planning tools do not predict the contractor.

The alternative hypothesis:

H5: Lean planning tools predict the contractor.

- The alternative sub-hypotheses are:

H5a: Master plan tool predicts the contractor

H5b: Critical path analysis tool predicts the contractor

H5c: Look ahead plans tool predicts the contractor

H5d: Weekly plans tool predicts the contractor

H5e: Daily progress report tool predicts the contractor

H5f: Percentage planned completed tool predicts the contractor

H5g: Work breakdown structure tool predicts the contractor

Table 5.30: Shows variables in the equation for Model 5

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1	Master plan	-.182	.238	.583	1	.445	.834
	CPA	-.070	.212	.109	1	.742	.932
	Look ahead plans	.466	.214	4.754	1	.029	1.594
	Weekly plans	-.051	.212	.057	1	.811	.951
	Daily progress report	.934	.259	12.971	1	.000	2.546
	PPC	.022	.205	.011	1	.916	1.022
	WBS	-.009	.196	.002	1	.963	.991
	Constant	-4.651	1.159	16.102	1	.000	.010

According to Table 5.30 (variables in equation), alternative sub-hypotheses H5c and H5e have been significantly accepted. Firstly, look ahead plan-H5c (independent variable) can predict (dependent variable) being a contractor (B=+0.466) with a significant value (0.029). Therefore, an increase in the independent variable (look ahead plan-H5c) predicts an increase in the dependent variable (contractor). Secondly, daily progress report-H5e (independent variable) can predict (dependent variable) being a contractor (B=+0.934) with a significant value (0.000). Therefore, an increase in the independent variable (daily progress report-H5e) predicts an increase in the dependent variable (contractor).

Model 6: Predicting the supplier by lean planning tools

Table 5.31 (Omnibus tests of model coefficients) shows that the model is significant (0.000) with a chi-square value = 62.796. According to Table 5.32 (model summary), Rn is equal to 0.480, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is 48%. Additionally, it can be explained as a 48% variability of the model that could be predicted using the variables of the model. Table 5.33 (classification table) indicates that the model could predict 78.8% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.31: Shows Omnibus of model coefficient for Model 6

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	62.796	7	.000
	Block	62.796	7	.000
	Model	62.796	7	.000

Table 5.32: Shows model summary for Model 6

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	127.348[a]	.350	.480

Table 5.33: Shows classification table for Model 6

Classification Table					
	Observed		Predicted		
			Supplier		Percentage Correct
			null	yes	
Step 1	Supplier	null	85	9	90.4
		yes	22	30	57.7
	Overall Percentage				78.8

The null hypothesis:

H06: Lean planning tools do not predict the supplier.

The alternative hypothesis is:

H6: Lean planning tools predict the supplier.

-The alternative sub-hypotheses are:

H6a: Master plan tool predicts the supplier

H6b: Critical path analysis tool predicts the supplier

H6c: Look ahead plans tool predicts the supplier

H6d: Weekly plans tool predicts the supplier

H6e: Daily progress report tool predicts the supplier

H6f: Percentage planned completed tool predicts the supplier

H6g: Work breakdown structure tool predicts the supplier

Table 5.34: Shows variables in the equation for Model 6

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1	Master plan	-.622	.281	4.898	1	.027	.537
	CPA	-.296	.249	1.414	1	.234	.744
	Look ahead plans	.067	.238	.080	1	.777	1.070
	Weekly plans	-.592	.248	5.695	1	.017	.553
	Daily progress report	-.954	.295	10.470	1	.001	.385
	PPC	-.076	.240	.100	1	.752	.927
	WBS	.287	.233	1.517	1	.218	1.333
	Constant	7.828	1.583	24.469	1	.000	2510.686

According to Table 5.34 (variables in equation), alternative sub-hypotheses H6a, H6d and H6e have been significantly accepted. Firstly, master plan-H6a (independent variable) can predict (dependent variable) not being a supplier (B=-0.622) with a significant value (0.027). Thus, the increase in the independent variable (master plan-H6a) predicts a decrease in the dependent variable (supplier). Secondly, weekly plans-H6d (independent variable) can predict (dependent variable) not being a supplier (B=-0.592) with a significant value (0.017). Therefore, an increase in the independent variable (weekly plans-H6d) predicts a decrease in the dependent variable (supplier). Lastly, daily progress report-H6e (independent variable) can predict (dependent variable) not being a supplier (B=- 0.954) with a significant value (0.001). Therefore, the increase in the independent variable (daily progress report -H6e) predicts a decrease in the dependent variable (supplier).

5.11.6 Predicting the Stakeholders by Using Lean Practices

Model 7: Predicting the consultant by lean practices

Table 5.35 (Omnibus tests of model coefficients) shows that the model is significant (0.000) with a chi-square value = 47.369. According to Table 5.36 (model summary), Rn is equal to 0.435, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is around 44%. Additionally, it can be explained as nearby a 44% variability of the model that could be predicted using the variables of the model. Table 5.37 (classification table) indicates that the model could predict 75.9% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.35: Shows Omnibus of model coefficient for Model 7

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	47.369	9	.000
	Block	47.369	9	.000
	Model	47.369	9	.000

Table 5.36: Shows model summary for Model 7

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	107.956[a]	.300	.435

Table 5.37: Shows classification table for Model 7

Classification Table					
	Observed		Predicted		
			Consultant		Percentage Correct
			null	yes	
Step 1	Consultant	null	82	15	84.5
		yes	17	19	52.8
	Overall Percentage				75.9

The null hypothesis:

H07: Lean practices do not predict the consultant.

The alternative hypothesis:

H7: Lean practices predict the consultant.

- The alternative sub-hypotheses are:

H7a: Value stream mapping practice predicts the consultant

H7b: Last planner system practice predicts the consultant

H7c: Five S practice predicts the consultant

H7d: First run study practice predicts the consultant

H7e: JIT practice predicts the consultant

H7f: Root causes analysis practice predicts the consultant

H7g: Gemba practice predicts the consultant

H7h: Weekly meeting with your team practice predicts the consultant

H7i: Weekly meeting with stakeholders predicts the consultant

Table 5.38: Shows variables in the equation for Model 7

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp (B)
Step 1	VSM	.163	.301	.294	1	.588	1.177
	LPS	.212	.343	.382	1	.536	1.236
	Five S	-.321	.225	2.030	1	.154	.725
	First run study	.074	.252	.087	1	.768	1.077
	JIT	-.021	.261	.006	1	.936	.979
	Root causes analysis	.486	.246	3.887	1	.049	1.625
	Gemba	.020	.232	.007	1	.932	1.020
	Weekly meeting with your team	.947	.399	5.633	1	.018	2.577
	Weekly meeting with stakeholders	.753	.385	3.825	1	.050	2.124
	Constant	-8.667	1.769	24.016	1	.000	.000

According to Table 5.38 (variables in equation), alternative sub-hypotheses H7f, H7h and H7i have been significantly accepted. Firstly, root causes analysis-H7f (independent variable) can predict (dependent variable) being a consultant (B=+0.486) with a significant value (0.049). Thus, an increase in the independent variable (root causes analysis-H7f) predicts an increase in the dependent variable (consultant). Secondly, weekly meeting with your team-H7h (independent variable) can predict (dependent variable) being a consultant (B=+0.947) with a significant value (0.018). Therefore, an increase in the independent variable (weekly meeting with your team-H7h) predicts an increase in the dependent variable (consultant). Thirdly, weekly meeting with stakeholders-H7i (independent variable) can predict (dependent variable) being a consultant (B=+0.753) with a significant value (0.05). Therefore, an increase in the independent variable (weekly meeting with stakeholders-H7i) predicts a decrease in the dependent variable (consultant).

<u>Model 8: Predicting the contractor by lean practices</u>

Table 5.39 (Omnibus tests of model coefficients) shows that the model is significant (0.016) with a chi-square value = 20.246. According to Table 5.40 (model summary), Rn is equal to 0.203, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is 20.3%. Additionally, it can be explained as a 20.3% variability of the model that could be predicted using the variables of the model. Table 5.41 (classification table) indicates that the model could predict 66.9% of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.39:Shows Omnibus of model coefficient for Model 8

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	20.246	9	.016
	Block	20.246	9	.016
	Model	20.246	9	.016

Table 5.40: Shows model summary for Model 8

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	168.955[a]	.148	.203

Table 5.41: Shows classification table for Model 8

Classification Table					
	Observed		Predicted		
			Contractor		Percentage Correct
			null	yes	
Step 1	Contractor	null	71	13	84.5
		yes	31	18	36.7
	Overall Percentage				66.9

<u>The null hypothesis:</u>

H08: Lean practices do not predict the contractor.

<u>The alternative hypothesis:</u>

H8: Lean practices predict the contractor.

- The alternative sub-hypotheses are:

H8a: Value stream mapping practice predicts the contractor

H8b: Last planner system practice predicts the contractor

H8c: Five S practice predicts the contractor

H8d: First run study practice predicts the contractor

H8e: JIT practice predicts the contractor

H8f: Root causes analysis practice predicts the contractor

H8g: Gemba practice predicts the contractor

H8h: Weekly meeting with your team practice predicts the contractor

H8i: Weekly meeting with stakeholders predicts the contractor

Table 5.42: Shows variables in the equation for Model 8

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	VSM	-.308	.264	1.363	1	.243	.735
	LPS	-.265	.314	.711	1	.399	.767
	Five S	.592	.197	9.065	1	.003	1.808
	First run study	.266	.224	1.412	1	.235	1.305
	JIT	-.452	.248	3.310	1	.069	.637
	Root causes analysis	-.255	.205	1.545	1	.214	.775
	Gemba	-.077	.202	.143	1	.705	.926
	Weekly meeting with your team	.408	.283	2.072	1	.150	1.504
	Weekly meeting with stakeholders	-.272	.296	.843	1	.359	.762
	Constant	-.619	.884	.491	1	.484	.538

According to Table 5.42 (variables in equation), the only alternative sub-hypothesis that has been significantly accepted is five S-H8c, which can predict (dependent variable) being a contractor (B=+0.592) with a significant value (0.003). Therefore, an increase in the independent variable (five S-H8c) predicts an increase in the dependent variable (contractor).

Model 9: Predicting the supplier by lean practices

Table 5.43 (Omnibus tests of model coefficients) shows that the model is significant (0.000) with a chi-square value = 49.591. According to Table 5.44 (model summary), Rn is equal to 0.427, which means that the percentage of variance of the dependent variable that can be accounted for by the independent variable is approximately 43%. Additionally, it can be explained as nearly a 43% variability of the model that could be predicted using the variables of the model. Table 5.45 (classification table) indicates that the model could predict 78.2 % of cases through the observed values with a proper percentage (i.e. over 60%).

Table 5.43: Shows Omnibus of model coefficient for Model 9

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	49.591	9	.000
	Block	49.591	9	.000
	Model	49.591	9	.000

Table 5.44: Shows model summary for Model 9

Model Summary			
Step	-2 Log likelihood	Cox and Snell R Square	Nagelkerke R Square
1	124.356[a]	.311	.427

Table 5.45: Shows classification table for Model 9

Classification Table					
	Observed		Predicted		
			Supplier		Percentage Correct
			null	yes	
Step 1	Supplier	null	75	10	88.2
		yes	19	29	60.4
	Overall Percentage				78.2

The null hypothesis:

H09: Lean practices don't predict the supplier.

The alternative hypothesis:

H9: Lean practices predict the supplier.

- The alternative sub-hypotheses are:

H9a: Value stream mapping practice predicts the supplier

H9b: Last planner system practice predicts the supplier

H9c: Five S practice predicts the supplier

H9d: First run study practice predicts the supplier

H9e: JIT practice predicts the supplier

H9f: Root causes analysis practice predicts the supplier

H9g: Gemba practice predicts the supplier

H9h: Weekly meeting with your team practice predicts the supplier

H9i: Weekly meeting with stakeholders predicts the supplier

Table 5.46: Shows variables in the equation for Model 9

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	VSM	.242	.277	.763	1	.382	1.274
	LPS	.132	.340	.151	1	.698	1.141
	Five S	-.472	.233	4.113	1	.043	.624
	First run study	-.592	.313	3.568	1	.059	.553
	JIT	.619	.286	4.684	1	.030	1.857
	Root causes analysis	-.140	.241	.335	1	.563	.870
	Gemba	.077	.234	.109	1	.741	1.080
	Weekly meeting with your team	-.896	.325	7.617	1	.006	.408
	Weekly meeting with stakeholders	-.316	.338	.878	1	.349	.729
	Constant	4.076	1.076	14.359	1	.000	58.914

According to Table 5.46 (variables in equation), alternative sub-hypotheses H9c, H9e and H9h have been significantly accepted. Firstly, five S-H9c (independent variable) can predict (dependent variable) not being a supplier (B=-0.472) with a significant value (0.043). Thus, the increase in the independent variable (five S-H9c) predicts a decrease in the dependent variable (supplier). Secondly, JIT-H9e (independent variable) can predict (dependent variable) being a supplier (B=+0.619) with a significant value (0.030). Therefore, an increase in the independent variable (JIT-H9e) predicts an increase in the dependent variable (supplier). Lastly, weekly meeting with your team-H9h (independent variable) can predict (dependent variable) not being a supplier (B=- 0.896) with a significant value (0.006). Therefore, the increase in the independent variable (weekly meeting with your team-H9h) predicts a decrease in the dependent variable (supplier).

To conclude, this chapter presents the outcome of the second phase (the questionnaire), including the current situation of construction logistics in relation to Jordanian construction factors (challenges), besides lean drivers and barriers. The results have been presented descriptively, and statistically by factor analysis i.e. trough the Kruskal Wallis test and logistics regression. The following chapter is the discussion chapter, where all points from the literature review, the semi-structured interviews, and the questionnaire are critically discussed and analyzed for the purpose of drawing a conclusion.

Chapter Six: Discussion

6.1 Respondents' Background and Current Situation of Logistics Process in Jordan

Before commencing the explanation of the factors affecting logistics and lean construction practices in Jordanian construction, it is necessary to present information with regard to the respondents. The number of engineers was high in the survey; the majority of the participants had a bachelor's degree, which also provides a significant indication that the vast majority of the respondents were well educated. It seems that the private sector was more willing to participate more than the government sector, as the percentage of private sector participants was just over 80%. Furthermore, it appears that residential buildings dominate more than other projects, which gives a sign of the significance of medium projects in the context of Jordanian construction. The participants' experience varied, but the majority had experience of between one and five years. Additionally, in this study, the researcher tried to share the research views equally with logistics stakeholders to gain the best results regarding the research question. The percentages of consultants, contractor and suppliers were 27.6%, 35% and 36.8%, respectively, which can be considered as reasonable and convergent to gain the best results possible.

In the context of discussing the current situation of construction logistics in Jordan, the first point discussed was the pillars of construction represented by cost, time, and quality. Newton (2015) declared that the key challenge to project management is accomplishing all of the project objectives whilst honoring the restraints on cost, time, quality, and scope. Construction projects have to be controlled and managed to achieve the desirable objectives, which are identified in accordance to the expectations of cost, time, and quality. In Jordan, Momani (2000) mentions the need for precise prediction of timing and controlling the cost within the project budget to avoid delays. According to this study, cost appears to be the most important and dominant feature as 56.7% of the participants agreed, whereas time and quality did not receive the same attention.

Moreover, reverse logistics is a very significant aspect in material supply and is a mechanism to reduce waste. The importance of this point is mentioned by Hosseini et al. (2014) as reverse logistics has appeared through manufacturing companies as an efficient measure for attaining sustainable development, as well as improving productivity. The construction industry followed the manufacturing organizations to exploit the benefits of reverse logistics in the construction logistics process. Surprisingly, half of the participants said that they are not using reverse logistics, and 20% said that they had never heard of it. Thus, this shows a critical weakness in managing material logistics and reducing waste in Jordan, which consequently affects the overall logistics process.

Another point worthy of note to explain the situation in Jordanian construction logistics is training sessions. Remarkably, around 83% of participants did not provide any type of training; this strongly clarifies the deficiency of improving construction logistics in Jordan where training sessions and programmes are not taking seriously. Type of procurement plays a main role in managing and controlling construction projects as this point also reflects the relationships among parties in the logistics process. Procurement types have recently occupied further attention by academics as well as professionals in the construction industry due to its prominence (Ruparathna and Hewage, 2013). The traditional design-bid-build is the most popular contract in Jordanian construction (60%) among design-build and management contracting. The result matched well with the study mentioned through the literature review in section 2.4.3 (Odeh and Battaineh, 2002). However, this type of contract (Design-bid-build) does not deliver full coordination and participation between all stakeholders to improve the project as well as the logistics process.

Based on the above, it seems that the current situation of construction logistics in Jordan has significant drawbacks in preferring the cost feature over time and quality, reverse logistic use, training sessions provided and the type of contract used. Consequently, these drawbacks need to be taken into consideration when building and mapping construction logistics in Jordan.

6.2 Factors (challenges) Affecting Construction Logistics

6.2.1. Planning

Planning is the main key of any project, and successful planning ensures a greater opportunity for the project to succeed. It is about the tactical and strategic processes used to scheme a project based on two main phases, pre-construction planning and onsite-planning. In construction logistics, both of the mentioned planning phases are used, firstly, to build a scheme and to choose trained and professional construction stakeholders, then dealing and controlling the operational procedures along with materials delivery from the supplier to the construction site (Johansen and Wilson, 2006).

Using SPSS, planning occupied first place in the factor analysis (dimension reduction, Table 5.7), which measures the percent of variance and loading value associated with each sub-factor (Field, 2013). The planning factor had the highest and most consistent loading values in accordance with each sub-factor. Other sub-factors with low loading values were deducted by factor analysis in SPSS, as they did not express the main factors, which means that they have no effect on the main factors.

Additionally, the planning factor achieved the highest advanced positions for its sub-factors in the descriptive results compared with others, based on the level of agreement by participants. It includes four main sub-factors, as follows:

Firstly, 'Lack of staff training is significantly affecting construction logistics in Jordan' is considered the first sub-factor in the planning factor based on the factor analysis, with the highest loading (0.787) among other sub-factors. This means that it highly represents and explains the main factor (planning) in the factor analysis (Field, 2005). In the descriptive results, 78% agreed with the importance of this sub-factor and 9.8% disagreed, which indicates the significance of this sub-factor over others as having the highest level of agreement and the lowest level of disagreement by participants.

In the interviews, this point was discussed also. Interviewee H said, 'Training the staff in significant sessions, especially abroad, will increase knowledge considerably. Trained people need to be qualified not just certified to help increase the knowledge in Jordanian construction'. Furthermore, Interviewees F and A mentioned how significant training sessions will improve Jordanian culture in several areas, which subsequently improves the construction field and the logistics process. Interviewee B thought that lack of training occurred because there is no clear strategy in Jordanian organisations for ways to improve and prioritizing what should be improved. This outcome matches the previous section (6.1), where around 83% of participants did not provide training session. This means that the majority of organisations have improvidence towards sufficient improvements in their abilities.

According to Rahman (2006), lack of training is one of the leading factors affecting the logistics process and preventing improvement. Moreover, there is a considerable increase in cost and time owing to the lack of training and understanding regarding planning (Gidado, 2004). Thus, according to all of this evidence, it seems that the lack of training has an extensive effect on the logistics process, and the need to improve construction staff and create a more trained and skilled culture is significant in Jordan in order to take further steps towards the improvement needed.

Secondly, ‘Deficiency and complexity in planning negatively affect Jordanian construction logistics’ is considered the second sub-factor in the planning factor according to the factor analysis. The loading value of this sub-factor is equal (0.641), which strongly means that this sub-factor consistently explains the main factor. In the descriptive results, 69.6% agreed with this sub-factor and 13.7% disagreed, which indicates the importance of this point based on the level of agreement by participants.

With regard to the interviews, Interviewee A mentioned that deficiency and complexity in planning have to be carefully taken into account in order for the project to succeed. Interviewee E added that one of the main reasons for excessive waiting is deficiency and complexity in planning. Furthermore, Interviewee I said, ‘The major failure, in my opinion, regarding the logistics process will be primarily related to planning deficiency’.

According to Koskela and Howell (2002), uncertainty in planning considerably affects supply and demand in terms of materials flow; thus, the master plan (general plan) appears unreliable because of this variability. Therefore, dependence on the master plan leads to poor short-term planning and, essentially, increases the complexity and deficiency of the planning. After illustrating the status of the second sub-factor based on a variety of facts, it is very clear that complexity and deficiency of planning has a negative impact on the planning factor regarding Jordanian construction logistics.

Thirdly, ‘The type of procurement and contract used between construction parties is not chosen properly in construction logistic’ was in third place in the factor analysis, with a loading value of 0.628, which shows how sturdily this sub-factor can explain and represent the main factor (planning). Furthermore, there was a solid indication of the importance of this sub-factor in the descriptive results as 66.9% agreed and 9.9% disagreed. Most of the participants had a high level of agreement and a low level of disagreement regarding this point.

According to the interviews, different stakeholders discussed this point. Interviewee A mentioned the role of contracts in Jordanian construction and the importance of having all liabilities and responsibilities in detail for each stakeholder. Interviewees D and C claimed that the problem in Jordanian construction contracts is the significant use of the design-bid-build procurement method, which does not give other parties a chance to share their views. This outcome is compatible with the current situation in Jordan as discussed in section 6.1, where 60% of procurement type is design-bid-build.

Procurement method and contract type are a vital aspect to govern the relationships, duties, risk sharing and liabilities between parties (Telford, 1998). Furthermore, according to Ruparathna and Hewage (2013), in construction project management procurement is the main process that produces and manages the contracts. It extends from defining the project requirements through to project closeout, creating a perfect approach to incorporate all stakeholders' strategic directions.

Subsequently, there is a significant effect from this sub-factor, which has been proved from by different aspects. Therefore, stakeholders have a to choose the proper procurement method suited to their project target instead of just depending on one to increase the efficiency of the construction logistics process.

Lastly, 'Poor delivery speed and responsiveness by the supplier negatively affect construction logistics' is also considered a vital sub-factor. This takes fourth place according to the factor analysis table, with regard to planning, with a high loading value of 0.624; this value expresses the main factor (planning) with great consistency. In the descriptive results, 65% of the participants agreed with this sub-factor while 7.7% disagreed, which provides a significant indication of the effect of this sub-factor in the Jordanian construction logistics process, as the level of agreement is considerable and the level of disagreement is very low.

Based on the interviews, Interviewee C noted, with regard to this sub-factor, that 'the problem in the flow lies in poor planning of speed delivery and responsiveness; most suppliers do not have the ability or desire to do this'. Furthermore, Interviewee F added that Jordanian suppliers need to build a mechanism to create speedy delivery consistent with sudden demand.

According to Wegelius-Lehtonen (2001) and Johansen and Wilson (2006), on-site planning provides proper management in operational processes, especially in speed of delivery and responsiveness from the supplier to the construction site. Furthermore, SCOR (2010) notes that fast delivery speed and responsiveness, fulfilment of orders and customer service lead to an effective logistics process. Therefore, based on the previous evidence, this sub-factor has an important role in the planning factor (main factor), as there is an essential requirement for the Jordanian construction industry to pay more attention to enhancing responsiveness and increasing the speed of delivery, especially by building. In the next part of this chapter, the lean planning tool will be discussed to discover the reasons for the poor planning factor in the logistics process in Jordan and to give a proper explanation regarding this factor.

On the other hand, increasing competence in the logistics process is done by maximising the efficiency and capability of the stakeholders involved in the process (Christopher, 2012). Furthermore, Vidalakis (2011) adds that improving the logistics process needs to consider the nature of the construction industry supply chain and logistics, and there is a need to assess each stakeholder throughout the organisation to achieve an effective logistics process that saves money, increases profits and achieves customer satisfaction. Therefore, in this research, the Kruskal-Wallis test and logistic regression were utilised among stakeholders (consultant, contractor, supplier) to clarify the differences and effects. With regard to the planning part, the Kruskal-Wallis result shows a significant result (0.000), given in Table 5.8, that the consultant has a higher agreement (28 over the median and 12 under the median) in planning compared with the contractor (28 over median and 26 under median) and then the supplier (12 over the median and 44 below the median). Furthermore, the logistic regression test shows that planning can predict the consultant (with sig 0.000, B=+0.44, Table 5.14/Model 1 in previous chapter) then the contractor (with sig 0.032, B= +0.181/Model 2 according to Table 5.18 in the previous chapter). This means that planning has a significant effect on then consultant and then the contractor. The improvements in planning need initially to commence with the consultant (engineering office) as both tests had the same outcome regarding this stakeholder.

Noulmanee et al. (1999) indicated that one of the main obstacles in Thailand (a developing country) is the lack of mutual collaboration between consultant and contractor in the planning phase. The consultant has to increase the level of cooperation with the contractor and other parties to avoid delays. Furthermore, a study in Saudi Arabia (a developing country) shows that the contractor censures the client team along with the consultants, as they are mainly liable to perfectly preparing the planning scheme (Assaf and Hejji, 2006).

However, the planning factor can predict not being the supplier (with sig 0.000, B=-0.759, Table 5.22/ Model 3 in previous chapter), which means that this factor has the least effect on the supplier compared with the others. This gives an indication of the supplier's level of agreement in the planning factor as supplying companies have the lowest agreement level regarding the planning factor. Nevertheless, and based on the aforementioned information, the supplier need to give significant additional consideration to planning to fully integrate with other parties in the logistics process.

Additionally, Hughes and Murdoch (2001) stated that lack of the integration process, particularly in planning among stakeholders, is considered one of the key issues identified by Egan report (1998). Nevertheless, the supplier has little commitment to the overall project in regards of this integration, unlike the consultant and contractor (ibid). In traditional construction, the act of client representative (consultant and engineering company) deems as a hurdle in using the experience, knowledge and skills of suppliers and then the contractor through design and planning stages (Egan, 1998).

The outcome of inferential tests is very reasonable as the consultant (engineering office) bears the responsibility of the master plan as well as finding the best way of fulfilling this plan according to the client's need and desire.

In the interviews, which are also compatible with the previous outcome, Interviewee B sturdily highlighted the role of the consultant in the logistics process in Jordan as well as ignoring the part of the supplier to participate in this process. Furthermore, Interviewee C emphasised the integration between all stakeholders, without excluding anyone, to build a robust planning process in Jordanian construction logistics.

This section discussed the planning factor and the four robust sub-factors: lack of training staff, deficiency and complexity of planning, type of procurement and the contract used between parties, as well as poor delivery speed and responsiveness by the supplier. The section discussed the previous literature, previous interviews, the descriptive results and the inferential outcome through factor analysis, Kruskal-Wallis and logistic regression. It is worth noting at this stage that the planning factor has drawn attention as the most significant factor among all others. Additionally, and based on the preceding outcome, the planning factor affects the consultant (engineer) more than other stakeholders, followed by the contractor and then the supplier. The reasons for poor planning in Jordanian construction logistics were discussed in the lean planning section, where each stakeholder mentioned the planning tools used and their frequencies, which provides a comprehensive understanding of the weaknesses of planning with regard to Jordanian construction logistics.

6.2.2. Transportation

Transportation is a one of the major and vital processes in logistics. It is about transporting the material from the original point to the construction site or storage place using suitable transport. Furthermore, this method is called outside transportation; inside transportation involves moving the material from the construction area (Baudin, 2004). Using SPSS software, transportation comes second in the factor analysis (dimension reduction, Table 5.7), which gives a ranking based on the percentage of variance and the sub-factor's loading value (Field, 2005). Furthermore, transportation was ranked with the second highest loading for its sub-factors compared with other factors. Moreover, Transportation factor has the second highest advanced positions for its sub-factors in the descriptive results based on the level of agreement. It includes four sub-factors. Firstly, 'Shared transportation is inadequately used between construction parties', according to the factor analysis, has a loading value of 0.685, which shows the strength of this sub-factor and how it can explain the main factor (transportation). In the descriptive results, this sub-factor has a significant high level of agreement: (65.8%) agreed with it and 16.8% disagreed, which signifies the importance of this sub-factor for the participants.

In the interviews, Interviewee A recommended using shared transportation as a strategy with different construction parties assisting to enhance the performance of the logistics process. Shigute and Nasirian (2014) strongly recommend that future logistics should include proper sharing of transportation in the logistics process. Cruijssen and Salomon (2004) conclude in their study that a 5% to 15% cost reduction could be made through sharing orders between transportation companies. Consequently, this sub-factor clearly appears as significant in the transportation factor based on the above critical discussion.

Secondly, 'Types of vehicle used in transportation are insufficient in the construction logistics process' is considered to be the second sub-factor in the transportation factor based on the factor analysis table, which ranks each sub-factor based on the percentage of variance and loading value. The loading value for this sub-factor was 0.650, which shows agreement with the descriptive analysis, with 54% of the participants agreeing with this sub-factor and 22% disagreeing, which shows the status of this sub-factor as being critical.

According to the interviews, Interviewee A highlighted the significant advantages of having sufficient transportation during logistics; Interviewee B mentioned that high demand requires adequate transport levels; and Interviewee F noted that improving the type of transportation used results in achieving suitable flow.

According to WRAP (2013), many factors need to be taken into account when scheduling the delivery process: transport size, transport type, the method of transport utilisation and the numbers of vehicles needed. Vidalia and Sommerville (2013) highlight that appropriate transportation means positively affect cost efficiency. Subsequently, it is clear that this sub-factor plays a vital role in the transportation factor (main factor).

Thirdly, 'Jordanian construction logistics suffers from unnecessary movement and excessive transportation' is the third sub-factor according to the transportation factor list (second main factor) in the factor analysis table, which ranks all sub-factors based on the percentage of variance and loading values. There is a slight drop in the loading value for this sub-factor (0.547) compared with the first two (over 0.6). Nonetheless, the sub-factor is still influential as it occupies a reasonable position under the main second factor (transportation). Furthermore, 42.7% agreed with the importance of this sub-factor, while 18.9% disagreed; the level of agreement is just over twice the level of disagreement according to the participants responses.

In the interviews, Interviewees A and G mentioned that Jordanian construction logistics suffers from unnecessary and extra movement in transportation. According to Matyusz (2011), redundant movement and excessive transportation are deemed to be substantial reasons for waste. Thus, there are diverse outlets, as discussed above, to consider this sub-factor as effective.

Fourthly, 'Government regulation regarding allowable loading and customs negatively affects construction logistics in Jordan' is the fourth sub-factor according to the factor analysis table (ranks based on the percentage of variance and loading values) with a proper loading value of 0.529. In the descriptive results, around half of the participants agreed with the sub-factors and 17% disagreed, which shows a higher level of agreement in comparison with the level of disagreement and gives a decent indication about the effects of this sub-factor.

In the interviews, the respondents discussed the slight improvement in government regulations allowing companies to buy their materials from everywhere and giving permission in some lands for mixers and crushers, as interviewee (D) noted. However, there are significant drawbacks in different aspects, which were mentioned by other interviewees. Interviewee B said that government regulation is inconsequential, especially in load permitted and customs rules, considerably increasing the waiting time and freezing other aspects in the logistics process, which can consequently lead to project failure. Ta et al. (2000) have strongly mentioned that governmental role has the main impact on regulation of transportation. A case study in China shows that there are key challenges affecting transportation, and government have the main responsibility to improve the situation, particularly in customs practices management along with excessive clearing time. Flexible regulations and deregulation help to increase the availability of carriers and service. So, it is clear that government is also liable to precisely create policies regarding trucks and loads. According to Tseng et al. (2005), government can also significantly help to reduce the number of trips, and the load of the single trip, by changing the transportation management (ex: e-commerce, Freight villages).

Finally, 'Fluctuations in materials negatively affect construction logistics in Jordan' is the fifth sub-factor in conformity to the transportation factor according to the factor analysis table (ranks based on the percent variance and loading values). It has a 0.501 loading value, which shows how this sub-factor explains the main factor, as seen previously, the loading values in the factor analysis table are decreasing as heading towards bottom of the table for each sub factors. Furthermore, in the descriptive results, the level of agreement is considerably higher than the previous sub-factors in the same main group (transportation factor), with 71.6% agreeing with this sub-factor and 7.7% disagreeing. This shows how fluctuations in materials play a significant role in the logistics process, particularly in the transportation factor. The higher level of agreement accompanied by the lowest level of disagreement indicates the significance of this sub-factor for the respondents. However, it comes last in this group because it has the lowest loading values, which means that other sub-factors have better consistent explanations for the main factor than this sub-factor.

In the interviews, Interviewees B, D and G highlighted that fluctuations of materials in the Jordanian market directly affect transportation, as most of the transport means are not fully loaded and there is uncertainty in trips as suppliers send their vehicles when the materials are available. Furthermore, this results in increasing the cost of the transportation process, especially as diesel fuel is quite expensive in Jordan, as Interviewees B, D and G stated.

The volatile market needs to be moderated by the development of a framework for an agile paradigm utilising market knowledge and feasible cooperation to exploit beneficial chances in the market (Vrihoef and Koskela, 2000). Furthermore, Bowersox et al. (2007) state that high levels of fluctuation in demand produce irregular delivery services. Additionally, fluctuations in the market can lead to few and half loads in transportation; inefficiency will be raised by increasing the amount of lorry movements (Fearne and Fowler, 2006). After illustrating this significant information, it can be said that 'Fluctuations in materials negatively affect the transportation in construction logistics in Jordan' has a noteworthy position among other sub-factors in the transportation factor (main factor).

In the inferential results, Kruskal-Wallis and logistic regression were utilised for the stakeholders (consultant, contractor, supplier) to gain further significance for the outcomes and find differences among them. With regard to the transportation factor, the Kruskal-Wallis result presents a substantial outcome of 0.001 sig (Table 5.8) that the supplier has higher agreement (36 over the median and 20 under the median) in the transportation factor compared with the second, the contractor (20 over median and 34 under medium) and then the consultant (12 over median and 28 below the median). Additionally, using the logistic regression test, transportation can predict the supplier with sig 0.000, B=+0.591, table 5.22/ Model 3 in the previous chapter. This means that the transportation factor has a substantial effect on the supplier. The improvements in transportation primarily start with the supplier, as both tests had the same outcome regarding this stakeholder.

Tseng et al. (2005) noted that movement and transportation of material is basically received from the supplier. Construction parties need to increase their attention in terms of the suppliers' part in transportation. Agapiou et al. (1998) stated that deliveries of material are to some extent overseen by the material coordinator in accordance to an agreed logistics process among parties - because suppliers have the main responsibility for arranging the transportation. Therefore, contemporary construction logistics requires increasing the supplier role by early involvement in the design phase, and resigning the responsibility for flow information associated with the product (material), the communication between supplier and receivers should mainly have sufficient details of transportation, order delivery, and packaging size.

However, the transportation factor can predict not being a consultant (sig 0.001, B=-0.274, table 5.14/ Model 1 in the previous chapter), which means that this factor has the least effect on the consultant compared with the others. It gives a significant sign of the consultant's (engineering office) level of agreement with the transportation factor as engineering companies have the lowest agreement level regarding this factor. Moreover, and consistent with the abovementioned evidence, the consultant (engineer) needs to get involved in this part to integrate with other construction parties in order to raise the efficiency of Jordanian construction logistics.

The results of Kruskal-Wallis and logistic regression are considered rational as the supplier principally takes the responsibility for transportation, including the type of transport used, excessive movement, government regulations and the negative impact of material fluctuations in the transportation process. Therefore, other stakeholders can participate to improve the current situation of transportation in Jordanian construction logistics. Furthermore, the interview outcomes match the inferential results, as Interviewee B mentioned the dilemmas that face the supply companies specifically in terms of transportation, where the supplier can sometimes bear the extra cost when managing transportation to fulfil customer orders.

This section explained the transportation factor in the construction logistics process in Jordan; there are five substantial sub-factors covering this main factor (transportation): shared transportation is inadequately used between construction parties; types of vehicle used in transportation are insufficient in the construction logistics process; Jordanian construction logistics suffers from unnecessary movement and excessive transportation; government regulation regarding allowable loading and customs negatively affect construction logistics in Jordan; and fluctuations in materials negatively affect construction logistics in Jordan. Critical explanation was delivered regarding the transportation factor through the literature review, interviews, descriptive outcomes and inferential results by factor analysis, Kruskal-Wallis and logistic regression. Therefore, it is obvious at this level to state that the transportation factor is the second main significant factor after planning . Furthermore, the outcome shows that transportation affects the supplier more than other stakeholders. Moreover, the current use of lean practices in transportation (JIT, VSM) is discussed later in sections (6.4), which will provides an in-depth understanding of the transportation factor in Jordanian construction logistics.

6.2.3. Transparency and Information Exchange

This is the visibility of the process, which is identified as a means of visualisation and controlling the activities of an organisation. It is the recognition of status, responsibilities, problems and interdependencies and the facilitation of system performance understanding (Klotz and Horman, 2008). Furthermore, logistics transparency requires controlling the SC; the network of different organisations is linked by material as well as the exchange of information between all parties from the first point to the final point (Sobotka, 2005). Using SPSS software, transparency has been ranked in the third position, according to the factor analysis (dimension reduction), shown in Table 5.7 in the previous chapter, which explains the consistent loading values of transparency's sub-factors (Field, 2005). Transparency has four sub-factors. Firstly, 'Tracking systems add unnecessary cost in Jordanian construction logistics' has the first place under the transparency factor through factor analysis, with a high loading value of 0.774, which explains how this sub-factor consistently explains the main factor. In the descriptive results, 45% agreed and 37.1% disagreed, which gives an indication that respondents are not sure about the extra cost of tracking system, with the results convergent between participants to some extent. Essentially, new technologies will add initial cost at the beginning, but there are many advantages to be gained afterwards as systems such as RFID (radio frequency identification) can improve the traceability of products and visibility through the whole logistics process, as well as creating consistent and accelerated operational processes such as tracking, checkout, shipping and counting processes, resulting in further precise information and advanced inventory flow. Furthermore, GPS is another technology that can also significantly assist companies in tracking their products, processing information and customer relationships (Alodeh, 2010).

Based on the interviews, Interviewee B highlighted the unnecessary cost of using tracking systems. In contrast, Interviewees C and F strongly argued that tracking systems need to be a priority to control the overall logistics process. The visualisation system is becoming the future of the logistics process and supply chain management; the initial cost of the new technology is subsequently remunerated in cost reduction, especially in transportation and warehousing (Dias et al., 2009).

Secondly, the sub-factor 'Lack of mutual information and instruction among construction parties negatively affects construction logistics in Jordan' is second under the transparency factor (main factor) with a consistent loading value of 0.697, which explains how strongly this sub-factor can explain the main factor. In the descriptive results, 67% agreed with this sub-factor and just 10.7% disagreed, which gives an indication of how this sub-factor affects construction logistics in Jordan and also gives a clear view of how the respondents are affected by this sub-factor.

In the interviews, the majority of interviewees (Interviewees A, B, E, F, G and I) highlighted the insufficient coordination between stakeholders in Jordanian construction. Most of them claimed that there is an urgent need to increase the level of communication and the means of transparency in Jordanian construction logistics to improve the current situation.

According to Johansen and Wilson (2006), Love and Edward (2004) and Lambert and

Cooper (2000), lack of coordination, instruction and exchange of information between construction parties in the logistics process are major drawbacks; this is due to the lack of information-collecting systems and distribution between parties. Besides this, poor relationships between parties, especially between the client and the supplier, is considered a significant issue in supply chain logistics. Therefore, there is a crucial necessity to deal with this sub-factor as soon as possible to upgrade the transparency factor in Jordan.

Thirdly, 'Controlling and monitoring of tracking systems are not used permanently in Jordanian construction logistics' is the third sub-factor under the transparency factor, as shown in the factor analysis table, with a loading value of 0.588. It is obvious that this loading value has somewhat declined compared with the first two sub-factors under the same main factor (transparency factor). Nevertheless, the loading value remains impressive as this sub-factor meaningfully clarifies the main factor (transparency factor). In the descriptive outcomes, 63% of the participants believed that controlling and tracking systems are not used permanently and regularly in Jordanian construction, with a minority of just 12.6% disagreeing. This descriptive result shows that tracking technology in Jordanian construction logistics is still immature.

In the interviews, Interviewee A noted that the construction industry in Jordan needs to keep pace with the advanced technology, especially to increase the communication and visualisation in the logistics process. Whereas Interviewee B said that the logistics parties in Jordan underestimate the need to develop their transparency, especially using a variety of technologies. He also added that there is a necessity to implement the technology permanently within the logistics process to gain the best value throughout.

According to Dias (2009), consistent and steady use of developed methods and advanced technologies with regard to tracking and controlling the logistics process will provide competitive advantages to the overall supply chain process. Remarkably, value stream mapping is considered one of the lean practices to increase the visualisation of the process, which leads to improvements in transparency. The frequencies of using this practice in Jordan are discussed in the lean practices section, which will provide further evidence and explanation regarding this sub-factor. So, there is a clear view of how this sub-factor affects the transparency factor (main factor) and leads to negative effects in the entire logistics process.

Finally, 'Distrust among parties negatively affects the construction logistics process' has the fourth position under the transparency factor (main factor), as shown in the factor analysis table, with a loading value of 0.517. It is clear that the loading value has slightly dropped compared with the first two sub-factors under the same main factor (transparency factor) but it is still considered significant as the value is over 0.5. The outcome of the descriptive data significantly shows the prominence of this sub-factor among others. Surprisingly, the level of agreement is around 75%, which is considered very high, and the level of disagreement is 10.5%, which is considered very low; thus, this sub-factor has a forward position in the descriptive outcomes.

In the interviews, distrust was stated several times by the interviewees as a fundamental sub-factor in determining the relationships between stakeholders. Interviewee C noted that, ‘Dealing with the consultant or supplier is not easy in Jordan because of the distrust; each company is required to take into account the reputation of the other company and its history’. Additionally, Interviewee E said that, ‘The lack of trust leads to not building long relationships, which is very important to develop the overall logistics process and, consequently, construction projects’. Interviewee F stated that, ‘There is huge distrust between supply chain parties, and, most importantly, a lack of truthfulness’.

Colledge (2005) notes that construction parties need to concentrate on building proper methods for reliable delivery that focus on trust and partnership, which aid in the development of working relations amongst entire construction parties, increasing effectiveness and efficiency in the whole process as well as enhancing the financial return. Moreover, Kwon and Suh (2006) state that trust is constructed on two columns: social exchange, which includes perceived conflict, partner’s reputation and perceived satisfaction; and the transaction cost, which includes asset specificity and behavioural uncertainty. Consequently, the presence of trust among parties noticeably improves the chance of successful logistics process performance.

After illustrating the four sub-factors of transparency statistically, descriptively and using previous interviews and literature reviews, there is no doubt that this factor (transparency) plays a major role in factors affecting construction logistics in Jordan. Construction parties need to implement further procedures to address this issue. To conclude, it could be said that building trust needs to focus on different aspects altogether, and all construction stakeholders need to be aware, involved and participate strongly from the beginning through the procurement process. Furthermore, a transparent environment is needed to provide a clear picture of the process as well as regular weekly meetings to have full control in order to avoid any misunderstanding and have full control of the process. Therefore, for the lean practices section, participants were asked to state the frequencies of meetings with their teams as well as frequencies of meetings with other stakeholders (construction parties).

6.2.4. Continuous Improvement (CI)

The Japanese term '*Kaizan*' is defined as the continuing effort to enhance service, products and overall processes. The effort is pursue constantly, to be developed over time. It includes all teams, without excluding anyone in the workplace, to gain the best benefits (Imai, 1997). By using factor analysis (dimension reduction) through SPSS software, this sub-factor occupied the fourth place in the Table 5.7 based on the loading values associated with each sub-factor (Field, 2005). There are three sub-factors. Firstly, 'Culture challenges are a vital aspect in construction logistics in Jordan' is the first sub-factor under the CI factor, according to the factor analysis with a high loading value of 0.745. The value shows how this sub-factor strongly explains the main factor (CI). In the descriptive results, 53% of the participants agreed with this sub-factor and just 14.7% disagreed. It seems that the level of agreement was over half, which indicates that there is an effect of this sub-factor over the main factor (CI) and, subsequently, an effect on construction logistics in Jordan.

In the interviews, this point was discussed by different Interviewees. Interviewees A and D emphasised that the main obstacle preventing continuous improvement is the gap between generations, whereby the previous generation still has different mentalities and cultures and cannot cope with the views of the new generation. Furthermore, Interviewees A and E highlighted a critical point with regard to this sub-factor as they claimed that Jordanian culture sometimes spends a lot of money on unreasonable causes and weakens the efficiency of logistic parties just to show off, which reflects the nature of Jordanian culture. Additionally, the mentalities and behaviours of Jordanian society are not easy to accept and deal with. New practices and views are difficulty to convey to owners or construction managers, as Interviewees F and E noted.

According to Rother (2009), building a valuable culture needs to be a priority for organisations to improve their processes and to gain considerable advantages in addition to saving time and cost. The organisations have to implement new views and practices and considering improving themselves regularly by integrating all workers and managers together in one nucleus. Continuous improvement is not exclusive to the Japanese, as many organisations throughout the world have built their organisational cultures effectively (ibid). Thus, the significance of this sub-factor was mentioned critically, as discussed above, which shows the prominence of this sub-factor under the main factor (CI).

Secondly, ‘Feedback and shared lessons are not essential among parties in Jordanian construction logistics’ is the second sub-factor under the main factor (CI), according to the factor analysis with a decent loading value of 0.638, which shows how this sub-factor explains the main factor. In the descriptive results, 59.2% of the participants agreed, and 14.1% disagreed. This level of agreement is quite high, and the level of disagreement is low, which delivers a sturdy sign of how this sub-factor has an essential position among the others.

In the interviewees, Interviewees A, B and E highlighted the feedback and shared lessons sub-factor, as Interviewee A stated that, ‘In the big projects, you could receive some feedback but most of it is not valuable and just paperwork. Additionally, in the residential sector, there is no feedback at all because it is fragmented’. Participant B said, ‘I see no benchmarks or learning loop in the construction field in Jordan’. Moreover, Interviewee E added, ‘Logistics needs to have systematic shared lessons among parties, especially in material control’.

According to Chang et al. (2010), the lack of feedback and learning consider a hidden dilemma. Supply chain logistics is considered to be temporary and there are many problems related with it. A framework is proposed to employ feedback and leaning through the finished projects to provide superior management of current and future logistics processes. Accordingly, and in accordance with the above information through a variety of sources, this sub-factor has a main role under the main factor (CI) and then over the Jordanian construction logistics process.

Thirdly, ‘Customer-client service is not a top priority for suppliers’ is considered the third sub-factor under the CI factor, according to the factor analysis with a loading value of 0.580. The value is lower than those of the previous CI sub-factors, but it is still meaningful statistically and can explain the main factor as the value is over 0.5. In the descriptive results, 64.4% of the participants agreed and 12.6% disagreed with this sub-factor. Taking a look to the percentage of agreement and disagreement clarifies the importance of this sub-factor descriptively.

In the interviews, Interviewee B stated that, ‘The first supplier concern is not always client satisfaction; his business is more important. The client is also responsible for a few parts of the problem because he asks always for cheapest price and wants the highest quality’. Furthermore, Interviewee G said, ‘customer service is not a priority especially for suppliers, as most of them are just looking to gain high benefits regardless of anything else'.

Frodell et al. (2008) emphasised that suppliers need to change their attitudes and place customer satisfaction in the top requirements, regardless of the transient sales and profits, as this will help to create continuous improvement for them and gain considerable returns in the long term. Therefore, customer satisfaction demands prioritization in developing continuous improvement in the Jordanian construction logistics process. However, the customer needs to enhance his knowledge and information to fill the gap as well. Thus, it can be said that this sub-factor is considered to be significant under the main factor (CI).

Accordingly, the CI factor has been identified and discussed through three main sub-factors by delivering statistical outcomes, descriptive outcomes, previous interviews and a literature review. After demonstrating the variety of evidence, it is clear to state at this stage that CI is one of the key factors affecting the construction logistics process in Jordan. On the other hand, in the lean practices section, the different practices regarding continuous improvement are discussed by the respondents, which offer a reasonable connection between the CI factor and the frequencies of using these practices, and also gives further evidence and justification in accordance with this factor.

6.2.5. Health and Safety (H&S)

Health and safety is one of the main concerns in the construction industry but it is executed inadequately and poorly in occupational health and safety. Regardless of the initiatives and conferences, the figures show that the situation is still misjudged as many construction workers continue to be killed or injured or suffer long-term illness in the construction field every year (Lingard and Rowlinson, 2005). Using SPSS, this factor falls in fifth place, according to the factor analysis table (dimension reduction) with two sub-factors (Table 5.7). Firstly, 'Health and safety are not taken into consideration in the Jordanian construction logistics process' is the first sub-factor under H&S, with a high loading value of 0.701. This explains how this sub-factor explains the main factor. In the descriptive data, this sub-factor is considered a key aspect in Jordanian construction, with 53.5% of the participants agreeing and 20.9% disagreeing. The sub-factor is seen as essential because half of the survey participants agreed on its importance.

In the interviews, this sub-factor was critically discussed and several participants explained the situation of health and safety in Jordan. Interviewee D noted that, 'Government legislation has to be advanced, particularly concerning environmental impact and health and safety regulations; I hope to see a real intent to alter the present situation'. Interviewee E stated that, 'Damaged blocks are thrown away close to the construction site as there is no way to return them or to apply reverse logistics and this harmfully affects the environment and the level of health and safety. The government needs to make further efforts in this area'.

The Safety Executive (2011) in the UK stated that, 'In 2009/10 there were 42 fatal injuries giving a rate of 2.2 per 100,000 workers. This is the third highest rate of fatal injuries, behind agriculture and extractive industries. Construction accounted for 35% (276 cases) of all reported injuries involving high falls and 24.8% (89) involving electricity. The incidence rate of reportable non-fatal injury was 1,300 per 100,000 workers (1.3%) in 2008/09 (three-year average)'. These numbers are statistically considerably greater than the average throughout all other industries. In Jordan, according to Ali and Nsairat (2008), there are several drawbacks in the health and safety system. Developing such a system is becoming necessary for solving existing building problems, limiting environmental impact and creating more productive and healthy workplaces. Based on the above information, this sub-factor is underestimated by the Jordanian construction industry, especially in the logistics process, as it is a key aspect under the main factor of H&S.

Secondly, 'Determining the most appropriate road is insufficient in Jordanian construction logistics and mainly affects health and safety' is the second sub-factor under the main factor (H&S) with a high loading value of 0.656, but less than the previous sub-factor. However, it is considered to be significant and the sub-factor can statistically explain the main factor. In the descriptive results, a considerable percentage (70%) of the participants agreed and just 14.7% disagreed. It is considered to be one of the highest results descriptively and draws attention to the importance of this sub-factor.

This sub-factor was mentioned several times by the interviewees, with Interviewee A noting that construction parties underestimate the type of roads and trips when sending material through the logistics system. Interviewee B added that, 'Selecting the finest roads, knowing the road status (damage, deflection) and vehicle quality used are substantial features across the logistics process, which aids in preventing accidents'. Rawling and Kainet (2012) note in their study that the supply chain logistics structure in the road transport industry has led to poor health and safety for road transport labourers. Road design and quality can create considerable hazards for all logistics parties, as well as affecting the road-travelling public. Therefore, and according to the data (statistically, descriptively), previous interviews and literature review, the health and safety factor has two key sub-factors, as mentioned in the above discussion, which illustrate how this factor affects Jordanian construction logistics. Nevertheless, consistent with the literature review, implementing 5s, 5whys, regular meetings and Gemba practices can significantly aid in advancing several factors in the logistics process, including health and safety. Therefore, participants were asked in the lean practices section to mention their frequencies in applying these practices. If applying these practices was shown to be low, this underlines the necessity of applying these practices in the Jordanian construction industry to increase the health and safety factor.

6.2.6. Material preservation (Preserving Material Quality)

The quality of material takes up a fairly large portion of the logistics process. Lundesjö (2015) emphasises that logistics in construction is described as the process of ensuring that the product or service is: in the right place, at the right time, of the right quality, the right quantity and the right price. Thus, quality is an important part of the construction logistics process. Additionally, Kannan and Tan (2005) also note that commitments to material quality especially, as well as understanding supply chain dynamics have the greatest effect on performance. Using SPSS, this factor falls in sixth place according to the factor analysis table (Table 5.7), with two sub-factors. Firstly, 'Poor quality of the finished goods occurs because of poor construction logistics' is the first sub-factor under material quality factor, with a high loading value of 0.717, which provides an indication of how this sub-factor meaningfully explains the main factor (material quality). In the descriptive outcomes, 45% of the respondents agreed with this sub-factor and 30% disagreed, which means that the agreement level is still higher that the disagreement level. Nevertheless, it additionally emphasises the outcome according to the previous section (current situation in Jordanian construction logistics, section 6.1), which underlined that cost and time, respectively, have a greater effect on the Jordanian construction logistics process than quality.

In the interviews, the main statement was affirmed, as Interviewee A noted that, 'The logistics process is affected by poor quality together with lack of productivity as many parts of constriction suffer from the same issues'.

According to Kaare and Koppel (2012) and Bowersox et al. (2000), construction parties underestimate roads in the construction supply chain; consistent road maintenance, as well as high standards besides the abilities and skills of the driver will prevent the material from breaking. Therefore, it seems that this sub-factor has a significant portion in the main factor, as explained above. On the other hand, government bears responsibility for the roads and their conditions; this is discussed later in the barriers section.

Secondly, 'Jordanian construction parties do not consider long waiting among the logistics processes, which affects the quality of product'. This sub-factor has a lower loading value than the previous sub-factor, with 0.517, which explains how this sub-factor explains the main factor. The loading value still appropriate as it is over 0.5. In the descriptive results, 58.1% agreed and 11.9% disagreed, which shows the importance of this sub-factor descriptively based on the respondents' answers.

In the interviews, Interviewee C noticed that materials have a greater chance of being damaged and ruined through because of the long waiting times among processes. Interviewee F added that material quality is vulnerable during the logistics process, particularly when materials are moved and are exposed throughout the processes.

According to Lundesjö (2015), the nature of construction makes quality production more challenging, as interruptions during the construction process and keeping the material waiting for long period can significantly cause material defects or damage. When materials are transferred through several places from the supplier to the construction site in the logistics process, this will have a negative effect on material quality (ibid).

Thus, based on the data results (statistically, descriptively), previous interviews and the literature review, the material quality factor has two main sub-factors, as mentioned above, and has an effect on the construction logistics process in Jordan. However, according to the previous literature, using 5s, 5whys, steady meetings and Gemba practices can strongly assist in improving many factors in the logistics process, including material quality. Accordingly, respondents were asked in the lean practices section to state their frequencies in implementing these practices. If implementation of these practices was low, this emphasises the need for Jordanian industry to implement these practices to improve the quality of materials.

6.2.7. Inventory

Inventory is defined as materials and products held and stored by an organisation to support the production processes, in addition to buffering stages in the supply chain, as Rother (2009) notes. Using factor analysis through SPSS, the inventory factor comes in seventh place

(Table 5.7). This shows an initial impression of how this factor is treated by the Jordanian construction industry. The inventory factor has three sub-factors. Firstly, 'Storage of materials by the contractor is desirable in Jordanian construction' is the first sub-factor under the main factor (inventory), with a high loading value of 0.651, which indicates that this sub-factor explains the main factor properly. In the descriptive outcomes, 60.3% of the respondents agreed and 16.3% disagreed, which shows how the contractor has a considerable desire to possess the materials in advance in order to reduce the risk of being without materials when they are needed.

In the interviews, Interviewee D noted that, regardless of the problems occurring due to storing materials in the construction site in several stages, the contractor still adheres to have the materials beforehand as he thinks only of getting paid by the client. Interviewee B stated that the contractor prefers to request extra material (especially stone) to choose the best quality and return the unfavourable materials, which means overproduction. However, he could improve his management to avoid this procedure.

The contractor, in traditional project-based contracting structures, seeks the earliest possible time of taking delivery of materials at the construction site (Walsh et al., 2004). Furthermore, in developing countries, contractors have a considerable tendency to purchase quantities of materials to secure themselves (Polat and Arditi, 2005). Jordan is deemed to be one of the developing countries and this situation, in accordance with the respondents' answers, is compatible with the existing condition in Jordanian construction logistics.

Secondly, 'Brining materials Just in Time is required by Jordanian construction logistics parties'. This sub-factor falls in second place under the main factor (inventory), with a high loading value of 0.634, but slightly less than the previous sub-factor, and has the capability to properly explain the main factor. In the descriptive data, 13% agreed and 61.3% disagreed with this sub-factor. The substantial variance between the level of agreement and the level of disagreement reveals that bringing materials Just in Time is not at all a priority in construction logistics in Jordan.

In the interviews, Interviewee F stated that bringing materials Just in Time is very difficult to do in Jordan as many materials come from outside. Interviewees D and G added that construction logistics in Jordan tends not to bring materials Just in Time, as they prefer to receive their orders as soon as possible to avoid any delays.

Case studies and research have shown effectiveness and efficiency regarding time, cost and quality gained by bringing materials when needed Just in Time (Novack, 1993; Cahn et al., 2009; Bryde and Schulmeister, 2012; Vidalakis and Sommerville, 2013). On the other hand, there are a few researchers who think that bringing materials Just in Time is risky, to some extent (Fearne and Fowler, 2006). However, the majority of studies notably agree that bringing materials Just in Time is one of the main features to distinguish between traditional construction methods and new construction methods (Patty and Denton, 2010). Additionally, intermediate storages could be a proper action when sending material JIT from these storages to the construction sites (Ala-Risku and Karkkaine, 2006). It can be a solution to properly applying JIT throughout organizations.

Thirdly, 'Jordanian construction logistics suffers unnecessary and large inventories' is the last sub-factor under the main factor (inventory) with the least loading value of 0.513. However, it still can explain the main factor as the value is over 0.5. In the descriptive outcome, 64.8% agreed and 16.6% disagreed, which makes this sub-factor an important one according to the respondents' descriptions.

In the interviews, Interviewee E noted that, 'My main worry is the storage area, as our projects rely on the space nearby to store the material. It is usually very small; usually we store material in the street, particularly before casting the first floor where we can store material under the casting floor later'. Interviewee G added, 'The key obstacle throughout the flow is the large storage size'.

According to Rother (2009), a large inventory is seen as an impediment in logistics process mapping, and most projects have unnecessary inventory that causes low-speed operation throughout the logistics process. Thus, it appears that this sub-factor also has also an effect on the inventory factor.

Consistent with the inferential data, model 1 (predicting the consultant by factors affecting construction logistics, previous chapter, Table 5.14) in logistic regression shows significant value (0.47) with B = -0.204, which means that the inventory factor can predict not being consultant. In another way, increasing the inventory factor effect decreases the chance of being the consultant. Furthermore, model 2 (predicting the contractor by factors affecting construction logistics, previous chapter, Table 5.18) in logistic regression shows significant value (0.014) with B = +0.224, which means that the inventory factor predicts being a contractor. This means that increasing the inventory factor value produces a significant effect on the contractor.

Accordingly, the outcome of logistic regression regarding the effect of inventory on the contractor is congruent with the above information in the first sub-factor related to this main factor, including the descriptive outcome, previous interviews and the literature review.

6.2.8. Material Handling

Material handling is the procedure of loading and unloading the material by labours, machines or both. Increasing the efficiency of these procedures provides better control of materials (Johnson, 1981; Josephson, 2013). This factor appends the factor analysis table as the least important, with just two sub-factors (Table 5.7). Firstly, 'Lifting and handling by machine increases the cost in the Jordanian construction logistics process', with a great loading value of 0.731, which explains the main factor (material handling) properly. In the descriptive outcome, 54.8% agreed and 25% disagreed, which indicates that there is, to some extent, approval about the cost produced regarding machines in loading and unloading.

In the interviews, Interviewee G stated that, "Machinery rent is quite expensive, if you need it for one day in a far place, and sometimes you need to rent it for three days'.

According to Brag (2011), there is a need for a framework comprising the finest practices that need to be considered throughout the logistics process, including material handling. Furthermore, Lundesjö (2015) also mentions this point, saying that material handling adds extra cost when products are handled from one place to another, especially by equipment. Therefore, it can be said that this sub-factor affects the main factor, as shown above.

Secondly, 'Lifting and handling by machines is not preferred by the contractor and the supplier' is the second sub-factor under the main factor (material handling), with a loading value of 0.675, which is less than the previous sub-factor but still quite valid, and can properly explain the main factor. In the descriptive outcome, 27.3% agreed and 45.5% disagreed, which means that Jordanian construction logistics believes that machines are more suitable than using labourers, regardless of the added cost, as mentioned above.

In the interviews, this sub-factor was explained by Interviewee F, who commented that material handling by machines is inevitable nowadays as construction parties have additional concerns about material quality and the time needed for loading and unloading through the logistics process.

According to Josephson and Saukkoriipi (2007), material handling takes about 14% of the labourers' time, and handling can cause reworking, waiting and interruptions. Therefore, machinery can provide a better solution if correctly taken into account. This sub-factor has an impact on the main factor, as clarified above. Finally, material handling with its two sub-factors has been justified statistically, descriptively, using interviews and the literature review, which provided a full picture regarding this factor. In addition, and as mentioned in the previous factors, the discussion of lean practices below will give an indication of the opportunities to improve this factor in Jordanian construction logistics.

To conclude, this section has discussed the factors affecting construction logistics in Jordan. This discussion has been comprehensively clarified by applying the information needed, including statistical results (factor analysis, Kruskal-Wallis, logistic regression) and descriptive outcomes, previous interviews and the literature review. The critical discussion shows that planning, undisputedly, is the first affecting factor in Jordanian construction logistics, followed by transportation, then transparency and exchanging information, continuous improvement, health and safety, material preservation (preserving quality), inventory and, lastly, material handling. Additionally, the Kruskal-Wallis test shows that the consultant has a greater effect on the planning factor, followed by the contractor and then the supplier. Secondly, Kruskal-Wallis also shows that the supplier has greater agreement on the transportation factor compared with the second, the contractor, and finally the consultant. Logistic regression shows that planning has an effect mainly on the consultant, then the contractor. In addition, logistic regression also shows that contractor is affected by inventory, and transportation has the most significant effect on the supplier and the least effect on the consultant.

At this stage, the similarities between the challenges affecting Jordanian construction logistics emerging through both the literature review and interviews, and the challenges affecting construction logistics emerging in the factor analysis table, can be significantly remarked upon. It seems that the main challenges (factors) shown through the literature review and the semi-structured interviews have a place in the factor analysis table, which justifies the trustworthiness and consistency of the factor analysis table. The only information is that the literature review extends the performance factor into two further factors: labour's performance and material handling. Although, the main arrangement of the factors structure remains the same. Consequently, Table 6.1 illustrates the factors (challenges) affecting construction logistics in Jordan, along with their sub-factors.

Table 6.1: Shows the main factors affecting construction logistics with sub-factors

Factors (challenges)	Sub-factors
Planning	Lack of training staff
	Deficiency and complexity in planning
	Type of contract procurement used between parties
	Poor delivery speed and responsiveness by supplier
Transportation	Using shared transportation vehicles with other parties
	Types of vehicle used in transportation
	Construction logistics suffers from unnecessary movement and excessive transportation
	Government regulations regarding customs and allowable loads
	Fluctuation of material in the market
Transparency and Information Exchange	Tracking system adds unnecessary cost
	Lack of mutual information and instructions
	Lack of controlling and monitoring tracking system
	Distrust among parties
Continuous Improvement	Cultural challenges and behaviors
	Feedback or shared lessons among parties
	Customer-client service is not a top priority for suppliers
Health and Safety	Lack of health and safety regulations
	Determining the most appropriate road is insufficient
Material preservation (preserving quality)	Poor quality of the finished product because of logistics process
	Construction logistics process in Jordan not considering the long waiting time among the processes

Inventory	Storage in construction sites is desirable by contractors
	Bringing material JIT is required by construction logistics parties
	Jordanian construction logistics processes suffer unnecessary inventory
Material handling	Lifting and handling by machines considerably increases the cost
	Lifting and handling by machines is undesirable

6.3 Lean Planning Tools

Planning is the key factor of the project. Successful planning is reflected in a successful project. Planning is about scheduling the project activities according to the time required, and includes pre-planning and on-site planning (Johansen and Wilson, 2006). As planning is considered the main affecting factor in Jordanian construction logistic it is a priority to discuss the tools used, so as to clarify the strengths and weaknesses regarding planning issues. These are ranked based on frequency of use, as follows: First, 'daily progress report' is the report explaining the status and progress of the planning activities throughout the day (Bassuk and Washington, 2013). This tool is the first tool as 67.3% agree to use this tool while 3.3% disagree with using this tool. So, the descriptive outcome displays that the majority of construction parties apply this tool throughout the logistics process. However, the Kruskal Wallis test (table 5.9) shows a significant result (0.002), in that there is a difference amongst stakeholders regarding this tool. It shows that the contractor has the highest usage of this tool, then the consultant, and lastly the supplier. Model 5 (Table 5.30, sig: 0.000, B= 0.934) in logistic regression shows that the daily progress report can predict the contractor, which means there is an effect on the contractor from this tool. Furthermore, model 6 (Table 5.34, sig:0. 001, B=- 0.954) shows that this tool cannot predict the supplier, which means this tool has the least effect on the supplier when compared with other stakeholders. The results of regression and Kruskal Wallis are very comparable in accordance of the preference of the contractor in using this tool more than others.

Secondly, the 'weekly plan' tool is the mutual arrangement between construction parties regarding production tasks for the next week through weekly meeting. It aims to plan a work schedule to be carried out during the upcoming week (Ballard and Howell, 2003; Mossman, 2009). This tool occupies second place based on the frequency of use with 44% agreed on using this tool, versus 22% who disagreed with using this tool. So, the weekly plan tool seems to some extent be essential in the Jordanian construction logistics process. The Kruskal Wallis test shows differences among stakeholders (sig= 0.000) where consultant appear to use this tool more than the contractor, and then the supplier. Logistic regression approved with the previous outcome and shows that the weekly plan tool (model 4, table 5.26, sig. 0.040, B= 0.527) can predict the consultant, which means this tool has a highest effect on the consultant, more than others. The weekly plan tool also can predict not to be a supplier, which means this tool (model 6, table 5.34, sig.017, B= -0.592) has the minimum effect on the supplier. So, based on the frequency of use, this tool is applied mainly by the consultant, then the contractor, and lastly by the supplier.

Thirdly, the 'master plan' tool is to develop and display execution strategies in order to show the feasibility of achieving the project within the required time (Ballard and Howell, 2003). This tool occupies the third place based in the frequency of use by the respondents with 44.3% agreed with using this tool and 43.3% disagreed. The results appear close to each other which means using and not using this tool is almost the same. The Kruskal Wallis outcome shows significant differences amongst stakeholders where the consultant has higher agreement in using this tool, then the contractor, and lastly the supplier. Logistic regression shows a similar outcome where the master plan tool can predict the consultant (model 4, table 5.26, sig .001, B= 1.278), which means this tool has the greatest effect on the consultant. As well as this, the outcome shows the master plan tool can predict not being a supplier (model 6, table 5.34, sig .027, B= -0.622), this means increasing use of this tool decreases the chance of being a supplier. Both tests agreed with the leading position of using this tool by the consultant, which clarifies the importance of using this tool through him.

Fourthly, the “critical path method” is the main path in the master plan where its activities need to be considered in a highly concern (Mossman, 2009). This tool comes in the fourth place based on the stakeholders’ frequency of use. The descriptive outcome shows that 36.6% agreed with using this tool whereas 46% disagreed. Regarding the percentage use of the master plan, it seems that critical path analysis is of little concern in the Jordanian industry, as those not using this tool are greater in number than those using it, which provides an indication that the master plan is not taken seriously. Kruskal Wallis shows differences among stakeholders (sig. 0.001) where the consultant has a higher agreement in using this tool followed by the contractor and finally the supplier. Logistic regression also presents a valuable outcome (model 4, table 5.26, sig. 0.046, B= 0.570), this tool can predict the consultant, which means the critical path analysis tool has higher effect on consultants, as their level of agreement on using this tool is higher than others.

Fifthly, 'look ahead plans' are about preparing targets when the accurate time arises. It is particularly applied in the construction industry to concentrate the management's attention on what is assumed will happen at an accurate time in the future (Henrich and Koskela, 2005). In the descriptive outcome, just 24% agreed with using the look ahead plans tool, whereas the majority of 49.4% disagreed with using the tool. This means that this tool is underestimated and not commonly used in the Jordanian industry. The Kruskal Wallis with a sig outcome (0.000) shows differences among stakeholders where the contractor comes first, and then the consultant, and lastly the supplier. The Kruskal Wallis also provides the same outcome where the look ahead plans tool (model 5, table 5.30, sig 0.029, B= 0.466) can predict being a contractor, which means that this tool has a considerable effect on the contractor. Furthermore, the look ahead plans tool can also predict not being a consultant (model 4, table 5.26, sig 0.029, B= 0.466), which means increasing the effect of this tool (a higher agreement in using the tool), results in decreasing the chance of being a consultant. So, the outcome of both tests presents the contractor as a main stakeholder affected by this tool, as well as indicating that consultants do not have an intention of involvement with the tool.

In Jordan, the consultant has a care of doing the master plan and the critical path analysis. However, he seems somewhat uncaring in the variations in the short daily planning progress, as the contractor bears this responsibility due to his status and duties in the construction site.

In the sixth place, work break down structure (WBS) is identified as a project planning in construction has concentrated principally on organizational structuring and creation of work breakdown structures that divide the work to be prepared. As mentioned previously in the literature review, Koskela's flow-based concept considers the finest mechanism of applying the WBS. Mainly, WBS divides the whole work scope into component parts to maximize value and minimise waste (Ballard et al., 2001). Descriptively, 10.7% agreed with using this tool, where surprisingly, the vast majority of 69.3% disagreed with using the tool, meaning that WBS is rarely used in Jordanian construction logistics. Therefore, the Jordanian construction industry is requested to raise their understanding and awareness of WBS, and subsequently utilise the tool with regularity across the entire breadth of their logistics processes, amongst all parties, in order to gain the best benefit. On the other hand, both the Kruskal Wallis test and logistic regression show no differences and effect between construction parties in applying WBS; meaning all of them alike are disinterested in the tools prominence.

In seventh place, 'percentage plan completed' (PPC) is the least used of all the planning tools. PPC is applied in order to improve production and measure productivity. It is the calculated percentage of the parts of promises accomplished on time. PPC is measured by dividing the number of activities completed as planned by the total number of planned activities (Ballard and Howell, 2003). By observing the descriptive responses given by survey participants, it is very noticeable that this tool is infrequently used in Jordanian construction logistics. Just 8.7% agreed with using this tool, with the massive majority of 68% disagreed with using it. PPC is considers to be the main root of the Last Planner System (reviewed in the next part), providing a substantial indication that Jordanian industry remains in the traditional stage of planning methods, and does not following the new planning method (lean planning). Furthermore, both the Kruskal Wallis and logistics regression tests display no differences and effect among stakeholders, all share the same poor view of the PPC tool benefits.

As the limitations of formal deterministic planning are becoming more widely recognized construction planning is receiving growing consideration (Winch and Kelsey, 2005). Viewing the general planning aspects in Jordan, of all involved parties, the engineering officer (consultant) appears to be carry the main responsibility for master planning, critical path analysis, as well as the weekly report. In the traditional design-bid-build contract, the client hires the architect (engineering office/consultant) to produce the effective documents which include the master plan and the critical path analysis (Gransberg and Windel, 2008). Furthermore, in conventional planning, the engineering company usually undertakes the planning task individually; whereas (for example) concurrent engineering required all parties to collaborate throughout the process (Ngowi, 2000). Remarkably, the procurement contract most used in Jordan is design-bid-build (clarified previously in Section 6.1), which explains the engineering officers' (consultant) role in the main aspects of planning. The traditional method gives the consultant (engineering office) the leading above all other stakeholders in fulfilling client requirements. And so, he obviously also carries the main responsibility for implementing the weekly meeting between parties. Furthermore, in the traditional planning method, the designer (architect) seems to be mainly responsible for the planning, inadequate design, combined with design-bid-build procurement;

and may leave the construction contractor no alternative but to rely on design errors and omissions to make the contract profitable (Ballard et al., 2001).

On the other hand, due to his position in the construction site, the contractor's concerns in planning details is aiming to record all daily details in order to substantiate his claim (Kumaraswamy and Yogeswaram, 2003), which explains why the daily progress report is used by contractor somewhat more than other parties. Moreover, the need for look ahead plans by the contractor is essential throughout the site operation. The contractor may have his own adaptive approach for executing the site operation work, as the occurrence of unforeseen events may require urgent rearrangement of priorities without influencing the master plan (Bertelsen, 2004).
The supplier appears to be ignored in the planning aspect, and not concerned with applying advanced planning tools, which reflects the current traditional method of planning in Jordanian construction industry. According to Akintan and Morledge (2013), the traditional method, once the main approach in the United Kingdom, on the whole failed to fulfil client satisfaction due to self-interests and lack of involvement by parties' in planning and coordination. To improve the efficiency of the construction logistic process, the supplier should adopt their role in the planning stage. Vrijhoef and Koskela (2000) suggested that improving the interface between site activities and the supply chain in the construction industry provides an opportunity for suppliers to become involved in the logistic process, where the main goal of supply chain management is to efficiently regulate the suppliers' interaction with the production line. Thus, the supplier should contribute in the planning aspect, as well as the use of planning tools inside the company be increased in order to facilitate the overall efficiency of Jordanian construction logistics. There is therefore a demand for structuring modern and advanced planning and scheduling by using systematic collaboration among all construction parties to reach an agreement on procurement plans derived from the master plan (Myer et al., 2015).

To conclude this part, planning tools used in Jordanian construction logistic are ranked as follows: daily progress report, weekly plan, master plan, critical path analysis, look ahead plan, work breakdown structure, and lastly percentage plan completed. However, the frequency of use for planning tools is still falls below the required expectations deemed necessary to build a robust planning process among parties. In Jordanian construction logistic, inferential outcome shows that to some extent the consultant has the focal part in planning, which includes the master plan, critical path analysis, besides the weekly plan. Whilst, to some extent, the contractor's concerns with the details of planning in the construction site include the look ahead plan, as well as the daily progress report.

Consequently, it could be discerned that there is an urgent demand for collaboration by integrating all logistics parties (stakeholders) through the planning part in the pre-construction phase, and during the construction phase, in addition to increasing the use of advanced planning tools (lean planning) to maximize values and minimize waste. ISM is implemented in the validation chapter to confirm the planning tools ranking and form the interactions among these tools in order to build the final model related to the planning part.

After discussing lean planning tools, the next part examines and assesses the lean practices used to clarify the entire picture of lean construction in Jordanian construction logistics. Consequently, Table 6.2 illustrates the ranking of lean planning tools based on the previous discussion.

Table 6.2: Illustrates the ranking of Lean Planning Tools

Rank	Lean Planning Tools
1	Daily progress report
2	Weekly plan
3	Master plan
4	Critical path method
5	Look ahead plans
6	Work breakdown structure (WBS)
7	Percentage plan completed (PPC)

6.4 Lean Construction Practices

Herein the section discusses lean practices across Jordanian construction logistics; the respondents are given their answers about the frequencies of using lean practices in their work. The main lean practices are mentioned in the survey and they are ranked based on frequency of use. The first two lean practices are clarified together, as they are describing the meeting aspect.

First, 'weekly meeting with your team' was ranked the first one among all lean practices based on the level of frequency used. Keeping in attention the work that is presently in the process, as well as collecting all knowledge and information required for the work that will be completed, weekly meeting with your team aims to scheme a work plan to be executed throughout the following week (Mossman, 2009). Almost 30% agreed in implementing this practice, where just over 40% disagreed in using this practice. The differences in using this practice is shown in the Kruskal Wallis test with a significant result (0.000) in Table 5.10, where the consultant comes first over others in applying weekly meeting with his team, then comes the contractor, and lastly the supplier. Logistic regression (Model 7, Table 5.38, sig. .018, B=0.947) shows that this practice can predict the consultant, which means that there is a high effect on the consultant by this practice. (Model 9, Table 5.46, sig. 0.006, B= -0.896) shows that this practice can predict not being a supplier, meaning that increasing implementing this practice, decreases the chance of being a supplier.

Second, 'weekly meeting with stakeholders' comes next in the rankings as almost 22% agreed with using this practice while 57% disagreed with using this practice. The result shows that more than half of the respondents are not frequently applying this practice, which is indicative of the weakness of cooperation among construction parties in the Jordanian construction logistics. Regular meetings will assist in discovering problem early on, as well as improving the construction logistics process. Weekly meeting with stakeholders' assists in discovering any interdependencies including resources, access, and equipment, which accordingly preserves the project plan reliable consistent with time limited and based on possibility and ability of achieving the scheduled work (Mossman, 2009).

The difference between stakeholders is clarified by Kruskal Wallis test (Table 5.10, sig.000), where the consultant has a higher agreement than others in implementing the weekly meeting with your team practice, then comes the contractor, and lastly the supplier. Logistic regression also shows a significant outcome according to (Model 7, table 5.38, sig. 050, B= 0.753), where the consultant can be predicted by this practice, as well as this practice having an effect on consultant (he has higher agreement with using this practice). Therefore, and based on the previous outcome in regards of the first two points, the role of the consultant in Jordanian construction is clear, especially when implementing a design-bid-build contract (the most popular contract in Jordan), as the one on the top of the pyramid according to the Jordanian procurement process he is the person mainly responsible for holding meetings. Therefore, as the consultant is directly connected to the client, this position engenders more care and responsibility in the consultant for the fulfilment of his requirement. So, this justifies the consultants desire to implement regular meetings with his team and with other stakeholders. On the other hand, the supplier cannot get involved in meetings and share his view, which makes him care less, as his role is very simple. The supplier could build long relationships and gain more advantages when participates in meetings. Consequently, by gathering all stakeholders in regular meetings the value will be increased and the waste will be decreased.

Third, 'Root causes analysis' identified by Ohno (1988) "The basis of Toyota's scientific approach is to ask *why* five times whenever they find a problem. Furthermore, by repeating *why* five times, the problem nature and its resolution become clear". In the descriptive outcome, just 17.1% percent agreed with using the practice, where more than half 58.9% disagreed with frequently using this practice. By avoiding regularly implementing this practice, Jordanian construction logistics misses a great opportunity to mitigate factors affecting construction logistics through application of root cause analysis.

The Kruskal Wallis test shows the differences between stakeholders as the consultant (sig. 0.012, Table 5.10) has a higher agreement with using this practice, then comes contractor, and lastly the supplier. Logistic regression (Model 7, Table 5.38, sig. 0.049, B= 0.486) also shows that the consultant can be predicted by this practice, which means this practice has an effect on the consultant. Ramkumar and Gopalakrishnan (2014) explore an approach to solving problems associated with the root causes of major project issues. The approach will be powerfully supportive provided all construction parties are prepared to cooperate in order to diminish problems and reduce delays. Whilst, in the traditional construction method being prepared to cooperate is difficult given that one party takes the most care and responsibility. Thus, there is a demand for significant change towards gathering all stakeholders in regular weekly meetings.

Fourth, 'Gemba' is a Japanese word that means "the real place", where one needs, in-person, to see with one's own eyes what is happening, and enquire about an issue, searching for explanations and solution opportunities, and being courteous with others (Womack, 2011). In the descriptive outcome, 15.3% agreed with using the Gemba practice where the majority of 66.4% disagreed with frequently using this practice. Jordanian construction logistics suffers from many factors; the Gemba practice provides further controlling and checking throughout the processes. Jordanian construction logistics has a requirement to more widely exploit this practice in order to create further development in factors affecting construction logistics, particularly to support the continuous improvement factor. The Gemba practice means consistently being in continuous touch with the operational site and other parties, which helps to keep an eye on real issues and aims to resolve these issues directly on appearance (Tyagi, 2015). Furthermore, the Gemba walk practice supports construction stakeholders in developing a common language and deepen project understanding based on shared visions, which also increase transparency throughout the processes (Tsao and Beikmann, 2012). The Kruskal Wallis shows significant differences among stakeholders (sig. 0.047, Table 5.10), where the consultant, to some extent, has a higher agreement with using this practice, more so than the contractor, and then the supplier. However, this outcome is not emphasized by the Logistic regression test (a very sensitive test) where the results are not significant.

It is very logical that the engineering and consulting company are primarily concerned with customer satisfaction, so the consultant should enrich his job quality by 'Go to Gemba', which means leaving the desk and going to the construction site to observe by his own eyes (Russ, 2006).

Fifth, 'First runs study/PDCA' practice focuses on non-value added aspects by carrying out the repetitive and consistent PDCA (four-steps cycle). Moreover, by implementing this method, along with reasonable visual wherewithal, the non-value added aspects can be specifically identified and reviewed (Forbes and Ahmad, 2009). The recognition of this practice validates organizations to reach customer satisfaction by means of continuous improvement and employee involvement (Kabirifar and Ghafourian, 2014). Furthermore, if frequently and properly used, this practice can also have a positive impact on health and safety in developing countries, such as Ghana (Kheni et al., 2008).

In the descriptive outcome, just 12.7% agreed with using this practice, and 78.1% disagreed. The absence of PDCA practice presents negative effects on several factors affecting logistic in Jordan, and this practice particularly considers the main feature of continues improvement (CI). Having mentioned in previously sections (Sections 6.2.4 and 6.2.5) that Jordanian construction logistics shows significant drawbacks in regards to the CI factor, and the health and safety factor, thus lack of implementation of this practice provides significant evidence concerning the reason for the drawbacks. In order to build lean strategy for companies, especially throughout construction logistics, there is an essential need to encourage the Jordanian stakeholders to apply First run study (PDCA) for the improvement of the site environment along with the engagement of all stakeholders in all levels (including workers).

The Kruskal Wallis test discovered differences among stakeholders with a significant value (sig. 0.009, table 5.10) where consultant has a higher agreement in Jordanian construction logistic to apply this practice than the contractor, followed by the supplier.

Continuous improvement is the key to quality management; first run study by PDCA is the approach to achieve the continuous improvement. As the consultant has somewhat of a unique individual connection with the client (unlike other parties, particularly in the traditional construction method) he is able to dedicate more time to further improvement levels, and consequently gains customer satisfaction. Accordingly, many American consultants are passionate about adopting quality implications from Japan, especially the repetitive PDCA cycle. These methods were created, advanced, and then improved through persistent processes of trial and error by engineers (Kabirifar and Ghafourian, 2014).

Sixth, '5S' is a practice comprised of five features: sort, set in order, shine, standardize, and sustain; and is utilised for the production of a well-organized, disciplined, and clean work environment (Chapman, 2005). In the descriptive outcome, a significant drop of 8.5% agreed with using this practice, where the vast majority of 75.9% disagreed with using this practice. The Kruskal Wallis test shows significant distinctions amongst stakeholders (sig. 0.012, Table 5.10), where the contractor uses this practice more than the consultant, and then supplier. Having mentioned in a previous section (Section 6.2.4), lack of application of this practice reflects the drawbacks in construction logistics in Jordan (factors affecting Jordanian construction logistics), especially the health and safety factor, the material preservation factor, the material handling factor, as well as the continuous improvement factor. According to Ab Rahman et al. (2010), 5S is one of the practices that enables improvement of health and safety in the workplace, as well as improving the quality of workplace environment; along with further benefits. Chapman (2005) noted that 5S creates an adding value environment by engendering fewer hazard and increase safety; less searching; decreased motion and walking; enhanced flow; along with fewer mistakes and defects.

Logistic regression emphasizes on the outcome (Model 8, Table 42, sig. 0.003, B= 0.592) and shows that 5S practice can predict the contractor and has an effect on the contractor, where (Model 9, table 46, sig. 0.043, B= -.472) shows that this practice can predict not being a supplier, which means that increasingly using this practice lessens the chance of being a supplier.

Sowards (2004) noted that contractor priority tends to increase the ability to implement 5S, compared with 1998 where 5S was to some extent unknown to contractors. This means that, due to their complex and critical position in the construction site, the level of 5S use has significantly increasing across contracting companies.

Seventh, 'JIT' practice aims to provide any material when demanded; where the main objective of JIT is to achieve continuous quality and productivity improvements through production with 'zero defects' and 'no waste' (Oral et al., 2003).

In the descriptive outcome, surprisingly, just a minor percentage (5.8%) agreed with using this practice, where a large mass of respondents (88.4%) disagreed with using this practice. As JIT is still underestimated and not trusted among the stakeholders, this proves that Jordanian construction is still under development and following the traditional method of logistics. As previously mentioned in Section 6.2.4, Jordanian construction logistics suffers large inventory throughout the processes; the use of JIT is rare, which justifies the cause of this problem. Stakeholders must work together, taking urgent action by implementing JIT over their delivery systems.

The Kruskal Wallis test does not show differences in using this practice between stakeholders. Nevertheless, to some extent, the supplier seems to have a higher agreement than other with using JIT practice according to logistic regression (Model 9, table 5.46, sig. 0.030, B= 0.619). It shows that JIT can predict the supplier, which means there is an effect by this practice on the supplier. In this context, it is surely significant to link a previous point with the current point: in Section 6.2.7, the contractor has a desire to store material early and to have inventory. Herein, to some extent, the supplier needs to send material in time in order to have more material availability, flexibility, and to avoid any fluctuations. This point was initially mentioned by Norris (1994). Norris noted that JIT comprises a risk of motivating in inflation; when there are material shortages the supplier tends to increase price, so he prefers to keep the materials and send them when needed. On the other hand, for the previous cause, the contractor tries to have inventories in order to avoid material shortages or delays (Abdelhalim and Duff, 1991; Ofori, 1994). Therefore, the entire construction parties' cooperation with the supplier is deemed the main basis for the implementation of JIT; especially in developing countries as the primary reason for not implementing Just-in-Time in a developing country such as Turkey was late deliveries by the supplier (Oral, 2003). There is a need to stabilize both supply and demand; along with developing a long relationships with the supplier in order to assure stability, quality, and also the significant relationships with the client directly. Though, the stability of demand needs to be controlled by government regulations (ibid). Consequently, the role of supplier in implementing JIT practice has been properly manifested based on the above information.

Eight, the 'Value Stream Mapping/ VSM' practice is a significant approach to enable exploration of a series of events from the original point to the final place; where material and information are included in the flow mapping (Rother, 2010). “It is a method to explore waste, inefficiencies, non-added valued steps in single, definable process out of complete product development process” (Tyagi et al., 2015). In the descriptive outcome, a small percentage (3.5%) agreed with using VSM practice, where a huge majority (82.6%) disagreed with using this practice. As previously mentioned in Section 6.2.4 Jordanian construction logistics has poor transparency. VSM practice would create a transparent operational system where everyone is engaged in the process, and would have clear information and view through material delivery and storage. It seems all stakeholders have the same ignorance of this practice, as the Kruskal Wallis test shows no differences between parties, and logistic regression shows no special effect for any party. Furthermore, Klotz and Horman (2008) noted that VSM has a great impact on the increasing transparency. The process assists organizations to determine problems early on, and understanding sequences of the work. Accordingly, VSM can be a valuable practice to solve several logistics problems, particularly increasing transparency.

Finally, 'Last planner system/LPS' is at the bottom of the ranking based on lean practices used in Jordan. LPS is a planning, control, and improvement system. The last planner system is made to increase productivity of labours and material; facilitate workflow; as well as measure the ratio of completed tasks, and discovering the cause for uncompleted tasks (Ballard, 2000). In the descriptive outcome, surprisingly, a very small percentage (2.8%) agreed with using the practice, whereas 92.1% disagreed with using the practice. So, the LPS practice is considerably underestimated. Construction parties are unawareness of the benefits of this system. In Section 6.2.4, the planning factor was seen to undoubtedly as the main factor affecting construction logistics in Jordan. LPS provides a sequential approach to improve the percentage of uncompleted tasks, as well finding reasons for incompletion.

Few studies have been made regarding the use of LPS in developing countries, as previously stated in the literature review. However, those study results do show significant advantages when implementing LPS. The effectiveness and efficiency of the last planning system practice has been exposed in developing countries. In Saudi Arabia (a developing country in middle east), LPS was implemented in two projects and significantly improved both construction planning and management in different ways, providing major benefits (AlSehaimi et al., 2009). Furthermore, a study in Egypt (a developing country) implemented lean construction practices including LPS to minimize risk factor effects on time. The results showed that the overall project time decreased by around 16%, and the PPC value also improved (Issa, 2013).

The Kruskal Wallis test and logistic regression show no significant values to describe any differences among parties, or any particular effect.

Therefore, LPS will lead to improve planning and flow reliability as it is a system for collaboratively managing a relationships network along with changes required for program coordination, production, planning, and project delivery (Ballard and Howell, 2003). As the importance and significance of the LPS practice becomes clearer to construction parties in developing countries the demand for using this practice will significantly increase day after day; especially when considering that LPS practice can solve several factors affecting construction logistics. The planning aspect included. Table 6.3 shows the ranking of lean practices based on the aforementioned discussion.

Table 6.3: Shows the ranking of Lean Planning Tools

Rank	Lean Practices
1	Weekly meeting with your team
2	Weakly meeting with the stakeholders
3	Root causes analysis
4	Gemba
5	First runs study/PDCA
6	5S
7	JIT
8	Value Stream Mapping/ VSM
9	Last planner system/ LPS

To conclude this section, the results shows the ranking as follows: weekly meeting with your team, weekly meeting with stakeholders, root cause analysis, Gemba, first run studies, 5S, value stream mapping (VSM), and finally the last planner system (LPS). Regardless of the frequencies of use for these lean practices among construction parties, as explained above, it is very clear that lean practices are extremely underestimated and not popularly used in the Jordanian construction industry, including the construction logistics aspect. Moreover, levels of not using lean practices are significantly greater than levels of using the practices, which indicates that all of them are insufficient used and below the expectations level of all construction stakeholders. So, the outcome of this section has proven an inverse relationship between lean practices used against factors affecting construction logistics, revealing the necessity for using lean practices to diminish the negative effects of factors affecting construction logistics. After discussing the importance of lean construction practices, the next section discusses the main drivers to encourage the use of lean planning tools and lean practices.

6.5 Lean Drivers

The importance of implementing lean planning and practices in order to mitigate the negativity of factors affecting construction logistics has been clarified in the previous sections of this chapter. Next, this research is built to provide a complete picture of all lean features. Thus, it is noteworthy to illustrate how Jordanian construction will be encouraged to acknowledge and successfully implement these new practices. Consequently, participants were questioned about the main drivers in the interviews chapter, then follows a survey where respondents were asked about their level of agreement in regards to each driver to implement lean practices. The responses frequencies in the survey were then descriptively ranked based on the level of agreement, as follows:

1. As expected “Reliability in cost” comes first with almost 72% agreed on this driver and just under 4% disagreed. Cost is considered one of the main pillars in the construction industry, and the main pillar in Jordanian construction logistics. In interviews, the interviewee I mentioned that reliability in cost is the utmost pillar among others (time and quality) in the Jordanian construction industry. Cost was strongly mentioned as primary aspect to identify lean production and construction practices, most of the advantages of lean commenced by illuminating cost reliability and reduction (Lanigan, 1992; Koskela, 1993; Grieves, 2005). Thus, this driver appears to persist as the supreme driver based on the above information.

2. “Need for fast delivery and responsiveness” comes second, where 68.7% agreed with this driver and only 7.5% disagreed. In interviews, Interviewee B stated “Fast delivery and responsiveness is significantly needed, where every supplier attempts to understand and develop himself to accomplish it. Therefore, it is an aim to learn and implement new practices to fast the delivery responsiveness.” According to Ballard (2000b), LPDS offers the capability of addressing the faults and lacking aspects of the traditional construction method, and improve the design and the construction process; especially in maximizing value and minimizing waste, as well as focusing on consumer-oriented product delivery. Furthermore, look ahead planning in the LPS is an appropriate procedure to design and speed up the delivery process (Henrich and Koskela, 2005; Ciarniene and Vienazindiene, 2012). So, the vital role of this driver is very clear.

3. “Better reputation” comes third, where 67.4% agreed on the importance of this driver and 7.4% disagreed. In interviews, Interviewees C and D wonder to what extent new practices can develop the reputation of the company. Regarding this point, Interviewee C noted “Applying new managerial practices develop the reputation level; thus many organizations will use them to have further benefits”. According to Forza (1996), implementation of lean practices is considered essential to differentiate an LP (lean practices) company’s reputation from non-LP companies. This outcome shows to the statement that both groups of companies are considered to vary from each other as far as lean practices are concerned. Consequently, applying lean practices will improve a company’s reputation. So, based on the previous information, this driver has a significant place among others.

4. “Reliability in time” comes fourth, where 64.7% agreed regarding the importance of the driver, whilst 11% disagreed. In interviews, Interviewee C highlighted “Applying any practices should take into account the reliability in time as most of the organizations always worried of the delays and paying penalties". Vrijhoef and Koskela (2000) have clarified that at the start and the end of each sub-process in the logistics system, substantial time buffers arise, particularly due to inventory and delays, which shows that

the waiting time is quite long. Moreover, the lack of coordination in planning is deemed to be one of the main problems producing the time buffers (ibid). Additionally, Ballard and Howell (2003) stated that independency through lean practices is required to reduce waste in terms of waiting time. Therefore, reliability in time is considered a proper driver to implement lean practices to Jordanian construction industry.

5. "Reliability in quality" comes fifth, where 64.4% of the participants agreed with this driver and 7.4% disagreed. In interviews, Interviewees A stated "Logistics process is suffering from poor quality and lack of productivity as many constriction parts endure from same concerns". Interviewee G affirmed "Poor performance through logistics process has seriously a negative effect on material quality through loading, transportation, unloading, storing and installing." According to Slack et al. (2004), when using new managerial methods that includes everyone experiences to face problems work quality will be enhanced, and material getting broken or old will be avoided. Furthermore, case studies show in how quality can significantly improve when implementing lean philosophy and practices in different projects (Chen et al., 2012; Dhandapanietal, 2007). Therefore, reliability in quality has a suitable place among other drivers in Jordanian construction logistics. Although, this driver ist still less crucial than reliability in cost and time, which is also comparable to the outcome in Section 6.1.

6. "Solve storage problem" falls into sixth place, where 63.5% of the respondents agreed and 9.5% disagreed. Interviewee C mentioned a fundamental point in regards of this driver by saying "As a Jordanian contractor, my focal worry in logistics process is material storage where I don't have usually adequate area in the store and sometimes I have to store material near the road outside. In my view, new practices can be widely used if this problem can be solved". According to Lundesjö (2015), there are several obstacles when storing material, particularly when moving the material from one storage place to another, and keeping material exposed causes damages. So, as discussed, this driver also has importance amongst others.

7. “Huge demand and delivery” is the seventh driver according to respondents’ answers, where 63.2% agreed with this driver and 9.5% disagreed. In interviews, Interviewee A said “Logistics in Jordanian construction suffers controlling and managing the demand required along with accomplishing delivery requirements. If new managerial practices could manage these features, many organizations will apply them”. Koskela’s concept of lean construction aims to maximize value and minimize waste, as well as consumer-oriented product delivery. Furthermore, Henrich and Koskela (2005) along with Ciarniene and Vienazindiene (2012) highlighted that the sufficient implementation of lean practices such as Look ahead planning (a part of LPS) can significantly help to plan the delivery process.

8. “Create value and customer satisfaction ” is the eighth driver based on the participants’ responses, where 63.2% agreed with this driver, and 13.2% disagreed. In interviews, Interviewee F said “Create value is missing in Jordanian logistics process, I worked with diverse companies as a logistics manager, and however we have never intended to improve the logistics process, or focusing on customer satisfaction". The whole concept of lean is formed in adding value, whilst the first lean principle icon in the lean cycle is identifying value (LEI, 2009; Shah and Ward, 2003; Womack et al. 2007; Womack, 2011). Surprisingly, Jordanian construction parties underestimate the need for identifying value to gain improvement, which reflects the traditional face of construction in Jordan. So, as discussed above, this driver is critical and impacts other drivers.

9. “Sustainable improvement” comes in ninth place, where 61.1% of the respondents agreed with this driver and 12.5% disagreed. In interviews, Interviewee (I), with regards to sustainability, highlighted the need to convince Jordanian construction parties to implement lean practices along with other elements in developing countries in order to gain best results. According to Nahmens and Ikuma (2011), a variety of case studies demonstrate the effects of lean on the triple bottom line of sustainability. The outcome shows that lean practices reduce material waste by 64%, lessened social effect by 31%, and dramatically decreased hazards. So, sustainable improvement is considered one of the drivers in Jordanian construction logistics, as previously discussed.

10. "Increase safety" is the tenth driver, where 60.7% agreed with this driver and 11.1% disagreed. In interviews, Interviewees A and H remark on the matter of safety. Interviewee A said "Safety is still misjudged and not taken sincerely; new managerial practices require to focus on this feature". Interviewee H emphasized, "Jordan is one of the developing countries, developing countries are mainly not bothering or properly employing safety rules, thus new practices need to knock this part to develop this logistics process." Lean practices have positive impact on safety, e.g. Forbes and Ahmad (2009) stated that visualization techniques cover many areas including the safety issue. Also, Ballard (2000a) mentioned that the failsafe for quality tool focuses on safety as a first matter throughout the lifecycle of construction. Therefore, safety is also considers one of the drivers to implement lean, as stated above.

11. "Catch problem early" is the eleventh driver, where 60.6% of the respondents agreed with this driver and 10.2% disagreed. In interviews, Interviewee A stated that problems in construction logistics are revealed very late, thus new managerial practices (e.g. lean) are required to clarify proper methods so as to catch problem at an early time. Lean tools and practices possess a great ability to dig deep and locate problems in advance (Ohno, 1989; Rother, 2010; Bassuk and Washington, 2013). Therefore, this driver is considered one of the drivers to assist Jordanian industry to implement lean practices.

12. "If your competitors use them" comes in twelfth place, where 58.1% of the participants agreed with this driver and 15.4% disagreed. In interviews, Interviewee B stated "if the competitor applies new managerial practices and techniques, my company will certainly apply them, following the strongest competitor keeps our company in a robust situation in the market". Handfield et al. (2002) mentioned how companies are obliged to grow their global market share in order to survive. They are required to strengthen themselves against their competitors. So, this driver has been clarified, but surprisingly, is not considered to be a highly vital driver among others.

13. "Help manage conflict" comes in the thirteenth place, where 57.8% of the respondents agreed and 10.3% disagreed. In interviews, Interviewee E noted "Problems always befall

throughout construction especially in logistics; construction industry in Jordan requires an aiding system to manage the conflicts”. Consequently, in order to discover problems at an early stage and help manage conflicts among parties, new practices are demand. Johansen and Wilson (2006) emphasized that lean practices, particularly the weekly meeting practice, are vital to the discovery of problems early on, so assist in avoiding potential conflicts as soon as possible. So, this driver effects the possible implementation of lean practices, but is not as significant as previous drivers.

14. “Labour shortage” is the fourteenth driver according to the respondents’ answers, where 53.3% agreed with this driver and 18.6% disagreed. In interviews, Interviewee E stated “Shortage of labours is a concern when it arises, if new practices can manage this concern, my organization will surely apply them". However, Interviewee G added, “Implementing new practices depends on to what degree these practices are efficient at decreasing your manpower”. Ballard (2000a) noted that LPS was made to gain the highest productivity of labour resources besides material. Rother (2010) stated that companies require implementing lean practices in order to precisely calculate the number of labourers needed, as many organizations are exploiting greater number of workers through work activities without knowing about LPS. Subsequently, lean practices, especially Takt time, aim to find the exact number of labourers needed (mainly reducing numbers, as companies tend to exaggerate when calculating labour) and exact time needed for a certain order. So, this driver has a lesser effect than other drivers to encourage Jordanian construction industry to apply lean practices.

15. “Employee satisfaction” is the last driver, where 47.5% agreed with this driver and 13.1% disagreed. In interviews, Interviewee I stated "satisfaction of employees is missing in Jordanian construction logistics whereas companies mainly asking for customer satisfaction”. Supporting employee involvement in the project and employee satisfaction creates a significant impact on the logistics process, and lean practices. In particular, Kaizan, daily group meetings, concurrent engineering, and visualization all assist in offering employees the opportunity for involvement and satisfaction. Also, lean practices intend to work collaboratively in the company by gathering all employees from various

steps to deal with problems (Ballard, 2000a; Forbes and Ahmad, 2009). Furthermore, employee satisfaction can positively impact upon customer satisfaction (Ciarniene and Vienazindiene, 2012). Consequently, based on respondents' answers, this driver carries the least effect to implement lean practices, as discussed. Although the Jordanian construction industry still appears to undervalue the importance of employee satisfaction.

It appears that drivers' outcome delivers an additional significant sign. The Jordanian construction stakeholders still hold conventional thoughts as their main lean focus, including employee satisfaction, with creating value occupying the lowest positions in this section. Thus, the drivers' outcome matched well with the previous results when viewed within the context of traditional construction. Table 6.4 displays the ranking of lean drivers based on the preceding discussion.

Table 6.4: Shows the ranking of Lean Drivers

Rank	Lean Drivers
1	Reliability in cost
2	Need for fast delivery and responsiveness
3	Better reputation
4	Reliability in time
5	Reliability in quality
6	Solve storage problem
7	Huge demand and delivery
8	Create value and customer satisfaction
9	Sustainable improvement
10	Increase safety
11	Catch problems early
12	If your competitor used the practices
13	Help manage conflicts
14	Labour shortage
15	Employee satisfaction

6.6 Lean Barriers

After discussing the encouraging drivers to implement lean practices in Jordanian construction logistics, it becomes vital to explore the other side i.e., the barriers. Furthermore, it is about clarifying the opponent of drivers in order to derive a complete picture of the Jordanian construction industry regarding the lean subject. Therefore, the barriers to implementing lean practices have been extracted initially by literature review, followed by interviews, and finally by survey. All the information is gathered, analysed, and ranked (based on the level of agreement given by respondents' answers) as follows:

Firstly, "Mindset issues" are the first barrier based on the questionnaire responses. 88% of the participants agreed on this barrier whilst 2% disagreed. This also explains the previous outcome as Jordanian construction logistic remains in a traditional phase. In interviews, Interviewee A stated "There is a significant gap among generations hindering employing new techniques in construction particularly in logistics, the challenge of culture deems a key obstacle against the improvement." Japanese culture is frequently mentioned as a unique culture that look forwards to improving (Womack, 2007; Rother 2010). Moreover, Mann (2012) clarified that culture challenges are considers a vital issue regarding implementation of lean practices. Any culture needs to work hard towards development by having all stakeholders involved in the process, sharing views and utilizing advanced practices to gain the best outcome. Therefore, as previously discussed, culture challenge needs to be taken into consideration. Hence, lean culture is certainly a key solution to prevent potential failure when implementing lean thinking and practices.

Secondly, "Lack of awareness and understanding" falls into the second place, where 83.2% of the participants agreed and 6.5% disagreed. In interviews, Interviewee F said "Lack of awareness and understanding as well as awareness when employing new practices in construction is misjudged; organizations need to raise their information to reach adequate levels of advantage". Lack of understanding lean is recognized in a case study in Malaysia (a developing country) as a significant barrier; all firms need to understand and beware of the theories and practices of lean in order to properly attain a desirable outcome (Nordin et al., 2010). Moreover, Salem et al. (2005) also mentioned that contemporary construction requires senior managers to gain high levels of awareness and understanding with regards to the scope of lean. Therefore, this barrier considers a vital one, as clarified above.

Thirdly, “Lack of education and training” comes next, where 78.7% agreed about this barrier and 4.4% disagreed. Certainly, this outcome is well suited with Section 6.1, where 83% of companies do not have training schemes, as previously discussed. In interviews, Interviewee A and H stated that "lack of training in universities as well as organizations hinders the construction parties to apply new practices, the level of training and education regarding this subject is still poor". Training and education to learn about lean practices and techniques has been mentioned by Mossman (2012), he believes that an organization’s benefit is not clear as their training and experience is not sufficient enough to enable them to manage changes. So, it seems that this barrier has its role among other barriers, as discussed earlier.

Fourthly, “Lack of mandate and top management commitment” comes next, where 71% agreed and 8% disagreed. In interviews, Interviewee F stated “Managers and employees need to be committed as well as mandate as applying new practices demand accomplishing this part”. Lack of top management commitment beside lack of mandate acts as a barrier which needs to be taken in the account. Thus properly applying lean practices generally creates a noteworthy change in a companies’ attitude, which can be considered challenging if a company is not well suited to cope with the changes (Ciarniene and Vienazindiene, 2012). Sarhan and Fox (2013) added that the advantages of middle management is usually not clear, as well as their experience and training not satisfactorily enabling them to cope with the required change. Thus, this barrier also affecting the implementation of lean practices in Jordanian construction logistics, but not as the previous ones.

Fifthly, “No support from government” is the last one among all barriers, where 63.8% of the respondents agreed and 13% disagreed. In interviews, Interviewee A said “Government need to inspire organizations by growing the published articles that support stakeholders to comprehend and finally develop”. According to (Janssen and Estevez, 2013), across the whole world governments are seeking for methods to reduce costs and stimulate innovation. However, many governments face critical challenges in attempts to engage stakeholders, determine social dilemmas, and manage to unite the whole environment so as to implement new tools, practices methods, and governance strategies. Thus, major changes need to take a place in what way these governments activate. Thus, to some extent, this barrier influences Jordanian construction industry, as government has its role to play in changing traditional management to be contemporary management. However, the impact of this barrier is less than others. Consequently,

Table 6.5 illustrates the ranking of lean barriers based on the previous discussion.

Table 6.5: Shows the ranking of Lean Barriers in Jordanian construction

Rank	Lean Barriers
1	Mindset issues
2	Lack of awareness and understanding
3	Lack of education and training
4	Lack of mandate and top management commitment
5	No support from government

To conclude this chapter, the discussion has comprised a variety of themes. The first theme was to analyze the current situation of construction logistics in Jordan. The outcome shows that the pillar of construction can be categorized respectively by cost, time, and quality. The outcome also shows that 70 percent of the logistics parties have a lack of operating reverse logistics; 83% percent of the logistics parties are not training their teams; and lastly the traditional contract (design-bid-build) is predominantly used among parties, as 60% percent agreed. In Section 6.1, the first theme has been explained in detail.

The second theme is the factors affecting construction logistics in Jordan (Section 6.2), where sub-factors have been grouped under main factors (latent factors) by using factor analysis; sequentially, planning is the leading factor, followed by the transportation factor, the transparency and information exchange factor, the continuous improvement factor, the material preservation factor, the inventory factor, and the material handling factor.

The third theme is lean planning tools (Section 6.3), where these tools have been descriptively ranked based on the level of usage by respondents. The outcome shows the arrangement respectively as: daily progress report, weekly plan, master plan, critical path analysis, look ahead plan, work breakdown structure, and then percentage plan completed.

The fourth theme is lean construction practices (Section 6.4), ranked in a descriptive method based on level of usage. The outcome presents the ranking as follows: weekly meeting, weekly meeting with stakeholders, root cause analysis, Gemba, first run studies, 5S, value stream mapping (VSM), and finally last planner system (LPS). Regardless of using these lean planning tools and practices, their level of usage remains insufficient. Furthermore, Jordanian construction logistics needs to take further action in order to increase levels of understanding and awareness of the lean subjects so as to gain the desired benefits.

The fifth theme is the drivers to implement lean practices. Based on the level of agreement, the ranking of these drivers is as follows: reliability in cost, need for fast delivery and responsiveness, better reputation, reliability in time, reliability in quality, solve storage problem, huge demand and delivery, create value, sustainable improvement, increase safety, catch problems early, if your competitor used the practices, help manage conflicts, , labour shortage, and employee satisfaction. The outcomes of drivers have been critically discussed in Section 6.5.

The final theme is barriers to implementing lean practices. Depending on the level of agreement by participants, barriers have been ranked as follows: mindset issues, lack of awareness and understanding, lack of education and training, lack of mandate and top management commitment, and no support from government.

Additionally, Inferential outcome shows the planning factor affected the consultant more than other stakeholders, followed by the contractor, and then the supplier. It also shows that the supplier has greater agreement on the transportation factor; as well showing that the inventory factor has the greatest effect on the contractor. Inferential outcome also shows that to an extent the consultant plays the central part in planning which includes the master plan, critical path analysis, and the weekly plan. Whilst, the contractor's concerns in the construction site planning include the look ahead plan, as well as the daily progress report. Consequently, regardless of uncommon use of lean practices in Jordanian construction, in the inferential outcome the consultant (designer) appears to make greater use of lean practices that other party, except for JIT, which is occasionally used by supplier more than other stakeholders.

Accordingly, this chapter assesses the challenges (factors) in construction logistics in Jordan, and then discovered and assessed the level of exploiting lean in Jordan, which is revealed to be poor and misjudged. Exploring supporting evidences justifies that implementing lean practices and tools can significantly mitigate the negative effects of factors affecting construction logistics. Afterward, finding ways to encourage Jordanian construction industry, and raising the level of comprehension and usage of lean practices by synthesizing knowledge and information gathered from literature review, interviews, and questionnaire, each point being clearly and fully realized. The themes have been clarified from various angles, expounding the need to deliver a complete picture regarding this important subject. Therefore, the information gained throughout this chapter has completely fulfilled objective three ‘To develop an approach for the adoption of lean logistics in order to assess the existing logistics processes in Jordanian construction’. Additionally, the outcome of this chapter also achieved objective four ‘To explore the differences amongst Jordanian stakeholders’ views in regards of factors (challenges) affecting construction logistics; lean planning tools and practices.’

Consequently, the next chapter validates the current outcome in regards to each part, and builds the final models using ISM, where each model illustrates one of the mentioned themes.

Chapter Seven: Validation

7.1 Introduction

The aim of the research is to develop models for assessing the adoption of lean logistics in Jordanian construction. Hence, it was very important initially to explore the factors affecting construction logistics, and then to assess the level of using lean practices in Jordanian construction. The research employed mixed methods by gathering data through semi- structured interviews (qualitative method) with numbers (9), and then a survey (quantitative method) numbers (150). The outcome of the interviews has been validated separately in chapter four based on credibility, transferability, dependability, and conformability; and the collected data has been exploited in the second data collection (survey).

Throughout the discussion chapter, the outcome critically expounds the main factors (challenges) affecting construction logistics in Jordan; then the results of applying lean planning and practices are seen to be absolutely under the level of expectation. Furthermore, lean practices have been proven through the discussion as a proper solution to mitigate the negative effects of these factors (challenges). So, Jordanian construction has a need to increase knowledge and awareness in order to implement lean planning and practices. Thus, this chapter displays three models, using the ISM method. The first model explains the interactions amongst the factors affecting construction logistics along with the level of importance of each one in order to assess the current situation and gain Jordanian construction logistics a better understanding about the dilemma. The second model clarifies and assesses the relationships between lean planning tools and the level of influence for each one. The third model assesses and illuminates the relationships accompanied by the level of influence in lean practices. The last two models are assessing lean planning tools and practices within the context of construction logistics in Jordan and can be reviewed by construction stakeholders to assist the adoption of lean planning tools and practices within construction logistics process (lean logistics) in Jordan. Consequently, the ISM approach is used as a validation method to scrutinize the research findings.

7.2 ISM (Interpretive Structural Modeling)

According to Sage (1977), this approach is mainly utilized to explore, identify, and then summarize the relationships between variables (factors), where the issue or problem is defined through the process of ISM. The complexity of the variables can be released through the means of ISM (Jharkharia and Shankar, 2005).

7.2.1 Focus Group

A focus group has been applied by gathering nine experts in regards to construction logistics (three of each: consultant, contractor, and supplier). They were invited to concurrently classify and rank the factors (challenges) affecting construction logistics, lean planning tools, and lean practices. Secondly, to explore the interactions amongst variables via creating three models as follows: factors affecting logistics process, lean planning, and lean practices. Recently, this type of qualitative data has expanded through the social science field, the dynamics of focus group which gathers a group of experts in a particular communication, produces a deeper and richer outcome than an individual interview (Richardson and Rabiee, 2001). Moreover, Green et al. (2003) noted that a focus group helps, to a high extent, in creating huge data in a short time. Furthermore, the importance of focus group gained the researcher a variety of ideas and thoughts from different professionals about particular matters. In addition, revealing the distinctions in viewpoints amongst the individuals in the group (Krueger, 1994).

Hence, it is clear that the fundamental of ISM is positioned on the views of the participated people. Thus, the attendant group has much experience along with high levels of skill in construction, production, and supply chain management, enabling them to perfectly provide an explanation of the convoluted interactions amongst factors. Therefore, three ISM models (factors affecting logistics, lean planning, lean practices) are constructed where the first model (ISM) assesses the challenges, the second model (IMS-2) assesses planning tools to be employed, and the third model (ISM-3) designates lean practices where both of the last two models are built to provide a comprehensive assessment for lean logistics and to imply keys for the construction logistics process in Jordan.

Drivers and barriers of adopting lean practices have been additionally discussed through the focus group. Seven experts out of nine strongly indicate the importance of cost as a main driver to encourage construction stakeholders to implement lean practices and tools in Jordan, which is comparable with the analyzed data. Furthermore, five out of nine experts stated that synchronously culture issues (mindset issue) along with levels of awareness are considered crucial barriers, and need to be developed together. Whereas another two experts emphasized that culture issues are considered the most undisputed barrier, though both opinions confirmed the result in the previous part.

Additionally, the focus group was requested to state the role of the construction logistics stakeholders (consultant/designer, contractor, supplier) within factors (challenges) affecting logistics, lean planning tools, and lean practices. Firstly, in factors affecting construction logistics, the majority of eight out of nine experts strongly stated that the planning part is predominantly linked with the consultant/designer, with the contractor occupying second place. In the transportation part, seven out of nine experts said that the supplier is the party most involved and affected. In the inventory part of construction logistics, just over half (five) of the gathered experts noted that the contractor is the party most affected, with the remaining experts (four) believing the supplier to be the stakeholder most affected. Secondly, in considering lean planning tools, seven out of nine agreed that the consultant plays the largest role in preparing the master plan and critical path analysis, but the group also mentioned that the contractor favours and exploits detailed daily planning. Finally, when asked about which party most uses lean practices, the focus group experts were silent for around a minute, after which they began to argue that lean practices are not well-known between all construction parties. Nevertheless, six out of nine group members eventually stated that in large organizations, to an extent and because of his position, the consultant (designer) is in favour of using lean practices, more so than other parties. They also added that both the consultant and the contractor seem to use RCA more than the supplier, and the supplier mostly favours the use of JIT when compared with the contractor and consultant. The only minor difference added lies with RCA; experts placed the contractor on the same level with the consultant in RCA usage. The group claimed that RCA is collaborative work to improve the current situation, and requires the combination of the contractor and consultant together on the construction site.

Consequently, to a large extent the previous discussion matched well with the outcome of the research, which demonstrates a significant confirmation in terms of proving the role of stakeholders in construction logistics; challenges facing construction logistics; lean drivers and barriers to adopting of lean; and also in the application of lean planning tools and practices.

7.2.2 ISM Methodology

First, when commencing the ISM model is to identify and clarify the components (variables) for the focus group. There are three clusters, as follows: challenges affecting construction logistics in Jordan, lean planning, and lean practices in Jordanian construction. Each one of these cluster has its own components. Thus, three ISM model are consequently developed. Further details in regards to the clusters and their components are individually illustrated later on.

Second, all kinds of components (variables) affecting the system are arranged and listed.

Third, based on step two, a relative relationship is structured between components (variables) taking into consideration which twosomes will be judged. A Structural Self-Interaction Matrix (SSIM) is established for variables, which designates pair-wise interactions between variables in the system under consideration. The Structural Self-Interaction Matrix (SSIM) is used to horizontally classify the relationships amongst components (variables). According to Jharkharia and Shankar (2005), the main symbols of SSIM are to indicate the relationship direction between variables, and are explained as follows:

V: the direction from (i) toward (j)/

A: the direction from factor (j) to (i).

X: both directions relations between (i) and (j), they influence each other.

O: no relation between (i) and (j).

Note: (i) indicates to vertical variables, and (j) indicates to horizontal variables.

Fourth, a reachability matrix is structured through converting the Structural Self-Interaction Matrix (SSIM). The transformation is prepared by:

1. Changing every "X" in the cell (i,j) to "1" (one) as well as cell (j,i) converted to "1" (one).
2. Changing every "O" in the cell (i,j) to "0" (zero) as well as cell (j,i) converted to "0" (zero).
3. Changing every "A" in the cell (i,j) to "0" (zero) as well as cell (j,i) converted to "1" (one).
4. Changing every "V" in the cell (i,j) to "1" (one) as well as cell (j,i) converted to "0" (zero).

Next, participants in the focus group are asked to find transitivity, which means if there is a straight correlation between "1" and "2", and also there is a straight correlation between "2" and "3", thus "1" has certainly a correlation with "3". All participants agreed to do this part concurrently with the previous part.

Fifth, the reachability set, antecedents set and intersection set are constructed from the previous point (Warfield, 1974; Farris and Sage, 1977). The reachability set is counted by taking "1" (one value) in each row associated to a separate variable. While the antecedents set is counted by taking "1" (one value) in each column related to each variable. Then, the intersection set can be done through the crossing amongst the reachability set and antecedents set. The outcome of the first iteration includes the top level within ISM hierarchy, which means that the first component has no connection with other components over its own level. Then, the highest component (top-level) is removed from the table and another iteration is executed in order to find the following level component. The iterations procedures regenerates until the levels of all components are reached and determined.

Sixth, after constructing the reachability matrix, independent and dependent powers are recognized. Driving (independent) power is estimated through summation "1" value in the corresponding row for each related component. While the reliance (dependence) power is estimated by counting "1" value in the corresponding column for each related component (Mandal and Deshmukh, 1994).

Seventh, rearranging the components consistent with their level, which means that all components with the same levels are clubbed together. Then, relationships and levels are drawn and variables nodes are replaced with the statement, which builds the ISM.

Finally, the developed ISM is critically revised for conceptual inconsistency, besides which further amendments could be made if needed.

Consequently, the fundamental of ISM is significantly positioned on the views of the participated people. According to Jharkharia and Shankar (2005), the methodology of ISM is a collaborative learning process, where a group of components (variables) affecting the system is constructed into a systemically thorough model. ISM specializes in converting the issue complexity into a decisive configuration utilizing a designed graph along with identified worlds. Thus, a group of nine participants who have much experience along with high levels of skill in construction, production, and supply chain management were invited concurrently in order to provide a significant explanation, as well as exploiting the directions symbols to indicate the interactions and then the levels among components. The interpretive meaning of ISM noticeably performs once the decision of group resolves.

7.3 Factors (Challenges) Affecting Construction Logistics in Jordan

Table 7.1: Illustrates Structural Self-Interaction Matrix (SSIM) for Logistics Challenges

		Planning	Inventory	CI	Transparency	Transportation	H&S	Material handling	Material preservation
Planning	1	X	V	X	X	X	V	V	V
Inventory	2		X	X	A	A	V	V	V
CI	3			X	A	V	V	V	V
Transparency	4				X	V	V	V	V
Transportation	5					X	X	V	V
H&S	6						X	V	V
Material handling	7							X	V
Material Preservation	8								X

Table 7.2: Illustrates Reachability Matrix for Logistics Challenges

		Planning	Inventory	CI	Transparency	Transportation	H&S	Material preservation	Material handling
Planning	1	1	1	1	1	1	1	1	1
Inventory	2	0	1	1	0	0	1	1	1
CI	3	1	1	1	0	1	1	1	1
Transparency	4	1	1	1	1	1	1	1	1
Transportation	5	1	1	0	0	1	1	1	1
H&S	6	0	0	0	0	1	1	1	1
Material handling	7	0	0	0	0	0	0	1	1
Material preservation	8	0	0	0	0	0	0	0	1

Table 7.3: Illustrates Reachability Matrix (with Driving and Dependent power) for logistics challenges

		Planning	Inventory	CI	Transparency	Transportation	H & S	Material preservation	Material handling	**Independence power:**
Planning	1	1	1	1	1	1	1	1	1	8
Inventory	2	0	1	1	0	0	1	1	1	5
CI	3	1	1	1	0	1	1	1	1	7
Transparency	4	1	1	1	1	1	1	1	1	8
Transportation	5	1	1	0	0	1	1	1	1	6
H & S	6	0	0	0	0	1	1	1	1	4
Material handling	7	0	0	0	0	0	0	1	1	2
Material preservation	8	0	0	0	0	0	0	0	1	1
Dependence power:		4	5	4	2	5	6	7	8	

Table 7.4: Illustrates Iteration 1 for Logistics Challenges

		Reachability set	Antecedents set	Intersection set	T	Level
Planning	1	1,2,3,4,5,6,7,8	1,3,4,5	1,3,4,5	4	
Inventory	2	2,3,6,7,8	1,2,3,4,5	2,3	2	
CI	3	1,2,3,5,6,7,8	1,2,3,4	1,2,3	3	
Transparency	4	1,2,3,4,5,6,7,8	1,4	1,4	2	
Transportation	5	1,2,5,6,7,8	1,3,4,5,6	1,5,6	3	
H & S	6	5,6,7,8	1,2,3,4,5,6	5,6	2	
Material handling	7	7,8	1,2,3,4,5,6,7	7	1	1
Material preservation	8	8	1,2,3,4,5,6,7, 8	8	1	1

Table 7.5: Illustrates Iteration 2 for Logistics Challenges

		Reachability set	Antecedents set	Intersection set	T	Level
Planning	1	1,2,3,4,5,6	1,3,4,5	1,3,4,5	4	
Inventory	2	2,3,6	1,2,3,4,5	2,3	2	2
CI	3	1,2,3,5,6	1,2,3,4	1,2,3	3	
Transparency	4	1,2,3,4,5,6,	1,4	1,4	2	2
Transportation	5	1,2,5,6,	1,3,4,5,6	1,5,6	3	
H & S	6	5,6	1,2,3,4,5,6	5,6	2	2

Table 7.6: Illustrates Iteration 3 for Logistics Challenges

		Reachability set	Antecedents set	Intersection set	T	Level
PLANNING	1	1,3,5	1,3,5	1,3,5	4	
CI	3	1,3,5	1,2,3	1,3	2	3
Transportation	5	1,5,	1,3,5	1,5	2	3

Table 7.7: Illustrates Iteration 4 for Logistics Challenges

		Reachability set	Antecedents set	Intersection set	T	Level
Planning	1	1,3,5	1,3,5	1,3,5	3	4

7.3.1 ISM Model: (Factors [Challenges] Affecting Jordanian Construction Logistics)

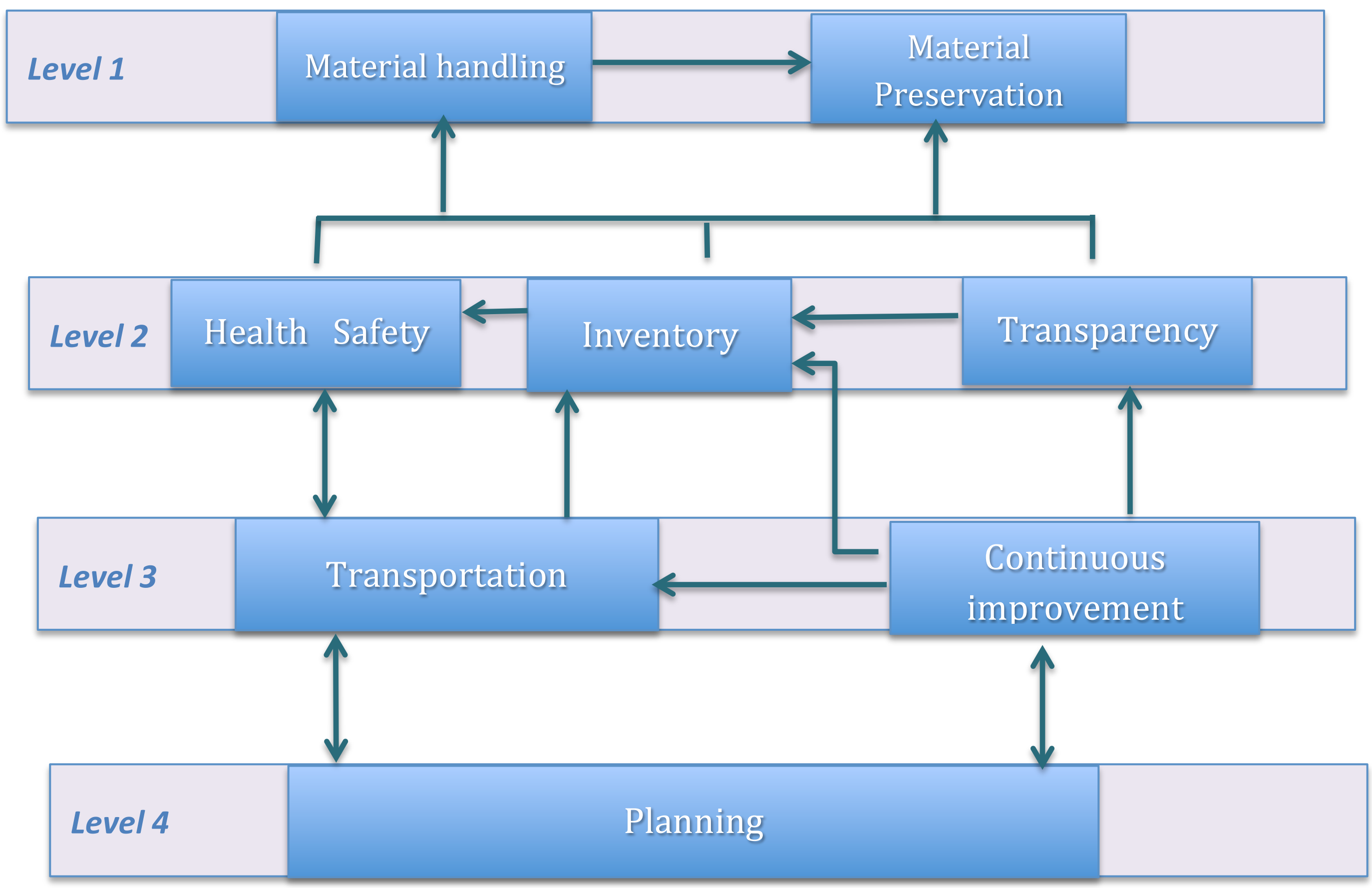


Figure 7.1: Final ISM-1 Model (Shows Levels and Relationships Between Components/ Challenges Affecting Construction Logistics in Jordan

7.3.2 Summary of Factors (Challenges) Affecting Construction Logistics

First of all, ISM hierarchy is understood by primarily considering the bottom level as exerting the greatest influence, with influence gradually diminishing as the levels grow higher. That is, the lowest level (bottom) indicates the highest influence over the other levels, and the highest (top) level indicates the least influence over the other levels. In other word, solving the problem in the bottom level solves the next problem in the above level, and so on, improving the current situation.

Furthermore, according to ISM methodology, the Structural Self-Interaction Matrix (SSIM) has been applied to challenges affecting construction logistics (Table: 7.1). Then, the reachability matrix was used based on the previous step (Table 7.2). Dependent power and independent power are shown in Table 7.3. After that, iteration processes have been achieved 4 times to level the factors (challenges) and build the ISM model (Table 7.4, 7.5, 7.6, 7.7). The outcome of the ISM model (Figure 7.1) is extremely similar to the outcome of the discussion chapter. Slight change has been rectified in comparison with data in the discussion chapter, where participant experts preferred to position Continuous improvement before the Transparency factor; and the Inventory factor before Material preservation factor. However, the majority of arrangements, particularly the first factor and last factor, remained as the data results and discussion previously explained.

The planning factor at the bottom level (4) has been considered the most important factor affecting others, in addition to having two-way relationships with the next level (3) which is the Transportation and Continuous improvement factors. Furthermore, a key finding of this model is the planning factor role in Jordanian construction logistics, as this factor has significant impact on other factors as well as having the highest driver power. So, the planning factor should be considered as a priority when reviewing the challenges in Jordanian construction logistic.

In level three (3), Continuous improvement and Transportation, arise secondly, where CI has a direct relationship (one-way) with the Transportation factor at the same level; as well as the CI factor also having a direct relationship with Transparency and Inventory (level 2); whereas Transportation has a direct link with Inventory and a mutual relationship with the health and safety factor (level 2). Thus, this level (Transportation factor and Continuous improvement factor) comes second in term of influence on other levels within the ISM model. However, the Continuous improvement factor has an influence on the Transportation factor through its direct link.

At level two (2) the Transparency factor has a one-way direct relationship with the Inventory factor, which also has a direct liaison with the Health and Safety factor. The three factors in level two (2) have direct relationships with Material preservation and Material handling in level one (1). So, the Transparency factor (also the highest driver power) influences the Inventory factor, as well as the Inventory factor having an impact on the health and safety factor, besides all of them have influences on level one (1) factors.

Finally, level one (1) is considers the last, and the top level in the ISM hierarchy, and comprises a direct link from the Material handling factor to the Material preservation factor (the highest dependent power). This means Material handling has an impact on Material preservation at the same level. In addition, level one (1) has no influences on the previous factors and levels, besides all other factors have their impact on level one (1).

Consequently, a bottom- up approach means that Planning factor (level 4) needs to be reviewed as a topmost priority when assessing the construction logistics in Jordan, followed by Transportation and CI factors (level 3). Transparency, Inventory and Health and Safety factors (level 2) come next, and finally Material Handling and Material Preservation (level 1).

7.4 Lean Planning

Table 7.8: Shows Structural Self-Interaction Matrix (SSIM) for Lean Planning

		CPA	Weekly report	Look ahead	WBS	PPC	Daily report	MP
CPA	1	X	V	V	X	V	X	X
Weekly report	2		X	A	A	V	A	A
Look ahead	3			X	X	V	X	X
WBS	4				X	V	V	X
PPC	5					X	A	A
Daily report	6						X	A
MP	7							X

Table 7.9: Shows Reachability Matrix for Lean Planning

		CPA	Weekly report	Look ahead	WBS	PPC	Daily report	MP
CPA	1	1	1	1	1	1	1	1
Weekly report	2	0	1	0	0	1	0	0
Look ahead	3	0	1	1	1	1	1	1
WBS	4	1	1	1	1	1	1	1
PPC	5	0	0	0	0	1	0	0
Daily report	6	1	1	1	0	1	1	0
MP	7	1	1	1	1	1	1	1

Table 7.10: Shows Reachability Matrix (with Driving Power and Dependence Power) for Lean Planning

		CPA	Weekly report	Look ahead	WBS	PPC	Daily report	MP	**Independence power:**
CPA	1	1	1	1	1	1	1	1	7
Weekly report	2	0	1	0	0	1	0	0	2
Look ahead	3	0	1	1	1	1	1	1	6
WBS	4	1	1	1	1	1	1	1	7
PPC	5	0	0	0	0	1	0	0	1
Daily report	6	1	1	1	0	1	1	0	5
MP	7	1	1	1	1	1	1	1	7
Dependence power:		4	6	5	4	7	5	4	

Table 7.11: Shows Iteration 1 for Lean Planning

		Reachability set	Antecedents set	Intersection set	T	Level
CPA	1	1,2,3,4,5,6,7	1,4,6,7	1,4,6,7	4	
Weekly report	2	2,5	1,2,3,4,6,7	2	1	1
Look ahead	3	2,3,4,5,6,7	1,3,4,6,7	3,4,6,7	4	
WBS	4	1,2,3,4,5,6,7	1,3,4,7	1,3,4,7	4	
PPC	5	5	1,2,3,4,5,6,7	5	1	1
Daily report	6	1,2,3,5,6	1,3,4,6,7	1,3,6	3	
MP	7	1,2,3,4,5,6,7	1,3,4,7	1,3,4,7	4	

Table 7.12: Shows Iteration 2 for Lean Planning

		Reachability set	Antecedents set	Intersection set	T	Level
CPA	1	1,3,4,5,6,7	1,4,6,7	1,4,6,7	4	
Look ahead	3	3,4,6,7	1,3,4,6,7	3,4,6,7	4	
WBS	4	1,3,4,6,7	1,3,4,7	1,3,4,7	4	
Daily report	6	1,3,6	1,3,4,6,7	1,3,6	3	2
MP	7	1,3,4,6,7	1,3,4,7	1,3,4,7	4	

Table 7.13: Shows Iteration 3 for Lean Planning

		Reachability set	Antecedents set	Intersection set	T	Level
CPA	1	1,3,4,5,7	1,4,7	1,4,7	4	3
Look ahead	3	3,4,7	1,3,4,7	3,4,7	4	3
WBS	4	1,3,4,7	1,3,4,7	1,3,4,7	4	
MP	7	1,3,4,7	1,3,4,7	1,3,4,7	4	

Table 7.14: Shows Iteration 4 for Lean Planning

		Reachability set	Antecedents set	Intersection set	T	Level
WBS	4	4,7	4,7	4,7	2	4
MP	7	4,7	4,7	4,7	2	4

7.4.1 ISM Model: (Lean Planning)

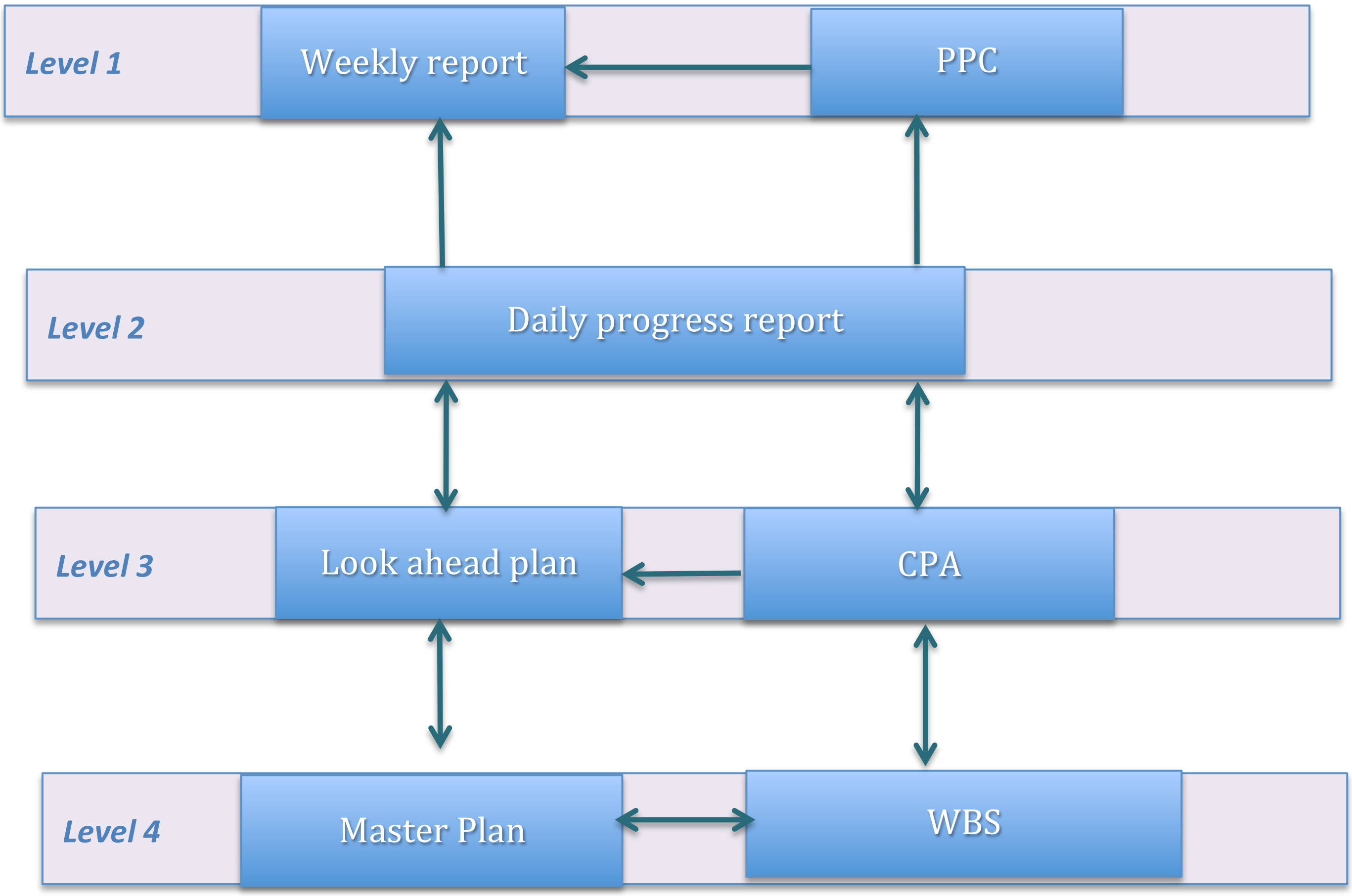


Figure 7.2: Final ISM-2 Model (Shows Levels and Relationships Between Elements/ Lean Planning Tools)

7.4.2 Summary of Lean Planning Tools

ISM methodology has been utilized the same as in the previous part (7.3), where the bottom level is considered as having the greatest influence over the other planning tools, with the influence of the planning tools gradually decreasing towards the upper level of ISM-2 (second interpretive structural modeling). However, before finding the interactions amongst the lean planning tools, the experts in a focus group meeting have discussed the nature of the question in the survey. This part in the questionnaire requested stakeholders to indicate the level of frequencies in exploiting planning tools. Thus, the focus group indisputably decided that the daily progress report tool and the weekly plan tool are the most common tools in Jordanian construction, due to their easiness and simplicity. On the other hand, the focus group believed that the frequency of using certain planning tools did not necessarily signify their importance as lean planning tools, to a far extent, are not well known as the majority of stakeholders have poor awareness, and insufficient information about the tools' significances. Therefore, and based on the previous explanation, the arrangement of planning tools by the focus group has been built on firstly considering the tools that mainly affect others. Thus, following the sequences of the planning tools through the ISM-2 model helps to mitigate poor planning in Jordanian construction. Nevertheless, the outcome of ISM-2 (Figure 7.2) is not much difference from the data results in the discussion chapter; the change occurred by moving the daily progress report and Weekly report to next steps in order to offer a proper planning model.

The procedures of the ISM methodology include building a Structural Self-Interaction Matrix (SSIM), as seen in Table 7.8. Next, a reachability matrix is created based on SSIM, as seen in Table 7.9. Dependent power and independent power for lean planning tools are displayed in Table 7.10. After that, iterations processes have been achieved 4 times to level the factors (challenges) and build the ISM model (Table 7.4, 7.5, 7.6, 7.7). Furthermore, Tables 11,12,13, and 14 show the iteration processes to level tools and consequently shape the final ISM-2 (Figure 7.2).

The Master Plan and Work Breakdown Structure (WBS) tools positioned at the bottom of the model (level 4), both influence one another and also have significant impact on the upper levels, particularly having two-way relationships with Critical Path Analysis (CPA) and Look ahead plan (level 3). Furthermore, planning should commence from the Master Plan, which is deemed as a basis for planning and provides a complete overview of the construction project, along with WBS to assist understanding details of all construction activities, and provides other planning tools better role and efficiency among stakeholders through fixing them. In level 3, CPA has a direct relationship toward Look ahead plan at the same level, which means CPA has impacts upon the Look ahead plan. Both have two-way relationships with the daily progress report tool. So, when scheduling a ideally Look ahead plan tool, there is a need to essentially taking into account Master Plan, WBS, and CPA tools. In level two (2), the daily progress report tool has a direct relationship with the weekly report and Percentage plan completed tools. This means the Weekly report and PCC tools rely on the efficiency of the daily progress report which has a significant effect upon them. Finally, level one (1) is the last level and has the least influence on the others, yet the PPC tool has an influence on the Weekly report tool at level one

(1), as the PPC tool provides significant information expressed by percentage with regards to completed work, reasons for unachieved work, and the viewpoints to resolve related dilemmas.

Consequently, the sequence of lean planning tools (bottom-up approach) seem logical, as the bottom level (level four) includes the master plan (MP), which considers the bases and the most significant part of construction planning along with the Work Breakdown Structure, which essentially simplifies the MP. The box (level 3) includes Critical Path Analysis, which is derived from MP and considers the critical path for the construction project, and has a substantial influence on preparing look ahead plan that occupies the same level. Daily Progress Report (level 2) comes solo next which influences firstly to estimate Planned Completed Percentages Estimation (PCP), and secondly assists to prepare a proper Weekly Report (level 1).

7.5 Lean Practices

Table 7.15: Illustrates Structural Self-Interaction Matrix (SSIM) for Lean Practices

		Gemba	**First run study**	**Weekly meeting/team**	**JIT**	**5S**	**Weekly meeting/ stakeholders**	**RCA**	**LPS**	**VSM**
Gemba	1	X	X	A	X	V	A	V	A	A
First run study	2		X	A	V	V	A	V	X	A
Weekly meeting/ team	3			X	V	V	X	V	X	V
JIT	4				X	A	A	A	A	A
5S	5					X	A	X	A	A
Weekly meting/ stakeholders	6						X	V	X	V
Root cause analysis	7							X	A	X
LPS	8								X	X
VSM	9									X

Table 7.16: Illustrates Reachability Matrix for Lean Practices

		Gemba	First run study	Weekly meeting/team	JIT	5S	Weekly meeting/ stakeholders	RCA	LPS	VSM
Gemba	1	1	1	0	1	1	0	1	0	0
First run study	2	1	1	0	1	1	0	1	1	0
Weekly meeting/ team	3	1	1	1	1	1	1	1	1	1
JIT	4	1	0	0	1	0	0	0	0	0
5S	5	0	0	0	1	1	0	1	0	0
Weekly meting/ stakeholders	6	1	1	1	1	1	1	1	1	1
Root cause analysis	7	0	0	0	1	1	0	1	0	1
LPS	8	1	1	1	1	1	1	1	1	1
VSM	9	1	1	0	1	1	0	1	1	1

Table 7.17: Illustrates Reachability Matrix (with Driving Power and Dependence Power) for Lean Practices

		Gemba	First run study	Weekly meeting/team	JIT	5S	Weekly meeting/ stakeholders	RCA	LPS	VSM	**Independence power:**
Gemba	1	1	1	0	1	1	0	1	0	0	5
First run study	2	1	1	0	1	1	0	1	1	0	6
Weekly meeting/ team	3	1	1	1	1	1	1	1	1	1	9
JIT	4	1	0	0	1	0	0	0	0	0	2
5S	5	0	0	0	1	1	0	1	0	0	3
Weekly meting/ stakeholders	6	1	1	1	1	1	1	1	1	1	9
Root cause analysis	7	0	0	0	1	1	0	1	0	1	4
LPS	8	1	1	1	1	1	1	1	1	1	9
VSM	9	1	1	0	1	1	0	1	1	1	7
Dependence power:		7	6	3	9	8	3	8	5	5	

Table 7.18: Illustrates Iteration 1 for Lean Practices

		Reachability set	Antecedents set	Intersection set	T	Level
Gemba	1	1,2,4,5,7	1,2,3,4,6,8,9	1,2,4	3	
First run study	2	1,2,4,5,7,8	1,2,3,6,8,9	1,2,8	3	
Weekly meeting/ team	3	1,2,3,4,5,6,7,8,9	3,6,8	3,6,8	3	
JIT	4	1,4	1,2,3,4,5,6,7,8,9	1,4	2	1
5S	5	4,5,7	1,2,3,5,6,7,8,9	5,7	2	1
Weekly meting/ stakeholders	6	1,2,3,4,5,6,7,8,9	3,6,8	3,6,8	3	
Root cause analysis	7	4,5,7,9	1,2,3,5,6,7,8,9	5,7,9	3	
LPS	8	1,2,3,4,5,6,7,8,9	2,3,6,8,9	2,3,6,8,9	5	
VSM	9	1,2,4,5,7,8,9	3,6,7,8,9	7,8,9	3	

Table 7.19: Illustrates Iteration 2 for Lean Practices

		Reachability set	Antecedents set	Intersection set	T	Level
Gemba	1	1,2,7	1,2,3,6,8,9	1,2	2	2
First run study	2	1,2,7,8	1,2,3,6,8,9	1,2,8	3	
Weekly meeting/ team	3	1,2,3,6,7,8,9	3,6,8	3,6,8	3	
Weekly meting/ stakeholders	6	1,2,3,6,7,8,9	3,6,8	3,6,8	3	

Root cause analysis	7	7,9	1,2,3,6,7,8,9	7,9	2	3
LPS	8	1,2,3,6,7,8,9	2,3,6,8,9	2,3,6,8,9	5	
VSM	9	1,2,7,8,9	3,6,7,8,9	7,8,9	3	

Table 7.20: Illustrates Iteration 3 for Lean Practices

		Reachability set	Antecedents set	Intersection set	T	Level
First run study	2	2,8	2,3,6,8,9	2,8	2	4
Weekly meeting/ team	3	2,3,6,8,9	3,6,8	3,6,8	3	
Weekly meting/ stakeholders	6	2,3,6,8,9	3,6,8	3,6,8	3	
LPS	8	2,3,6,8,9	2,3,6,8,9	2,3,6,8,9	5	
VSM	9	2,8,9	3,6,8,9	8,9	2	4

Table 7.21: Illustrates Iteration 4 for Lean Practices

		Reachability set	Antecedents set	Intersection set	T	Level
Weekly meeting/ team	3	3,6,8	3,6,8	3,6,8	3	5
Weekly meting/ stakeholders	6	3,6,8	3,6,8	3,6,8	3	5
LPS	8	3,6,8	3,6,8	3,6,8	3	5

7.5.1 ISM Model: (Lean Practices)

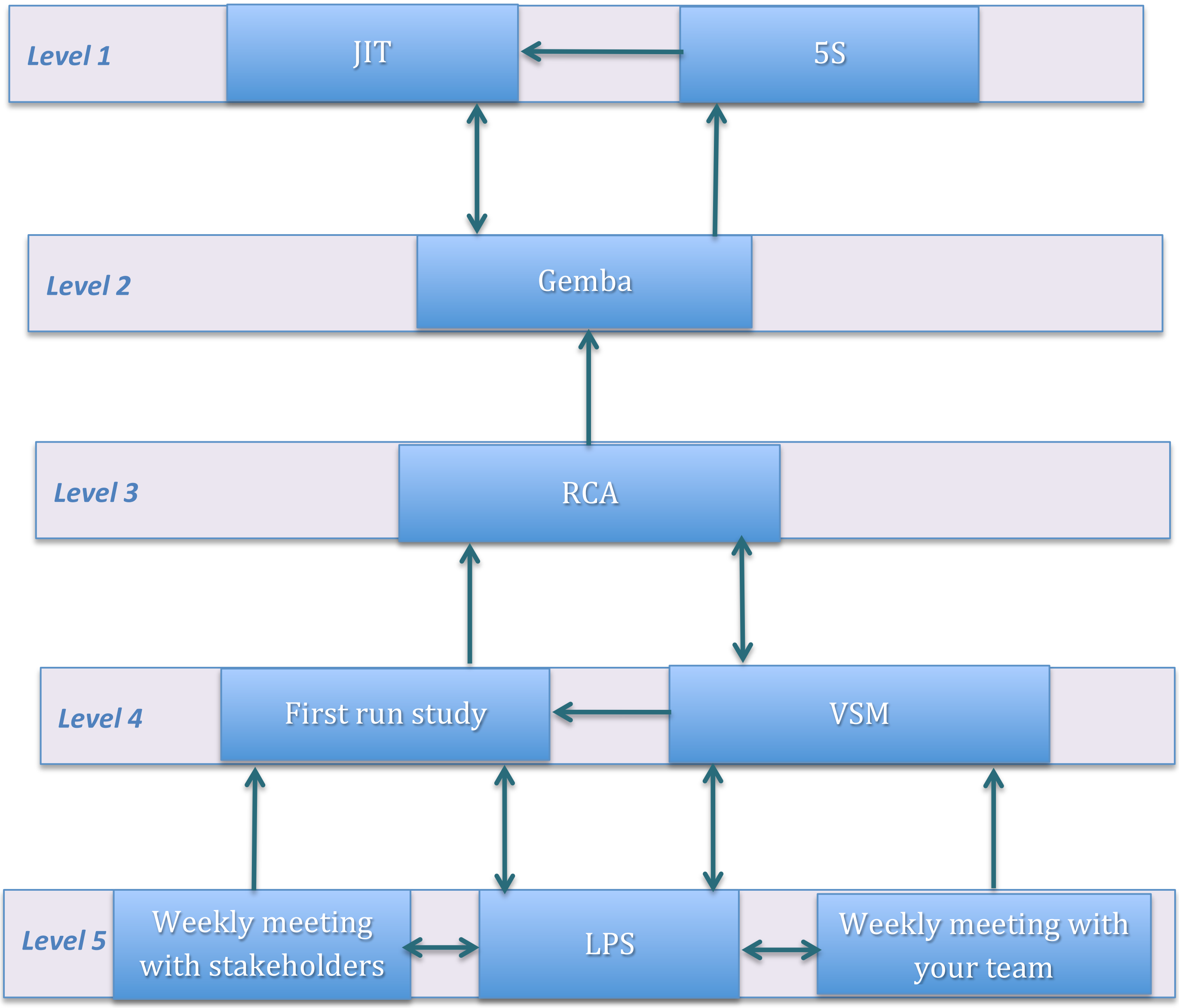


Figure 7.3: Final ISM-3 Model (Shows Levels and Relationships Between Elements/ Lean Practices)

7.5.2 Summary of Lean Practices

Firstly, the same ISM methodology is implemented in this part as in the previous parts. A Structural Self-Interaction Matrix (SSIM) has been used for lean practices components, as shown in Table 7.15. A reachability matrix (Table 7.16) has then been demonstrated based on SSIM. Next, iteration processes have been fulfilled four times to find the components' (practices) level in order to construct ISM-3.

There is a similarity between ISM-3 (Figure 7.3) and data consequence in the discussion chapter. The differences among them indicate that the Last Planner System (LPS) needs to be positioned in the most affecting level between weekly meeting with your team and Weekly meeting with stakeholders, then Value stream mapping (VSM) needs to follow. Focus group justify the change between collected data and ISM-3 as majority of Jordanian construction parties don't have enough knowledge and awareness in regards of LPS as well as VSM.

According to ISM-3 (Figure 7.3), Weekly meeting with your team, Weekly meeting with stakeholders, as well as the last planner system (LPS) have been placed at the bottom of level five (5) as the most important practices influencing other practices. All of them have two-way relationships with one another, along with Weekly meeting with your team and stakeholders' practices having a one-way relationship toward VSM and First run study (level, 4). While LPS has mutual relationships with VSM and First run study. The key finding of this model reflects on how Weekly meeting with your team and stakeholders' practices have a significant association with LPS. This point emphasizes the vital capacity of LPS to increase the efficiency of meetings (team and stakeholders), which is consistent with the literature review as meetings are considered a main part when applying LPS. Therefore, construction companies in Jordan are required to properly take into consideration the implementation of LPS. Furthermore, according to Table 7.17, the three practices in level five (5) have the highest driver power, which signifies their effect amongst others.

VSM and First run study come next in level four (4) where a direct relationship commences from VSM toward First run study. This means First run study procedures (plan, do, check, act) depend on initially mapping the activities through VSM to clarify the way of applying First run procedures.

Furthermore, VSM has a mutual relationship with root cause analysis (level 3), where First run practice has a one-way direct relationship with root causes practice (level 3). RCA can contribute when mapping the value stream by preventing mistakes being made earlier; as well as its importance being clearly shown after the First run practice, and significantly helps to increase the Continuous improvement.

RCA placed in level three (3) and has a direct relationship with the Gemba practice. RCA collects the problems and analyzes them in different stages, thus a Gemba walk can be used to inspect the situation and increase the control.

At level two (2) the Gemba walk practice has a direct relationship towards 5S and a two-way relationship towards JIT practice. This indicates how Gemba is very important in controlling and monitoring the 5S practice on site. Moreover, JIT needs a suitable strategy and proper practical procedures, thus the Gemba practice significantly supports, particularly playing a practical part in JIT.

Finally, level one (1) is considered the least affecting level amongst others, where the 5S practice has a direct relationship towards the JIT practice. Additionally, implementing the 5S steps accurately in the work place will significantly enhance the efficiency and effectiveness of the JIT technique. This also reveals the reason 5S has the pre-highest dependent power (8), as well as JIT having the highest dependent power (9) according to Table 7.17.

Consequently, the bottom-up approach for lean practices seems also rational; level (5) comprises Weekly Meeting with your Teams, Weekly Meting with Stakeholders and LPS, which mainly aim to improve the level of cooperation among construction parties (stakeholders). Thus the collaboration between teamwork is essentially to commence employing other lean practices. Level (4) includes Value Stream Mapping, which considers a scheme mapping for the teamwork that can be utilized by initially applying First Run Study (level 4). After that, level (3) illustrates Root causes analysis (RCA) that can be followed and resulted after the previous two levels. Level (2) includes Gemba (see with your eyes); it is an essential practice to support and assist RCA practice. Finally, Understanding the interactions between all levels assists in implementing 5S and Just In Time (JIT) in the work area (construction site) as both them are considered operational practices (level 1).

After developing the ISM models for the previous parts as well as identifying all interactions among all components. At this level, determining the level of interactions amongst components in each part is reasonably essential, thus the MICMAC principle (Cross-Impact Matrix Multiplication Applied to Classification) is used to achieve this end.

MICMAC principle is grounded on multiplication properties of matrices and used to identify the key factors that drive the system in various categories based on their drive power and dependence power (Sharma et al., 2014). The main use of MICMAC analysis is to identify the nature and the degree of the interrelationship between all variables (construction logistics; lean planning tools; and lean practices) and categorised them into dependents, independent, linkage, and autonomous factors based on their driving and dependency power. Additionally, in MICMAC, the driving power is estimated by the summation of digit "1" in the corresponding row for each factor in final reachability matric, whereas the summation of digit "1" in the corresponding factor column achieves the dependence power (ibid).

So, it is a significant tool for the analysis of driver (independent) power as well as reliance (dependence) power.

Furthermore, in the MICMAC figures there are four quarters. The first quarter (number 1) contains components that have both weak independence and weak dependence, and are called autonomous factors. These components to far extent are insignificant except for possessing a few noteworthy relations. The second quarter (number 2) includes components that have both weak independence power and solid dependence power. The third quarter (number 3) includes components that have both robust dependence and independence powers. These components are considered unsteady, where any action from any one leads to actions upon others. Thus, this quarter is deemed to possess a linkage amongst independence and dependence powers. The last quarter (number 4) has substantial independence along with weak dependence. Each component has been plotted using an X-Y coordinate system. (ibid).

Subsequently, Figure 7.4 has been built based on Table 7.3, where all dependent and independent powers in regards of factors (challenges) affecting construction logistics have been categorized as follows:

- Dependent factors (weak independence power and solid dependence):
    - Factor 6 (Health and Safety)
    - Factor 7 (Material handling)
    - Factor 8 (Material preservation)

These factors are considered surely dependent, and have little influence on other factors; and consequently on the ISM model. They are particularly sensitive to the evolution of the independent factors, and so it can be significantly stated that they have a modicum of effect.

- Linkage between dependent and independent factors:
    - Factor 2 (Inventory)
    - Factor 5 (Transportation)

These factors have dependent and independent powers concurrently; they occur midst position among factors as they depending on some factors as well as other factors are depending on them. So, this overlap creates a particular linkage for these factors in the model.

- Independent factors (robust independence power and weak dependence):
    - Factor 1 (Planning)
    - Factor 3 (Continuous improvement)
    - Factor 4 (Transparency)

These independent (drivers) factors are substantial throughout the model. They are considering the main core of the ISM-model. At this stage, it can be stated that the remaining factors on the system are depending on how much improvement and control could be achieved by these driver factors. This outcome contains the entry of the system planning factor; continuous improvement factor; and transparency factors. So, other factors are considered a lesser influence that these.

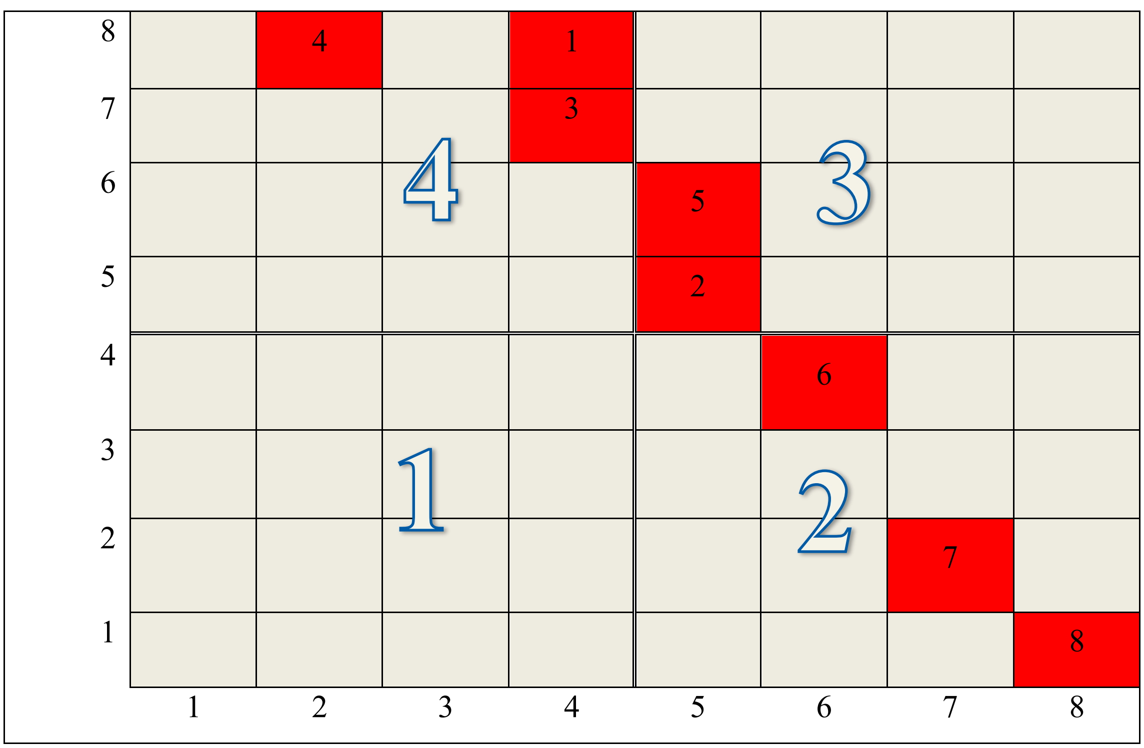


Figure 7.4 MICMAC Analysis for Factors (Challenges) Affecting Construction Logistics

Secondly, Figure 7.5 has been formed according to Table 7.10, where all dependent and independent powers in regards of lean planning tools have been classified as follows:

- Dependent tools (weak independence power and solid dependence):
    - Tool 5 (PPC)
    - Tool 2 (Weekly report)

These tools are deeming certainly dependable, having slight influence on the remaining factor and subsequently on the ISM-2 model. They are mainly sensitive to the development of the independent tools, so it can be significantly stated that they have a smidgen of effect.

- Linkage between dependent and independent tools:
    - Tool 7 (MP)
    - Tool 1 (CPA)
    - Tool 3 (Look ahead)
    - Tool 4 (WBS)
    - Tool 6 (Daily report)

The particular places for these tools provide high dependency along with high independency at the same time. So, these planning tools are have enormous influences and links among each other, where none can individually and unconnectedly play a significant role to affect the model.

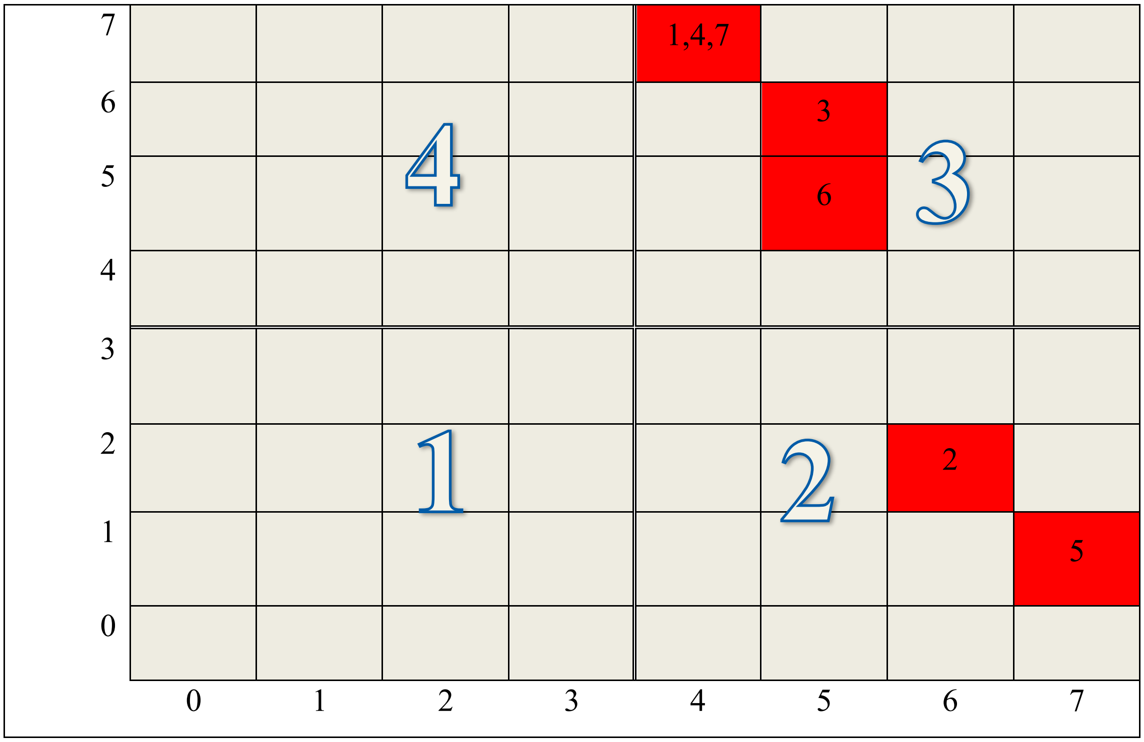


Figure 7.5: MICMAC Analysis for Lean Planning Tools

Thirdly, Figure 7.6 has been designed depending on Table 7.17. All dependent and independent powers in regards of lean practices have been categorized as follows:

- Dependent practices (weak independence power and solid dependence):
  - Practice 4 (JIT)
  - Practice 5 (5S)
  - Practice 7 (RCA)

These practices reckoned as dependent along with having low influence on the remaining practices and on the ISM-3 model; they are sensitive to the progression of the independent practices, so it can be noted that their effect upon other practices is insignificant.

- Linkage between dependent and independent practices:
  - Practice 8 (LPS)
  - Practice 9 (VSM)
  - Practice 2 (First run study)
  - Practice 1 (Gemba)

These practices occur in a central place with regards to independency and dependency; they have both powers alongside on another. These practices are positioned in the middle of the model, where their influences can affect some practices, and they themselves are affected by other practices.

- Independent practices:
- Practice 3 (Weekly meeting with your team)
- Practice 6 (Weekly meeting with stakeholders)

These independent (driver) practices are very significant within the model. They are deemed the main fundamental of the model. It can significantly be stated that other practices on the system are dependent on how much controlling and enhancing can be achieved on these drivers' factors. This outcome contains Weekly meeting with your team and Weekly meeting with your stakeholders, which are positioned at the entry of ISM-3 model.

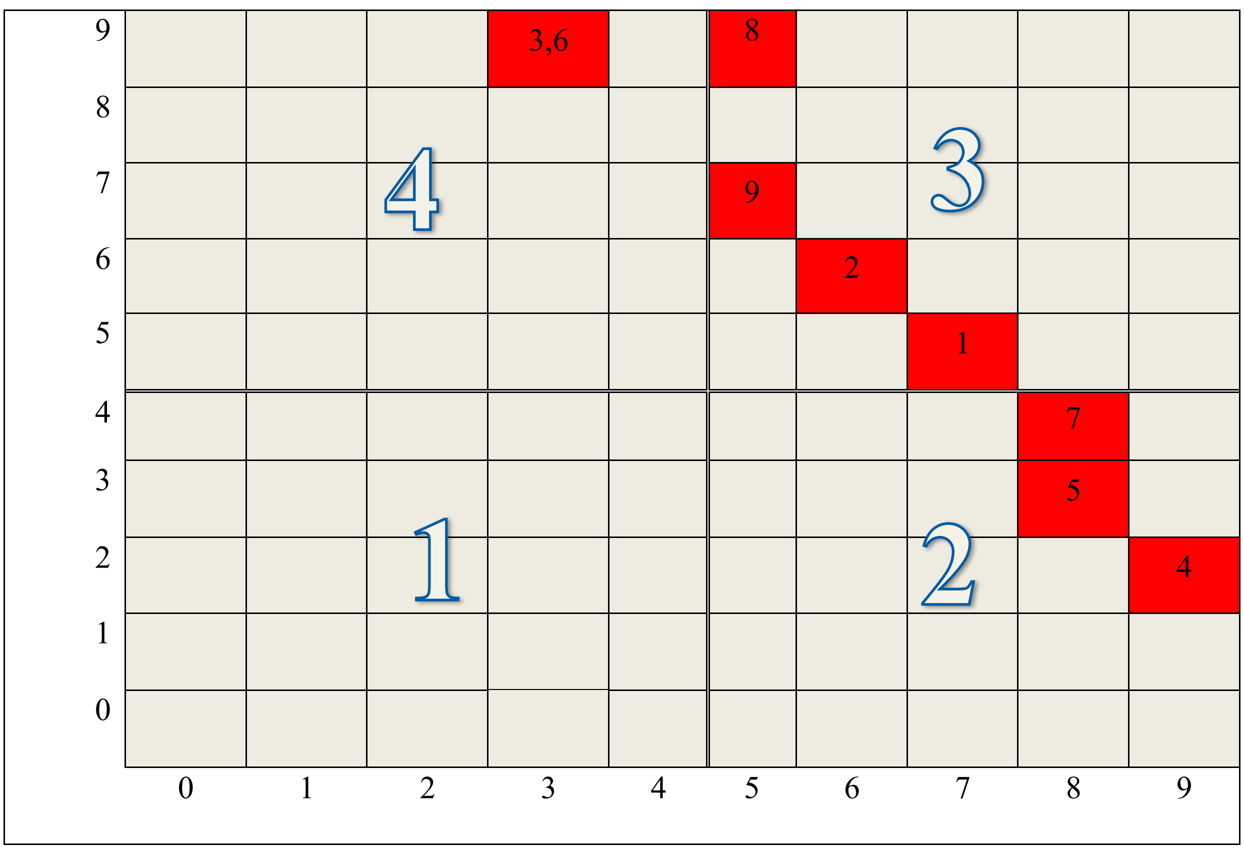


Figure 7.6: MICMAC Analysis for Lean Practices

To conclude, the previous section has gained the research significant validation with regards to collected and analyzed data (the results and discussion chapters). Returning to the research baseline, the aim of the research is to develop models for assessing the adoption of lean logistics in Jordanian construction organizations. The objectives of the research required the assessing of challenges affecting logistics (logistics factors) in Jordanian construction, and then to assess the level of usage and awareness of lean planning and practices. Consequently, with respect to logistics challenges, lean tools, and lean practices the research outcomes have been evaluated and validated in this chapter (objective number five has been fulfilled). This was achieved firstly by understanding the ISM background, ISM methodology (SSIM; reachability matrix; reachability matrix with dependent and independent power; iterations to identify levels; and establishing the model), then undertaking a focus group through gathering experts from the construction logistics field to designate the relationships between all components in order to build the three ISM models.

Furthermore, MICMAC analysis has classified both the nature and the level of the interrelationship amongst all components, and has been applied in the three cores. Firstly, MICMAC indicates factors (challenges) affecting construction logistics in Jordan, these three factors of Health and Safety; Material handling; and Material preservation are considered to be dependent factors with reliance power. Factor 2 (Inventory) and factor 5 (Transportation) have driver and dependent powers together. Factor 1 (Planning), factor 3 (Continuous improvement), and factor 4 (Transparency) are considered to be independent factors with strong driver powers; so, they are very strong to be able to affect the remaining challenges (factors) in the model.

The second core comprises lean planning tools, where MICMAC suggests that tool 5 (PPC) and tool 2 (Weekly report) are considered to be dependent powers along with having weak driving powers. Tool 7 (MP) and tool 1 (CPA), tool 3 (Look ahead), tool 4 (WBS) and tool 6 (Daily report) have linkage between the dependency and the independency.

The third and last core includes lean practices where MICMAC signifies that practice 4 (JIT), practice 5 (5S), and practice 7 (RCA) are considered to have weak independent power, as well as strong dependent power. Practice 8 (LPS), practice 9 (VSM), practice 2 (First run study), and practice 1 (Gemba) have driving powers along with strong dependency powers. Finally, practice 3 (Weekly meeting with your team) and practice 6 (Weekly meeting with stakeholders) have driving powers and weak independency and so are reasonably significant in affecting all other practices.

Finally, it could state that using ISM appears to be the most proper method that provides the information needed for this research more than other methods. For example, Analytical Hierarchy Process (AHP) is a method starts from top to bottom. It used to reflect the human thought process and to quantify the relations and weigh the significance of different risks and chances between variables (Gorvett, 2006). However, AHP doesn’t display the interrelationships between variables at the same level as well as doesn’t have the ability to describe the relationships between variables in different levels.

On the other hand, ISM (bottom-up approach) explains the interrelationships between variables at the same level and at different levels, the relationships can be one or two way relationship based on the ISM. Besides, MICMAC in ISM provides a full description for each variable as dependents, independent, linkage, or autonomous based on their driving and dependence power.

Chapter Eight: Conclusion

8.1 Introduction Overview

The construction logistics process is considered a substantial dilemma facing Jordanian construction and needs to be altered as fast as possible (Sweis et al., 2008; Momani, 2000). Likewise, the research showed no evidence of the implementation of lean planning and practices within Jordanian construction generally, and particularly in the construction logistics process. Thus, the aim of this research is to develop models for assessing the adoption of lean logistics in Jordanian construction organizations. Achieving this aim was prepared through five objectives. The next part discusses objectives separately along with their associated consequences.

8.2 Research Objectives Revised

Objective1: To review the challenges (factors) affecting construction logistics within the worldwide construction industry as well as in Jordanian construction.

Objective2: To explore both success factors and difficulties of implementing lean practices within the global construction industry and through Jordanian construction.

Objective 3: To develop an approach for adoption of lean logistics in order to assess the existing logistics processes in Jordanian construction.

Objective 4: To explore the differences amongst Jordanian stakeholders' views in regards of factors (challenges) affecting construction logistics, lean planning tools and practices.

Objective 5: To validate the developed approach and assessment models.

Objective 1: To review the challenges (factors) affecting construction logistics within the worldwide construction industry as well as in Jordanian construction.

In order to fulfill this objective, the researcher offered a noteworthy review of literature in regards of construction logistics process. The second part of the literature review considered logistics and supply chain management. Examining the meaning of 'supply chain' and defining the role of supply chain management (SCM) in the production industry lead to consideration of supply chain management (SCM) within the construction field, and delivered a significant distinction between supply chain management (SCM) and logistics in terms of construction. Hence, both the significance and status of logistics within the construction field has been realized through the comprehensive literature review.

On the other hand, challenges (factors) affecting construction logistics have occupied considerable attention through the critical literature review, where challenges are clustered together and clarified into seven groups: Planning; Transportation; Continuous improvement; Transparency and Information Exchange Health and Safety; Inventory; Material Preservation and Performance.

The semi-structured interviews (first data collection/ qualitative data collection) offered an explanation of the current situation regarding the construction logistics process within Jordanian construction, to discover additional and significant information with regards of construction logistics in Jordan. The consequences show that the current situation of construction logistics is still conventional and poor. The construction logistics challenges in Jordan are explained as follows: Continuous improvement factor; Health and Safety (H & S) factor; Planning factor; Transportation factor; Inventory factor; Transparency and information exchange factor; Material Preservation factor; and Material handling factor. Thus based on the previous discussion, objective number one has been fulfilled.

Objective2: To explore both success factors and difficulties of implementing lean practices within the global construction industry and through Jordanian construction.

In order to accomplish this objective, the researcher provided a comprehensive review of literature in regards of lean. It was vital to provide comprehensive knowledge to initially identify lean background and its importance. Literature review delivered a unique viewpoint on how implementing lean provides a significant improvement to the construction logistics process.

After that, as waste of material occupies a main portion in construction, adequate information was provided with regards to the ability of lean to reduce waste. The research has reviewed a critical literature review concerning the main benefits of implementing lean in construction sector: maximizing value and minimizing waste in all processes and sub-process; increasing efficiency and effectiveness of transportation; perusing perfect flow; zero inventory and buffers; customer satisfaction; increasing productivity, especially in labor and time; effective communication; sufficient feedback; and improvement in health and safety.

Lean benefits at the organizational level include organization attitudes showing positive change that consider challenging and competitive, outcomes also presented improvement in initiatives, and overall quality and profit showed enhancement. Furthermore, when using lean practices, organizations' reputation appears to be superior organizations that do not utilize lean practices. So, it was realized that lean construction methods provide a unique strategy for addressing a variety of aspects through the improvement of material procurement, design, the construction phase and through providing adequate delivery and employment.

Furthermore, a few professionals have claimed that implementing lean practices still holds challenges and difficulties, claiming that lean construction is still immature and the philosophy of lean needs further justifications. Also, a few construction parties have criticized JIT as being a high-risk strategy with a restricted benefit given the relatively extreme amount of unpredictable delivery. Others have also argued that the attitude of culture is not always prepared to change: lean practices are affected by supplier efficiency level, a lack of acceptance by employees and employers is evident, training and understanding are also lacking, as well as high cost implementation and productivity. However, the literature review also revealed how organizations resolve these challenges.

The link between the two cores (lean and logistics) came next in the literature review. Review of a comparison between traditional logistics versus lean logistics in construction ascertained how implementing lean practices could notably maximize value and minimize waste, a point underscored by an illustrative successful case study, which followed.

Nine experts including contractors, consultants (Engineering office), and suppliers participated in the semi-structured interviews (semi-structured interviews/ qualitative data collection). The first data collection digging deep to discover additional and significant information with regards of barriers, as well as drivers of adopting lean practices. Besides lean drivers, according to the interviews participants are: reliability in cost; the need for fast delivery and responsiveness; a better reputation; reliability in time; reliability in quality; solutions to storage problems; huge demand and delivery; creating value and customer focus; sustainable improvement; catching problems early; increased safety; whether your competitor uses the practices; to help manage conflicts; labour shortage; and employee satisfaction. Whereas, lean barriers are: mindset issues; lack of understanding and awareness; lack of training and education; lack of top management commitment and lack of mandate; then lack of support from government.

So, the outcome of the semi-structured interviews has firstly, gained the research further justification, as well as fulfilled objectives number one and two within the Jordanian construction logistics, and has also answered the first research question. Moreover, the interviews have also assisted in building the questionnaire (phase two), where the collected interview data has been spread across a wider range in order to cover as many as stakeholders (contractor, consultant [designer], supplier) as possible, so as to gain the researches' robust outcome. Consequently, objective number two has been fulfilled.

Objective 3: To develop an approach for adoption of lean logistics in order to assess the existing logistics processes in Jordanian construction.

In order to achieve this objective, sequences of steps were applied throughout a survey (quantitative data). It was divided to five pillars and the survey sample was comprised of 150 participants, which was considered to be both significant and adequate to identify these points. All questions in the survey (questionnaire) were extorted within theoretical foundations through a comprehensive literature review, as well as by interviews held in the field of Jordanian construction which aimed to capture the area both adequately and clearly, and to increase consistency and reliability of findings. In order to avoid any confusion, the structure of the survey was based on reducing ambiguity and diminishing misunderstanding, using simple English language accompanied by an attached translated Arabic version of the survey. Furthermore, the Likert scale was used for core questions. As previously mentioned, the questionnaire was divided into five pillars, the sample was comprised of 150 participants, which was considered to be both significant and adequate to identify these points. Subsequently, the pilot study was applied as a pre-test to identify the strengths and weaknesses of the survey. So, the pilot study resulted in either reducing vague questions, or changing the phrases.

Reliability for each part of the questionnaire was also sufficient and over 0.7. The next step was to analyze all data descriptively in the five pillars:

Firstly, it launched by introducing valuable information regarding the current situation of logistics within Jordanian construction. The outcome sequentially determined cost, time, and then quality as affecting influences in construction logistics. Also, 70% of logistics parties do not use, or rarely use, reverse logistics. As well as showing that 83% of construction logistics stakeholders are not executing training sessions for staff. Additionally, it was found that the main procurement contract used is the traditional contract.

Secondly, the next pillar assessed the level of agreement with regards to challenges affecting the logistic process within Jordanian construction. Also, factor analysis was used in the second pillar to cluster all sub-factors into eight main groups, as well as cross loads and week loads (less than 0.5) were removed. Consequently, the groups were categorized as follows: Planning factor; Transportation factor; Transparency and information exchange factor; Continuous improvement factor; Material Preservation factor; Inventory factor; Health and Safety factor; and Material handling factor.

Thirdly, assessing the level of application of lean planning tools in Jordanian construction, the results ranked the tools as follows: Daily progress report, Weekly plan, Master plan, Critical path analysis, Look ahead plan, Work breakdown structure, and Percentage plan completed.

Fourthly, assessing the level of implementing lean practices, the results are ranked as follows: Weekly meeting with your team, Weekly meeting with stakeholders, Root cause analysis, Gemba, First run studies, 5S, Value stream mapping, and the Last planner system.

Fifthly, discovering the drivers to implement lean planning tools and practices. The outcomes of the fifth pillar are categorized as follows: reliability in cost; the need for fast delivery and responsiveness; a better reputation; customer focus; reliability in time; reliability in quality; solutions to storage problems; huge demand and delivery; creating value; sustainable improvement; catching problems early; reduction in defects; increase safety; whether your competitor uses the practices; to help manage conflicts; labour shortages; and employee satisfaction. Finally, barriers to the implementation of lean planning tools and practices are ranked as follows: mindset issues; lack of understanding and awareness; lack of training and education; lack of top management commitment and mandate; then lack of support from government. Consequently, The second data collection significantly covered objective number three.

Objective 4: To explore the differences amongst Jordanian stakeholders' views in regards of factors (challenges) affecting construction logistics, lean planning tools and practices.

To determine the differences among stakeholders (consultant [designer], contractor, supplier), literature review has discussed the role of stakeholders through lean and construction logistics process and the results to a large extent matched well with the outcome of questionnaire (second data collection/ quantitative data).

The questionnaire outcome in regards of construction stakeholders has been obtained by applying Kruskal Wallis and logistics regression tests in challenges affecting construction logistics, lean planning tools, and lean practices.

In the construction logistics challenges pillar, the planning factor affects the consultant more than the other stakeholders, followed by the contractor, and then the supplier. The Transportation factor affects the supplier and then the contractor. And the Inventory factor affects the contractor and then the supplier. In the lean planning pillar, the consultant is affected by the planning tools more than other stakeholders, except by the Weekly report and Look ahead plan, which affect mostly the contractor, then the consultant (engineer), and lastly the supplier. In lean practices, Weekly meetings with your team, Weekly meetings with stakeholders, root causes analysis, and First run studies mainly affect the consultant (engineer), then the contractor, and lastly the supplier. While Just-in-Time affect the supplier then the contractor. Finally, 5S practices affect mostly the contractor, then the supplier, and lastly the consultant (engineer). So, objective four has been achieved as well.

Objective 5: To validate the developed approach and assessment models.

In order to accomplish this objective, the outcome from the discussion chapter has been validated through ISM (Interpretive Structural Modeling). ISM gained the research study a substantial validation regarding analyzed data. It provided three ISM models to accomplish the required aim. The first model identified and assessed the challenges (factors) affecting construction logistics in Jordan. Then, the second and third models are assessing the adoption of lean planning tools and lean practices, which eventually support to develop the overall lean logistics in Jordanian construction. The ISM models were developed based on proper methodology as well as the MICMAC principle (Cross-Impact Matrix Multiplication Applied to

Classification) being utilized to determine reliance power (dependence) and driver power (independent) for all components including challenges affecting construction logistics, lean planning tools, and practices.

Therefore, achieving all objectives provide a valuable answer for the research aim as well as proposing answers for research questions as to how lean logistics can be assessed with in the context of Jordanian construction. Thus, it could be considerably stated at this stage that the answers to the research questions are given mainly by demonstrating two areas as follows:

- The first area considers the area of change. There are challenges (factors) obstructing the construction logistics process to be advanced, there is thus a necessity for change, which is mainly related to the construction stakeholders (Answer for the first research question).
- The second area comprises an assessment to form an approach for change, which means the way to change (employ a bottom-up approach). It provides and enables Jordanian construction stakeholders in Jordan to understand, identify and then assess interactions amongst all challenges that affect their construction logistics process (ISM-1). Afterward, employing lean models (ISM-2, ISM-3), to assess lean planning tools and practices within the context of construction logistics in Jordan, the models also could consider as a basis to evolve towards lean logistics through following the procedures from bottom level to upper level. So, construction stakeholders in Jordan who seek to develop the degree of their construction logistics process are advised to take into consideration the two mentioned areas to assess their current situation regarding construction logistics process and to assess lean tools and practices use, then to reach further development towards lean logistics (Answer for second research question).

Consequently, the findings of this research are as follows:

- The comprehensive literature review delivers an analytical and further knowledge with regards to lean and construction logistics area.

- Through the first data collection (semi-structured interviews) where challenges of construction logistics, lean drivers, and barriers have been identified, the research sufficiently justifies the significance of the problem in Jordanian construction industry

- In the second data collection (questionnaire) the research explored the major factors (challenges) affecting construction logistics in Jordan and ranked them based on their effect, as follows: the planning factor; the transportation factor; the transparency and information exchange factor; the continuous improvement factor; the material preservation factor; the inventory factor; and lastly, the material handling factor.

- Along with drivers and barriers, the research shows the level of lean usage amongst stakeholders within Jordanian construction logistics. The research shows an extremely inadequate level of lean usage in operating the construction logistics process amongst construction stakeholders.

- Inferential outcome, Kruskal Wallis, and logistics regression showed the differences between stakeholders as follows: the planning factor mostly affected the consultant, followed by the contractor, and then the supplier. Also, the supplier has greatest agreement on the transportation factor; and the inventory factor has the greatest effect upon the contractor.

- The inferential result also provides information showing that the consultant plays the key position in planning, which includes the Master Plan (MP), Critical Path Analysis (CPA), and the Weekly Plan. Whilst, contractor's concerns in construction site planning involve the Look Ahead Plan, and the Daily Progress Report. Nevertheless, the application of lean planning tools still undervalued.

- So, the research significantly proves that Jordanian construction logistics remains conventional and must follow a systematic approach towards the implementation of lean. Thus, the application of lean is undervalued.

- Three models have been constructed using ISM-modelling. The first model (ISM-1) includes the factors (challenges) affecting Jordanian construction logistics, where all factors have been positioned from the most influence to the least influence (bottom-up approach) and the relations between them have been identified. Planning occupies the bottom place (the most influential factor), and material handling along with material preservation occupy the uppermost place (the least influential). Furthermore, (ISM-1) provides a significant opportunity for stakeholders to assess their construction logistics based upon their position (consultant, contractor, or supplier) and the associated influencing factors. In addition to assessing and understanding the effect of associated factors upon construction party members, stakeholders will be supported in improving their construction logistics processes.

- The second model (ISM-2) highlights the relations of lean planning tools and levels them according influence. Master plan (MP) and work break down structure (WBS) occupy the bottom place; and weekly report and percent plan complete (PPC) occupy the top place.

- The third model (ISM-3) underlines the relations amongst lean construction practices and levels them according to the influence. Last planner system (LPS), weekly meeting between the team, and weekly meeting between stakeholders occupy the bottom place. Just in time (JIT), and 5s occupied the top place.

- The last two models (ISM-2 and ISM-3) deliver a full vision of how to understand the relations among lean planning tools (ISM-2) and the relations among practices (ISM-3), leading to increased awareness and understanding of the connections and positions of those tools and practices. Accordingly, stakeholders can assess the level of lean planning tools and lean practice usage. So, the research provides two supplementary models (ISM-2) and (ISM-3), offering an assessment opportunity for construction practitioners regarding the usage of lean planning tools and lean practices.

- Academics can use different research approaches to compare their results with this research outcome; or adopt the same approach used in this research in order to examine the construction industry in other developing or developed countries, and so discovering the differences.

- Finally, the research explains several limitations, and offers valuable recommendations for further research, as this research is considered as a basis in this area in Jordan.

8.3 Research Contribution

There is a noteworthy demand for further research to reflect the structure and the nature of supply chain and logistics in the construction industry (Vidalakis et al., 2011).

According to Vidalakis and Sommerville (2013), supply chain logistics remains an area which has been inadequately examined within the context of the construction industry, many aspects need to be properly revealed. There is a noteworthy demand for further research to reflect the structure and nature of the supply chain and logistics within the construction industry (Vidalakis et al., 2011). Additionally, Bryde and Schulmeister (2012) noted that lean practices have a substantial ability for maximizing value and minimizing waste throughout construction logistics processes.

In Jordan, there is a need to develop the Jordanian construction sector in particular the logistics process, which is considered a fundamental feature that requires improvement. Furthermore, Momani (2000) noted that 130 projects were reviewed in a research study in Jordan, where 81% failed to accomplish their target. The results show that site conditions, delivery of material, and disputes between parties (contractor and supplier) were deemed substantial reasons for the problems within the Jordanian construction industry. Moreover, Sweis et al. (2008) also mentioned in their case study of 13 projects that the part of the logistics process which includes delivery procedures; loading and unloading; as well as storing material constitutes a considerable challenge. Additionally, there is no sign that lean planning tools and practices have been employed in Jordanian construction, and particularly in logistics process. So, this research was aimed to assess the construction logistics process through lean planning tools and practices. Consequently, three (ISM) models consider a significant contribution to the knowledge, that is: which launching approaches to identify, diagnosing construction logistics challenges (First-ISM), and then mitigating their negative effects throughout the second and third ISM models.

Moreover, this research offered both practitioners and academics the following contributions:

- Construction stakeholders will gain further guides and perceptions on understanding, identifying, and then assessing their construction logistics process within Jordanian construction.

- Practitioners will have comprehensive assessment through lean planning tools and practices, which eventually can develop their current construction logistics process towards lean logistics based on their position.

- Academics will also have a significant opportunity to use the contribution of this research as a benchmark in Jordanian construction to increase their research in this field as the vast majority of developing countries still underestimate this subject.

- This research also encourages developing countries to extend their research in the lean subject, as well as the subject of construction logistics, in order to assess and develop their current situation.

- International academics can exploit this research to recognise the level of awareness and understanding in regards to the subject of lean logistics in Jordan (developing country), and create a comparison between developing country and developed country in order to know the reasons for gaps.

- According to a few critics, lean implementation studies are still an immature subject and need a lot of research to show their efficiency and effectiveness across the world; this research has added further significant knowledge for academics and practitioners related to a new culture such as Jordan.

- These models are considerably beneficial for construction companies, particularly, upper-intermediate and large sized companies. Adopting these models assists in assessing the affectivity of the lean logistics process, indicating which factors of the construction logistics process requires intervention and how these factors connected with one another, then the process will develop. Consequently, reduction in cost and time along with high quality will be gained.

- The research also contributes by determining significant distinctions throughout the construction logistics process between the consultant (engineer/architect), the contractor, and the supplier, as well as discovering the degree of implementation of lean planning tools and practices between them. Accordingly, this aids to separately detect their difficulties, which assists in achieving straightforward solutions.

- This research extends two topics together and generates relevance between them. The first topic is the construction logistics process, and the second topic is lean adoption techniques.

8.4 Limitation and Recommendations for Further Research

- Research procedures were successful in achieving the objectives and answering all research questions. On the other hand, several obstacles occurred during the data collection. Firstly, a lack of significant Jordanian specific literature regarding the topic. Secondly, some participants were reluctant to participate in the questionnaire. Finally, there was a need to give the questionnaire by hand as many construction people neglected to reply via email. Some, however, submitted incomplete questionnaire forms, which were unusable and so eliminated. Due to these difficulties, extra time was required to obtain a sufficient number of questionnaires.

- This research has applied mixed methods through interviews and questionnaire. However, further research could use action research in order to test the ability of adopting lean practices, and record any significant advantages in cost, time, and quality.

- Some participants had criticism because of the length of the questionnaire form; they claimed that it took a long time to fill in. Further research needs to take this point into account when forming the questionnaire.

- This research was limited in scope from large to upper-intermediate sized organizations; further research could use the same study in medium and small sized organizations.

- As the subject of lean is large and complex, further research could specialise in one technique, such as JIT (Just-in-Time), CI (Continuous Improvement), IPD (Integrated Project Delivery), or LPS (Last Planner System).

- Further research could produce a comparison between this research and other research within the same scope.

- Exploratory factor analysis was used for this study with regards to challenges (factors) affecting Jordanian construction logistics, and the level of using lean planning tools and practices. In order to confirm the consistency outcomes, further data collection could be gathered and a confirmatory factor analysis could be used to validate and confirm the findings of the research.

- The vast majority of the participants in this research are working in the private sector, so the study is limited to the Jordanian private sector. Therefore, further studies could concentrate on the public, government, or non-profit sectors.

- This research was limited to Jordan (one developing country); due to time limitations it was impossible to carry out the same study in other developing countries. So, it is suggested that cross-cultural studies could be applied to examine the applicability of the three proposed models, and discover the differences between these developing countries.

- To gain further development in the future, research can combine this subject with Building Information Modelling (BIM) as lean practices can be significantly boosted with BIM.

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Appendix

Appendix one: Ethical approval

Academic Audit and Governance Committee

College of Science and Technology Research Ethics Panel (CST)

University of Salford MANCHESTER

MEMORANDUM

To Yaser Labib (and Prof Mohammed Arif)

cc: Professor Hisham Elkadi, Head of School of SOBE

From Nathalie Audren Howarth, College Research Support Officer

Date 6/01/2015

Subject: **Approval of your Project by CST**

Project Title: **Improving logistics in Jordan by means of lean practices**

REP Reference: **CST 14/46**

Following your responses to the Panel's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the Panel as soon as possible.

Regards,

Nathalie Audren Howarth
College Research Support Officer

College Ethics Panel

Ethical approval must be obtained by all postgraduate research students (PGR) prior to starting research with human subjects, animals or human tissue.

A PGR is defined as anyone undertaking a Research rather than a Taught masters degree, and includes for example MSc by Research, MRes by Research, MPhil and PhD. The student must discuss the content of the form with their dissertation supervisor who will advise them about revisions. A final copy of the summary will then be agreed and the student and supervisor will 'sign it off'.

The signed Ethical Approval Form and application checklist must be forwarded to your College Support Office and also an electronic copy MUST be e-mailed to the contacts below at your College Support Office;

CASS: Deborah Woodman – d.woodman@salford.ac.uk

CHSC: Jill Potter - j.potter@salford.ac.uk
Rachel Shuttleworth - r.shuttleworth@salford.ac.uk

CST: Nathalie Audren-Howarth – n.audren@salford.ac.uk

The forms are processed online therefore without the electronic version, the application cannot progress. Please note that the form must be signed by **both the student and supervisor**.

Please ensure that the electronic version of this form only contains your name and your supervisor's name on this page, where it has been requested.

All other references to you or anyone else involved in the project must be removed from the electronic version as the form has to be anonymised before the panel considers it.

Where you have removed your name, you can replace with a suitable marker such as [.....] Or [Xyz], [Yyz] and so on for other names you have removed too.

You should retain names and contact details on the hardcopies as these will be kept in a separate file for potential audit purposes.

Please refer to the 'Notes for Guidance' if there is doubt whether ethical approval is required

The form can be completed electronically; the sections can be expanded to the size required.

Name of Student: Yaser Labib

Name of Supervisor: Mohammad Arif

School: Built Environment

Course of study: PhD

Name of Research Council or other funding organisation (if applicable):

1a. Title of proposed research project

Improving logistics in Jordan by means of lean practices

1b. Is this Project Purely literature based?

No

2. Project focus

The focus of this research is to develop an implementation strategy of logistics in Jordan, especially by applying lean practices.

3. Project objectives

1. To explore the extent of lean practicesand logistics contribute to the reduction of waste in construction processes.
2. To review the success factors and the challenges of using lean practices in construction industry.
3. To investigate the current status of logistics construction in Jordan and the level of awareness regarding lean practices.
4. To develop an approach for implementation and adoption of lean logistics in order to improve the existing supply chain processes in Jordan.
5. To validate the developed implementation and adoption strategy.

4. Research strategy

(For example, outline of research methodology, what information/data collection strategies will you use, where will you recruit participants and what approach you intend to take to the analysis of information / data generated)

A combination of primary and secondary data will be collected and considered in this research in order to answer the research questions and to meet the objectives.

In primary data, the recruitment of participants will be divided in two groups in Jordan. The first one is the academic sector; the second one is the practical sector (companies). Interview as qualitative strategy will be applied to collect data where Professors, doctors, lecturers in Universities as well as senior managers, engineers and main foremen in the construction companies will participate to give a full explanation about the situation in Jordan. After that, Action research strategy will be implemented in the second part of the collecting data.

Respondents

There are two major groups for data collection:

- **The first one** is governmental and private universities by interviewing the academics staff in University of Jordan, Applied University, Israa University. Petra University, Etc.
- **The second one** consists of private and governmental companies and factories.

Data collection

A. **Phase one (Defining the root causes):**

1. Case Study-(Interview strategy): Semi-structured interview will be used

as the main source for data collection purposes. This type of interview is a significant method for data collection as it involves an interaction between the interviewer and the interviewee for which the purpose is to obtain valid Information. The interviews will be used to discover the root causes of the problem in Jordan and will be applied in the two major groups mentioned in the previous part. The interview is divided into the following sections:

1. Current Application on logistics and Lean Practices in Jordan.
2. Benefits of having robust Supply Chain Logistics.
3. Barriers of improving the logistics system in Jordan.
4. Opportunities that lean logistics provides.

2. Observation in the construction sites and factories and collection of supporting documentation will also be utilized.

3. Modelling the value stream mapping to understand exactly the full processes of logistics.

B. **Phase two- (Action research)**: After discovering the root causes, Action research cycles will be implemented by using appropriate lean practices to solve discovered problems and build the strategy. According to Coghlan and Brannick (2005) action research cycle includes the points shown below:

1. Context and purpose (by literature review and phase one).
2. Diagnosing (Literature Review and phase one).
3. Planning action (Literature Review and chosen lean practices methods).
4. Taking action (Field case study).
5. Evaluating action (Discussion of the outcome).

Qualitative data which is collected from interviews will be analysed qualitatively using NVivo software. Furthermore, the validation of the strategy will be done by focus group (Yin, 2003).

5. What is the rationale which led to this project?

(For example, previous work – give references where appropriate. Any seminal works must be cited)

According to World Economic Forum (2010), Jordan ranked number 44 globally which means that Jordan has become a competitive country and on the way to develop. Besides, The position of the country in the middle east and the stable political situation encourage the invistors to invest their projects in Jordan. The construction sector is one of the vital sectors in the development process of Jordan. The construction industry in Jordan considers as a fundamental part to the social and economic growth, innovation in construction industry has a key role in delivering solutions, to provide more value for money and more sustainability in the buildings for clients and society (Momani, 2000). Moreover, The government contributes to the development of the construction industry in several ways. However, there are limitations and even draw backs to these efforts (ibid). Furthermore, Jordanian government is one of the governments that found out that if it needs to improve its economy it has to improve its logistics and SCM in almost every part of life (Shwawreh, 2006). The economic development will not be achieved without a new way of thinking and practices (ibid).

Firstly, a study has been made in Jordan to investigate the causes of delay excessive cost and disputes in the construction industry. Altogether, 130 projects were examined in the research study including school building, medical centres, communication facilities and administration buildings; the result was that 81.5 percent of the projects failed to achieve their goals within the contract time limit and the agreed cost (Momani, 2000). Delivery of materials, site conditions and disputes between parties (supplier and contractor) are considered significant causes of the problems in the Jordanian construction industry in accordance with this research study (ibid). These managerial problems are attributed to the logistics, whereas developing logistics will significantly aid construction parties in establishing an adequate and mutually system (Shwawreh, 2006).

Secondly, According to Sweis et al. (2008), a case study was conducted in 13 Jordanian construction projects in a comparison with UK and USA shows that more time is spent in Jordan on uploading, offloading, moving and storing than is spent on similar activities in developed countries. As a consequence (ibid):

4. More work-hours spent in unloading because of unplanned introduction of advanced work methods of construction.
5. Temporary, inefficient placement of materials near the delivery points as a result of a lack of advanced storage planning.
6. Additional manual handling to move materials from the storage to the work areas, even if advanced tools and equipment exist on the project.

This means there is a need of advanced construction methods which require to be implemented properly to solve the improper planning and execution and to increase the level of productivity (ibid). After revealing the necessity of improving the logistics in Jordan, the role of lean thinking and practices appear in this point where the techniques and tools of lean can be implemented in order to overcome the fragmentation problems of traditional functional business (Jones et al., 1997).

Research on lean thinking and practices shows no evidence of their practical implementation within the construction industry in Jordan. Therefore, this research will be the first application of lean intending to improve the logistics and to establish a basis for the development of research in the area of lean logistics in Jordan.

To conclude, In the Kingdom of Jordan and according to the researcher's best knowledge, lean construction and logistics are relatively young areas of research. However, due to the shortage of history regarding these topics in Jordan, lean construction techniquea can be one of the promising solutions for the logistics in Jordan. These reasons were seen as an important rationale to develop the strategy in Jordan.

6. **If you are going to work within a particular organisation do they have their own procedures for gaining ethical approval**

   (For example, within a hospital or health centre?)

   NO

   If YES – what are these and how will you ensure you meet their requirements?

7. **Are you going to approach individuals to be involved in your research?**

   YES

   If YES – please think about key issues – for example, how you will recruit people? How you will deal with issues of confidentiality / anonymity? Then make notes that cover the key issues linked to your study

Written brief information about the research will be provided to all participants. After that, they will be asked signing a consent form to show their acceptance to participate in the interview. All information is collected during the PhD study will be kept strictly confidential as anonymity will be assured when analysing the data. Moreover, all collected data will be stored electronically on a password protected computer, accessed only by the researcher and will be destroyed when no longer value to this research.

8. **More specifically, how will you ensure you gain informed consent from anyone involved in the study?**

All participants will be provided with an information sheet. Subsequently, they will be asked to sign a consent form as well as they will be free to leave the interview at any stage.

9. **How are you going to address any Data Protection issues?**

See notes for guidance which outline minimum standards for meeting Data Protection issues

This research will be conducted in a compliance with Data Protection Act 1998. For instance, considering the first principle of Eight Data Protection Principles, personal data must be processed lawfully and fairly. Following the second principle, the data gathered from the field will be used only for academic intentions mainly for this researh.

All data collected will be erased from the computer that is used for data analysis based on the fifth and seventh principles which mentioned personal data must be kept securely, and all participants' data will be kept safely and will be deleted and destroyed at the time of completion the PhD research in order to defence the result or further academic publications.

The requirements of data protection and human rights issues in principle will be maintained with complete security. The data will not be passed on to anyone. All data will be kept in the personal storage available on laptop and securely backed up in F-Drive provided by the University with unique username and password known to the researcher only. The laptop and external hard-disk in particular will be protected by password to secure the data inside them. All those data and equipment will also only be accessible for the researcher. Information about identifiable individuals will be encrypted and the researcher ensures that the anonymity of the participants is assured as any data will be accessible just by a unique identification number specific for each participant.

10. Are there any other ethical issues that need to be considered? For example - research on animals or research involving people under the age of 18.

No

11. (a) Does the project involve the use of ionising or other type of "radiation"

NO

(b) Is the use of radiation in this project over and above what would normally be expected (for example) in diagnostic imaging?

NO

(c) Does the project require the use of hazardous substances?

NO

(d) Does the project carry any risk of injury to the participants?

NO

(e) Does the project require participants to answer questions that may cause disquiet / or upset to them?

NO

If the answer to any of the questions 11(a)-(e) is YES, a risk assessment of the project is required and must be submitted with your application.

12. How many subjects will be recruited/ involved in the study/research? What is the rationale behind this number?

Approximately 15 to 20 interviews (based on similar previous research) will be contributing in this research at the first phase in order to obtain the best sufficient data which will enble observation and pracrtical field study through action research to be addreseed in a good manner. My supervisor agrees that number of interviews may increase or decrease based on the outcome that will be received by participants.

13. Please state which code of ethics has guided your approach (e.g. from Research Council, Professional Body etc).

Please note that in submitting this form you are confirming that you will comply with the requirements of this code. If not applicable please explain why.

Data Protection ACT 1998 and Social Research Association Ethical Guidelines 2003

Remember that informed consent from research participants is crucial, therefore all documentation must use language that is readily understood by the target audience.

Projects that involve NHS patients, patients' records or NHS staff, will require ethical approval by the appropriate NHS Research Ethics Committee. The University College Ethics Panel will require written confirmation that such approval has been granted. Where a project forms part of a larger, already approved, project, the approving REC should be informed about, and approve, the use of an additional co-researcher.

I certify that the above information is, to the best of my knowledge, accurate and correct. I understand the need to ensure I undertake my research in a manner that reflects good principles of ethical research practice.

Signed by Student ____

Print Name ____

Date ____

In signing this form I confirm that I have read this form and associated documentation.

I have discussed and agreed the contents with the student on ____________________
(Please insert date of meeting with student)

Signed by Supervisor ____

Print Name ____

Date ____

College Ethics Panel: **Application Checklist**	**Ref No:** *Office Use Only* New Submission / Resubmission

Name of Applicant:

Title of Project:

The checklist below helps you to ensure that you have all the supporting documentation submitted with your ethics application form. This information is necessary for the Panel to be able to review and approve your application. Please complete the relevant boxes to indicate whether a document is enclosed and where appropriate identifying the date and version number allocated to the specific document (*in the header / footer*), Extra boxes can be added to the list if necessary.

Document	**Enclosed? (indicate appropriate response)**				**Date**	**Version No**
Application Form	Mandatory			If not required please give a reason		
Risk Assessment Form		No	Not required for this project	The answer to questions 10 and 11(a,b,c,d,e) in the Risk Assessment Form is NO		
Participant Invitation Letter		No	Not required for this project	Beginning of Participant Information Sheet includes an invitation to participant.		
Participant Information Sheet	Yes		Not required for this project			
Participant Consent Form	Yes		Not required for this project			
Participant Recruitment Material – e.g. copies of posters, newspaper adverts, website, emails		No	Not required for this project	Interviews will be done face to face		
Organisation Management Consent /		No	Not required for this project	The recruited participants will reach individuals, rather than organisations, to		

Agreement Letter				participate in the research.		
Research Instrument – e.g. questionnaire		No	Not required for this project	Interviews, observation and action research will be done in this research to gain a deep understanding and full explanation.		
Draft Interview Guide	Yes		Not required for this project			
National Research Ethics Committee consent		No	Not required for this project	The research is not undertaken in the NHS or through local government social care services		
Note: If the appropriate documents are not submitted with the application form then the application will be returned directly to the applicant and will need to be resubmitted at a later date thus delaying the approval process						

College Ethics Panel Approval Form, PGR Version 2011-12

Appendix Two: Interview forms

Participant Information Sheet
(Interviews)

What is the purpose of the study?

The purpose of this interview is to identify the current application of logistics and lean practices in Jordan, investigating the benefits and opportunities of having robust logistics system and discovering the root causes of logistics in Jordan. The collected data along with the observation will support developing the strategy of logistics in Jordan especially by applying lean techniques.

Why have I been invited?
You have been invited to participate in this research as you are an effective member of the Jordanian construction industry.

Do I have to take part?
It is up to you to decide. It is really appreciated if you participate and you are free to withdraw at any time, without giving a reason.

What will happen to me if I take part?
- Your identity remains anonymous.
- Data will be stored in a secured PC and then will be destroyed after the completion of this research.

What will I have to do?
You will be asked to sign a consent form to show that you agreed to take part. All what you have to do then is answering the interview questions.

What if there is a problem?
If you have a concern about any aspect of this study, you should ask to speak to me; I will do my best to answer your questions. If you remain unsatisfied and wish to complain formally you can do this through my supervisor: Prof. Mohammad Arif.
(Email: m.arif@salford.ac.uk)

Will my information in the study be kept anonymous?

- All information which is collected about you during the course of the research will be kept strictly anonymous.
- Collected data will be stored electronically on a password protected computer, accessed only by me.
- Procedures for handling, processing, storage and destruction of data match the principles in the Data Protection Act 1998.
- The data is not to be used for future studies.
- Collected data will be stored and archived. After that, data will be deleted after the completion of this research.

What will happen if I don't carry on with the study?
If you withdraw from the study, all the information and data collected from you will be destroyed and your data removed from all the study files

What will happen to the results of the research study?
The results of the study in which you are involved in will be made available on your request.

Further information and contact details:

Name: Yaser Labib
PhD Researcher
College of Science and Technology
University of Salford
Maxwell Building
e-mail: eng.yaserlabib@hotmail.com

Participant Invitation Letter
(Interviews)

Dear Participant,

I would like to invite you to take part in a research project entitled: Developing an implementation strategy of logistics in Jordan, especially by applying lean practices.
The purpose of this interview is to identify the current application of logistics and lean practices in Jordan, investigating the benefits and opportunities of having robust logistics system and discovering the root causes of logistics in Jordan.
The interview is in a form of semi-structured type of questions. There are no identified risks from participating in this research and it is completely voluntary and you may refuse to participate without consequence.
Attached to this invitation is a Participant Information Sheet. This will provide you with further information about the interview and who to contact if you have any questions.
I hope you choose to take part in this interview and to consider sharing your experience, which will help me identifying ways to improve Jordanian construction industry.

Sincerely,
Name: Yaser Labib
PhD Researcher
College of Science and Technology
University of Salford
Maxwell Building
e-mail : eng.yaserlabib@hotmail.com

<u>Participant Consent Form</u>
<u>(Interviews)</u>

IMPROVING LOGISTICS IN JORDAN BY MEANS OF LEAN PRACTICES

Name of the researcher: Yaser Labib
Name of the supervisor: Mohammad Arif

<u>The use info in this consent is being granted for:</u>
A study aims to develop an implementation strategy of construction logistics in Jordan, especially by applying lean practices.

Please tick the appropriate boxes:

	Yes	No
• I have read and understand the project information sheet.	☐	☐
• I have been given the opportunity to ask questions about the project.	☐	☐
• I understand that my taking part is voluntary; I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part.	☐	☐
• I agree to take part I n this interview.	☐	☐

Name of the participant: ……………………………………………………………………………
Signature: ………………………………………………………………………………………………

(Interview Form)

Improving logistics in Jordan especially by means of Lean practices

Name of the researcher: Yaser Labib

Name of the Supervisor: Mohammed Arif

Section I. Current Application of logistics and Lean Practices in Jordan

1. **Could you please give a brief introduction about yourself and your experience in construction?**

2. **In your opinion, to what extent the construction industry in Jordan has been improved recently?**

3. **What is your impression about logistics process? (Kind of definition and understanding about the meaning).**

4. **Have you worked as a part of logistics process in construction and how would you summaries your experience of logistics?**

5. **In which of the following construction categories (residential, commercial, infrastructure, industrial or heavy construction).**
   - **All of them**

6. **What are the major problems you have faced in the logistics process?**

7. **What are the root causes for each one of these problems?**

8. **Whose usually responsible managing the logistics among parties?**

9. **What are the type of relationships between client and contractor and between the contractor and supplier in the majority of the projects (short term or long term)?**

10. **What kind of projects (building sectors) than need to implement highly robustly logistics system from your perspective?**

11. **Have you experienced any failure because of the poor logistics process that has been used?**

12. **What are the main feedbacks that you have received recently regarding logistics system and where the feedbacks come from?**

13. **Have you heard about lean techniques (Ex: Last planner, JIT, Value mapping, Takt time) and to what extent have you used them?**

Section II Benefits of having robust Supply Chain Logistics

1. **What are the motivations to improve the logistics process in Jordan?**

2. **What are the main benefits for the company to improve their logistics?**

3. **What are the problems that can be solved or positively affected by enhancing the logistics process?**

4. **Do you think, the contract form (type) could significantly influence the management of logistics process?**

5. **Do you believe improving logistics will assist you to provide a higher level of customer satisfaction, increase the profits or both? How?**

6. **Is there a need to improve the storage area in construction projects in Jordan? To what extent improving material storage or reducing the storage area will improve the overall logistics processes and eventually the project?**

7. **Are there any other benefits you (your company) have experienced?**

Section III Barriers of improving the logistics system in Jordan

1. **Which one of logistics stage causes the majority of problems in the Jordanian construction industry?**

2. **Is the level of construction planning and site management at a good sufficient level to facilitate logistics processes in Jordan?**

3. **To what extent better communication could improve the logistics process?**

4. **Does improving logistics techniques and practices could reduce the error of information exchange and consequently the overall cost compared with the conventional practices? How?**

5. **Can you specify the most significant materials that cause insufficient logistics system while transporting, handling and storing?**

6. **Are there any systematic efforts by the construction companies learn from and implement their logistics processes?**

7. **Are there any specific barriers that prevent the improvement of logistics?**

Section V Opportunities that lean logistics provides

1. **Based on your view, to what extent the Jordanian culture (culture in construction facilitates or hinder improvement) is prepared to improve?**

2. **Would you adopt new techniques or practices more widely if your major competitor is using them more?**

3. **Would you prefer to build logistics system with long-term or short-term relationships? (Relationship between client and contractor and between contactor and supplier)?**

4. **What are the benefits and barriers to implement new practices such as lean?**

5. **Do you have any recommendations to implement better management of construction logistics in Jordan?**

Appendix Three: Questionnaire form

Questionnaire Draft

Improving logistics in construction industry in Jordan especially by lean practices

- The questionnaire is divided into the following sections:

1. Respondent background
2. Current situation of logistics process in Jordan
3. Factors affecting logistics process
4. Lean practices (maximising value and minimising waste) and adoption opportunities

- For your information, this questionnaire is designed to describe your opinions about the current situation of construction logistics processes (logistics materials) in Jordan, and the factors that possibly affect the logistics process. Furthermore, the last part explores the opportunities for adopting new managerial practices (lean construction) in Jordan.
- Please take into consideration your experience in logistics materials and lean construction when answering these questions.

Please answer the following questions by putting [X] mark in the boxes.

Part One: Respondent background	
1. Your original field of study: 1. Project manager ( ) 2. Engineer ( ) 3. Foreman ( ) 4. Skilled labour ( ) 5. Other ( ), Specify...................	**2. Your highest educational level:** 1. High school ( ) 2. Diploma ( ) 3. Bachelor's ( ) 3. Higher Diploma ( ) 4. Master's ( ) 5. PhD ( )
3. Your experience in construction: 1. Less than 5 years ( ) 2. Between 5 to 10 years ( ) 3. 11 to 20 ( ) 4. Over 20 years ( )	**4. Your experience is gained by:** 1. Government sector ( ) 2. Private sector ( ) 3. Both ( )
5. Rank top 2 of your experience: 1. Residential / housing building ( ) 2. Commercial building ( ) 3. University ( ) 5. Infrastructure ( )	**6. The origination considered as:** 1. Client ( ) 2. Consultant ( ) 3. Contractor ( ) 4. Sub-contractor ( ) 5. Supplier ( ) 6. Other ( ), Please specify..............

7. **Your company's classification:** - Consultant (Architect): - Contractor/ sub-contractor: - Supplier:

Part Two: Current situation of logistics process in Jordanian construction
- The level of waste produced in construction logistics on time, cost and quality: Quality ( ) Cost ( ) Time of waiting ( )
- What is the most common contract used between you and other parties? Traditional Design-bid-build ( ) Management contracting ( ) Design and build ( ) Other ( )
- Do you have reverse logistics process (the remaining/damaged materiel moves from the site to the production point): Yes ( ) No( ) Never Heard ( ) If the answer is Yes, please specify the material: ....
- **Have you provided training sessions on new construction management practices such as lean practices for your employees?** Yes ( ) No ( ) Not sure ( ) If Yes, Please specify:…………………………..

Part Three: State your level of agreement about the effect these factors (challenges) have on the Jordanian logistics process					
	Strongly Disagree	**Disagree**	**Can't say**	**Agree**	**Strongly Agree**
Deficiency and complexity in planning negatively affect the construction logistics process in Jordan.					
Construction logistics process in Jordan not considering the long waiting time among the processes					
Lifting and storing don't need skilled labours					
Poor quality of finished goods					

occurs because of poor construction logistics					
Construction logistics in Jordan suffers overproduction more that the required quantity.					
Lifting and handling by machines is undesirable to contractors and suppliers					
Lifting and handling by machines considerably increase the cost of construction logistics process.					
Types of vehicle used in transportation are insufficient in the construction logistics process.					
Jordanian construction logistics suffers from unnecessary movement and excessive transportation.					
Determining the most appropriate road is insufficient in Jordanian construction logistics and particularly affects health and safety					
Shared transportation is inadequately used between construction parties					
Controlling and monitoring of the tracking system are not used permanently in Jordanian construction logistics					
Tracking system adds unnecessary cost throughout the logistics process.					
Determining the most appropriate road is not usually negotiable between construction parties in Jordan'					
Distrust among parties negatively affects the construction logistics process					
Lack of mutual information and instruction among construction parties negatively affects construction logistics in Jordan					

Interference in decision making by contractors or subcontractors is insignificant in construction logistic’					
Interference in decision making by the supplier is inadequate in the Jordanian construction logistics process’					
Lack of meeting between construction parties negatively affects construction logistics in Jordan					
Different languages and dialects negatively affects the construction logistics process’					
Advanced technology is insignificant in the construction logistics process					
Type of contract or procurement used between construction parties is not chosen properly in construction logistics’					
Government regulation regarding allowable loading and customs negatively affects construction logistics in Jordan’					
Health and safety are not given great consideration in Jordanian construction logistics processes					
Fluctuation in material negatively affects construction logistics in Jordan					
Shortage of machinery and equipment negatively affects Jordanian construction logistics					
Feedback and shared lessons are not essential among parties in Jordanian construction logistics					
Lack of trained staff significantly affects construction logistics in Jordan					
Customer-client service is not a top priority for suppliers’					
Cultural challenges are a vital					

aspect in construction logistics in Jordan					
Storage material by contractors is desirable in Jordanian construction’					
Jordanian construction logistics has unnecessary and large inventories’					
Poor delivery speeds and responses from suppliers negatively affect construction logistic					
Mapping the material route from the original point to the construction site is insufficient in Jordanian construction logistics					
Bringing material just in time is required by Jordanian construction logistics parties					

Part Four: Lean adoption opportunities in Jordanian construction					
How frequently does your company use the following practices?					
Practices	**Always**	**Mostly**	**Some times**	**Rarely**	**Never**
Value stream analysis					
Last planner system					
5s (visual workplace)					
First run study					
Just-In-Time					
Root cause analysis					
Gemba					
Weekly meeting with stakeholders					
Weekly meeting with your team					

How frequently does your company use/get involved in the following tools for planning purpose?					
Frequency	**Always**	**Mostly**	**Sometimes**	**Rarely**	**Never**
Master plan					
Critical path method					
Look-ahead plans					
Weekly Plans					
Daily progress report					
Planned completed percentages estimation					
Work breakdown structure					
Other, specify.........................					

In your opinion, what are the drivers to implement lean practices?	**Strongly agree**	**Agree**	**Can't say**	**Disagree**	**Strongly disagree**
If your competitors use them					
labour shortage					
Huge demand and delivery requirements					
Need for fast delivery & responsiveness					
Reliability in time					
Reliability in cost					
Reliability in quality					
Solve storage problems					
Sustainable improvement					
Increase safety					
Create value and customer focus					
Employee satisfaction					
Catch problem early					
Helps manage conflicts					
Better reputation					

What are the barriers to implement new managerial practices such as lean practices in Jordan?					
Barriers	**Strongly agree**	**Agree**	**Can't say**	**Disagree**	**Strongly Disagree**
Mindset issues					
Lack of awareness and understanding					
Lack of training and education					
Lack of mandate and top management					
No support from government					

Appendix Four: Questionnaire Data

Questionnaire data (BG)

ResponseID	var3	var4	var5	Exp. Sec	Consl.	Contra	Supplier	H
1	3	3	1	2	0.00	0.00	1.00	0.00
2	3	3	1	2	0.00	0.00	1.00	0.00
43667644	3	3	1	2	0.00	0.00	1.00	3.00
43537321	3	3	1	2	0.00	0.00	1.00	1.00
46238351	1	5	1	2	1.00	0.00	0.00	3.00
46172975	3	3	2	3	1.00	0.00	0.00	3.00
46299158	1	3	1	1	1.00	0.00	0.00	1.00
45113934	3	5	2	2	1.00	0.00	0.00	2.00
46238446	3	3	1	3	0.00	0.00	1.00	3.00
44257857	3	3	2	2	1.00	0.00	0.00	2.00
46183109	3	3	1	2	0.00	0.00	1.00	2.00
44374078	2	3	1	2	1.00	0.00	0.00	2.00
43491220	3	3	1	2	1.00	0.00	0.00	1.00
44203446	3	5	1	2	0.00	0.00	1.00	2.00
46289413	3	2	2	2	0.00	0.00	1.00	2.00
45893471	4	1	2	2	1.00	0.00	0.00	2.00
45943399	3	3	2	2	1.00	0.00	0.00	2.00
45910891	2	2	3	2	1.00	0.00	0.00	2.00
44122060	3	3	1	2	0.00	0.00	1.00	1.00
45946793	3	3	1	2	0.00	1.00	0.00	2.00
43794648	2	3	3	3	1.00	0.00	0.00	2.00
45945956	3	3	2	2	0.00	1.00	0.00	1.00
46298006	5	4	3	3	0.00	1.00	0.00	2.00
45945310	3	3	1	2	0.00	1.00	0.00	2.00
45947312	3	3	3	0	0.00	1.00	0.00	2.00
45956779	1	3	1	2	0.00	0.00	1.00	2.00
44287598	3	3	1	2	0.00	1.00	0.00	3.00
43490038	3	5	1	2	0.00	0.00	1.00	2.00
43529778	3	3	1	2	0.00	0.00	1.00	1.00
45950673	5	3	1	1	0.00	1.00	0.00	1.00
43599055	2	3	3	2	0.00	1.00	0.00	2.00
45956080	3	3	1	0	1.00	0.00	0.00	1.00
44293257	1	6	1	2	1.00	0.00	0.00	3.00
43471868	3	3	1	2	0.00	0.00	1.00	2.00
44401977	3	3	1	2	0.00	1.00	0.00	3.00
46236608	2	5	2	3	0.00	0.00	1.00	3.00
45951551	5	2	1	2	0.00	1.00	0.00	2.00
43484785	2	3	2	2	1.00	0.00	0.00	3.00
46297604	3	3	1	2	0.00	0.00	1.00	2.00
43583318	3	3	1	2	0.00	0.00	1.00	1.00
43537592	3	3	1	2	0.00	0.00	1.00	1.00

43620655	3	5	2	2	0.00	0.00	1.00	2.00
44202180	3	5	1	3	1.00	0.00	0.00	2.00
45933354	6	3	1	2	0.00	0.00	1.00	2.00
45945003	3	3	1	2	0.00	0.00	1.00	1.00
44254461	3	5	1	0	0.00	0.00	1.00	1.00
43484302	3	3	1	2	0.00	1.00	0.00	2.00
45945641	4	2	2	2	0.00	1.00	0.00	2.00
44291335	3	3	1	2	0.00	1.00	0.00	3.00
43350421	2	3	3	3	0.00	1.00	0.00	2.00
45911849	6	1	1	2	0.00	0.00	1.00	2.00
46298887	3	3	2	1	0.00	1.00	0.00	2.00
46289709	1	3	1	2	0.00	1.00	0.00	3.00
45951225	3	3	2	2	1.00	0.00	0.00	2.00
45944291	3	3	1	2	0.00	1.00	0.00	3.00
43486472	3	3	2	2	1.00	0.00	0.00	1.00
45894130	2	2	3	2	0.00	0.00	1.00	2.00
45541694	2	3	2	2	0.00	0.00	1.00	2.00
45371018	0	3	2	2	0.00	0.00	1.00	2.00
43486996	3	3	1	2	0.00	0.00	1.00	1.00
43350777	3	3	1	2	0.00	0.00	1.00	2.00
45115459	3	3	1	2	0.00	0.00	1.00	2.00
43350312	2	3	2	2	0.00	0.00	1.00	2.00
46182793	1	5	1	1	1.00	0.00	0.00	3.00
46173226	3	3	1	2	0.00	1.00	0.00	3.00
45956216	1	5	1	2	0.00	1.00	0.00	3.00
44843483	3	3	1	2	0.00	0.00	1.00	3.00
46298775	5	2	2	1	0.00	1.00	0.00	3.00
43484897	3	3	1	2	0.00	1.00	0.00	1.00
43503056	3	5	1	2	0.00	0.00	1.00	2.00
43357336	3	3	1	2	1.00	0.00	0.00	2.00
46236872	3	3	4	2	1.00	0.00	0.00	2.00
45912919	4	1	3	2	0.00	0.00	1.00	2.00
45906990	4	2	3	2	0.00	1.00	0.00	2.00
46261304	3	5	2	2	1.00	0.00	0.00	2.00
45906452	6	1	2	2	0.00	0.00	1.00	2.00
45943983	1	3	4	3	0.00	1.00	0.00	3.00
43492896	3	3	1	2	1.00	0.00	0.00	3.00
45955216	5	2	2	2	0.00	1.00	0.00	1.00
45946498	3	3	2	2	0.00	0.00	1.00	2.00
43484883	2	3	2	2	1.00	0.00	0.00	1.00
45955492	3	3	1	2	0.00	0.00	1.00	1.00
46299024	3	2	2	1	0.00	1.00	0.00	3.00
45905952	4	1	3	2	0.00	1.00	0.00	2.00

46289586	3	3	1	2	0.00	0.00	1.00	2.00
45913286	4	2	2	2	0.00	0.00	1.00	2.00
46183474	3	3	1	2	0.00	0.00	1.00	3.00
43509558	3	3	1	2	1.00	0.00	0.00	2.00
44402699	3	3	1	2	0.00	1.00	0.00	1.00
45955979	3	3	1	2	1.00	0.00	0.00	1.00
45907772	4	1	3	2	0.00	0.00	1.00	2.00
45943728	3	3	2	2	0.00	0.00	1.00	2.00
44287168	2	5	1	2	1.00	0.00	0.00	3.00
46237964	3	3	2	2	1.00	0.00	0.00	3.00
46297862	4	1	1	2	1.00	0.00	0.00	2.00
45933164	6	3	2	2	0.00	0.00	1.00	3.00
45947076	3	3	2	2	0.00	1.00	0.00	2.00
43660394	3	5	2	2	1.00	0.00	0.00	1.00
43350296	3	5	3	2	0.00	1.00	0.00	2.00
45909008	2	2	2	2	0.00	0.00	1.00	2.00
45944638	2	3	4	2	0.00	0.00	1.00	2.00
45904124	6	1	3	2	0.00	0.00	1.00	1.00
44233526	3	3	1	2	0.00	0.00	1.00	2.00
46298502	3	5	2	3	0.00	1.00	0.00	2.00
45956608	3	3	1	2	1.00	0.00	0.00	1.00
45952187	3	3	1	1	1.00	0.00	0.00	2.00
45954991	6	4	2	3	0.00	0.00	1.00	3.00
45952039	3	3	1	3	0.00	0.00	1.00	2.00
46298256	3	3	1	2	1.00	0.00	0.00	3.00
43658633	3	3	4	2	0.00	1.00	0.00	2.00
44352929	2	3	1	2	0.00	1.00	0.00	2.00
45954954	3	3	1	2	1.00	0.00	0.00	1.00
44843447	3	3	1	2	0.00	0.00	1.00	3.00
45323876	2	3	3	2	0.00	1.00	0.00	2.00
45322834	4	2	3	2	0.00	0.00	1.00	2.00
43536878	3	3	1	2	0.00	1.00	0.00	2.00
43528461	3	3	1	2	0.00	1.00	0.00	1.00
45955582	3	3	2	2	0.00	1.00	0.00	2.00
44126465	3	3	1	2	0.00	1.00	0.00	2.00
45956395	3	3	1	2	1.00	0.00	0.00	1.00
45904864	2	2	2	2	1.00	0.00	0.00	2.00
45905467	4	1	2	2	0.00	1.00	0.00	2.00
45894440	6	2	2	2	0.00	1.00	0.00	2.00
45955894	3	3	1	2	0.00	0.00	1.00	1.00
46298100	3	5	2	2	0.00	1.00	0.00	2.00
45893811	6	1	1	2	0.00	0.00	1.00	2.00
46298677	3	3	3	2	0.00	1.00	0.00	2.00

43486276	3	3	2	2	0.00	1.00	0.00	1.00
43493053	3	3	1	2	0.00	1.00	0.00	1.00
45955268	3	5	2	2	1.00	0.00	0.00	1.00
46172639	3	5	1	2	0.00	1.00	0.00	2.00
43351317	3	5	2	2	1.00	0.00	0.00	2.00
45912391	6	1	3	2	1.00	0.00	0.00	2.00
45581718	6	3	2	2	0.00	1.00	0.00	2.00
45894712	6	1	3	2	0.00	0.00	1.00	1.00
44122718	3	3	1	2	0.00	1.00	0.00	1.00
45909846	4	1	2	2	0.00	0.00	1.00	1.00
45956210	1	6	4	2	0.00	1.00	0.00	2.00
43764258	3	5	2	2	0.00	0.00	1.00	1.00
44398343	2	3	3	2	0.00	1.00	0.00	1.00
45384804	6	2	2	2	0.00	1.00	0.00	1.00
45956484	3	3	1	2	0.00	1.00	0.00	2.00
44235537	2	3	3	2	1.00	0.00	0.00	2.00
43484673	3	3	1	2	1.00	0.00	0.00	1.00
43541571	3	3	1	2	0.00	0.00	1.00	1.00
44231306	3	5	2	1	0.00	1.00	0.00	1.00
46299169	5	2	2	1	0.00	0.00	1.00	3.00
45955724	3	5	2	2	0.00	1.00	0.00	1.00
45932838	4	1	1	2	0.00	1.00	0.00	3.00
45956755	3	3	1	2	0.00	1.00	0.00	1.00

Questionnaire data (Factors/challenges)

responseID	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10	i11	i12	i13	i14	i15	i16	i17	i18	i19	i20	i21	i22	i23	i24	i25	i26	i27	i28	i29	i30	i31	i32	i33	i34	i35
43837691	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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43667644	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Questionnaire data (Lean Planning Tools)

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44231306	4	2	1	2	4	2	2
46299169	3	3	4	4	4	3	3
45955724	5	5	4	4	5	4	4
45932838	1	1	1	3	4	2	4
45956755	3	3	1	2	3	1	1

Questionnaire data (Lean practices)

responseID	L1	L2	L3	L4	L5	L6	L7	L8	L9
43837691	0	0	0	0	0	0	0	0	0
43774869	0	0	0	0	0	0	0	0	0
43667644	1	1	1	1	1	1	0	1	2
43537321	0	0	0	0	0	0	0	0	0
46238351	3	3	2	3	3	3	4	5	4
46172975	2	3	3	4	4	4	3	5	4
46299158	2	3	3	4	5	3	4	5	3
45113934	2	2	2	1	1	3	2	4	3
46238446	2	2	1	1	2	2	2	2	2
44257857	1	2	1	2	2	2	1	5	3
46183109	3	2	3	2	2	2	2	4	3
44374078	2	1	2	2	3	3	4	4	3
43491220	2	3	1	3	3	4	1	4	4
44203446	1	1	1	1	3	2	1	4	3
46289413	4	2	5	1	2	2	5	4	4
45893471	2	1	2	2	2	2	1	3	2
45943399	1	3	3	4	3	3	0	5	4
45910891	2	2	2	2	2	2	3	5	4
44122060	2	3	1	1	1	3	2	2	1
45946793	2	2	1	2	1	2	4	5	4
43794648	5	1	1	1	1	1	1	4	3
45945956	1	1	1	1	1	2	2	5	4
46298006	2	2	5	4	0	3	5	5	4
45945310	2	1	2	2	2	3	4	5	4
45947312	1	1	4	1	1	2	4	4	3
45956779	2	1	1	1	1	1	2	4	3
44287598	2	4	4	3	4	3	2	4	4
43490038	4	1	1	2	4	1	1	4	2
43529778	0	0	0	0	0	0	0	0	0
45950673	3	3	3	4	3	1	1	5	5
43599055	2	1	2	2	2	3	1	5	4
45956080	2	2	2	4	1	3	5	5	4
44293257	1	1	1	4	2	4	4	4	3
43471868	1	1	2	1	2	3	3	3	2
44401977	2	2	4	4	5	3	3	5	4
46236608	2	2	2	1	3	3	5	1	1
45951551	2	2	3	2	2	1	2	3	2
43484785	2	2	3	4	1	3	3	5	4
46297604	2	2	1	2	1	3	4	4	4
43583318	3	5	3	4	5	3	5	2	2
43537592	1	1	1	1	1	1	1	3	2

43620655	2	1	2	2	2	3	1	5	4
44202180	0	0	0	0	0	0	0	0	0
45933354	2	3	1	2	1	2	4	4	2
45945003	2	4	1	2	5	4	5	2	2
44254461	2	1	2	1	1	2	2	4	2
43484302	2	2	5	4	1	2	3	5	4
45945641	2	3	3	3	2	2	1	5	2
44291335	2	2	3	3	1	3	3	4	3
43350421	2	1	2	2	1	1	1	3	3
45911849	2	1	2	2	4	2	1	4	4
46298887	2	2	4	2	1	3	3	4	2
46289709	1	1	4	1	2	2	1	5	3
45951225	3	2	1	2	1	4	4	4	4
45944291	1	1	1	2	1	5	1	3	3
43486472	1	1	2	2	1	5	1	5	4
45894130	1	1	2	2	4	2	1	3	1
45541694	1	1	1	1	0	3	0	4	3
45371018	2	0	2	0	1	2	1	2	3
43486996	2	1	2	1	1	2	2	3	2
43350777	2	2	1	2	2	4	1	3	3
45115459	4	2	3	2	2	3	4	4	3
43350312	2	1	1	1	1	1	1	3	2
46182793	3	1	1	1	1	1	2	4	4
46173226	3	1	1	3	1	1	2	5	4
45956216	3	1	1	1	1	3	2	5	3
44843483	1	1	1	2	1	3	3	3	3
46298775	2	1	1	2	1	1	2	3	2
43484897	2	2	2	1	1	2	2	2	2
43503056	2	1	1	1	2	2	1	1	1
43357336	2	1	2	1	1	4	4	5	5
46236872	2	1	2	1	3	1	1	5	4
45912919	2	1	2	1	1	1	2	3	2
45906990	1	1	1	1	1	1	1	5	4
46261304	4	2	1	4	1	2	4	4	4
45906452	2	1	2	2	1	1	2	4	2
45943983	3	2	2	4	1	1	3	5	4
43492896	2	2	3	1	1	1	4	5	3
45955216	1	2	2	2	3	2	2	4	3
45946498	1	1	1	1	1	1	2	3	2
43484883	2	1	0	2	0	3	2	5	4
45955492	1	1	1	2	1	1	1	3	1
46299024	2	1	1	2	1	2	2	3	3
45905952	2	1	1	2	1	3	2	4	4

46289586	1	1	1	2	1	1	1	2	1
45913286	1	1	2	1	1	3	1	3	3
46183474	2	1	1	1	1	2	1	5	4
43509558	1	1	1	1	1	4	1	5	4
44402699	2	1	2	1	1	2	2	4	2
45955979	2	4	1	1	1	4	3	5	3
45907772	1	1	2	1	1	1	2	1	1
45943728	2	2	3	2	1	2	3	3	3
44287168	0	0	0	0	0	0	0	0	0
46237964	2	1	2	1	1	1	1	5	3
46297862	3	3	3	2	1	3	3	4	3
45933164	1	1	1	2	4	1	2	2	2
45947076	2	1	1	2	1	2	4	4	2
43660394	5	1	1	5	4	4	4	5	4
43350296	1	1	1	1	1	1	1	3	1
45909008	1	1	2	1	1	2	2	1	1
45944638	1	1	1	1	1	1	2	3	3
45904124	1	1	2	1	2	2	1	3	2
44233526	2	1	2	2	1	3	2	3	3
46298502	3	1	1	1	2	3	3	4	4
45956608	2	2	3	1	1	3	3	4	4
45952187	3	1	1	3	2	1	4	4	4
45954991	3	3	4	3	1	4	4	5	3
45952039	3	1	2	3	2	3	3	5	4
46298256	1	1	3	2	1	3	3	4	4
43658633	2	1	3	2	1	3	2	4	3
44352929	1	1	3	2	1	1	2	4	4
45954954	3	1	3	5	2	3	3	5	4
44843447	3	2	1	3	3	2	3	3	3
45323876	1	1	1	1	1	2	1	4	2
45322834	1	1	1	1	1	0	0	3	3
43536878	2	0	2	1	0	1	1	4	3
43528461	0	0	0	0	0	0	0	0	0
45955582	1	1	2	3	2	1	4	4	3
44126465	3	3	4	2	2	4	3	3	2
45956395	3	1	3	1	1	4	3	5	4
45904864	1	1	1	1	2	2	1	5	4
45905467	1	1	1	2	1	2	1	3	3
45894440	1	1	1	2	2	3	1	4	2
45955894	2	3	3	1	2	1	3	2	2
46298100	3	1	4	1	2	4	4	1	1
45893811	1	1	2	1	1	2	2	1	1
46298677	1	2	2	2	2	3	3	5	3

43486276	2	1	2	1	1	2	2	3	3
43493053	1	1	1	2	1	1	3	4	3
45955268	2	1	4	1	1	4	3	5	5
46172639	1	1	3	1	1	1	3	4	3
43351317	1	3	4	4	2	4	1	4	3
45912391	1	1	2	2	2	2	1	5	3
45581718	1	0	2	2	1	2	1	4	2
45894712	1	1	3	3	3	4	4	2	2
44122718	3	1	3	5	2	3	3	3	1
45909846	1	1	1	2	2	3	1	4	2
45956210	2	1	4	1	1	2	1	3	2
43764258	1	1	2	1	1	2	2	2	2
44398343	3	1	4	1	1	1	2	4	3
45384804	1	0	0	1	2	2	0	4	3
45956484	1	1	3	1	1	1	3	2	1
44235537	1	1	3	2	2	2	1	4	4
43484673	2	1	2	5	3	2	2	5	4
43541571	1	1	1	2	2	2	1	2	2
44231306	1	1	1	2	1	1	1	4	3
46299169	3	1	4	2	2	1	2	4	2
45955724	3	1	5	1	2	4	4	4	2
45932838	1	1	5	2	1	4	2	4	2
45956755	1	2	5	3	3	4	2	4	3

Questionnaire data (Drivers)

responseID	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
43837691	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43774869	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43667644	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43537321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46238351	4	4	3	4	4	4	4	3	4	4	4	3	4	4	3
46172975	4	3	4	3	3	4	4	3	3	5	4	4	3	3	4
46299158	5	4	3	4	4	4	4	4	5	5	5	3	5	4	5
45113934	4	1	4	4	5	5	5	4	4	4	4	4	4	4	4
46238446	3	3	4	4	3	3	4	4	4	3	4	4	3	4	3
44257857	4	4	4	4	4	4	4	4	3	4	4	4	3	3	3
46183109	4	4	4	3	4	3	3	3	3	4	4	4	4	4	3
44374078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43491220	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4
44203446	4	2	3	5	4	5	2	5	5	2	5	2	5	2	5
46289413	4	5	1	4	3	4	4	3	3	4	5	3	4	4	3
45893471	3	4	3	4	3	4	4	4	4	4	4	3	3	4	3
45943399	3	3	4	4	4	4	3	3	4	0	4	4	4	3	3
45910891	2	3	3	3	4	4	2	3	4	4	4	4	3	4	3
44122060	1	3	3	1	3	5	5	2	1	3	2	2	2	1	5
45946793	3	4	3	4	3	4	3	4	3	3	4	3	4	4	3
43794648	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
45945956	3	4	4	4	4	3	4	4	4	4	4	4	4	4	4
46298006	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3
45945310	3	3	4	4	3	4	4	5	4	4	4	3	4	4	4
45947312	3	4	3	3	4	3	3	4	3	3	4	4	3	3	3
45956779	4	3	3	3	5	5	5	3	4	5	2	4	5	4	5
44287598	5	4	4	5	5	5	5	4	5	5	5	5	5	4	5
43490038	4	5	4	4	4	4	4	5	4	3	5	4	5	4	4
43529778	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45950673	5	4	3	4	4	4	4	4	5	5	5	3	5	4	5
43599055	4	5	4	4	5	5	5	5	5	5	4	4	4	4	4
45956080	3	3	3	0	4	5	3	2	4	5	5	4	5	2	2
44293257	5	2	4	3	3	4	4	3	3	3	3	4	3	3	4
43471868	3	4	5	0	3	3	2	3	3	5	4	4	4	3	4
44401977	5	3	5	5	3	3	3	4	5	5	4	5	4	4	5
46236608	3	2	4	4	4	4	4	4	4	3	4	4	4	5	4
45951551	4	4	3	5	4	4	4	4	4	4	5	3	4	4	5
43484785	4	3	5	3	4	4	3	5	4	5	4	3	4	4	5
46297604	1	3	4	5	4	4	3	4	3	3	4	3	4	3	3
43583318	3	4	2	4	4	0	4	5	3	3	4	4	5	5	5

43537592	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
43620655	4	5	4	4	4	4	4	5	4	5	3	4	5	4	4
44202180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45933354	2	4	2	3	2	2	1	1	2	3	4	4	3	3	3
45945003	4	4	2	3	2	2	3	4	4	1	3	2	4	4	1
44254461	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
43484302	3	3	4	3	3	3	3	3	4	4	3	4	4	4	3
45945641	4	3	3	3	4	4	4	4	3	3	2	2	3	4	4
44291335	4	2	4	4	4	4	4	4	4	2	4	2	4	3	4
43350421	4	4	4	4	4	4	4	4	4	4	4	3	3	4	3
45911849	3	4	3	4	3	4	4	4	4	4	4	3	3	4	3
46298887	4	3	4	3	4	4	4	4	4	3	4	4	4	4	4
46289709	4	4	4	4	4	4	4	4	3	4	4	3	3	4	4
45951225	4	4	4	4	4	4	4	4	3	4	4	3	4	4	4
45944291	3	3	3	4	1	3	5	4	3	4	4	3	2	4	3
43486472	2	2	4	5	4	4	3	3	4	4	5	4	4	3	4
45894130	2	3	4	4	3	4	4	3	3	4	4	3	4	3	4
45541694	3	4	5	4	5	5	5	4	3	4	3	3	4	3	5
45371018	3	2	5	3	3	3	3	4	3	2	2	3	3	3	5
43486996	4	2	4	5	2	3	3	3	0	2	4	5	2	3	3
43350777	3	4	4	3	4	4	4	4	4	4	3	5	4	4	4
45115459	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4
43350312	4	3	4	4	4	4	4	4	4	3	4	4	4	4	4
46182793	3	4	4	5	4	4	4	5	5	3	4	4	5	5	5
46173226	3	4	4	4	5	4	4	5	5	5	4	4	5	5	5
45956216	3	4	4	4	5	4	4	5	5	5	4	4	4	5	5
44843483	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
46298775	2	2	3	3	4	4	4	4	3	4	3	4	3	3	3
43484897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43503056	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
43357336	4	3	4	4	1	4	3	3	3	3	3	3	4	4	4
46236872	4	4	4	5	5	5	4	4	3	3	3	3	4	4	5
45912919	3	4	4	4	4	4	4	4	3	3	4	5	4	3	4
45906990	4	2	5	3	3	4	4	3	3	4	3	3	4	3	4
46261304	4	5	3	4	3	4	4	3	3	4	5	4	4	4	3
45906452	3	4	5	3	4	4	4	4	3	3	3	3	3	3	4
45943983	4	3	3	4	4	0	4	4	4	4	4	4	4	4	4
43492896	4	3	5	4	5	5	5	3	3	4	5	5	5	5	5
45955216	4	0	3	4	5	4	3	3	5	2	5	2	5	4	4
45946498	3	4	2	4	3	3	4	4	4	1	4	2	4	4	1
43484883	4	3	4	4	4	4	4	4	4	4	5	3	4	4	4
45955492	0	4	3	2	2	3	2	3	4	3	2	3	3	3	3
46299024	4	4	4	3	3	4	4	3	4	4	3	3	4	4	4

45905952	3	4	4	3	4	3	3	4	2	3	3	3	3	2	3
46289586	4	2	3	2	3	3	3	3	3	3	2	3	3	3	3
45913286	3	3	3	3	3	4	4	0	3	3	3	4	3	4	4
46183474	2	3	4	3	4	4	3	4	4	3	3	3	2	2	3
43509558	4	3	2	4	4	4	4	4	4	4	3	2	3	3	4
44402699	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
45955979	2	1	2	2	2	3	4	3	2	2	4	1	2	2	2
45907772	4	4	4	4	4	4	4	4	3	4	3	3	3	4	4
45943728	3	2	3	2	3	4	3	4	3	3	2	3	4	4	3
44287168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46237964	4	4	3	3	3	3	3	4	4	4	3	3	4	3	3
46297862	2	2	4	4	3	3	4	4	4	3	4	3	4	3	3
45933164	3	4	3	4	4	4	4	4	4	4	4	1	4	3	5
45947076	4	4	3	3	2	3	3	4	4	2	3	3	4	3	4
43660394	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
43350296	0	1	1	5	4	4	3	2	1	1	5	2	1	1	5
45909008	4	3	4	3	4	3	3	2	3	4	3	3	3	3	4
45944638	3	4	4	4	4	4	4	3	3	4	4	2	4	3	4
45904124	4	3	3	3	4	4	3	3	2	4	4	3	3	3	3
44233526	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
46298502	4	4	4	4	4	4	4	4	4	3	3	3	3	4	4
45956608	4	3	5	4	4	5	0	5	5	5	3	4	5	5	4
45952187	4	4	4	5	5	5	4	4	4	3	5	5	5	5	5
45954991	4	4	4	5	5	4	4	4	5	3	5	5	5	5	5
45952039	4	4	3	5	5	5	4	4	4	4	5	4	5	5	5
46298256	4	4	5	4	5	5	4	4	5	5	5	5	4	5	5
43658633	4	2	4	4	3	3	4	4	4	4	4	4	5	5	5
44352929	5	2	5	5	5	5	5	2	5	5	4	5	5	5	4
45954954	5	5	5	5	5	5	4	5	5	5	5	4	5	5	5
44843447	4	4	3	5	5	5	5	4	4	4	3	1	3	2	4
45323876	4	4	5	4	5	5	3	5	2	4	3	2	3	2	4
45322834	3	4	4	4	4	3	3	5	3	4	3	2	3	3	4
43536878	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0
43528461	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45955582	2	1	5	1	2	2	1	2	1	2	2	3	2	1	2
44126465	4	5	3	4	4	5	5	5	4	4	4	3	4	4	5
45956395	2	1	1	0	2	2	3	4	2	2	3	4	3	2	2
45904864	3	0	3	5	3	4	4	3	4	3	3	3	4	3	4
45905467	3	4	4	3	4	4	4	4	3	2	3	4	3	2	3
45894440	4	3	4	4	3	4	4	4	4	4	4	3	3	4	4
45955894	4	4	3	4	5	4	4	3	4	3	4	4	4	5	3
46298100	4	5	1	4	3	4	4	3	3	4	5	3	2	2	3
45893811	4	3	4	3	4	3	3	2	3	4	3	3	3	3	4

46298677	4	4	4	3	3	4	3	5	4	4	3	4	3	4	4
43486276	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
43493053	4	2	4	4	5	4	1	2	2	4	4	1	4	5	5
45955268	2	1	4	2	3	4	4	2	2	3	3	3	2	1	2
46172639	2	1	4	2	2	3	3	2	2	3	3	3	2	1	2
43351317	4	4	2	0	3	3	3	4	4	0	4	4	4	4	0
45912391	2	3	4	4	4	3	3	2	3	4	4	3	3	3	4
45581718	4	3	4	5	4	4	3	5	3	4	4	3	3	4	5
45894712	2	3	4	4	5	5	5	5	5	5	4	4	2	4	4
44122718	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45909846	4	3	4	4	3	4	4	4	4	4	4	3	3	4	4
45956210	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
43764258	4	4	4	4	4	4	4	4	4	4	3	4	4	4	0
44398343	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4
45384804	2	3	0	4	4	3	3	5	0	4	0	4	4	0	5
45956484	2	1	4	2	2	3	4	2	2	3	3	3	2	1	2
44235537	4	5	4	4	3	5	5	2	4	4	5	3	4	4	5
43484673	4	4	4	4	4	3	3	3	3	4	5	3	2	3	4
43541571	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44231306	4	4	4	4	4	4	2	5	4	4	4	4	4	4	4
46299169	4	4	5	5	4	5	4	4	4	5	5	5	5	4	5
45955724	4	5	2	5	4	3	4	5	3	3	4	1	3	4	4
45932838	3	2	3	4	3	4	4	4	4	4	4	4	4	5	5
45956755	1	5	5	4	5	5	5	3	3	1	3	4	4	5	5