CRANFIELD UNIVERSITY

MOHAMMED AL MANEI

Lean manufacturing implementation framework based on change management theory and interpretive structural modelling

SCHOOL OF AEROSPACE, TRANSPORT AND MANUFACTURING

PHD
Academic Year: 2016 - 2019

Supervisor: Professor Konstantinos Salonitis
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ABSTRACT

Lean management focuses in reducing waste and improve the efficiency of companies. Although in many instances, what is proposed by lean philosophy sounds like common sense, companies do struggle with implementing lean principles.

The current research presents a novel framework developed in order to support the lean transformation for manufacturing companies. The framework is based on the change management theory and interpretive structural models. The proposed framework was validated in the United Arabic Emirates (UAE) manufacturing sector.

The framework is composed of two main parts, a change transformation approach based on Kotter's leading change model, and a roadmap for implementing lean tools. The framework proposed was validated using experts' opinion.

The manufacturing sector in UAE is mostly composed of Small and Medium Enterprises, and as such they face a number of challenges when they attempt introduction of lean manufacturing. A questionnaire has been developed for assessing the status of lean manufacturing in the UAE. The level of understanding of lean principles and lean techniques and methods is assessed. The drivers promoting lean thinking and the barriers in the implementation are investigated. The analysis of the responses is currently undertaken.

Interpretive structural models (ISM) were also developed for understanding the relationships between the critical success variables and the barriers when implementing lean. The ISM model fed to the lean implementation framework developed. The results and overall feedback from the validation reflected a high level of acceptance of the framework structure and approach. The novel framework has the capability to improve the lean implementation process.

Keywords:

Lean Manufacturing; Lean Implementation; Change Management; Interpretive structural modelling

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LIST OF PUBLICATIONS

Journal Publications

[1]. Almanei M., Salonitis K. (2019) “Lean manufacturing implementation framework based on ISM and Change management” submitted for publication

[2]. Alefari M., Almanei M., Salonitis K. (2019) “Lean manufacturing, leadership and employees: the case of UAE manufacturing sector” submitted for publication

Conference Publications

[3]. Almanei M., Salonitis K. (2019) “Continuous improvement initiatives: an ISM analysis of critical success factors and barriers” Advances in Transdisciplinary Engineering, Vol. 9, pp. 485-491, DOI: 10.3233/ATDE190085 (Proceedings of the 17th International Conference of Manufacturing)

[4]. Almanei M., Salonitis K., Tsinopoulos C. (2018) “A conceptual lean implementation framework based on change management theory”, Procedia CIRP, Vol. 72, pp. 1160-1165 DOI: 10.1016/j.procir.2018.03.141 (Proceedings of the 51st CIRP Conference on Manufacturing Systems)

[5]. Almanei M., Salonitis K. (2018) “Challenges of implementing lean in UAE manufacturing sector”, Advances in Transdisciplinary Engineering, Vol. 8, pp. 499-504, DOI: 10.3233/978-1-61499-902-7-499 (Proceedings of the 16th International Conference on Manufacturing Research)

[6]. Almanei M., Salonitis K., Xu Y. (2017) “Lean Implementation Frameworks: The challenges for SMEs” Procedia CIRP, Vol. 63, pp. 750-755. DOI: 10.1016/j.procir.2017.03.170 (Proceedings of the 50th CIRP Conference on Manufacturing Systems)

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LIST OF ABBREVIATIONS

CS	Critical Success Factor
GCC	Gulf Cooperation Council
ISM	Interpretive Structural Modelling
JIT	Just in Time
LIB	Lean Implementation barier
LM	Lean Manufacturing
MICMAC	Matriced' Impacts croises-multipication applique' and classment
PDCA	Plan Do Check Act
RO	Research Objective
SME	Small and Medium Enterprise
SMED	Single Minute Exchange of Dies
SOP	Standard Operating Procedure
SSIM	Structural Self-Interaction Matrix
TPM	Total Productive Maintenance
TPS	Toyota Production System
UAE	United Arab Emirates

1 INTRODUCTION

1.1 Background and motivation

Lean manufacturing, that has evolved in lean management and thinking, has a history of almost 70 years. It was developed for the needs of the automotive sector at Japan after the second World War. The term “lean manufacturing” was proposed by Krafcik (1988), quite some time after the first introduction of the production system. Lean manufacturing is the Toyota Production System (TPS). A comprehensive definition for lean manufacturing is had been provided by Shah and Ward, (2007): “*Lean manufacturing is an integrated socio-technical system, whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability*”. The overall aim of lean manufacturing aims is to perform at the same and even better level with less input. As input in the lean terminology is considered the required time, space, human resources, machinery and equipment, material and obviously capital (Womack et al., 1990).

Although there is a tendency of oversimplification suggesting that lean management and manufacturing is only a set of tools that can help boost productivity, reality is quite different as many publications on the topic have proved till now. Lean impacts the whole of the organization, and in many instances is considered as a new management philosophy. The culture of the organization and the acceptance of change can have a great impact on the successful lean implementation. The frameworks available are characterized by high complexity and in many instances vagueness. It is thus obvious, that several factors need to be considered even before the beginning of any lean implementation project as stakeholders within and outside the organization can have conflicting interests.

Experience and industrial anecdotes indicate that most organization are willing to start implementing lean, only to find out that there is not a straightforward process for doing so and there can been no guaranteed successful end. As experience has shown, when lean implementation is not successful, it can result in a very negative impact on the organization as a whole, due to misuse of available

resources. Such a misfortune can affect the morale of the employees and their confidence in lean philosophy (Marvel and Standridge, 2009). A large number of roadmaps and frameworks have been proposed by both academic and consultancy firms that promise to guide organizations to fully implements lean philosophy.

The introduction of lean thinking and management in Small and Medium Enterprises (SMEs) is more challenging compared to large organizations. As highlighted by Achanga et al. (2006), SMEs need to have a clear understanding of both the cost of implementation and the potential benefits for the organization, in order to commit themselves in such a big change programme. To reinforce this statement, most SMEs when compared to large organizations they have limited resources, and in many cases the senior management lacks the long term commitment required.

Within the United Arab Emirates (UAE), manufacturing sector in contributes up to 14% to the overall GDP in 2015 (Rahman, 2015). An objective aim has been set to reach 20% by 2021 and ultimately 25% by 2025. Figure 1 indicates the UAE manufacturing sector status for year 2014. The manufacturing sector in UAE is composed mostly of SMEs; Tsetsonis (2014) reports that 94% of the manufacturing sector companies are SMEs. It is thus obvious that the challenges identified for SMEs are the challenges that the whole manufacturing sector is facing in UAE.

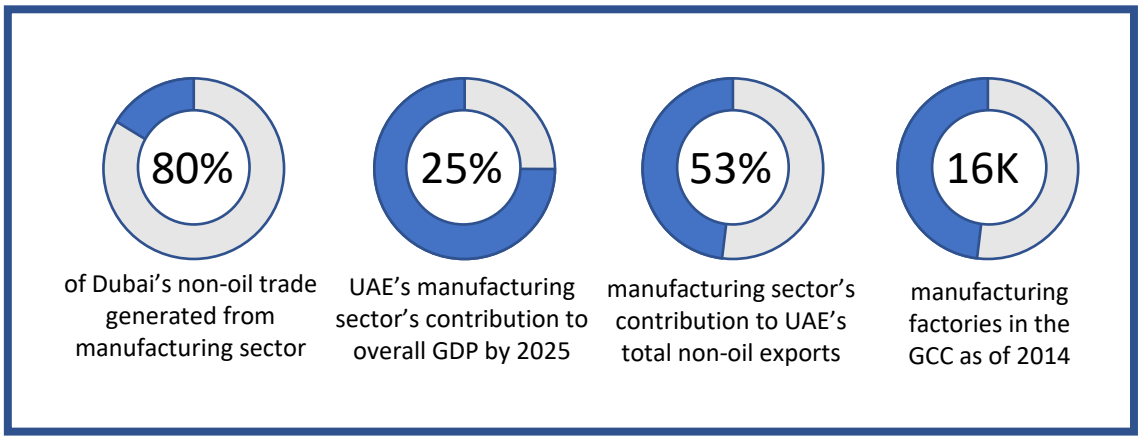


Figure 1-1 UAE manufacturing sector insight (based on GCCmanufacturing, 2017)

1.2 Aim and objectives

The **aim** of the present study is:

> to develop a Lean Manufacturing framework based on interpretive structural modelling and change management theory to enhance the productivity and performance of manufacturing companies focusing on UAE manufacturing sector.

To achieve this aim, the following objectives (ROs) have been set for the research:

RO1: To analyse the current global trends in lean thinking and the use of organisational change management theory in implementing lean through literature review

RO2: To assess the current practices with regards lean implementation in Middle Eastern countries and UAE in particular focusing in identifying (i) the success factors affecting organisational performance, (ii) the enablers that smoothen the introduction and implementation of lean management (LM)

RO3: To develop a framework for implementing lean philosophy in the manufacturing companies, that can be tailored to UAE manufacturing sector, based on interpretive structural modelling and change management theory, including the guidelines and the associated processes that has to be adopted by manufacturers.

RO4: To validate the framework based on experts' judgement.

1.3 Novelty of the framework and contributions to knowledge

The research will lead to a framework that can be used from SMEs in the middle east for introducing and implementing lean manufacturing. Such a framework will be composed of the necessary steps for the introduction of the lean tools, the sequence of the tools to be used and the methods that can be employed for

changing the culture of the employees. For the latter reason, the model will be developed based on the most recent change management theories and approaches.

No model/framework has been found in the literature for the lean implementation that is based on change management theory. Furthermore, no model has been developed or adjusted to the needs of middle east manufacturing SMEs. Whether there is a need for such tailoring is something that the present study will investigate.

1.4 Thesis structure and organization

The thesis is structured in seven chapters (Figure 1-2). In the following section a brief introduction of all the structures is presented.

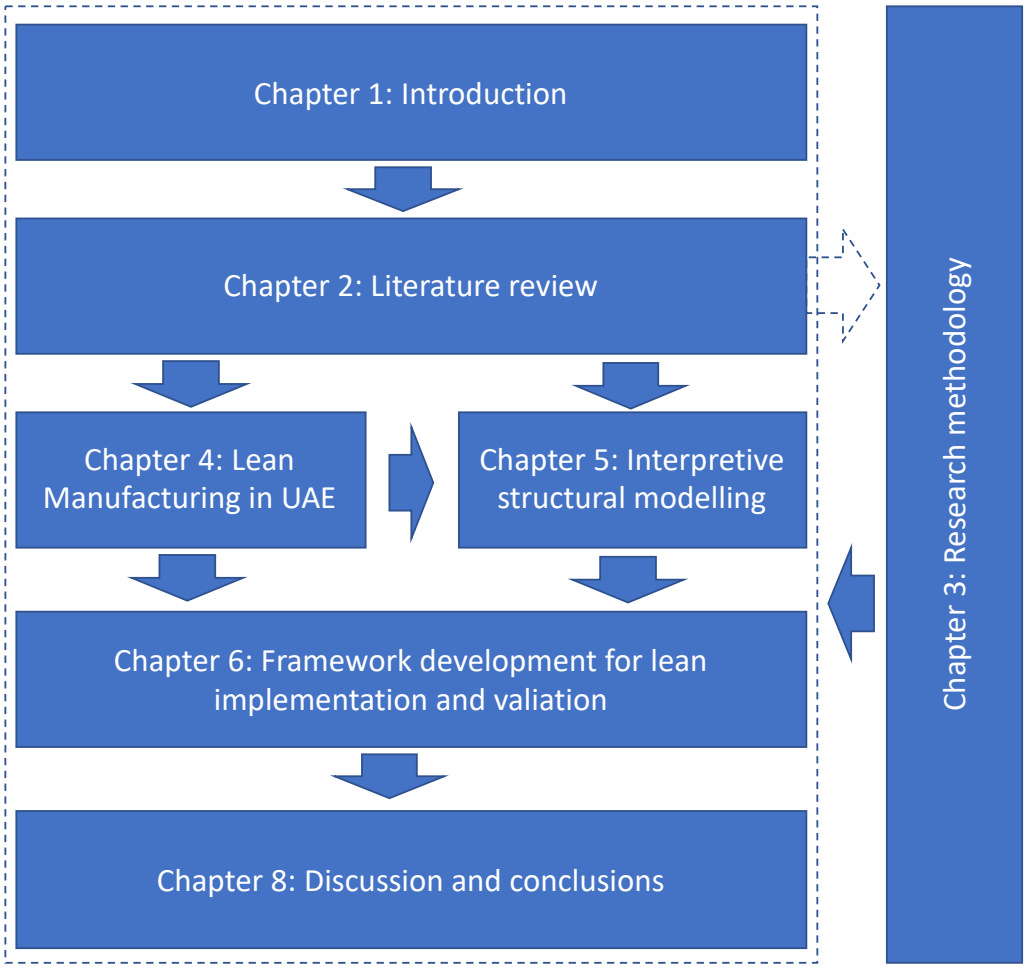


Figure 1-2 Thesis Structure

The present first chapter presents a brief introduction on the research problem and the motivation behind this research. These lead to the research aim and objectives.

Chapter 2 presents a thorough review on the literature that is related to the present study. Two main themes are covered within the literature review, the lean manufacturing and how it is implemented both from academia and industry, as well as the change management theory and the models that have been proposed over the years.

Chapter 3 presents the research methodology adopted for the present research. The chapter focuses in providing information with regards the research approaches and strategies that have been selected and the selection of data collection methods.

Chapter 4 presents a questionnaire that was developed based on the findings of the literature review, as to capture the lean understanding, maturity and implementation within the UAE manufacturing SMEs.

Chapter 5 presents the development of a structural model based on the interpretive structural modelling (ISM) methodology. This complements the findings of chapter 4 with regards capturing the views of experts in lean manufacturing in UAE. MICMAC analysis of the developed ISM model is presented, as to understand the driving power and dependence of the variables.

In Chapter 6 the developed framework that is based on change management and interpretive structural modelling for lean implementation is introduced with description for its different parts. The process phases, stages, and activities to be performed throughout the process to ensure successful implementation are covered. In the same chapter the validation and verification of the full framework is presented. Using experts opinion, the framework is assessed for a number of dimensions.

The final chapter (Chapter 7) presents the discussion of the findings, the contributions to knowledge, the conclusions and ideas for future research.

2 LITERATURE REVIEW

2.1 Introduction[1]

The present chapter summarizes the literature review process adopted foe the needs of the study, as well as the key literature review findings. The literature review is based mainly on peer reviewed papers published on journals and referred conferences. Several academic databases and search engines such as Google Scholar and Scopus, were searched for finding relevant studies. A structured literature review process was adopted, following Fink's (2005) paradigm.

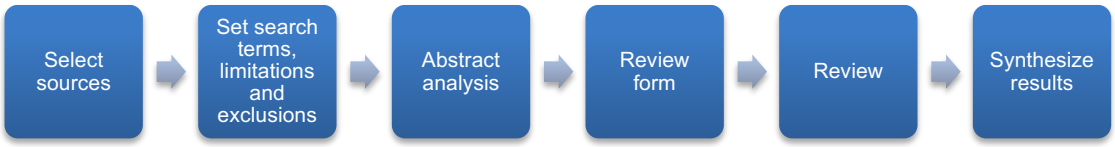


Figure 2-1 Literature review approach adopted in the present study (based on Fink, 2005)

Chapter 2 is divided into two main subchapters, one focusing on "lean manufacturing" and one on "change management".

2.2 Literature review on lean manufacturing

The review of the lean manufacturing literature included several keywords. The following mind map illustrates the areas that were studied in the context of the literature review. Figure 2-2 presents the key keywords that were used for investigating lean manufacturing. For setting the background, the literature review started with reviewing the history of lean manufacturing and the key

[1] Parts of the work presented in Chapter 2 has been published into two papers, namely:

- Almanei M., Salonitis K., Tsinopoulos C. (2018) "A conceptual lean implementation framework based on change management theory", Procedia CIRP, Vol. 72, pp. 1160-1165
- Almanei M., Salonitis K., Xu Y. (2017) "Lean Implementation Frameworks: The challenges for SMEs" Procedia CIRP, Vol. 63, pp. 750-755.

figures who played a critical role in its development, such as Ohno, Shingo, Womack, Jones and Roos. In any proposed change, including implementing lean, the anticipated benefits, the challenges and the critical success factors need to be discussed. The five lean manufacturing principles and the tools that can be used are discussed also in the context of implementation. Finally the literature review focuses on the various implementation frameworks that have been presented in the literature, critically discussing their limitations.

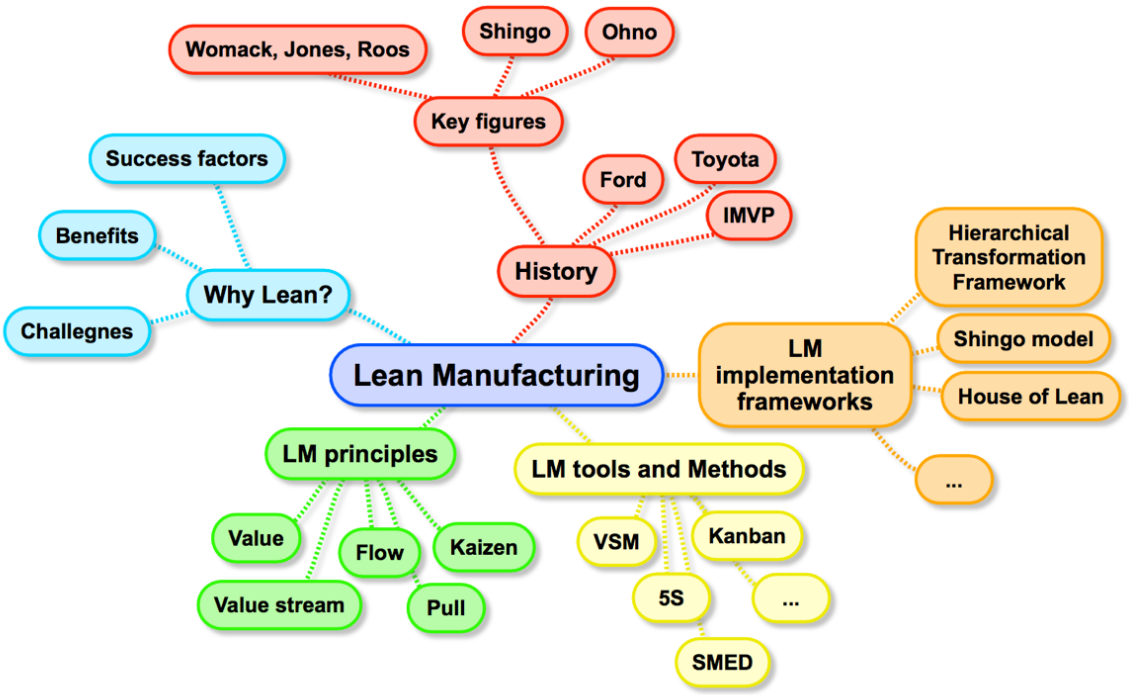


Figure 2-2 Literature review mind-map

2.2.1 Definitions and history

Shah and Ward, (2007) provided a comprehensive definition for lean manufacturing: *"Lean manufacturing is an integrated socio-technical system, whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability"*.

Lean manufacturing was introduced about 70 years ago as the Toyota Production System. Ohno, who is considered as one of the "fathers" of the Toyota Production System, in an attempt to develop the most appropriate production system for the Japanese automotive manufacturers, adapted Ford's approach to the special

needs of Toyota (Hines et al., 2004). He experimented with several ideas such as Just in Time (JIT), Single Minute Exchange of Dies, Supermarkets, Kanban, etc. that led to the establishment of the Toyota Production System (TPS). This production system has been developed gradually for more than 40 years within Japan automotive sector and their suppliers, before it was finally discovered by the western manufacturers. Lean manufacturing is the evolution of the Toyota Production System. Figure 2-3 summarizes the lean philosophy milestones over the years.

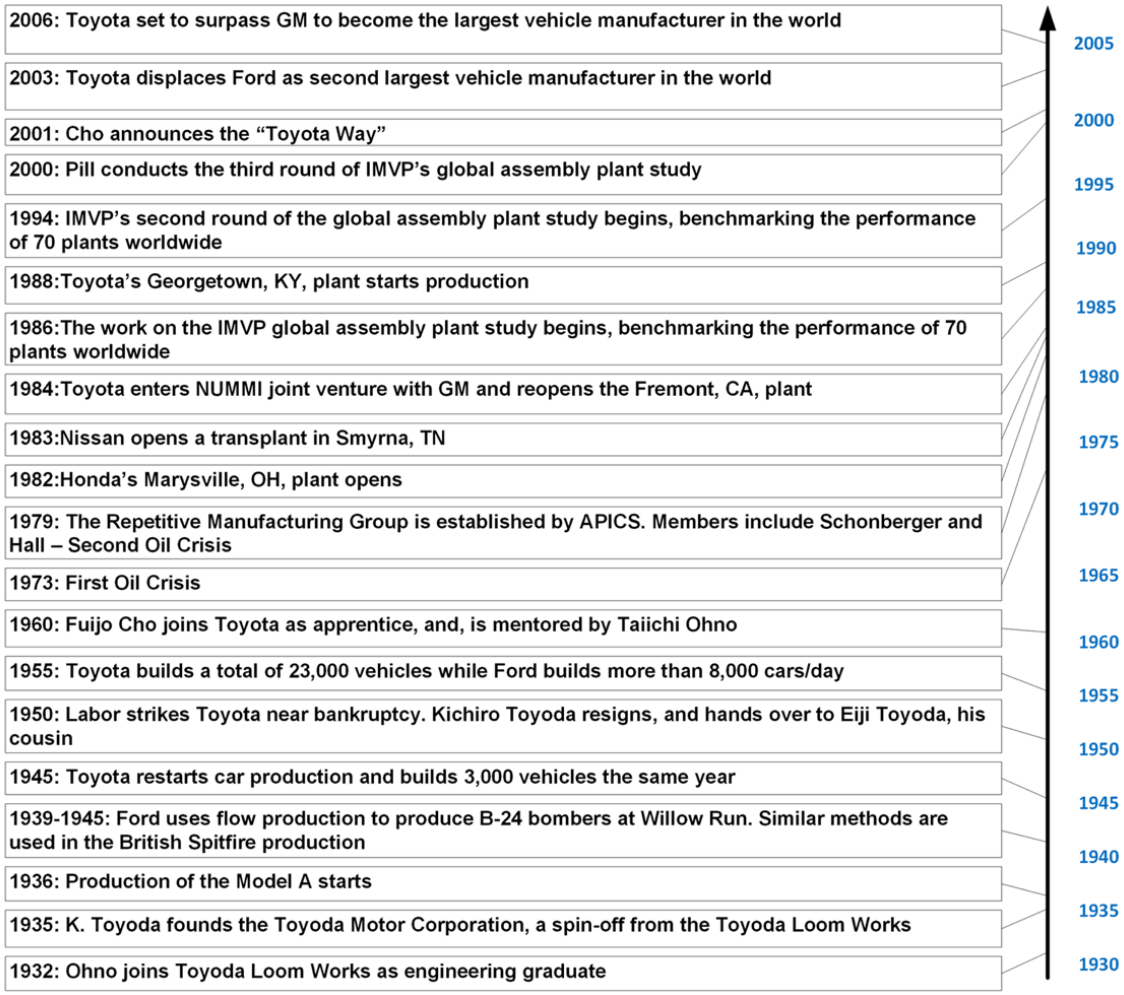


Figure 2-3 Lean philosophy evolution over time (Mourtzis and Doukas, 2014)

Womack and Jones, (1996) in their ground braking work on lean defined five principles that characterize lean, these are:

- *Value from customer's perspective*: the product or service offered by the

organization must be what the customer actually wants. This indicates the need for the organization to be able to identify what is that the customer values in a product or a service

- *Map the value stream*: the production system for the manufacturing of products, following the product from the order request to satisfying the customer at delivery. All the processes and their sequence inside an organization as to identify where value is created
- *Flow*: for maximizing the value of a production system, products need flow within the system with no obstructions. Such obstructions, reffered to as waste in lean terminology, need to be identified as non-value adding activities and eliminated
- *Pull*: a manufacturing system or programme plan that resources used are only replaced once they have been consumed. Such an approach allows the downstream processes to control the upstream ones (the type of activities, their workload, and objectives)
- *Seek perfection or continuous improvement*: the culture of the organization to continually working on how to improve the quality of the products and services that offers to its customers (both internal and external ones)

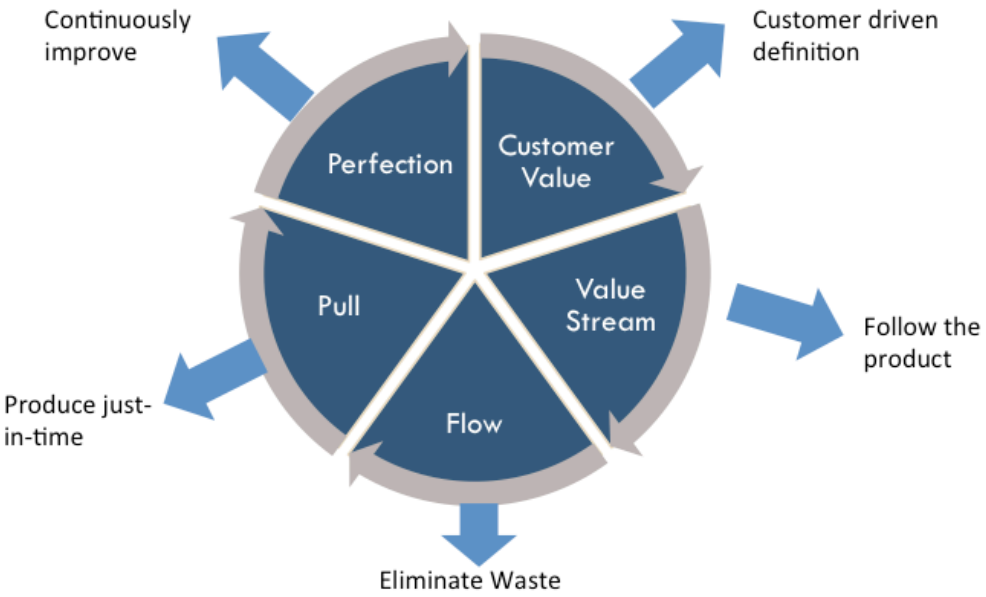


Figure 2-4 Lean principles

These principles can help setting the vision, but they do not provide any guidance on how to achieve this. One of the first “implementation” frameworks was the so called “house of lean”. This virtual “house” is composed of three elements, the foundations, the walls and the roof. In a similar process of building a house, the lean tools need to be applied in order to first set the “foundations” (namely increase the stability and control the variation in the organization), shown as I. in figure 2-5. Then the “walls” (through manufacturing, continuous improvement, and quality) have to be build (groups II, II and IV in figure 2-5 respectively). Finally build the “roof” (with the appropriate policy deployment, shown as V, in figure 2-5). Each element is supported with a number of lean tools that can be used for facilitating the implementation (Figure 2-5).

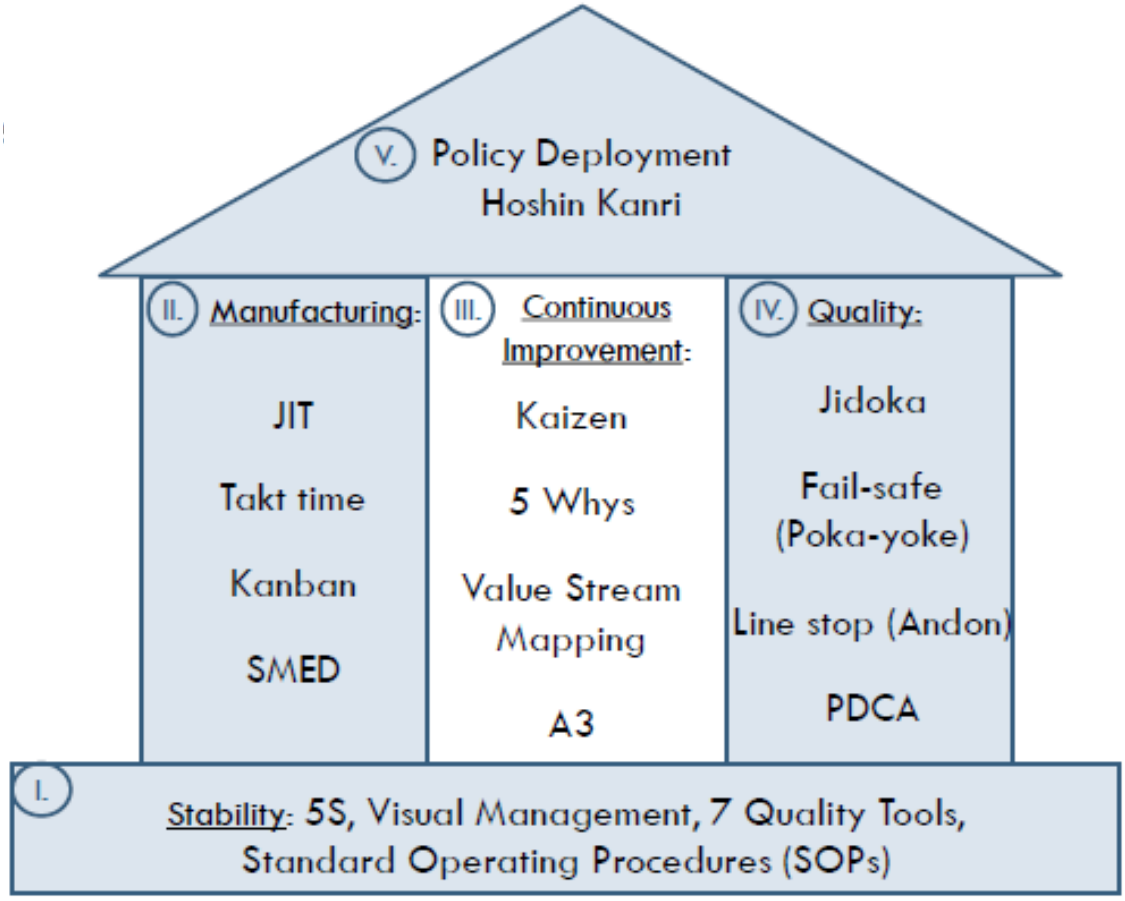


Figure 2-5 House of lean

2.2.2 Lean Implementation

Lean manufacturing is implemented in most companies for reducing or even eliminating waste, reducing cycle times and inventory levels, improve labour productivity etc. to name few. This eventually leads to the reduction of unit costs. The benefits thus of using lean manufacturing are well reported in the literature.

Furthermore, a review of the available lean tools was conducted. The ones that most commonly appear in the relevant literature include (alphabetically ordered):

- A3
- Andon
- Cellular manufacturing
- Continuous Flow
- Customer engagement
- Five S
- Gemba
- Heijunka
- Identifying and eliminating waste
- Jidoka
- Just in time (JIT)
- Kanban
- Kaizen
- Lean supply chain
- Leveling
- Muda
- Poka-yoke
- Preventive maintenance (TPM)
- Single minute exchange of dies (SMED)
- Six Sigma / Lean Sigma
- Supplier engagement
- Pull production
- Quality circles
- Value stream mapping (VSM)
- Visual control (Andon)
- Workforce engagement

The list is not exhaustive, Marchwinski (2014) provided a lexicon for lean terms, that includes more than 150 lean related terms. For the present study the focus is on the few most frequently found in academic papers. These can be classified as per their focus into five categories (Figure 2-6):

- “customer relationships”,
- “supplier relationships”,
- “human recourses”,
- “manufacturing planning and control” and
- “process and equipment” related ones.

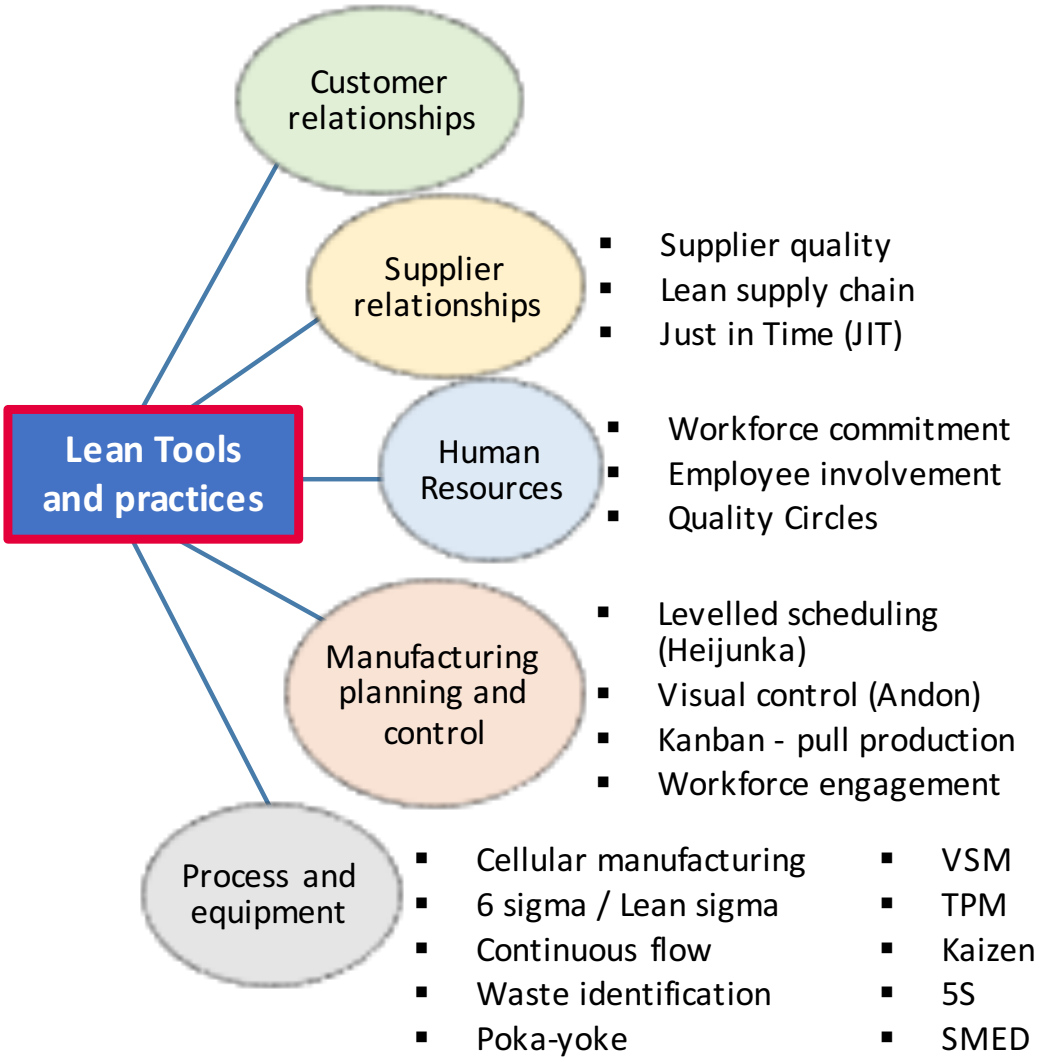


Figure 2-6 Lean manufacturing tools and practices classified in five categories

2.2.3 Review of existing lean implementation frameworks

Several lean implementation frameworks were reviewed as part of research objective one that focuses on analyzing the lean implementation approaches and frameworks presented in the literature.

In the last 30 years, a number of lean implementation frameworks have been presented in academic papers and conference publications. In most of the cases, such frameworks are formatted as roadmaps, guiding the lean practitioners and champions how to implement lean principles, focusing on the sequence of the lean tools to be introduced in the organization.

2.2.3.1 Academic lean implementation framework

The earliest lean implementation framework found in the literature, was proposed by Shingo (1989). Shingo suggested a set of lean projects that a company should start with when they try to introduce lean such as 5S, setting up SOPs, Kanban etc. Kowalski (1996), structured his own framework, that is composed of 10 steps focusing on the effectiveness of working systems and the standardization of work. Similarly, Beck (1999) came up with also a 10 steps framework, although his focus was in the design and layout planning. Kowalski (1996) and Beck (1999) roadmaps shown for comparison reasons in figure 2-7.

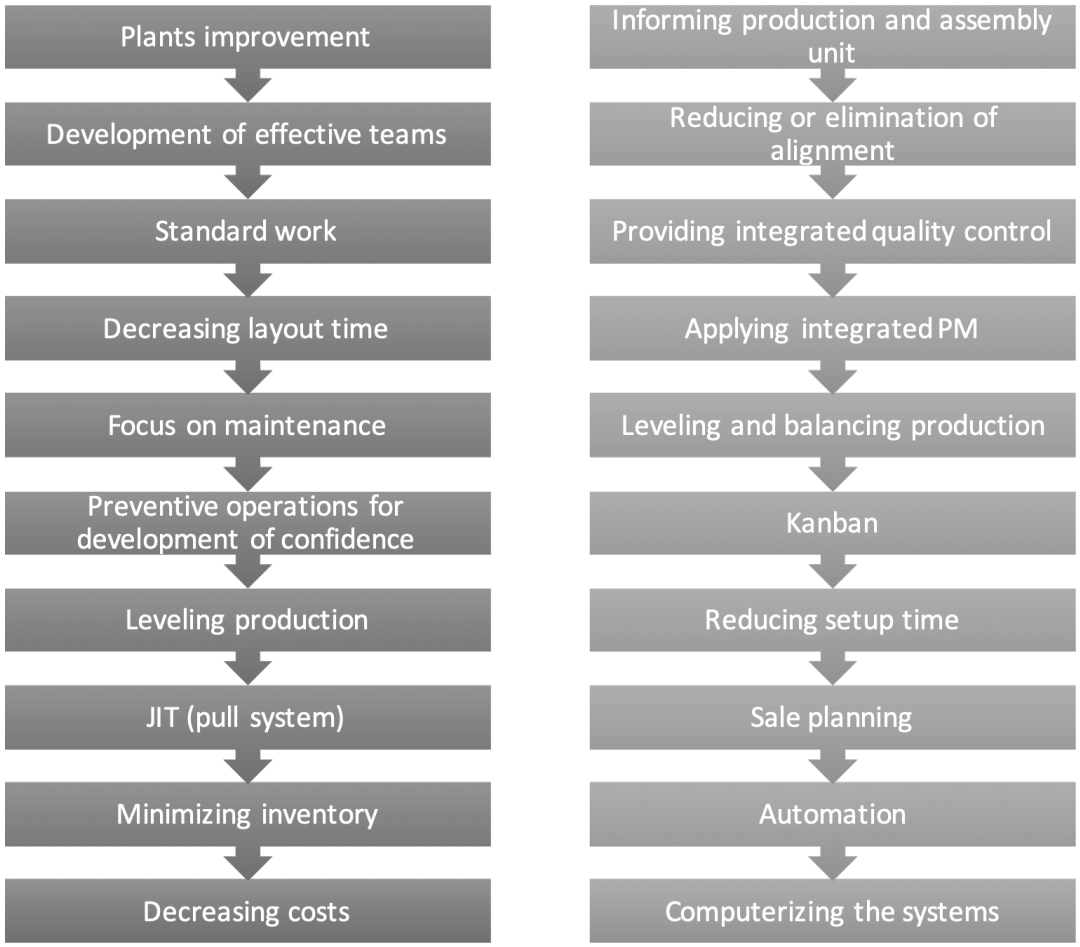


Figure 2-7 Kowalski (left) and Beck (right) lean implementation frameworks

Hilbert (1998) proposed a two-phase model for implementing lean. The first phase is composed of seven steps whereas the second phase is composed of four key stages. The stages within the first phase are “identifying a launch team,

a production team and key leadership"; "establishing a shared vision among stakeholders"; "establishing a method of evaluating the performance of the change effort"; "establishing stability of current system"; "providing a definition for suitable policy to integrate social and technical aspects of lean elements"; "creating design process with regard to coordinating hardware and software resources to leanness"; and "offering necessary alternatives to solving the probable conflicts". These stages need to be completed before moving to the second phase. The stages in that case include: "building a shared vision", "planning and designing the change", "managing the change", and "celebration and continuous improvement". Hilbert focus more on social, cultural, and educational aspects instead of just the use of tools and their operational components as the frameworks discussed previously.

Åhlström (2011) presented a framework as well. His framework is composed of core and supporting principles after building a "foundation". For the foundation, specific initiatives need to be undertaken, that include "zero defects" and "decentralization and integration of functions" initiatives. These are considered as pre-requisites for stabilizing the organization to a minimum lean maturity level before setting off to implement the full transformation. The core elements of his framework include the "elimination of waste", the "setting up multifunctional teams", and the introduction of "pull scheduling" in the shop floor. These elements are supported from a set of integration tools such as the "vertical information system" and capable and committed team leaders.

Anvari et al. (2011) presented a thorough review of available lean frameworks in the literature published from 1996 to 2001. They focused in identifying their key similarities. They found out that almost all frameworks are composed of three phases: the preparation phase, the design phase and the implementation phase. Table 2-1 presents the outcome of their analysis. A dynamic model was suggested that accounts for the volatility the organizations have to phase when they set-off to implement lean.

Table 2-1 Lean implementation phases and the specific steps to be implemented (based on Anvari et al., 2011)

Lean phase	Step
Phase 1: Preparation	Gap assessment of current performance
	Strategic planning of next steps
	Understanding the notion of (lean) waste
	Setting the objectives
	Align the organizational structure to the change
	Appointing a change agent
	Setting up an implementation team
	Training the implementation team
	Engagement of the supply chain and customers
	Acknowledge the need for change
Phase 2: Design	Perform VSM
	Identify opportunities for improvement
	Plan of the changes to be implemented
	Identify the metrics / KPIs to measure performance
	Set up a feedback mechanism
Phace 3: Implementation	Initiate with a small pilot lean project
	Initiate the follow up (more complex) implementation projects
	Evaluating and sustaining changes
	Changing the material SC systems and philosophies
	Selling the benefits of “lean” thinking
	Pursue perfection
	Expansion of the scope to SC and customers

Table 2-2 Frequency of specific steps occurring in most of the reviewed frameworks (Anvari et al., 2011)

High frequency	Medium frequency	Low frequency
- Initiate with a small pilot lean project - Plan of the changes to be implemented - Perform VSM - Analysis of the organization - Training of implementation teams	- Evaluating changes - Acknowledge the need for change - Appoint a change agent Determining objectives - Aligning the organisational structure - Establishing change teams	- Gap assessment of current performance - Expansion of the scope to SC and customers - Promote lean thinking internally - Set-up the feedback mechanism - Identify the metrics / KPIs to measure performance - Strategic planning of next steps

MIT has been pioneering in the investigation of the TPS system. Their Lean Aerospace Initiative (LAI, 2001) has been working in developing frameworks for more than 20 years now. The “Enterprise Level Roadmap” was proposed in 2001, for organizations to move to higher levels of lean. This can be used by the leadership and senior management within the organization to identify the sequence of steps that they need to follow. For each step and requirements are provided and a set of tools and processes are proposed.

The roadmap is composed of three main stages, the “Entry”, the “Long term” and the “short term” cycle. The process starts with a high-level description and sequence of first important activities that the management needs to adopt. The key advantage of this approach is the holistic systems approach of the enterprise and not just focusing on shop floor. LAI also provides a lean implementation roadmap for helping organization to move and existing production operation to a more lean one, composed of seven phases (Figure 2-8).

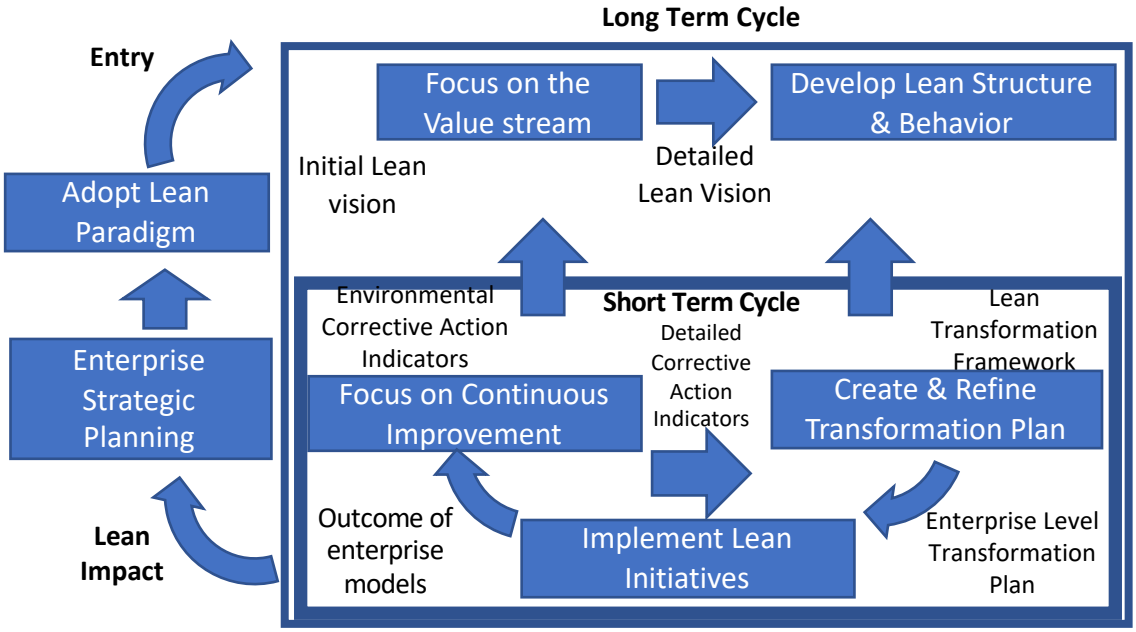


Figure 2-8 Lean Enterprise roadmap (LAI, 2001)

Mostafa et al. (2013) also proposed a framework that is composed of four phases. The framework starts with a conceptual phase and then moves to a phase on designing the implementation. The third phase is on implementation and evaluation of the performance, and finally a last phase on completing the lean transformation closes the process. Monitoring and controlling are integrated to all phases in order to make sure that lean transformation is delivered as expected. Each phase is a model on its own with input and output and a set of tools that can be used for achieving the output. All the lean tools are mapped to the various phases of the framework.

2.2.3.2 Lean implementation frameworks proposed by industry

Further to academia being highly active in developing lean frameworks, consultancy firms are also presenting and intensively marketing theirs.

Wright (2015) presented a lean implementation roadmap that is compose of twenty processes (Figure 2-9). Each process is a basically a lean tool, and the benefit of the proposed roadmap is the proposed sequencing of the introduction of these tools. As per the researcher who introduced the framework, it needs to adopted and tailored to the specific needs of the organisation.

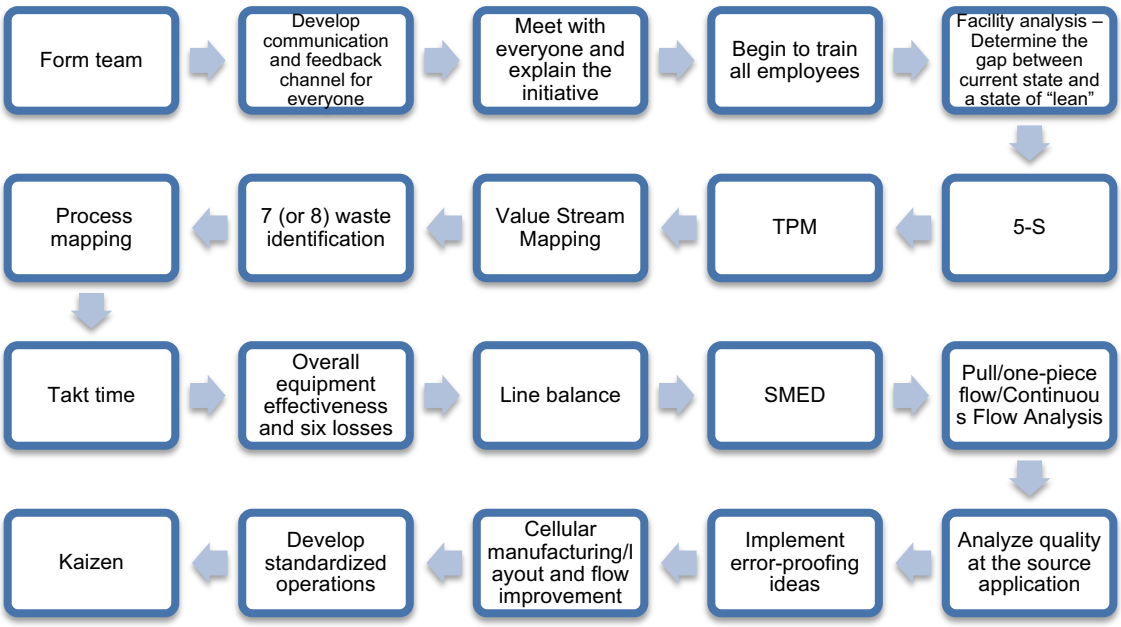


Figure 2-9 Lean implementation plan based on 20 steps (based on Wright, 2015)

Harbour (2012) highlighted the importance of "people systems", as a critical factor when introducing lean in an organization. Although lean tools and methods are valued, he claims that the implementation success depends on how people engaged in the transformation implement these. Therefore, he suggests that before setting off to implement any tools, a set of requirements must be met. These include the selection of the proper people's system, the definition of the roles and responsibilities and the proper training of all stakeholders. His framework is composed of four stages, namely: the "organizational development", the "discipline building", the introduction of "lean tools of quality, delivery and cost improvement" and finally the change in the organization's culture that will allow "continuous improvement and collaboration".

Obviously, it is not within the scope of this research to provide an exhaustive list of the lean implementation frameworks that are available in the public domain. This is a really dynamic research area and new framework are constantly presented and developed, as well as the existing ones are adapted and tailored to new needs, cases and sectors. One key finding that can be however mentioned is that after the literature review it was evident that there is no lean implementation framework developed specifically for the needs of SMEs.

2.2.4 Challenges SMEs facing when implementing lean

Another key literature question, that is aligned to the first research objective, was to review surveys presented in the literature that are focused in specific geographical regions. The various academic sources were searched for surveys in countries around the globe that present lean implementation attempts and frameowkrs. Issue of interest within this survey ware the the critical success factors and the barriers that organizations face during implementation. The search for the literature resulted in studies from 19 countries. In Table 2-3, the key findings from literature review are summarized for each paper. The study of the relevant surveys allows for commonalities to be identified, and the key lean practices, success factors and barriers can be identified.

Table 2-3 Surveys in 19 countries with regards lean implementation (focused on studies presented during the last 10 years).

Country / Reference	Key findings / study process
Australia Sohal and Egglestone (1994)	Researchers focused on assessing the level of introduction of lean thinking 42 SMEs in Australia
Bangladesh Ferdousi and Ahmed (2009)	The study was focused in assessing the adoption of lean tools in 9 SMEs in Bangladesh within the garment manufacturing sector
Egypt Salaheldin (2005)	The researcher focused on documenting and assessing the major challenges that manufacturers phase when implementing lean. He also discussed the changes that need to be undertaken prior to initiating the lean implementation. He surveyed 94 Egyptian manufacturing firms.
Greece Salonitis and Tsinopoulos (2017)	The researchers investigated the level of understanding of lean philosophy and tools, as well as the drivers and barriers that Greek manufacturing SMEs are phasing, especially in the

	context of the financial issues that the country has been facing for the last 10 years
India Mahapatra and Mohanty (2007)	The researchers focused on the continuous process industry and the degree the lean tools have been adopted. They further compared the implementation challenges of this sector with the ones faced in the discrete manufacturing sector.
India Singh and Sharma (2010)	The researchers employed the analytical hierarchy process (A. H. P.) for the paired comparison of key elements (integration of functions and vertical information systems, JIT deliveries, zero defects, elimination of waste, continuous improvement, multifunctional teams, pull of raw material and components, and decentralization) in 52 Indian manufacturing companies. Their concluded that the elimination of waste has potentially the maximum impact in lean implementation. The minimum impact on the other hand was accredited to the integration of functions and the vertical information system.
India Devakim and Jayanthi (2014)	The researchers identified the barriers to lean implementation and the extend of adoption of lean principles in the Indian construction sector. They highlighted the following ones: the culture and human attitudinal issues, the tendency to apply traditional management, the lack of exposure on the need to adopt lean construction, the lack of commitment from top management, the uncertainty in the supply chain and non-participative management style for workforce
India Yogesh, Chandra Mohan and Arrakal (2012)	The authors focused in the electrical and electronics manufacturing sector in India. They investigated the rationale in introducing Lean in

	this sector. The main finding of this research is that lean manufacturing is adopted to allow for preventive maintenance to take place.
Iran Duradi, Moradi and Toomari (2012)	The authors presented the only relevant study for lean implementation in Iran. They discussed the barriers that manufactures phase when they attempt to implement lean.
Italy Staudacher and Tantardini (2007)	The researchers compared lean implementing SMEs with ones that have not yet introduced lean in the Italian manufacturing sector. They focused on the expectations the companies have, the perceptions about lean, and their understanding of the available lean tools. They have presented a thorough questionnaire that was answered by 105 SMEs.
Jordan Al Tahat and Alkhalil (2012)	The researchers presented the only study with regards lean manufacturing in Jordan. The study was extensive as they managed to have access to 350 Jordanian manufacturing companies. They focused in assessing the degree of implementation of six lean practices (total preventive maintenance, new equipment / technologies, equipment configurations, visual control, processes reengineering and shared vision of perfection).
Kenya Ondiek and Kisombe (2013)	The researchers presented one of the very few studies on lean manufacturing within African manufacturing sector in the sugar processing sector. They investigated the degree of understanding of lean manufacturing tools. Focusing on companies that already implement lean tools, they assessed the impact on time efficiency metrics.

Lebanon Khlat, Harb and Kassem (2014)	The investigators focused in the Lebanese pharmaceutical industry. They presented a study on the extent lean tools are used in the sector. They identified relationships between the application of these tools and discussed the effectiveness of lean on their productivity.
Malaysia Wong, Wong and Ali (2009)	A number of studies have been presented with regards the lean implementation in Malaysian manufacturing sector. In this specific one, the researchers focused on the extend of adoption of lean techniques and methods in the electrical and electronics industry.
Malaysia Nordin, Deros and Abd Wahab (2010)	The researchers focused in identifying the drivers and barriers towards lean implementation in the Malaysian automotive sector. 60 automotive component manufacturers participated in the survey that the researchers put together.
Malaysia Rose, Deros and Rahman (2013)	The researchers focused in Malaysian SMEs automotive suppliers manufacturing sector. They assessed the status of lean implementation in the sector. Their analysis highlighted the importance of lean practices; however, it was also revealed that the level of actual implementation and practice is relative low compared to western and Japanese manufacturing suppliers.
Malaysia Rose, Deros and Rahman (2014)	The investigators focused on the critical success factors for implementing lean in the automotive sector in Malaysia. Based on an extensive literature review, they grouped the critical success factors into 13 themes with 78 elements were considered. For validating their findings, they conducted a survey that 97 automotive suppliers, mainly SMEs, participated.

Pakistan Zhang et al. (2012)	The only study that was focused in the manufacturing sector in Pakistan. The researchers focused on the critical success factors for implementing lean six sigma in SMEs within Pakistan.
Slovenia Herzog and Tonchia (2014)	The authors focused on eight critical factors (Value and customer, value stream mapping, Pull and flow, Waste elimination, productive maintenance, Just in time, employee involvement and suppliers), for lean success. However, they refer as critical factors the lean tools available for implementation. They conducted 72 medium and large sized manufacturing companies using a survey to assess the extent of use of these tools
Spain Bonavia and Marin (2006)	The authors focused in the ceramic tile industry in Spain They researched the most frequently used lean practices and the level of penetration in the specific market. 76 manufacturers participated in a survey that was developed from the researchers for discussing these. The key finding was that the sector is quite mature in implementing lean.
Thailand Lila (2012)	The researcher focused on the behavioural aspects of lean. She investigated the level of understanding of lean concepts within the automotive manufacturing suppliers' sector in Thailand. Their analysis highlighted the need for training of the employees to lean concepts and thinking. They concluded a survey that 70 companies participated.
UK Achanga et al. (2006)	One of the earliest studies on the topic, with a very large number of citations by the rest of the academic community. The researchers focused on the critical factors that constitute a successful

	implementation of lean production within manufacturing SMEs in the UK. Instead of using a questionnaire, the researchers conducted interviews with production managers from 10 British SMEs.
UK Sarhan and Fox (2013)	The researchers focused on the barriers to the successful implementation of lean philosophy in the UK manufacturing sector. The most significant ones indicated include: the lack of adequate lean awareness and understanding; the lack of top management commitment; and the cultural and human attitudinal issues.
USA White, Pearson and Wilson (1999)	The researchers, in one of the earlier studies in the topic, investigated the differences in implementing lean practices between SMEs and large companies. A survey was undertaken among 174 manufacturing SMEs and one large manufacturer.
USA Wu (2003)	The researcher investigated the practical differences between lean suppliers and non-lean suppliers. Through a survey with 103 American first tier automotive suppliers he highlighted the key differences and similarities.

2.2.5 Lean implementation fails

Implementing lean manufacturing can be considered as any other change introduced to an organization. Through change, the culture of the organization shifts. There are a number of studies indicating that only a small percentage of change initiatives succeed. Kotter (1996) after analysing a large number of change projects fails, he estimated that only 30% of change programs are successful, LaClai and Rao (2002) being more optimistic indicated 42% are successful, Eaton (2010) dropped the rate down to 25%.

However, in both the academic literature and the trade magazines, successful change programmes are reported more often than failures. These are usually

kept confidential for sustaining the profile of the companies where these initiatives have been attempted.

Obviously, there are not many studies on lean manufacturing implementation fails. This can be attributed to the fact that companies do not wish to publicize their investments that did not have high return. However, it is a common understanding, further to Kotter's, LaClai and Rao's and Eaton's estimations, that many implementations do fail.

The common root cases with regards the lean implementation fails, are:

- Non committed leadership
- Business systems with different aims and goals
- Poor employee involvement and engagement
- Not engaged and supportive supply chain management
- Lack of understanding of lean tools and techniques

Kumar and Kumar (2014) focused on the barriers organizations face when trying to implement lean manufacturing. They have identified seven categories: namely "management", "knowledge", "resource", "conflicts", "financial", "employee", and "past experience" (Figure 2-10).

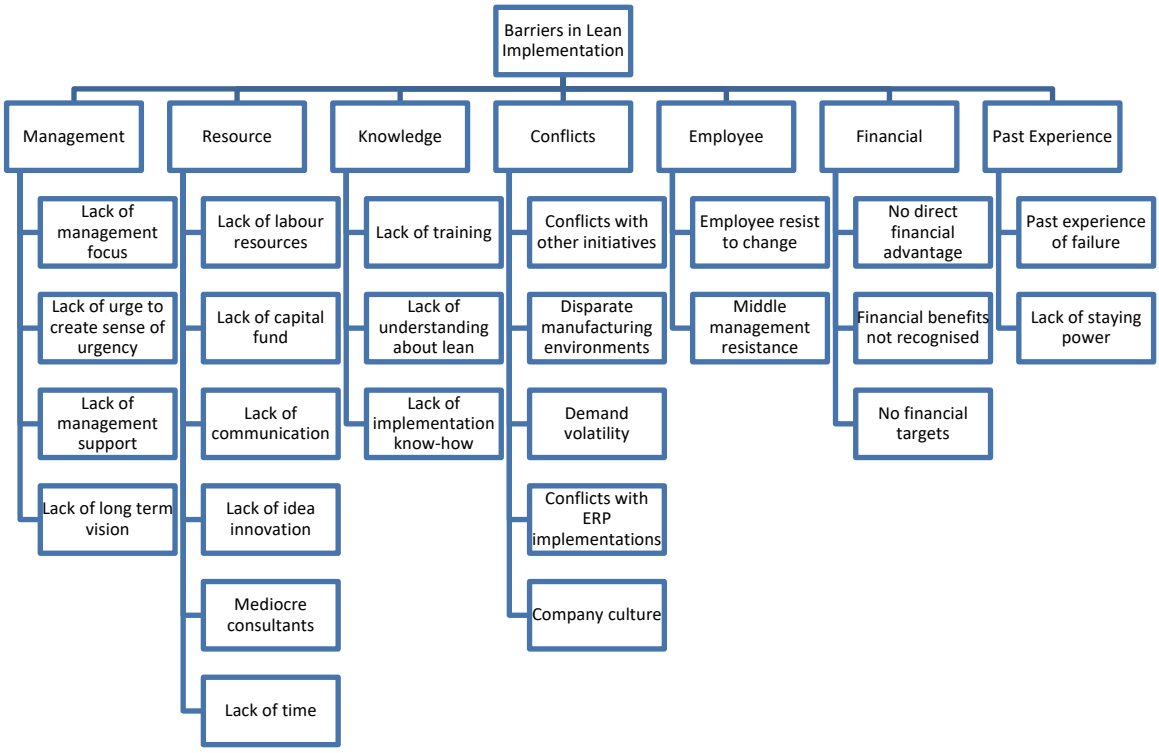


Figure 2-10 Classification of lean manufacturing implementation barriers (Kumar and Kumar, 2014)

It has been widely reported that the senior management and leadership of an organization can have either a positive or a negative impact on any change. Thus, it can potentially be a barrier to any change or a keen driver, depending on how senior management understand their role and how this is exhibited. When management is considered as a barrier, this is evident through a number of indications, such as specific attitudes and behaviours. As an example, senior management might be exhibiting a number of attitudes such as lack of long term vision for the organization, focusing only on short term wins and performance indicators, lack of communication with regards the changes and evidently failing to create urge of urgency, and support the lean initiatives.

Additionally, senior management lack of commitment can be exhibited though the lack of the necessary resources (in human, capital, communication etc.) that prohibit the implementation of lean manufacturing (Kumar and Kumar, 2014).

Further to academia being highly active in developing lean frameworks, consultancy firms are also presenting and intensively marketing theirs (as highlighted in section 2.2.3.2). All the big management consultancy firms have suggested implementation frameworks that they help their clients with. Table 2-4 presents briefly some of these frameworks from some of the most well-known consultancy firms. A number of companies that do not have the resources, or the strong will to introduce lean on their own, rely on consultants. Even then resources for consultancy are key. The quality of the services the consultant is offering is also critical, and in many cases superficial knowledge of the subject and lack of implementation experience can result into confusion about lean philosophy, thinking and manufacturing. It is thus clear that profound knowledge of the subject and practical experience in real cases is of great importance.

Table 2-4 Lean implementation solutions proposed by consultancy firms (links accessed on January 2020)

Boston Consulting Group	https://www.bcg.com/capabilities/lean-manufacturing/default.aspx
McKinsey and Company	https://www.mckinsey.com/business-functions/operations/how-we-help-clients/service-operations/lean-management
Deloitte	https://www2.deloitte.com/ie/en/pages/operations/articles/lean-fit.html
Accenture	https://www.accenture.com/us-en/careers/jobdetails?id=00718361_en&title=Accenture+Strategy%2C+Lean+Transformation+Manager
PWC	https://www.pwc.com/ca/en/services/consulting/operations/driving-organizational-performance-lean-perform.html

One of the key success factors in implementing lean is the engagement of employees. Resistance thus to any change by the workforce is a widely referenced barrier as well. The resistance from the workforce can be exhibited in a number of different ways, as shown in Table 2-6. This resistance can be rooted to the lack of knowledge on the benefits of lean, miscommunication, fear of the unknown, complacency and fear of losing jobs. In a large number of publications, investigations are focused in firstly identifying and secondly ranking

the critical success factors. Doing so can help identify strategies for overcoming the barriers. Hamid (2011) in his instigation classified the success factors into internal to the organization and external ones. He identified eight internal high-level factors and two external high-level factors. Table 2-5 summarizes the critical success factors for lean implementation as per Hamid's classification.

Table 2-5 Lean implementation success factors (adapted by Hamid, 2011)

Internal organizational factors
Top Management: leadership approach (strong vs. weak), support and involvement, top management commitment, , and leadership quality.
Training and Education: knowledge management within the organization, communication of changes within the organization, employee skills,
Thinking Development: understanding of lean philosophy, lean learning curve.
Employees: engagement of employees, employees' teamwork culture, empowerment of employees, motivation, recognition and rewards.
Working culture: tradition, way of thinking, change management, and barriers to change.
Communication: communication of change initiatives, the communication channels between top management and employees (both ways)
Resources: financial, employee resources and time.
External organizational factors
Customers Focus: customer relations and customer engagement (voice of the customer).
Government Intervention: government policy and legislation, government mandates, political change in government, and government support.

The literature thus review revealed a wide range of factors related to the successful implementation of Lean, that are summarized in the following table, with the supporting references for these critical success factors summarized.

2.2.6 Lean implementation in Middle East countries

Only few studies have been focused in the Middle East area. Albliwi et al., (2017) compared challenges of lean implementation in the literature with lean barriers in Saudi Arabia. He did confirm the challenges reported in the literature as with Saudi in terms of lack of committed leadership, lack of awareness of the potential benefits due to lean, the excessive internal resistance to change and the lack of resources.

Almutairi et al. (2019) focused on the implementation of lean in the health sector in Saudi Arabia (KSA). He assessed the lean performance of the suppliers in hospitals and the national health organization.

In table 2-3, a number of middle east countries are included, such as Iran, Jordan, Lebanon, Saudi Arabia and Pakistan. It was evident that no study has been presented that focuses in the case of UAE manufacturing sector.

Table 2-6 Critical success factors for lean implementation

CS no	Critical Success factor	References
CS1	Organisational culture	(Hamid, 2011), (Rose, Deros and Rahman, 2014), (Salonitis and Tsinopoulos, 2017), (Salonitis, 2015), (Zhang et al., 2012), (Herzog and Tonchia, 2014), (Achanga et al., 2006)
CS2	Organisational readiness	(Achanga et al., 2006), (Zhang et al., 2012), (Salonitis and Tsinopoulos, 2017)
CS3	Senior management commitment	(Achanga et al., 2006), (Rose, Deros and Rahman, 2014), (Salonitis and Tsinopoulos, 2017), (Salonitis, 2015)
CS4	Availability of resources for supporting the lean transformation	(Achanga et al., 2006), (Salonitis, 2015), (Salonitis and Tsinopoulos, 2017)
CS5	External support (employing consultants, lean experts etc)	(Zhang et al., 2012), (Salonitis and Tsinopoulos, 2017), (Achanga et al., 2006)
CS6	Effective communication and engagement through the organisation	(Achanga et al., 2006), (Salonitis and Tsinopoulos, 2017), (Herzog and Tonchia, 2014)
CS7	Strategic approach to improvements	(Salonitis, 2015), (Herzog and Tonchia, 2014), (Salonitis and Tsinopoulos, 2017), (Achanga et al., 2006)
CS8	Teamwork and systems thinking	(Achanga et al., 2006), (Zhang et al., 2012), (Salonitis and Tsinopoulos, 2017)
CS9	Time planning for realistic change	(Achanga et al., 2006), (Salonitis and Tsinopoulos, 2017)
CS10	Effective use of commitment and enthusiasm for change	(Zhang et al., 2012), (Rose, Deros and Rahman, 2014), (Salonitis, 2015), (Salonitis and Tsinopoulos, 2017)

Table 2-7 Barriers in implementing lean

LBI no	Lean Implementation barrier	References
LIB1	Every day operational distractions	(Yadav et al., 2018), (Devakim and Jayanthi, 2014), (Salonitis and Tsinopoulos, 2017)
LIB2	Multiple production sites	(Yadav et al., 2018), (Salonitis and Tsinopoulos, 2017)
LIB3	Difficulty in quantifying the benefits upfront	(Yadav and Desai, 2016), (Albliwi et al., 2017), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013)
LIB4	Poor commitment of workforce because of fear of job cutting	(Albliwi et al., 2014), (Yadav et al., 2018), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013), (Kumar and Kumar, 2014)
LIB5	Poor commitment of workforce because of change inertia	(Albliwi et al., 2014), (Radnor et al., 2006), (Yadav et al., 2018), (Albliwi et al., 2017), (Devakim and Jayanthi, 2014), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013), (Kumar and Kumar, 2014)
LIB6	Poor commitment of workforce because change was not shared	(Radnor et al., 2006), (Yadav et al., 2018), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013), (Kumar and Kumar, 2014)
LIB7	Poor commitment of workforce because of poor understanding of lean	(De Souza and Pidd, 2011), (Yadav et al., 2018), (Devakim and Jayanthi, 2014), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013)
LIB8	Senior management commitment lasted too shortly	(Radnor et al., 2006), (Albliwi et al., 2017), (Salonitis and Tsinopoulos, 2017), (Kumar and Kumar, 2014)
LIB9	Poor commitment of senior management because of change inertia	(Albliwi et al., 2014), (Radnor et al., 2006), (Yadav et al., 2018), (Albliwi et al., 2017), (Alkhoraif and McLaughlin, 2018), (Devakim and Jayanthi, 2014), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013), (Kumar and Kumar, 2014)
LIB10	Poor commitment of senior management because of the poor belief on the approach	(Albliwi et al., 2014), (Radnor et al., 2006), (Albliwi et al., 2017), (Alkhoraif and McLaughlin, 2018), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013)
LIB11	Poor commitment of workforce because of poor understanding of lean	(De Souza and Pidd, 2011), (Radnor et al., 2006), (Alkhoraif and McLaughlin, 2018), (Devakim and Jayanthi, 2014), (Salonitis and Tsinopoulos, 2017), (Sarhan and Fox, 2013), (Kumar and Kumar, 2014)
LIB12	Necessity of high capital investments	(Albliwi et al., 2014), (Radnor et al., 2006), (Yadav et al., 2018), (Albliwi et al., 2017), (Devakim and Jayanthi, 2014), (Salonitis and Tsinopoulos, 2017)

2.2.7 Literature review findings – research gap

The review confirmed the initial assumption that although there are many frameworks published already, there is not a straightforward guide that can be adopted for the introduction and implementation of lean. Furthermore, the review of the papers with regards implementation of lean manufacturing in SMEs indicated the plethora of drivers and barriers that a company faces when it attempts to introduce lean manufacturing.

The literature review repeated the benefits that a company can gain when successfully implementing lean. This includes the efficient and smooth running of the organization both internally but also with regards its ecosystem: the suppliers and customer as well as the close environment. In terms of clear benefits, these are the increased market share and the increased customer satisfaction. Further to these benefits, successful companies experience as well improved internal performance of the company (such as increased flexibility, introduction of realistic and meaningful key performance indicators, desire of workforce to engage, to name few).

The barriers to the introduction and implementation of lean manufacturing, can be linked to management, lack of necessary resources, resistance to change etc. As any other change project, resourcing is critical as well, and their lack is a major barrier. Lack of resources does not only limit the lean practitioners' freedom but also conveys a clear message that senior management is not fully in support and do not prioritize the lean change.

The decision of the organization of how to introduce lean is critical as well. As discussed there are a couple of options: either introduce lean by employing a senior manager who has lead lean changes in the past, or relying on an external consultant. Absence of knowledge on lean philosophy, principles and tools and can be a great barrier in the implementation.

Resistance to change by the workforce is a common barrier as well. As mentioned in the previous paragraphs, the root causes of such resistance can be attributed to the lack of knowledge on the benefits of lean, miscommunication,

fear of the unknown, fear of losing jobs and complacency. Salonitis and Tsinopoulos (2016) classified the barriers into four groups: financial, top management related, workforce related and other barriers.

For the visual representation of the "fight" between the drivers and the barriers, a "force field analysis" can be used. This type of graphical visualisation was introduced by Lewin (1951) and is used widely for the clear illustration of the driving and hindering factors for a planned change. This type of analysis can help the organization to develop strategies that will allow the exploitation of the drivers and simultaneously help emanating (or reducing) the impact of the barriers.

In Figure 2-11 the force field analysis that concludes the literature review on lean manufacturing implementation is presented. This diagram was put together from the analysis of the whole literature and does not focus in any specific geographic region, or any specific type of organizations.

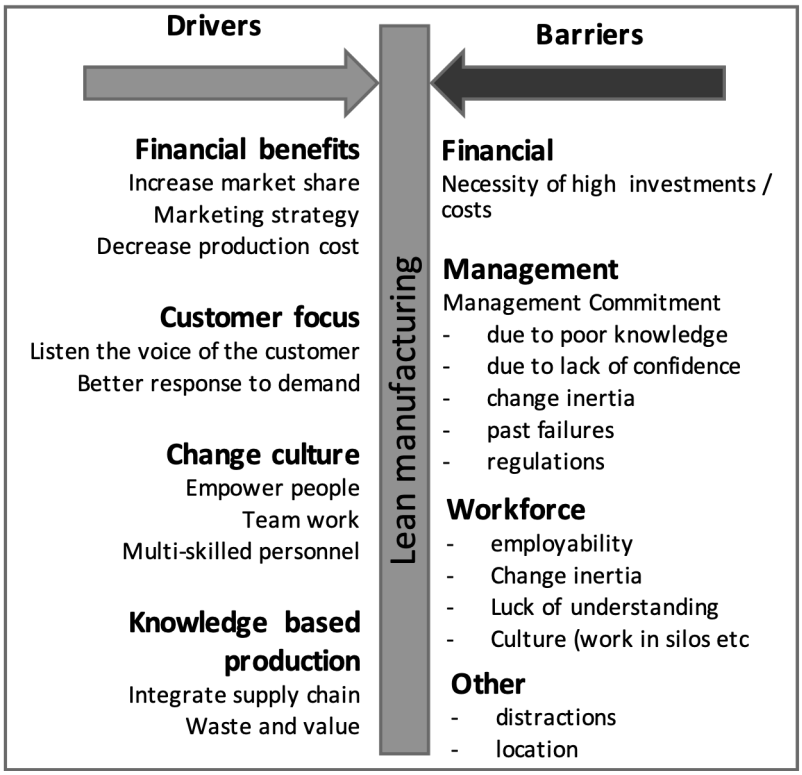


Figure 2-11 Force field analysis for lean implementation

2.3 Literature review on change management

As highlighted in chapter 1, lean implementation is major change for any organization. A large body of knowledge exist with regards change management. In the following paragraphs, change management will be defined according to the existing academic sources, the various types of change will be discussed, and the models that have been developed for helping with the implementation of change will be reviewed and compared.

2.3.1 Definitions

A number of definitions have been proposed for change and the management of change. The extensive presentation of these definitions is out of scope for the present study. However, as identified in research objective one and two, change management is assumed to be critical for the successful lean implementation.

In the following paragraph, a number of definitions have been selected that will help put change into perspective and within the context of lean transformation. Price and Chahal (2006) have defined change can as the behavioural shift of "*the organization as a whole, from one being to another*". Change management can be defined as "*the process of continually renewing an organization's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers*".

Price and Chahal, (2006) state that change in an organisation is always necessary. The organisation misalignment to the external environment is used as a measure for assessing the need for change. Organizations are operating in in harsh environments, and they have to constantly adjust strategies through the use of the available technology, processes etc. that they possess in orred to survive. Change has evolved to be a steady on-going process, rather than an exemption to the regularity.

The main aim of change management is to lead and guide the process from the transition of the organization from state that it currently is, to the intended future one. This is achieved by managing and controlling the different difficulties (in order to overcome resistance (Goff, 1994).

2.3.2 Classification of change

Classifying the change, that is intended to take place, into different types can help better manage it. Change can be classified based on a number of different criteria. The scale of the change, as an example, can be a criterion. As such change can be characterised as radical or incremental change, ranging from the change of a single process (either technical or managerial) to the transformation and reconstruction of the whole organisation.

Change can also be characterised as core or peripheral. Balogun and Hope Hailey (2008) classified change based on two dimensions. One dimension has to do with the intended outcome, and the two extremes are a transformational change to a small change. The second dimension has to do with the urgency of the change processes, ranging from rapid change to incremental change. Figure 2-12, presents these two dimensions in a matrix format, and as such depending on which quadrant the change lies, it can be characterized as:

- A revolution, i.e. a large scale change that is carried out in a very short time, usually as a result of externally imposed changes,
- An evolution, this is again a large-scale change carried out over a long period of time,
- A reconstruction, which is a small-scale change rapidly carried out, and finally,
- An adaptation, that is a small-scale change that is brought about gradually.

		Outcome	
		Transformation	Readjustment
Process	Incremental	Evolution	Adaptation
	Rapid	Revolution	Reconstruction

Figure 2-12 Matrix for the classification of change (based on Balogun and Hope Hailey (2008)).

Huy and Minzberg (2003) classified organizational change in a slightly different way as organic, systematic and dramatic. Organic referring to the change that happened naturally due to the evolution of the system, systematic referring to a wall planned change and dramatic to rapid transformation resembling a revolution.

Alternatively, the scope and the scale of the initiative can be used as dimensions for characterizing change. The scope dimension defines the content of the change, whereas the scale dimension is related to the number of people affected. On the other hand, the scale of a change (in order of size) can be described as “fine tuning”, “incremental adjustment”, “modular transformation” and “corporate transformation” (Hughes, 2006). The scope dimension on the other hand can be categorised as “individual”, “group” or “whole organisation”.

Newton (2011) presented two classifications for change initiatives that considers both the scale and scope dimensions:

1. Transformational change: a long duration change, an example is a project spanning the whole organization focusing in improving customer satisfaction
2. Bounded change: a smaller change compared to transformational change with clear boundaries.
3. Deliverable led change: a change project that has a specific tangible objective. It resembles a project, with a variable duration.

Another way of classifying change can be based on the source of the proposed changes. The source can either be the senior management, so in that case it is classified as a “top down” change, or it can be from the operators in the front line and thus pushed up, thus known as “bottom up” change. Bottom up change, as being driven locally, usually has higher credibility and it can be easier for other employees to accept. However, it can take considerably more time to get support from the senior management and thus introduced and adopted across the whole organization. Top down change tends to be more structured and systematic. This is attributed to the fact that the change manager takes that in consideration from the planning phase.

2.3.3 Coping with change and the impact of organization culture

A lot of research has been undertaken with regards the way change is accepted by the ones who are affected by that. Any change is usually accompanied with uncertainty, ambiguity and anxiety to the individuals and the teams involved. Carnall (2007) studied how individuals copes and adjusts to change and identified five main states of development (Figure 2-13). In the order of appearance, these are the “denial stage”, the “defence stage”, the “discarding stage”, the “adaptation stage” and the “internalization stage”. In more detail:

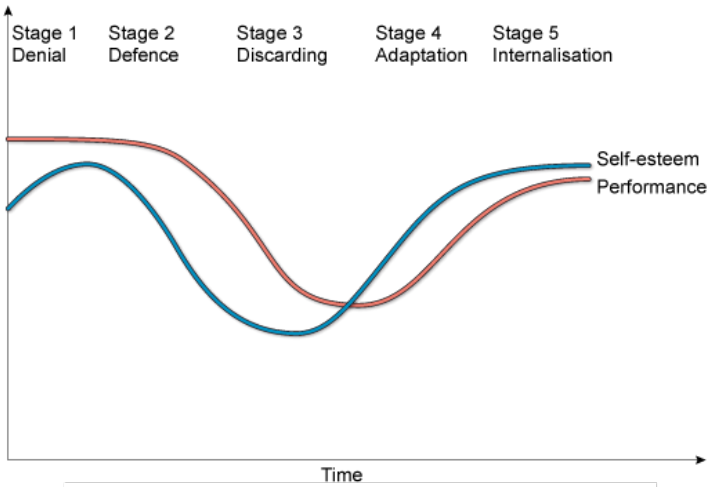


Figure 2-13 Carnall’s (2007) change coping cycle

- An individual or a group experiences the “*denial stage”* straight after a new change has been initiated. This is accompanied by the group challenging the necessity and urge for the change. As a result of that the group becomes more cohesive and fight against the initiative. Carnall notes that during this phase, the team carries on performing as before, and the self-esteem of the group is possible to increase (Figure 2-13).
- The denial stage is followed by the “*defence stage*”. At this stage the group members start to realize that the change might be inevitable, and as a result of that their behaviour becomes defensive in order to protect their roles. In contrast to the previous stage, the teams’ self-esteem and performance is likely to decrease.
- At the “*discarding stage*” the individuals start realizing that they will have to

accept the change. This leads to discarding previous behaviours and accepting the need for the change. As shown in Figure 2-12 both performance and self-esteem start to gradually improve.

- During the "*adaptation stage*" the individuals and groups have already started accepting the change. For this reason, they become more flexible in adapting to it and eventually they commit to. Self-esteem followed by performance further improves.
- Finally, in the last stage ("*Internalisation stage"*) the change has been accepted and new standards are developed as everyday practice.

In a very large number of publications, a common theme appears with regards the successful change implementation: the aspect of the organizations culture. Culture is what characterizes uniquely an organization. Introducing thus change in an organization is questioning the established culture. Accepting the change practically means allowing the organisational culture to change.

Robbins and De Cenzo (2008) investigated the characteristics of the culture and how this can impact the change introduced, such as:

- The identity of the organization
- The mentality of the organization with regards to team and individuals
- The degree of focus of the organization to people
- The integration of the various departments/units in the whole of the organization
- The level and type of control exhibited by the management
- The willing of the organization to take risks and innovate
- The way conflicts are managed and the tolerance to different and opposing views
- The focus in the deliverables (means ends orientation) and
- The level of externalization of the organization.

2.3.4 Models of leading change

Models have been used widely for describing processes and situations. They usually are simplified vies of reality. In change management, models are used for helping organizations to organize solutions, plan for potential challenging situation, and keep the team informed about the progress of the transition. In the following paragraphs the most widely used and accepted models will be presented briefly and compared under the context of the present study.

2.3.4.1 Rationale models of change management

The change management models (or leading change models as quite frequently are referred to) are classified into two major categories: the rational ones and the social process ones. The rational models were developed first. Their basic assumption is that the organisation and the employees' behaviour are ordered and controllable, and thus can be predicted and manipulated. In that case, the management of change can be thought as a systematic and logical process. The typical steps involved in such a change model are shown in Figure 2-14. These models are appropriate for change initiatives of relatively small scale that have clear goals.

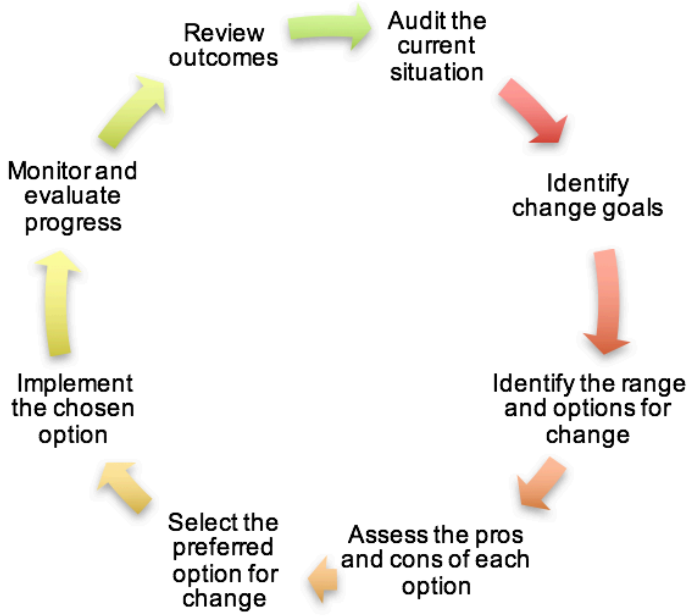


Figure 2-14 Olson and Eoyang (2001) generic rational model of change

One of the most classic rational models of change was developed by Lewin (1947). Lewin's change model is composed of three phases (Figure 2-15), namely, the unfreeze phase, the change phase and the re-freeze phase. The first phase is considered by Lewin to be the most important one. During this unfreeze phase, senior management with the help of the change manager shares the need for change. Through this all the stakeholders are prepared to cope with the change and a clear plan for change is agreed. The second phase, named the change phase, is focused in implementing the change plan. It is considered to be the hardest phase, as a lot of opposition to the change is expected by the affected stakeholders and will need to be addressed. The success though depends a lot on the plan and the actions that have been foreseen in the first phase. Finally, the third stage attempts to establish stability after the change implementation. The organization (including the stakeholders) will have accepted the change, and the new standards need to be established.

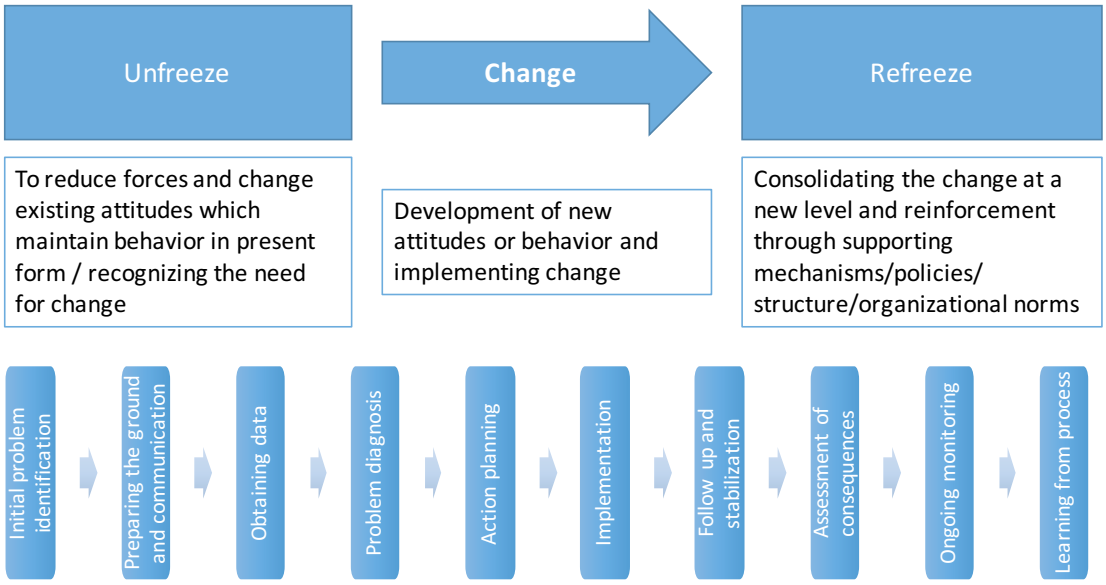


Figure 2-15 Lewin's (1947) change model

2.3.4.2 Social process models of change management

Social process models of leading organisational change are focused more on the human dimension of change. The social process of change is considered in the centre of these models. One of the most well-known social models was proposed by Kotter (1996). It was based on extensive research on change in a wide range

of different organisations from a number of different sectors. The model is structured in eight consecutive steps. It highlights areas where significant advantages for change management can be seen. The eight steps briefly are (Figure 2-16):

- Steps 1 to 3 focus on creating the climate for change, through the forcing of urgency inside the organization that can lead to establishing a change team and set up a clear vision
- Step 4 focuses on how this vision can be communicated, focusing on the benefits for both the organization and the employees
- Step 5 focuses on the employees and sets activities that increase their motivation and step 6 facilitates the implementation of small projects for creating some small quick wins
- Steps 7 and 8 focus in making the change a sustainable status for the organization

A lack of employee engagement in change initiatives is often cited as reason why lean projects fail. Kotter updated the eight-step model in 2012 (Kotter, 2012) where the eight steps became eight accelerators and it is not required to be followed in an ordered sequence. Although Kotter's model has been criticized of being too mechanistic, Gough (2009) supports it as being one of the most powerful ones, due to the two first steps.

Figure 2-16 Kotter's (2012) model for leading change

Both Kotter and Lewin models are focused on the organizational changes. However, the changes have impact on the individuals as well. This research gap has been filled in by the introduction of individual change models. The literature review resulted in a number of models of this type. ADKAR (2018) model and Covey's 7 habits model (Covey, 2004) are typical examples.

ADKAR is a research-based, individual change model that represents the five milestones an individual must achieve in order to change successfully:

1. The individual becomes aware of the need for change,
2. He then is convinced and starts supporting the change,
3. He acquired the required knowledge and skill sets to implement the change,
4. He possesses the ability to demonstrate the new skills and behaviours and finally
5. He exhibits the reinforcement to make the change stick.

A potential problem with this model is that focusing on an individual often may not work in a hierarchy structure (which is the typical management structure in many organisations).

Covey (2004) also presented an individual's change model. He has highlighted the seven habits that an individual must exhibit for facilitating the change. These focus on personal change and interacting with others. Given these habits are based on becoming a highly effective person, it is unsurprising to find that there are many synergies between this model and the change model presented by Kotter which focus on change leadership.

The change management theories explored above have common themes (Table 2-8). The literature reviewed a number of commonalities. These are the communication, the flexibility, the urgency, the personal drive and sills required and last but not least the strong team work. Table 2-7 illustrated potential gaps within each framework. For instance, improving individual skills is overlooked by Kotter when focussing on leading change. Yet many logical arguments are

presented within the works of Lewin, Covey and ADKAR which suggest this should be accounted for when implementing a change process.

Table 2-8 Common Individual Change Themes.

	Change model			
Theme	Kotter (1996)	Lewin (1947)	Covey (2004)	ADKAR (2018)
Communication	X	X		
Individual flexibility		X	X	X
Urgency / criticality	X		X	
Personal drive	X		X	X
Improving Individual Skills		X	X	X
Strong team-working	X	X	X	

Whilst many authors of change management theories do not limit their theories to particular classifications of change, it is possible to propose a logical suggestion for their suitability as shown in Figure 2-17. The works of Covey, ADKAR and Lewin focus on individual change and are therefore more aligned with the smaller scale/scope projects which will only impact smaller numbers of people. In focussing on the leadership of change, Kotter's eight steps more closely aligns with larger scale changes which have the potential to impact a large number of people. The principles outlined with the eight steps can also be used within project orientated (bounded) changes which can affect a team of people. A number of these smaller projects may make up a major change initiative, for which the leadership focus of the eight steps is ideally suited.

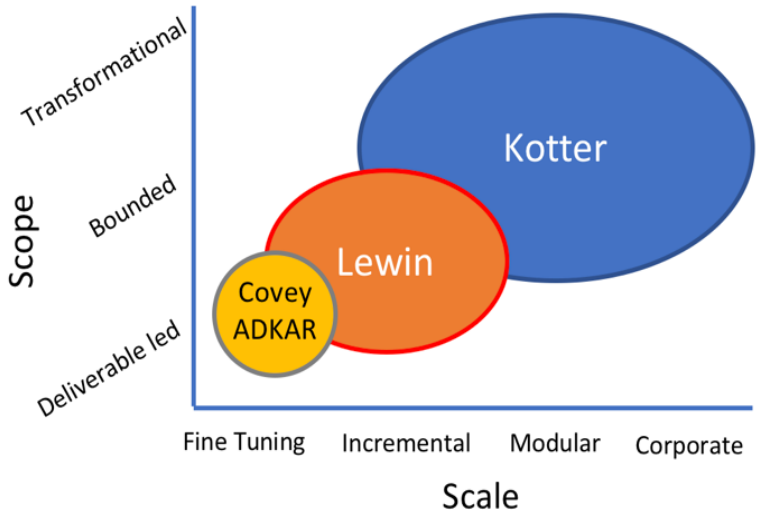


Figure 2-17 Change Theories and Project Scope

2.3.5 Change management fails

As highlighted in section 2.2.5 (Lean implementation fails), change programmes quite frequently fail. Such failures can be attributed to a number of issues. Hoag et al. (2002) discussed the main barriers to change initiatives. They concluded that in most of the cases the root cause for the failures are external to the system and lie outside the influence of the ones who manage the change. Table 2-9 lists the main barriers to change.

Kotter (1996) has extensively researched the reasons for change fails. The eight key reasons for failure as listed by Kotter are:

1. Organization are characterized by excessive complacency
2. Management is not successful in in creating a sufficiently powerful guiding coalition
3. Change managers and the management do not put enough emphasis on the vision
4. The vision is not shared and communicated effectively in the organization
5. Management allows obstacles and everyday issues to block the vision
6. The power of short-term wins is overlooked
7. Short and small wins are presented as full victory, the change creeps
8. Once a change project has achieved the required changes, these are not standardized and institutionalized within the corporate culture

Table 2-9 Barriers to organisational change as per three main categories: leadership, Management and Culture (based on Hoag et al., 2002)

Category	Barrier	Description
Leadership	Lack of vision	Lack of goals, plans or strategies, unable to prioritise issues for change
	Lack of support	Leaders unable to articulate need or methods for change
	Obstructive managers	Disagreement within or resistance to change from key individuals
	Postponing mentality	Senior managers reduce pace of change
	Lack of change motivation	Managers fail to see reason to change
Management	Everyday operational disruptions	Challenges addressed individually (fire-fighting)
	Internal systems	Organisational systems upheld even though preventing change
	Victim mind-set	Managers claim victims of external factors and staff believe they will always be victims of change
	Status quo	Management failing to challenge 'business as usual' attitudes
Culture	Uncertainty	Staff feeling threatened by change itself: "What does it mean to me?"
	Turf protection	Staff clinging to status quo and traditions
	Cannot cope	Staff lacks knowledge, skill or training to cope with change initiative
	Internal politics	Interdepartmental rivalry, a fear of shift in the balance of power

LaClai and Rao (2002) presented twelve factors for successful change. These factors are spread over three levels within an organisation: Senior managers, Middle managers and Frontline staff. With regards the senior managers, the points that they have to stress include Commitment Communication", "Financial incentives", "Nonfinancial incentives", "Leadership", and "Stretch targets". With

regards middle managers, the success characteristics that they have to exhibit include “Decision authority”, “People managing skills” and “Project managing skills”. Finally, for the frontline staff, they have to have the skills, know really well the needed tools and have the motivation to succeed.

2.3.6 Literature review findings – research gap

The literature review highlighted that there are a number of change management models depending on the researchers’ assumptions about change. This section follows up the literature review on lean implementation frameworks and confirmed that there have been no studies on using change management theory for driving the lean implementation.

2.4 Chapter Summary

The literature review was divided into two parts, the first one dealing with lean manufacturing and the second one with change management.

With regards the first part, the literature review revealed a wide range of factors related to the successful implementation of Lean (table 2.5). Furthermore, the analysis of the literature review also revealed the barriers / obstacles that prohibit the implementation of lean manufacturing (table 2.6). However, no studies were found that are investigating the implementation of lean in the UAE manufacturing sector, highlighting a gap in the research.

The second part of the present chapter was focused in change management theories and models. The most widely used ones were discussed and compared, in order to help decide for the most suitable one for the needs of the present study. The literature review also revealed that no studies have been published that consider a change management model for the introduction of lean in a manufacturing organization.

3 RESEARCH METHODOLOGY

3.1 Introduction

The main aim of this chapter is to present the research design and methodology that have been adopted to achieve the research aim and objectives. The chapter is divided in five subchapters. The first one is the present where an introduction to the chapter is provided. The second section highlights the philosophical stance of the researcher with regards the aim and objectives of the present study. The third section presents the research structure, i.e. the sequence of research tasks that were undertaken for completing the present study, and finally the last section presents the research tools used.

3.2 Positioning research philosophically

Bunge (1999) has defined the research as the methodological search for knowledge. Having that in mind, and focusing on the "methodological" aspect of this definition, it is clear that research must be structured. A number of structured approaches have been presented in the literature. Bickman and Rog (1997) suggest that research can be broken down into five key components: research purpose, conceptual context, research question, methods and validity.

The clear philosophical position of the research allows for the researcher to design the research properly, identify and plan the research work to be undertake, and allow the discussion of the implications of such decisions (Easterby-Smith et al., 2012). When discussing the research philosophy, the following terms are usually used:

- Research ontology, that defines the researcher's assumptions with regards the nature of reality
- Research epistemology, defines the assumptions with regards the approach to inquire the nature of the world
- Research methodology, that includes the techniques to be used in order to inquire a specific problem or situation
- Research methods, that are the specific tools used for data collection and their subsequent analysis

Sunders, Lewis and Thornhill (2012) highlighted that these components cannot be decided independently and have to considered as whole. They have presented research as an “onion” with the research philosophy being at the outer layer (Figure 3-1).

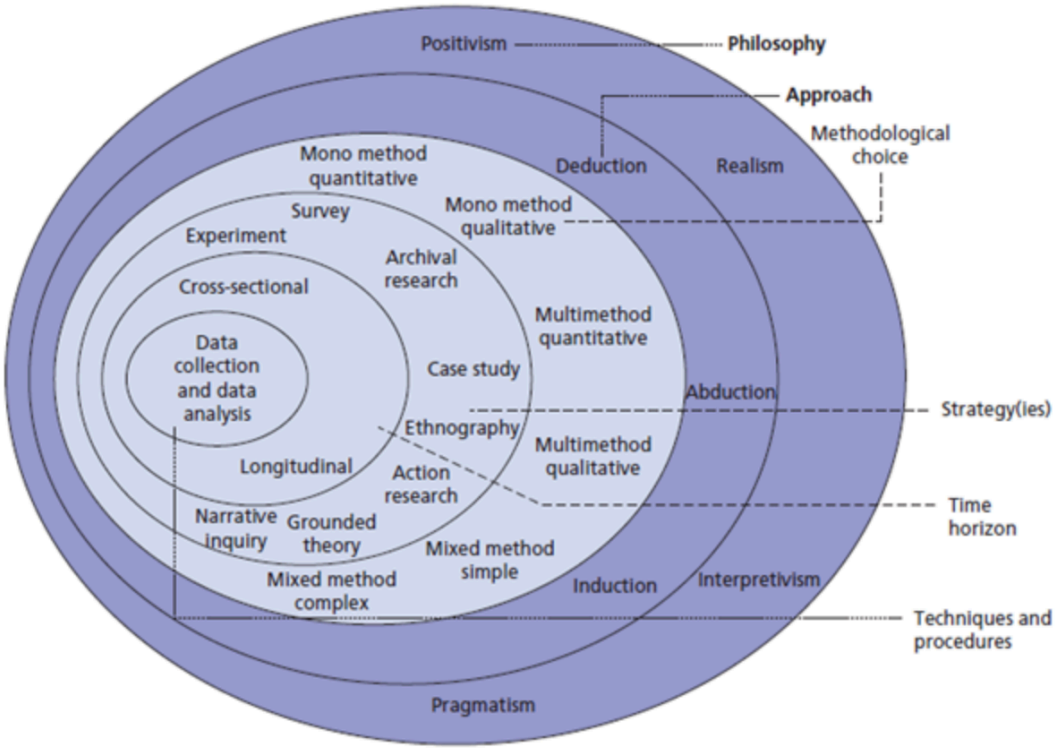


Figure 3-1 Research onion (adapted by Sunders, Lewis and Thornhill (2012))

In the following paragraphs, the present study is positioned with regards these philosophical terms

3.2.1 Research ontology

The determination of the researcher’s stance with regards the ontology of the research will help in deciding the research design. As mentioned, the ontology of the research indicates the researcher’s assumption and vies with regards the nature of reality. Two main views have been presented in the literature:

- The subjective view of reality, i.e. reality exists in the way we view it as individuals, or

- The objective view of reality, i.e. reality is to be considered common and thus it exists regardless of how the individuals understands it.

The former one is known as *Interpretivism*, and the underlying assumption is that there are multiple realities, either given or socially constructed. These realities are accessed by the researcher, who becomes part of them, and present frameworks that are applicable only from his specific point of view. This philosophical stance is widely used in social sciences, and inductive approach as well as qualitative methods are quietly used (Creswell, 2013). Interpretivism aim to extract meaning from reality by understanding the people's views (Hatch, 2012).

On the other hand, *Positivism*, is based on the assumption that there is only one reality. This approach is rooted in the physical sciences and is also referred to as systematic or scientific. A framework developed based on such philosophy is supposed to be based on natural laws, and as such is applicable to every situation (Kumar, 2011). The researcher in this case needs to be objective and external to the reality.

From the above two brief descriptions, it is obvious that for the present study the research ontology better describing the problem under investigation is the interpretive one. The research problem is directly related to a real-life scenario (implementation of lean) and experience and there is no theory in the literature for implementing lean SMEs in the Middle East in general. The research requires capturing in-detail the social reality through the investigation of people's opinions, interpretations and attitudes in implementing lean. Therefore, phenomena interpretation constructed based on experts' knowledge, interpretations and understanding.

3.2.2 Research epistemology

Ontology focuses on the assumptions about reality, whereas epistemology focuses on the assumptions on how reality can be investigated. Hallebone and Priest (2009) defined epistemology as the study of the criteria that the researcher will use for deciding what does and what does not constitute knowledge.

Referring to the two previous ontology stances, i.e. interpretivism and positivism, the epistemology referred to these two stances is presented in the following table.

Table 3-1 Research philosophical stance, ontology and epistemology

Research philosophical stance	Ontology	Epistemology
Positivism	A single reality exists	Reality can be measured accurately, as long as reliable and valid tools are used
Interpretivism	No single reality exists. Reality is created by individuals, social groups etc.	Reality is described through interpretation. It focus in understanding and revealing the underlying meaning of behaviours, activities and events.

For the shake of completion, it should be mentioned that there are more philosophical stances (research paradigms) than just positivism and interpretivism. These include pragmatism, subjectivism, realism and hybrid ones.

Table 3-1 further justifies the decision on adopting the interpretivism paradigm

3.2.3 Research approach

As shown in the research “onion” approach (Figure 3-1), tree main research approaches exist, namely “deduction”, “abduction” and “induction”. Saunders et al. (2012) defines deduction as the research focusing on testing a theory, whereas induction is on building a theory. Deductive approach tests the validity of assumptions, whereas inductive facilitates the emergence of new theories and generalizations (Bryman and Bell, 2015). Finally, abductive research, starts with research questions and the research process is focused their explanation.

In the deductive approach, the theory or the underlying assumptions, or the hypothesis of the study, are tested through observation. The result of such study is the confirmation or rejection of the theory / assumptions / hypothesis (Saunders et al., 2012).

Inductive approach does not involve the formulation of a robust hypotheses. Instead research is based and formulated on research questions (or alternatively aims and objectives) that need to be asnwered during the research process (Saunders et al., 2012). According to Saunders et al., (2009), inductive approach starts with collecting data, then developing the theory.

Finally, in the abductive approach, the research process is focused in discussing and explaining of 'incomplete observations' or 'surprising facts' specified at the beginning of the study.

It is thus obvious that the present study follows the inductive approach, with specific research aim and objectives that are to be achieved by the end of the research process.

3.2.4 Research methodology

In the simplest terms, research methodology can be classified as qualitative and quantitative.

Qualitative research methodology is widely adopted for social sciences research problems, such as the ones related to management. Such research design is inductive in nature and includes some type of interaction between the people and the researcher (Hussey & Hussey, 2003). Qualitative approach is usually small-scale and emphasize on details rather than statistical methods. The nature of data in qualitative method are primarily are words, action, non-numerical and behaviour. The purpose is to understand the (hidden) meaning. This is based on observing and interpreting situations and behaviours. The preferable data collection mechanisms include interviews (free, semi-structured or structured) and observation. The analysis thus is inductive in nature and as such it is quite difficult to result in generalizations. Such methods are aligned with the interpretivism paradigm.

Quantitative research methodology on the other hand is aligned with the positivism paradigm. As such it is based on rules of measurement, logic, prediction, principles and truth (Weaver and Olson, 2006). A quantitative research design is deductive in nature. Quantitative research design focuses on statistical generalization of results to demonstrate and predict social phenomena by searching causal relationship between constituent factors (Muijs, 2011). The main purpose of quantitative approach is to test hypotheses with regard to the relationship between variables under examination in the study. It uses sampling approach to boost the generalization of the results from the certain study population to a bigger population by adopting deductive approach.

Further to pure quantitative and qualitative research, mixed methods are used as well, and as a matter of fact this is the norm rather than the exception.

3.2.5 Research methods or research strategy

The research strategy is the structured set of guidelines or activities to help in generating valid and reliable results. Sunders, Lewis and Thornhill (2012) highlight a number of alternative research strategies, that a researcher might be adopting for his research. These include the conduction of experiments, surveys, case studies, ethnographic studies, action research, grounded theory and narrative inquiry, to mention the most widely used ones. The following table compares these research strategies with regards their characteristics.

Table 3-2 Research strategies (based on various sources)

Research strategy	Description	Characteristics
Survey	Measurement based research of participants views.	Questionnaires and interviews
Case study	Analysis of specific issues within the boundaries of a specific environment, situation or organization	Results difficult to be generalized Case is studies within its context Various data collection tools available
Ethnographic study	Analysis of a specific group, organization or community way of living and experiencing the world	Selection of a community, group, or an organisation Researcher involvement in the setting observation can be used
Action research	Research simultaneously participates (takes action) and does research. These two are linked together by critical reflection	Research is an interactive inquiry process that includes both problem-solving and data-driven collaborative analysis Research aims to understand the underlying causes, enabling future predictions about personal and organizational change
Grounded theory	Systematic building of a theory based on data gathered	Interview based
Narrative inquiry	Uses field texts for understanding the way people create meaning in their lives	Data can be gathered from multiple sources such as stories, autobiography, journals, field notes, letters, conversations, interviews, family stories, photos (and other artefacts)

3.2.6 Research techniques and procedures

According to Sunders, Lewis and Thornhill (2012) refer to data collection and analysis techniques. The first decision that a researcher has to deal with is whether there are available data for his research, or he needs to generate them. Data from other sources are referred to as secondary data. They have been gathered by other researchers and in most of the cases for other reasons. They are reported in various sources, and a thorough literature review can result in collecting these. On the other hand, data that the researcher himself generates (or collects) are called primary data and can be gathered by interviews, observations or surveys. It is time consuming and usually highly costly. The gathering of secondary data is usually less time consuming and with lower cost than the gathering of primary data (Saunders et al., 2009).

The most popular data collection techniques in qualitative research are through conducting interviews, establishing a focus group (sometimes called group discussion) and through observation.

Interviews are widely used in social sciences studies. The main aim is to capture the perception and the views of the interviewees. Robson (2011) classified interviews into three kinds: structured, semi-structured and unstructured ones. Structured interviews are based on questionnaires that have verified and validated questions with specific wording. They have low flexibility and do not allow for explanatory questions. Semi-structured interviews on the other hand give this flexibility to the interviewer to select questions from available ones and look for meaning. Finally, the unstructured ones give freedom to the researcher to discuss openly on the topic and allow the responds to be validated. Obviously the more unstructured the interview, the more complex and demanding the analysis after the end of the interviews it becomes.

Focus groups are also widely used in social science research. It is based on the establishment of a group and interviewing it, rather than having one to one interview. The use of focus groups allows for the validation of results and discussion in more detail specific aspects of the research. The dynamics of the group itself allow for focusing on the most important issues. Experts involved in

focus group can play vital role in validating the research and reducing the bias level (Robson, 2011).

Finally, observations can also be used in qualitative research for gathering data. Direct observations allow the researcher to experience real-life scenarios and capture practices.

In the present study, all three techniques have been used for collecting data.

3.3 Research structure adopted

Having clarified the philosophical stance of the researchers with regards the present study, the data gathering techniques and methods, the present section illustrated the adopted research structure.

The structure followed for tackling the problem set in chapter 1 is outlined in Figure 3-2. As it can be seen the methodology is composed of four phases:

- Phase I: research problem definition
- Phase II: thorough literature review
- Phase III: field study and analysis
- Phase IV: development and validation of the framework

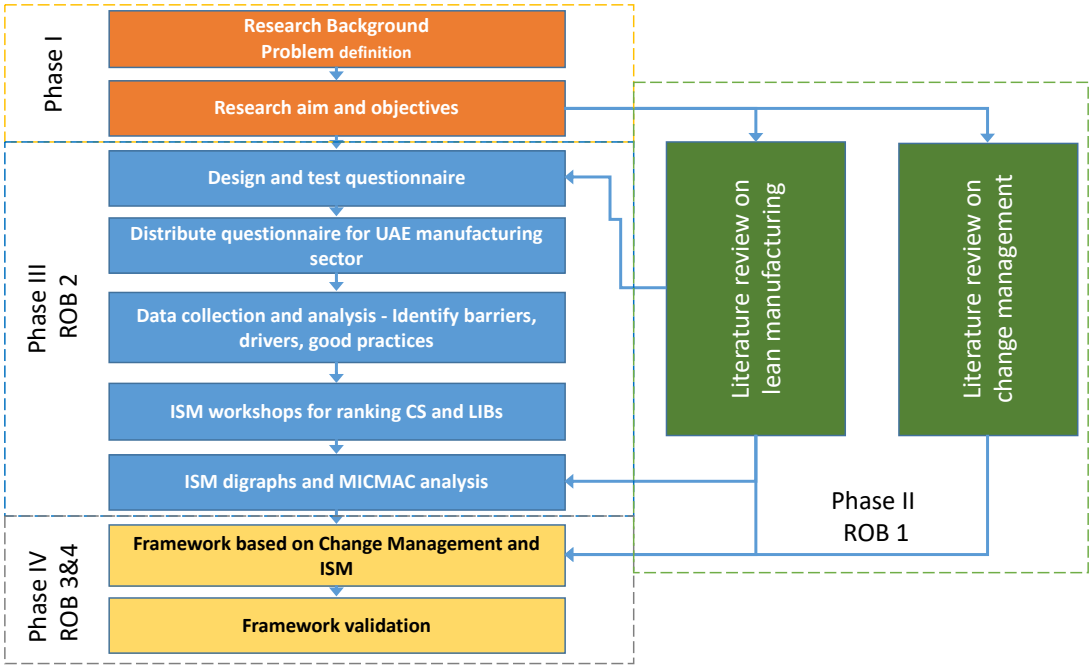


Figure 3-2 Research structure outline

3.3.1 Phase I: research problem definition

The first phase focuses in the formulation of the research problem and understanding the context of the research. It is composed of two key parts. In the first part, the research background is explored, and the problem is defined in detail. In the second part, research objectives are defined, and research questions are developed. The most appropriate research methods are selected. As highlighted in the previous sections, the research follows the interpretivism paradigm, following and induction approach linked to qualitative studies. The strategy adopted is surveys, whereas the data collections methods include both structured interviews through the use of pre-determined questionnaires and focus groups.

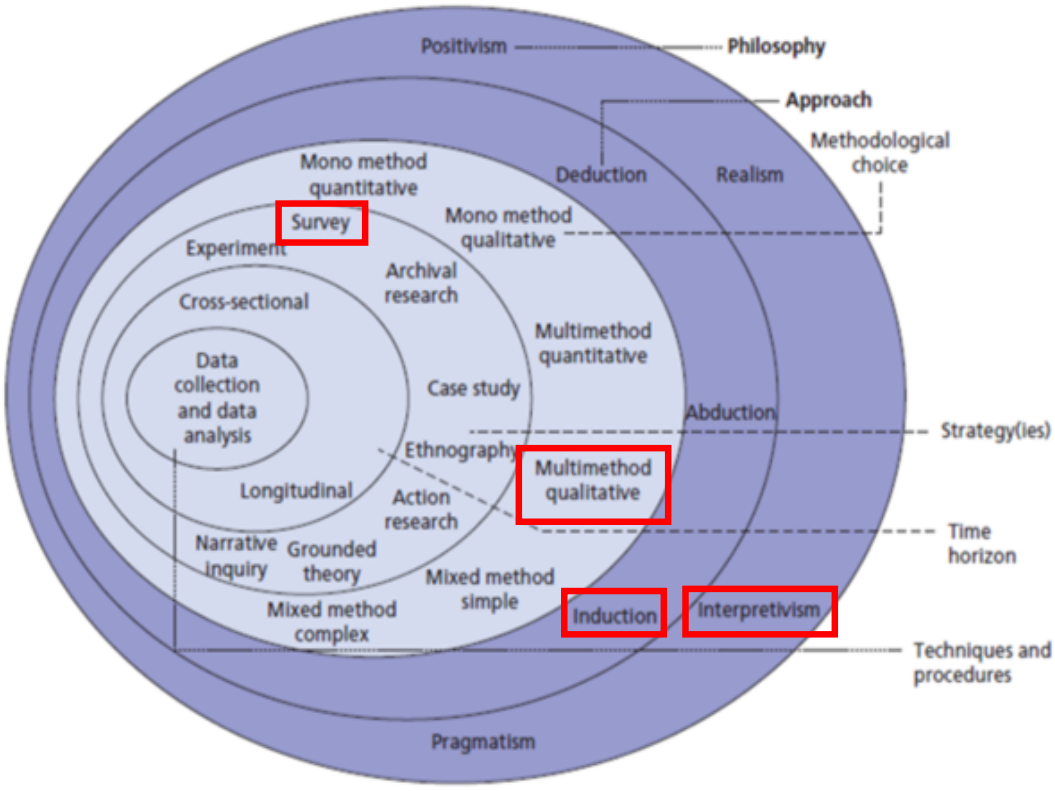


Figure 3-3 Research positioning

3.3.2 Phase II: thorough literature review

Within the second phase, a comprehensive literature review related with the Lean manufacturing implementation and Organizational Change Management (OCM) theory was completed. Phase II of the study is related to research objective one (RO1). The literature review has been presented in chapter 2, and resulted in the research gap as well as the key lean barriers and critical success factors to be investigated in the context of UAE.

The research used several material sources, such as books, theses, reports, and electronic sources, such as Google Scholar, Emerald, Business Source Complete (EBSCO), Elsevier, Science-Direct, Scopus, and ProQuest. The literature reviewed and a number of areas were covered including lean implementation and change management.

3.3.3 Phase III: field study and analysis

The third phase of the present study focuses in collecting data and analyzing them with the focus being to achieve research objective 2 (To assess the current practices with regards lean implementation in Middle Eastern countries and GCC in particular focusing in identifying (i) the success factors affecting organisational performance, (ii) the enablers that smoothen the introduction and implementation of lean management (LM)).

As part of this phase, a survey was decided to be undertaken in order to assess the practices in UAE. This thus included the design and testing of a questionnaire for the manufacturing sector in the country. The questionnaire was structured in order to validate the literature review findings with regards the lean implementation barriers and critical success factors in the context of UAE but also to assess the understanding and maturing of lean in the country. Once the questionnaire was validated, it was circulated in a large number of manufacturing SMEs in the UAE (as will be described in detail in chapter 4).

Further to capturing the perception of lean practitioners within UAE manufacturing sector, the key success factors as well as the implementation barriers were investigated in more depth in order to identify hidden relationships

and provide the background for the development of the framework. For this reason a focus group was established, where both the critical success factors and implementation barriers were discussed under the Interpretive Structural Modelling (ISM) protocol.

3.3.4 Phase IV: development and validation of the framework

The last phase of adopted research methodology is the development of the framework and its validation. The framework developed is based on change management for implementing a Lean approach for manufacturing companies in the GCC countries, including the guidelines and the associated processes based on the current and the desired manufacturing practices.

The validation of the framework through was mostly qualitative.

This research phase is related to research objectives three and four (RO3 & RO4).

3.4 Chapter Summary

In this chapter, the research methods and data collection techniques were presented. Next, the rational of the selected research methods and strategy were justified. Then, research methodology adopted was illustrated.

4 FIELD STUDY ON LEAN MANUFACTURING IN UAE

4.1 Introduction[2]

Research objective two has been set to assess the current practices with regards lean implementation in Middle Eastern countries and UAE in particular, focusing in identifying (i) the success factors affecting organisational performance, (ii) the enablers that smoothen the introduction and implementation of lean management (LM). The literature review presented in chapter 2 highlighted as a research gap the lack of relevant investigations. For this reason, a questionnaire was developed based on the findings of the literature review, as to capture relevant information. This chapter presents the findings of this survey. Sections 4.2 describes the field study approach and how the questionnaire used was developed.

The questionnaire was approved by the Cranfield University Research Ethics Committee.

4.2 Field Study approach

During the initial phases of the research an extensive scientific literature review was conducted in Chapter 2. The literature review highlighted the lack of studies on how lean is implemented by UAE manufacturing companies. In order to clarify this, as well as gain an industrial perspective of the areas of inquiry an industrial field was conducted. Table 4-1 identifies the major areas of inquiry in relation to the research gaps which formed the basis of the field study.

[2] Parts of the work presented in Chapter 4 has been published into the following paper:

- Almanei M., Salonitis K. (2018) “Challenges of implementing lean in UAE manufacturing sector”, Advances in Transdisciplinary Engineering, Vol. 8, pp. 499-504

Table 4-1 Major areas of field study inquiry in relation to the research gaps

Literature review – research gap	Field study inquiry
Although there is a large number of lean implementation examples in the western manufacturing companies, there is no research presented for the UAE manufacturing sector	Capture of industrial implementation of lean principles in the UAE manufacturing sector.
A large number of lean tools and methods exist, presenting however different complexity and thus different levels of success when implemented	Capture the level of diffusion of lean tools and techniques within the UAE manufacturing sector
The barriers and challenges when implemented lean has been discussed extensively in the literature for manufacturing companies in the west, however such discussion does not consider the difference in culture of developing world	Capture the challenges, barriers and the success factors when introducing and implementing lean in the UAE manufacturing sector organizations.

4.3 Survey

4.3.1 Questionnaire

As highlighted in the research methodology chapter, for achieving research objective 2, a survey is the most appropriate approach as it allows the capture of a large number of opinions. The questionnaire follows the regular format of similar questionnaires, and consists of three parts:

(1) the first one collects personal information of the interviewees,
(2) the second part collects general information of the interviewees' company,
(3) the third part assesses the understanding of lean, the attitude toward lean implementation and the problems and barriers that organizations face.

The two first parts have four questions each. The last part has nine questions, with few of them being multiple choice and few Likert type. The scale for the Likert question was ranged from 1 to 5, with 1 meaning that the interviewee totally disagrees to the statement and 5 that he totally agrees. The result is interpreted according to three classes of average score; 1 – 2.33, 2.34 – 3.67 and 3.68 – 5.00 as negative, neutral and positive perception for each item. For the basis of the development of the questionnaire, a previous one proposed by Salonitis (2016) and Salonitis and Tsinopoulos (2017) was used.

Before releasing the questionnaire, it was tested by academics for its academic merit and lean practitioners with long experience in successful lean implementation. The comments and feedback received were analysed and a few minor amendments were introduced. The feedback from the experts was positive.

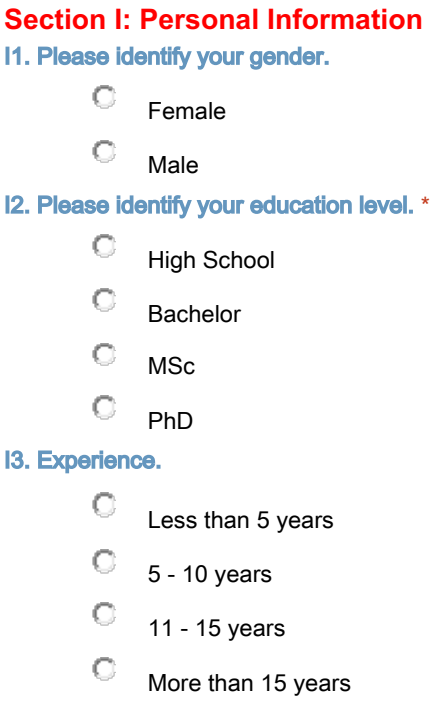


Figure 4-1 Part I of the questionnaire

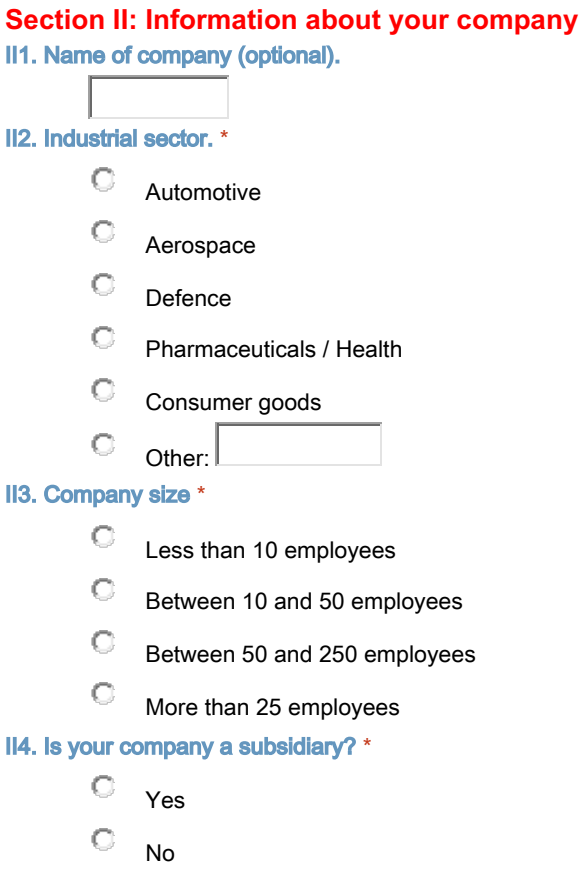


Figure 4-2 Part II of the questionnaire

The questions for the first two parts are typical ones used for capturing demographic information (Figure 4-1 and Figure 4-2) . The questions in the third part were based on the key literature review findings with regards the drivers, success factors and barriers in implementation. The rationale for using them is presented in the following paragraphs.

III1. Company's history in lean

The company's first attempt to implement lean manufacturing is documented as an indirect way of assessing the organization's lean maturity and history.

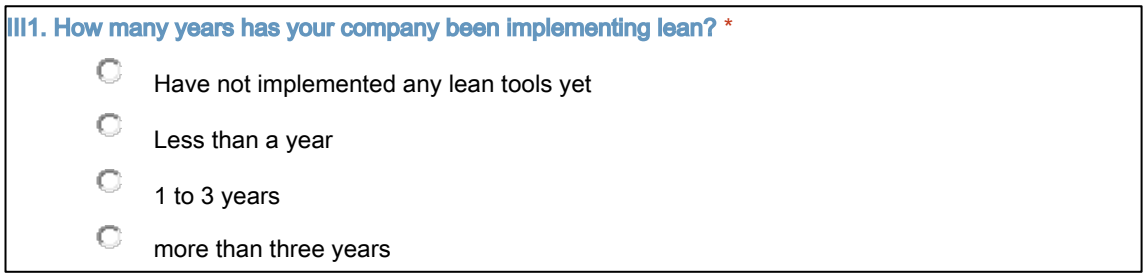


Figure 4-3 Part III: question on company's history in lean

III2. Lean introduction method

It is quite common, as highlighted in the literature review, that companies employ external consultants for implementing lean manufacturing. This is especially the case when companies did not have any prior experience in lean. Alternatively, companies can rely on their internal skills and capacity. This can be achieved either through the training of the existing workforce, or by employing a lean manager that has already gained experience in lean, while working for other organizations. This specific question aims to capture this information and then corelate the perceived success of lean implementation to this.

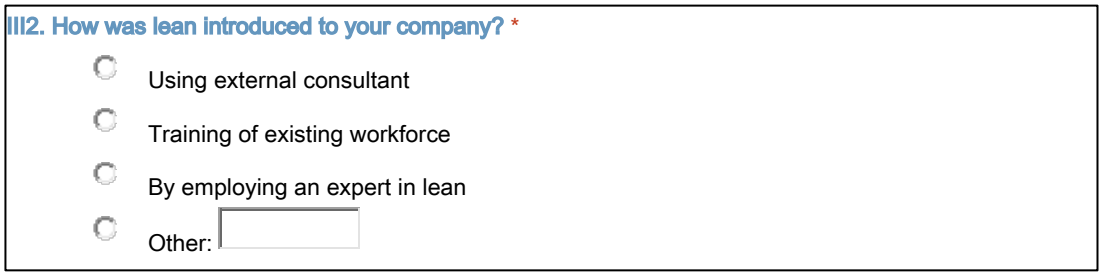


Figure 4-4 Part III: question on how lean was introduced

III3 & III4. Lean manufacturing and Lean techniques understanding

Both questions aim to assess the degree of understanding on lean philosophy and tools in the interviewee's company. The first question is more generic and aims to capture the general understanding of lean philosophy and lean thinking. Questions III4 aims to capture the understanding of specific lean tools.

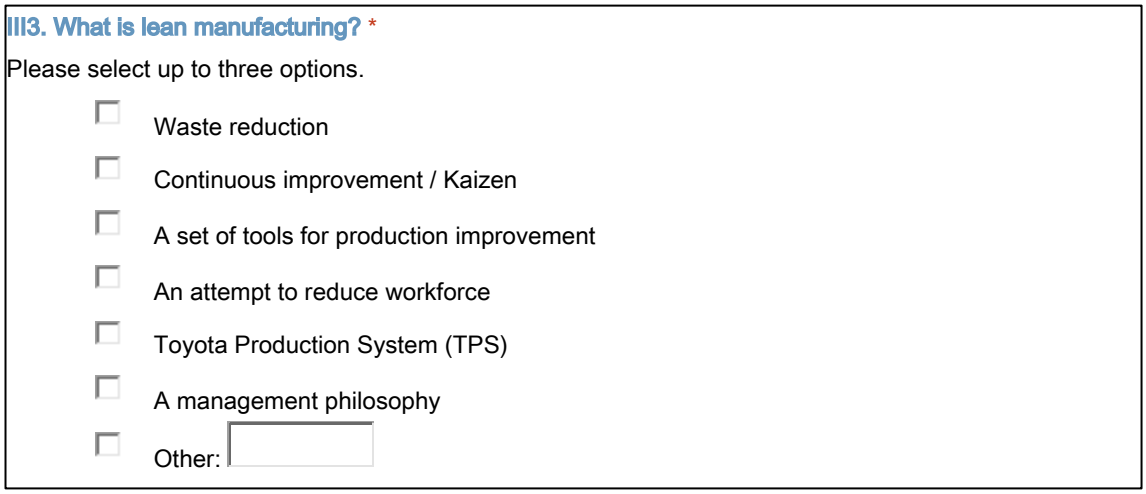


Figure 4-5 Part III: question on company's generic understanding of lean

III4. Lean Techniques understanding. *

For each one of the following lean methods, indicate the level of understanding within your company.

	Not clear what it is	Have heard of that before	Understanding of basics	Could be applied with some help	Considered to be a Champion!
5S	○	○	○	○	○
Setup time reduction (SMED)	○	○	○	○	○
Kaizen	○	○	○	○	○
Identifying and removing waste	○	○	○	○	○
Cellular manufacturing	○	○	○	○	○
VSM	○	○	○	○	○
Continuous Flow	○	○	○	○	○
Kanban - pull production	○	○	○	○	○
Just in time (JIT)	○	○	○	○	○
Poka-yoke (error-proof) design	○	○	○	○	○
Preventive maintenance (TPM)	○	○	○	○	○
Six Sigma / Lean Sigma	○	○	○	○	○
Lean supply chain (supplier involvement)	○	○	○	○	○
Workforce engagement	○	○	○	○	○
Quality circles / cross functional teams	○	○	○	○	○
Visual control (Andon)	○	○	○	○	○

Figure 4-6 Part III: question on company's understanding of specific lean techniques

III5. Lean techniques diffusion in manufacturing organizations

The degree of diffusion of the lean techniques within manufacturing organizations can be correlated to their lean maturity. The respondents were asked to indicate if they are already implementing the techniques in question, whether they consider doing so in the future, or whether they do not plan to implement them.

III5. Lean Techniques diffusion. *

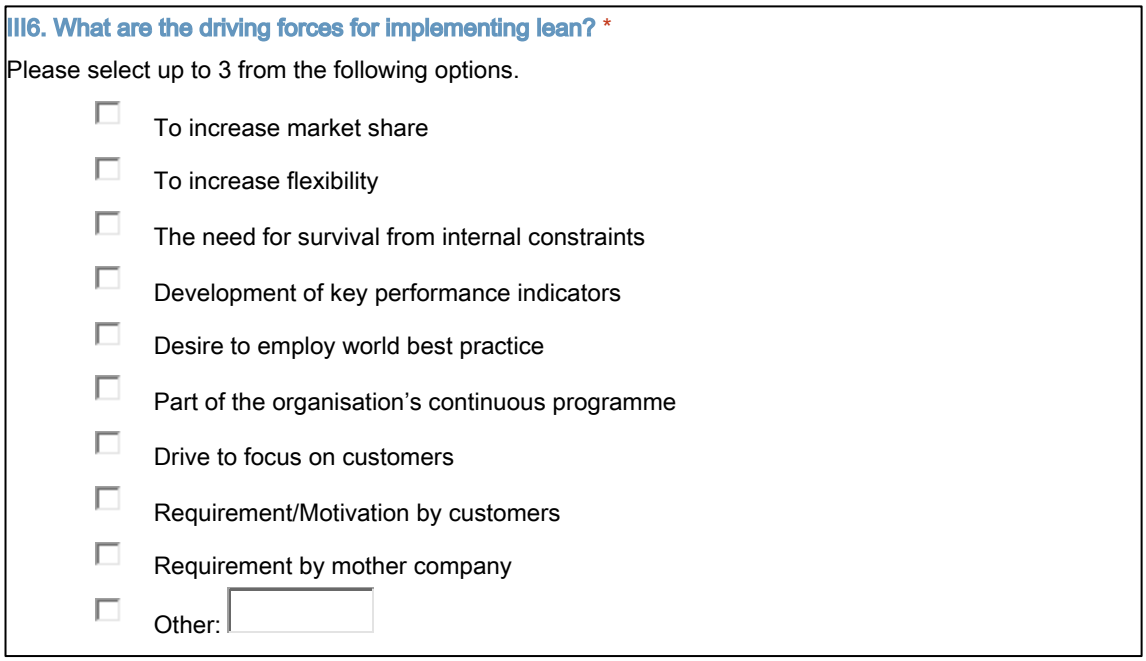
For each one of the following lean methods, indicate if it has been / is implemented, if you are not implementing and if you are thinking to implement in the close future

	We are not implementing it	We will implement it	We have / are implementing it
5S	○	○	○
Setup time reduction (SMED)	○	○	○
Kaizen	○	○	○
Identifying and removing waste	○	○	○
Cellular manufacturing	○	○	○
VSM	○	○	○
Continuous Flow	○	○	○
Kanban - pull production	○	○	○
Just in time (JIT)	○	○	○
Poka-yoke (error-proof) design	○	○	○
Preventive maintenance (TPM)	○	○	○
Six Sigma / Lean Sigma	○	○	○
Lean supply chain (supplier involvement)	○	○	○
Workforce engagement	○	○	○
Quality circles / cross functional teams	○	○	○
Visual control (Andon)	○	○	○
Customer involvement	○	○	○

Figure 4-7 Part III: question on the diffusion of lean techniques in the company

III6. Driving forces to Lean Manufacturing Implementation

The driving forces identified during the literature review, were listed in the questionnaire, for the respondents to select the ones that they feel are more suitably describing their companies' views.


III6. What are the driving forces for implementing lean? *

Please select up to 3 from the following options.

- To increase market share
- To increase flexibility
- The need for survival from internal constraints
- Development of key performance indicators
- Desire to employ world best practice
- Part of the organisation's continuous programme
- Drive to focus on customers
- Requirement/Motivation by customers
- Requirement by mother company
- Other:

Figure 4-8 Part III: question on company's driving forces for implementing lean

III7 & III8. Lean Manufacturing Implementation Barriers

Similarly, the barriers highlighted in the literature review, were also listed in the questionnaire. The respondents were asked to indicate the level of their agreement (using Likert scale) with these.

III7. Main causes of difficulties in developing the Lean Implementation (Lean barriers) *

Please indicate how strongly you agree (or disagree) with the following difficulties in implementing lean initiatives

	I strongly disagree	I disagree	Neutral	I agree	I strongly agree	Not applicable
Distractions / slow downs due to firefighting on other project / problems	○	○	○	○	○	○
Multiple production sites	○	○	○	○	○	○
Difficulty in quantifying the benefits upfront	○	○	○	○	○	○
Poor commitment from the bottom because of employees' fear of job cutting	○	○	○	○	○	○
Poor commitment from the bottom because of change inertia	○	○	○	○	○	○
Poor commitment from the bottom because change was not shared	○	○	○	○	○	○
Poor commitment from the bottom because of poor knowledge / understanding	○	○	○	○	○	○
Top management commitment lasted too shortly	○	○	○	○	○	○
Poor commitment from the top because of change inertia	○	○	○	○	○	○
Poor commitment from the top because of the poor belief on the approach / advantages	○	○	○	○	○	○
Poor commitment from the top because of poor knowledge / understanding	○	○	○	○	○	○
Necessity of high investments / costs	○	○	○	○	○	○

Figure 4-9 Part III: question on company's perception on lean barriers

III8. Please indicate whether there are any other difficulties in the lean implementation in your company.

Figure 4-10 Part III: questions on lean barriers

III9. Level of meeting the expectations

Finally, the respondents were asked their views on whether the lean implementation so far in their companies met their expectation. This question, in conjunction to the lean maturity and lean introduction method questions, can reveal if there is any correlation between the satisfaction and the maturity of the organization with regards lean manufacturing.

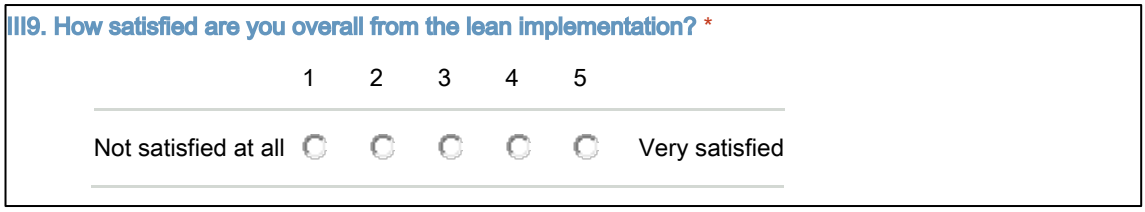


Figure 4-11 Part III: question on company's satisfaction from lean implementation

4.3.2 Survey targeted audience

In total 150 questionnaires were emailed to operations managers and manufacturing engineers of small and medium manufacturing companies within the UAE representing different sectors (including fashion, aerospace, defense, consumer goods, etc.). 87 completed questionnaires were received (58% response ratio). Following the companies' classification proposed by the government of Dubai (DUBAI SME, 2018), 23% of the responses were from companies within the fashion sector (manufacturers of wearing apparel), food and beverage manufacturers (22%), manufacturing of wood and wood products (14%), manufacturing of Fabricated Metal (except machinery and equipment) (21%), Manufacturing of Basic Metals (10%), and Manufacturing of other Non-metallic Mineral products (10%). The demographics of the survey are presented in Figure 4-12.

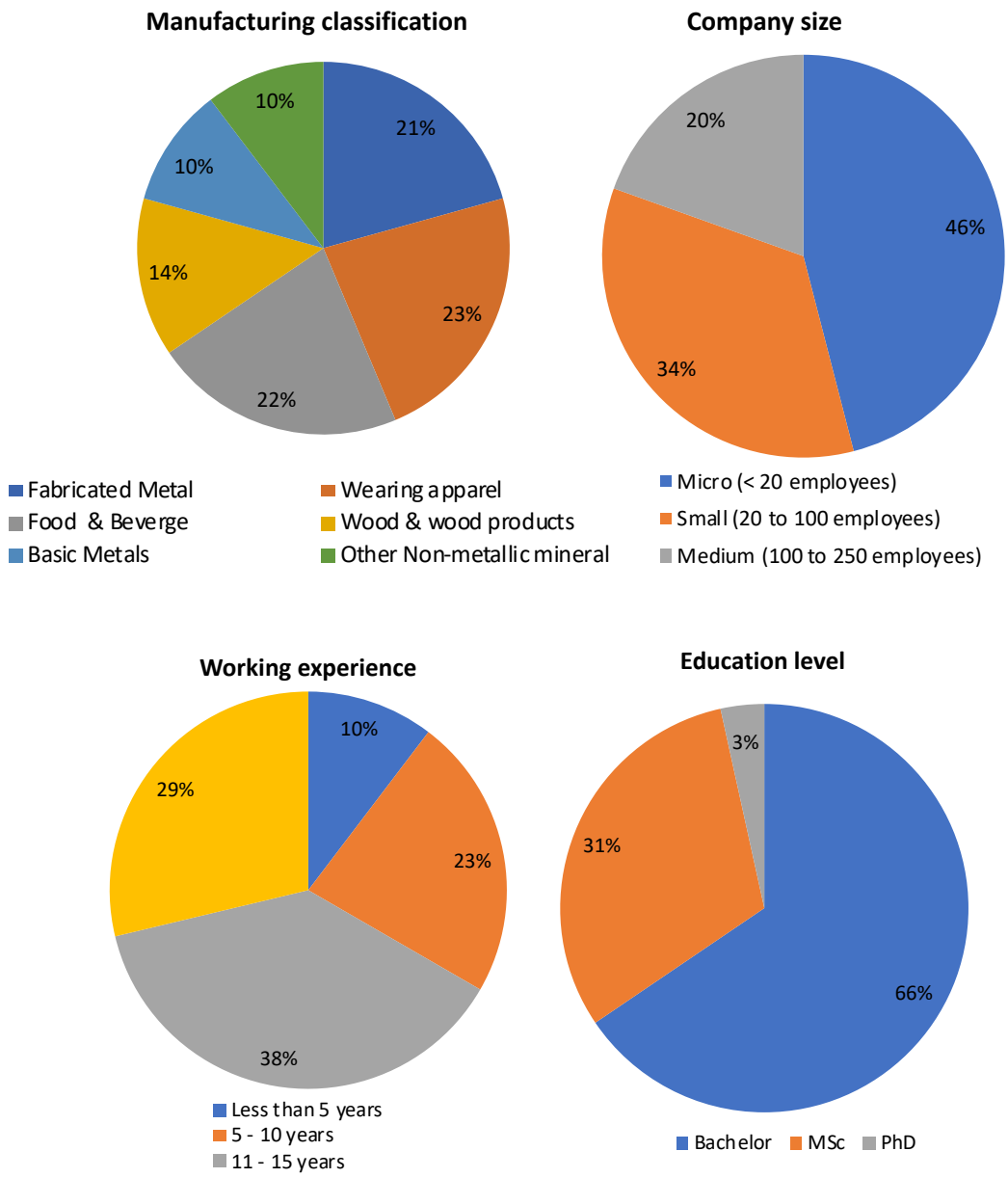


Figure 4-12 Survey demographics

4.4 Survey results

4.4.1 Lean implementation maturity

The lean implementation maturity of the participating companies was assessed by asking the number of years that the company has been in their lean journey and the way this was implemented in the company (whether an external consultant was used, or by employing a lean expert, or through training of the

existing stuff). In Figure 4-13 the results of the answers to the questionnaires are presented. An interesting point here is to mention that the size of the company is very important on whether a company is implementing lean or not. 55% of the micro companies (less than 20 employees) participated in the survey have not yet attempted to implement lean, and most of the rest have just started experimenting with lean philosophy. Compared to small and medium size companies, this is a significant difference.

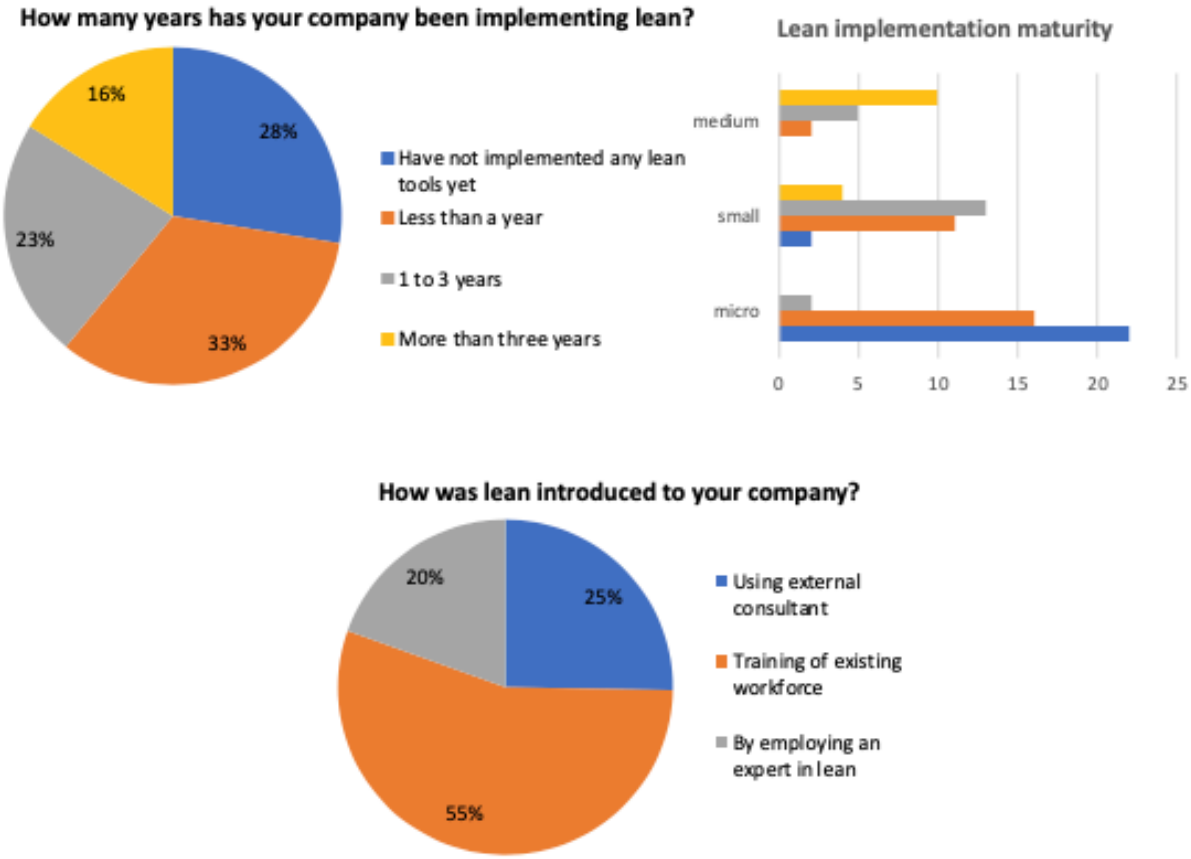


Figure 4-13 Lean implementation maturity

4.4.2 Lean understanding

The lean understanding status was also assessed by asking questions on what respondents understand lean is about, what the focus of implementing lean is, the knowledge and use of lean tools and finally the diffusion of these techniques. For the assessment of the general understanding of lean, the respondents had to associate lean manufacturing with key objectives / ideas, such as waste

reduction, continuous improvement, set of tools, management philosophy etc. They could select up to three different ideas as the ones who they associate most with lean. Figure 4-14 presents the results of this association.

The first ranked association was “a set of tools for production improvement”. Characterizing lean manufacturing as a “set of tools”, can be considered as an indication of early understanding of lean manufacturing. Furthermore, the third most frequently selected association is “workforce reduction”. Such perception is negative and not in line to lean manufacturing core principles. It can definitely be a barrier to lean manufacturing implementation. “Waste reduction” scores second and “Kaizen” fourth. Both are lean principles. One of the most relevant associations is “management philosophy” that however scored second to the last one. This is another indication that lean understanding is not yet mature at UAE manufacturing SMEs.

The level of understanding was found to vary with the company size and the time the company is implementing lean. Larger companies with more than three years focus more on the management philosophy and kaizen aspects of the lean manufacturing. Companies relatively new in lean implementation (less than three years of experience) focus on the waste reduction and the set of tools for production improvement. Only responses from micro and medium companies with less than one year indicate that lean might be associated with an attempt to reduce the workforce. This is in agreement with previous findings in other countries.

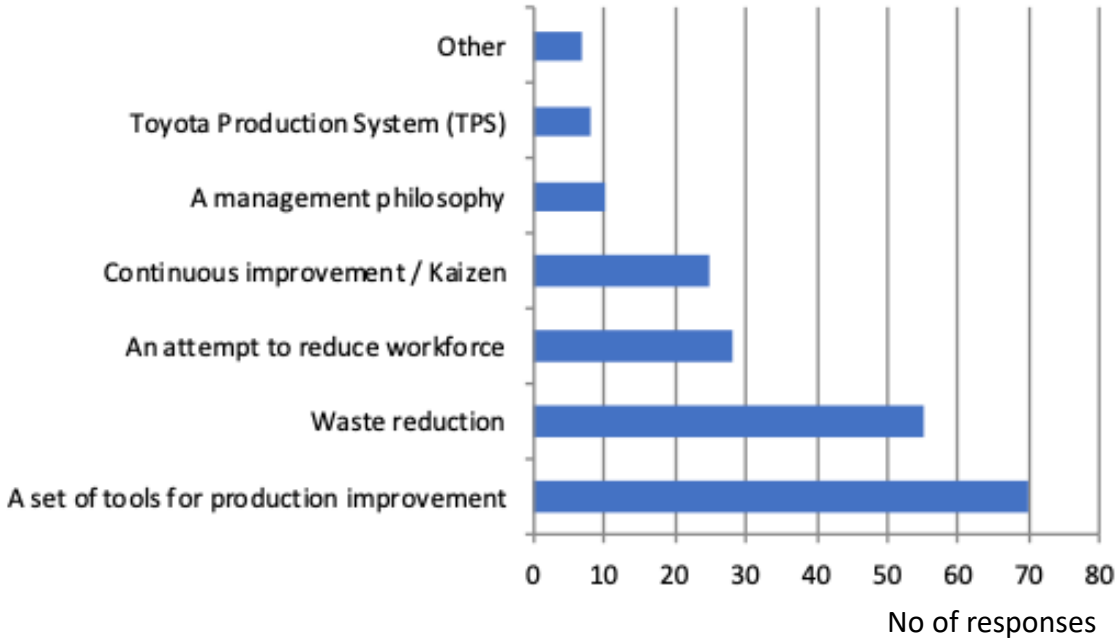


Figure 4-14 Lean understanding

4.4.3 Lean techniques understanding

As indicated in figure 4-14, there is a wide perception that lean is a "set of tools for production improvement". This is a valid perception, if we consider the number of different tools available that are considered under the lean umbrella. The most widely used were included in the questionnaire, and the respondents were asked to state their familiarity by selecting between five options, namely: "Not clear what it is", "I have heard of that before", "I understand the basics", "I could apply this with some help", and "I am considered to be an expert". For the quantification of the results, the same approach as per Salonitis and Tsinopoulos (2016) used. The scale ranged from 1 to 5 representing the perception levels. The result would be interpreted according to three classes of average score; 1 – 2.33, 2.34 – 3.67 and 3.68 – 5.00 as negative, neutral and positive perception for each item. As shown in figure 4, 5S was ranked first. This a logical result, as 5S is usually one of the first lean tools implemented when a company is embarking to its lean journey. This is also in agreement with similar surveys from other countries.

The classification proposed by Panizolo (1998) was used, where lean practices are grouped into five categories, namely: process and equipment, manufacturing planning and control, human resources, supplier relationships, and customer relationship. Figure 4-15 presents the average score for each category. The process and equipment category ranks first for understanding. The findings are in agreement with results presented by Panizzolo (1998) and Salonitis and Tsinopoulos (2016), where in countries where there is not a strong manufacturing history; organizations seem to have difficulty in adopting lean ideas with regards external relationships such as with suppliers and customers.

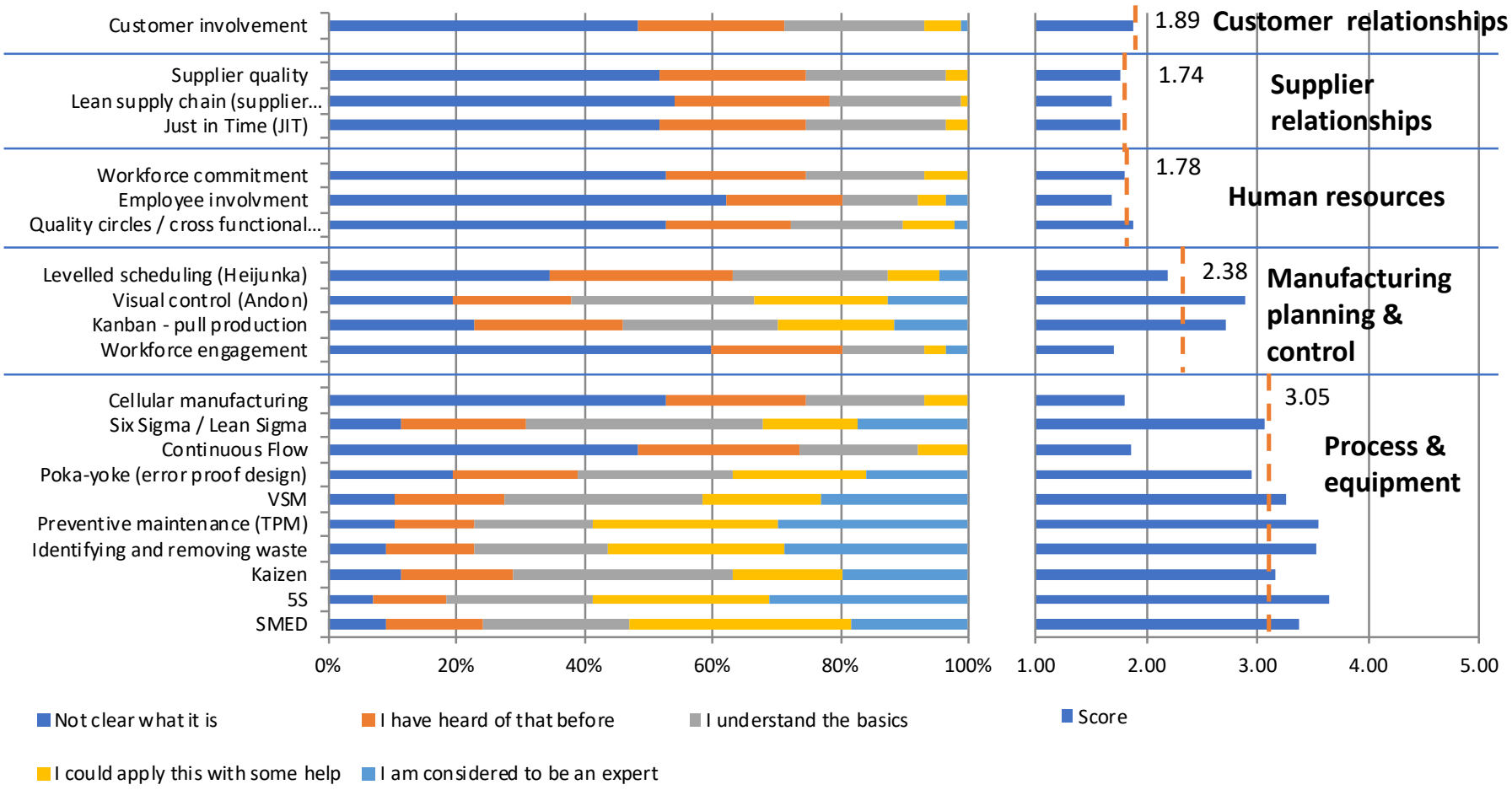


Figure 4-15 Lean techniques understanding

4.4.4 Lean drivers and barriers

In order to assess the challenges for implementing lean manufacturing, the lean drivers and barriers had to be assessed. Previous studies have focused in analysing these through comprehensive literature review and surveys. Through the extensive literature review in chapter 2, the common root causes that lead to lean initiatives failure were identified and related to: lack of supply chain integration, lack of leadership commitment, lack of employee involvement, poor understanding of lean tools and techniques and finally objecting business systems. This can serve as a starting point for putting together the questionnaire that would allow ranking these factors for the case of UAE manufacturing SMEs.

The lean drivers were listed in the questionnaire, and the survey participants were asked to select up to three. The key driver was revealed to be the increase of market share. This is again in agreement with previous studies. As per the understanding of techniques and tools, the potential benefits from the engagement with employees, customers and suppliers are not valued.

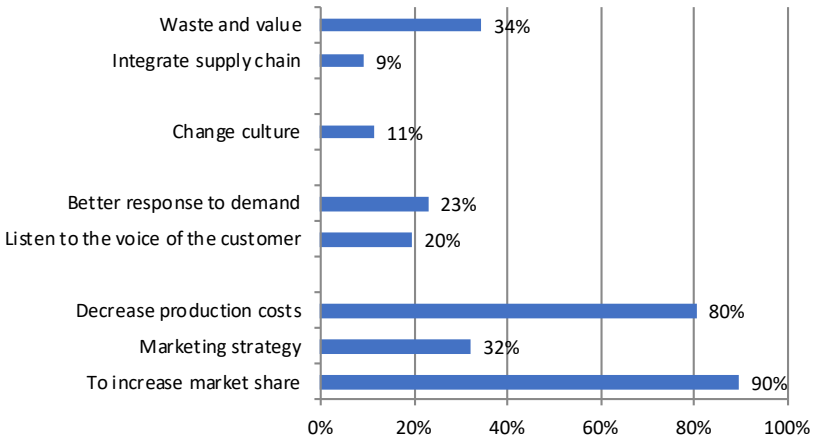


Figure 4-16 Lean drivers

With regards the barriers, a number of statements were listed, and the participants had to indicate whether they agree or disagree in a Likert scale. The average value for each barrier is presented in figure 4-17. Respondents consider equally important the lack of commitment from both the top (higher management) and the bottom (employees).

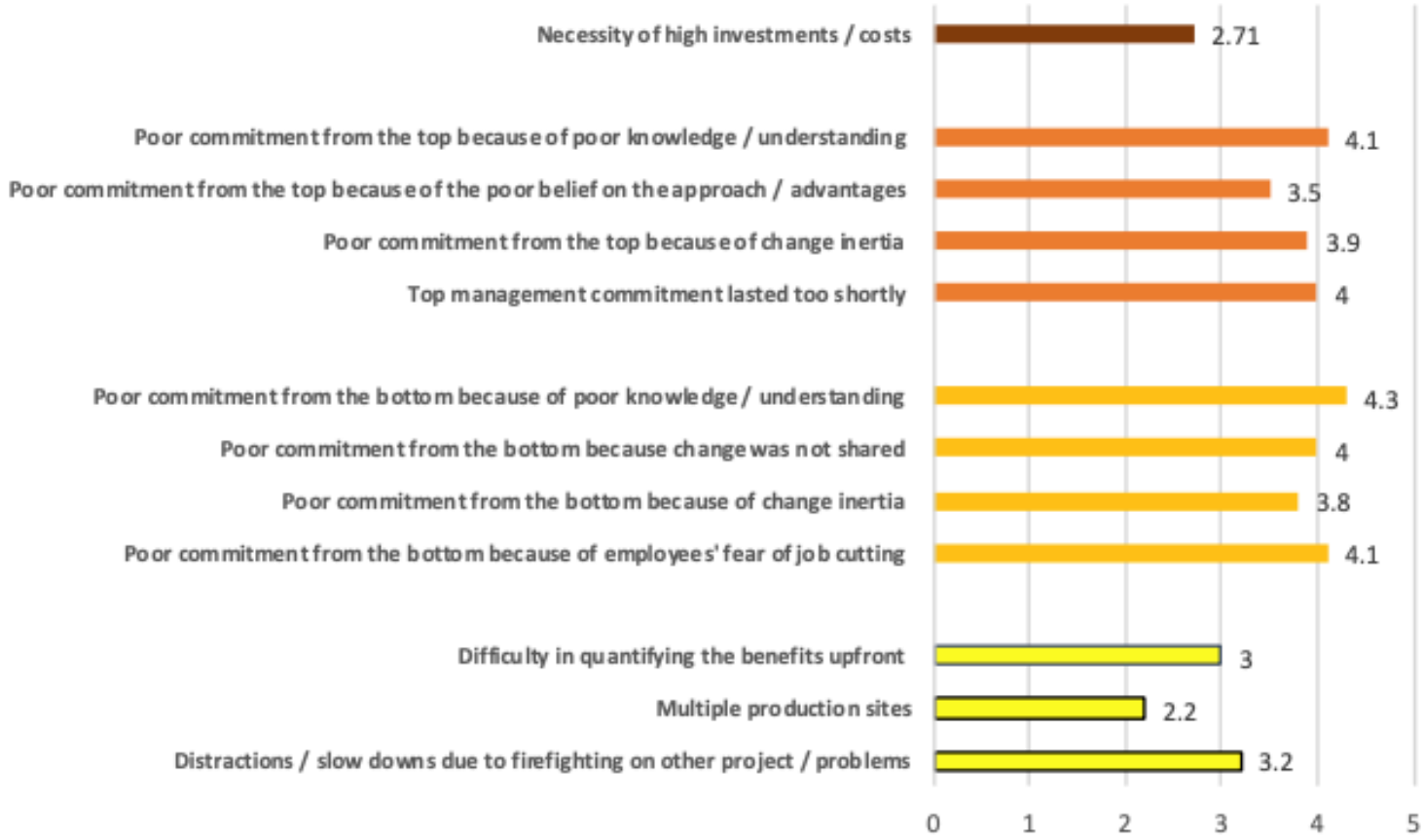


Figure 4-17 Lean barriers

4.5 Summary of the chapter

The chapter's aim was to assess the way lean manufacturing is introduced in manufacturing companies in the UAE. In order to capture and assess the lean maturity and compare to the literature review findings in other countries, a questionnaire was developed and circulated in manufacturing companies. The analysis of the questionnaires highlighted the level of understanding of lean thinking in UAE. It also allowed the ranking of the key barriers to implementation and the significance the drivers have.

5 INTERPRETIVE STRUCTURAL MODELLING

5.1 Introduction[3]

The literature review presented in Chapter 2 helped identify the key success factors as well as the barriers when implementing lean manufacturing initiatives. However, as it was highlighted at the summary of Chapter 2, no studies have been presented putting these into the UAE context. As a follow up thus, a survey was undertaken in order to confirm these in the context of UAE manufacturing sector. The results of this survey were presented in Chapter 4. In order to get a better understanding of the UAE manufacturing context as well as identify specific dynamics between the various factors, in the present chapter, a structural model based on the interpretive structural modelling (ISM) methodology is presented. The chapter starts with briefly presenting the ISM methodology, then ISM is applied for modelling the factors. Finally, MICMAC analysis of developed ISM model has been carried out to understand the driving power and dependence of the variables.

5.2 ISM methodology

5.2.1 Introduction

Interpretive structural modeling (ISM) methodology was proposed by Warfield (1974) for investigating the variables that define a problem as well as identifying the relationships between these variables. ISM has been used in a number of different problems since then, such as:

- Assessing different technologies for implementation (Watson, 1978)
- Supply chain risks (Pfohl et al., 2011)
- Organizational change forces (Sushil, 2012)
- Implementation of total productive maintenance (Poduval et al., 2015)

[3] Parts of the work presented in Chapter 5 have been submitted for publication into the following paper:

- Almanei M., Salonitis K. (2019) “Lean manufacturing implementation framework based on ISM and Change management” submitted for publication

- Competitiveness of Indian Manufacturing sector (Dewangan et al., 2015)
- Investigating the AIDS pandemic in south Africa (Nien-Tsu Tuan, 2017)
- Remanufacturing in India (Singhal et al., 2018)
- Biodiesel production from waste (Avinash et al., 2018)

From the above list, which is not exhaustive but rather indicative, it is obvious that ISM has been used in a wide spectrum of problems. Within the lean implementation body of knowledge, only recently a paper was published where ISM was used for discussing the variables that have an impact on lean implementation within Indian automotive manufacturing sector (Kumar et al., 2013).

5.2.2 Methodology

The ISM methodology can be considered a qualitative research tool. It is a structured approach that is based on interviewing a small number of experts. The interviews are focused on revealing if there is an interrelationship among the factors that have been predefined by the researcher. The outcome of this interviews is analyzed through the development of matrixes that allow the visualization of the interrelationships.

The ISM methodology is well structured and is composed of eight consecutive steps. Kumar et al. (2013) suggest seven steps, however in the present study, an additional one has been included for the review of the proposed ISM model as per Kannan et al. (2010). The ISM methodology steps are:

1- *Variables identification*: in this phase the critical success factors as well as barriers to lean implementation are identified as variables. This phased usually is based on a thorough literature review. In the present study the literature review in chapter 2 and the industrial survey results in chapter 4 serve as the basis

2- Establishing the contextual relationship among variables. During this phase, the experts are asked to establish the existence or not of the contextual relationships between the variables.

3- Developing a structural self-interaction matrix (SSIM) of variables: During this phase, a matrix is developed that indicates pair-wise relationship between the variables of the system.
4- Developing a reachability matrix from the SSIM: Based on the previous step, a reachability matrix is developed and then checked for transitivity. Transitivity of the contextual relation is a basic assumption in the ISM which states that if variable X is related to Y and Y is related to Z, then X is necessarily related to Z.
5- Partitioning the reachability matrix into different levels: The matrix that was developed in step four, is partitioned in different levels
6- Removal of transitive links: Based on the relationships in the reachability matrix, the transitive links are then removed. As a result of this step, a directed graph is drawn.
7- Construction of the ISM model: The directed graph is step 6 is then converted in the ISM model by replacing the variable nodes with statements.
8- Review of the ISM model: The last step is to check the ISM model for conceptual inconsistency and make the necessary modifications.

5.2.2.1 Structural Self-Interaction Matrix (SSIM) and reachability matrix (steps 3 and 4)

The contextual relationship among the variables can be represented using a matrix. This is the step 3 that was outlined in the previous section. Four symbols have been used to denote the direction of the relationship between the variables (i and j):

- A: variable i has an impact on variable j;
- B: variable j has an impact on variable i;
- C: variable i and j have an impact on each other; and
- D: variable i and j are unrelated.

The experts thus are required for every pair of variables to select which symbol better reflects their interrelationship. As an example, the following matrix (Table 5-1) highlights some of these interrelationships for a system that is characterized

by five variables. Variable 1 has impact on (leads on) to variable 5 and thus symbol “A” is used in the cell (1,5). Variable 5 leads on variable 2, and thus symbol “B” is used in the cell (2,5). Variables 3 and 4 lead to each other, and thus symbol “C” is used in cell (3,4). Finally, variables 2 and 3 are unrelated, thus symbol “D” is used in cell (2,3).

Table 5-1 SSIM for a system with 5 variables

Variables	5	4	3	2	1
1	A	A	A	A	
2	B	B	D		
3	B	C			
4	B				
5					

The next step (step 4) is the establishment of the reachability matrix that is completed in two sub-steps. The first sub-step is the development of the initial reachability matrix and the second one is the development of the final reachability matrix.

The initial reachability matrix (IRM) is based on the SSIM after it is transformed to a binary matrix. This is achieved by substituting the symbols A, B, C and D by 0 and 1 applying the following rules:

- If (i,j) value in the SSIM is A, (i,j) value in the reachability matrix will be 1 and (j,i) value will be 0 (as an example for the SSIM shown in Table 5-1, for A in cell (1,5) in SSIM, ‘1’ has been given in cell (1,5) and ‘0’ in cell (5,1) in initial reachability matrix).
- If (i,j) value in the SSIM is B, (i,j) value in the reachability matrix will be 0 and (j,i) value will be 1 (similar as before for B in cell (2,5) in SSIM, ‘0’ has been given in cell (2,5) and ‘1’ in cell (5,2) in initial reachability matrix).

- If (i,j) value in the SSIM is C, the value in the reachability matrix will be 1 for both (i,j) and (j, i) cells (for C in cell (3,4) in SSIM, '1' has been given in cell (3,4) and '1' in cell (4,3) also in initial reachability matrix).
- Finally, if (i,j) value in the SSIM is D, the value in the reachability matrix will be 0 for both (i,j) and (j,i) cells (for D in cell (2,3) in SSIM, '0' has been given in cell (2, 3) and cell (3,2) also in initial reachability matrix).

Following these rules, and for the SSIM in Table 5-1, the initial reachability matrix is developed in Table 5-2. Then final reachability matrix is obtained by incorporating the transitivity (if variable X is related to Y and Y is related to Z, then X is necessarily related to Z). If the transitivity rule is not satisfied, the experts are asked to review and modify the SSIM. The revised SSIM is again then worked out and tested for the transitivity rule. This process is repeated till the reachability matrix meets the requirements of the transitivity rule (Sushil, 2012).

In more detail, the final reachability matrix (FRM) is obtained after checking for transitivity and removing transitivity if there is any. To remove the transitivity in table 5-1, the steps to be followed should be:

1- Look for "0" entries in the Initial Reachability Matrix.
2- Check for the transitivity e.g., if Variable X leads to Variable Y ((x,y) is 1) and Variable Y leads to Variable Z ((y,z) is 1) this implies that Variable X leads to Variable Z is 1 (thus (x,z)=1)
3- If there is any transitivity replace the 0 with 1*

For the sake of the example, Table 5-2 is considered to satisfy the transitivity rule, and thus it is also the final reachability matrix.

Table 5-2 Initial Reachability Matrix

Variables	1	2	3	4	5
1	1	1	1	1	1
2	0	1	0	0	0
3	0	0	1	1	0
4	0	1	1	1	0
5	0	1	1	1	1

5.2.2.2 Partitioning the reachability matrix into different levels (step 5)

After extracting the final reachability matrix, it needs to be analyzed for extracting the digraph and associate structural models. For this reason, the reachability and antecedent sets for each variable are derived. The reachability set contain the factor itself and the factors that influence it. The antecedent set on the other hand again contains the factor itself, and the other factors which impact it. The intersection set contain the common factors between the reachability set and antecedent set. The variable for which the reachability and the intersection sets are the same is given the top-level variable in the ISM hierarchy. Such a top level variable would not help achieve any other variable above their own level. After the identification of the top level variable, it is discarded from the other remaining variables. This means that the process is iterative and carries on till all variables are discarded.

In Table 5-3, the level partition table for the example presented previously is shown. Variable 3 is ranked as a level 1 variable, as the reachability set (3,4) and the intersection set (3,4) are identical. That is the case for variable 2 as well. Variables 2 and 3 are then discarded and the level partition table is drafted again (Table 5-4). From this table variable is then ranked as level 2. In the next iteration (Table 5-5) variable 5 is then identified as being a level 3 variable. Thus variable 1 is a level 4 variable.

Table 5-3 Level partition table (1st iteration)

Variable	Reachability set	Antecedent set	Intersection set	Level
1	1, 2, 3, 4,5	1	1	
2	2	1, 2, 4, 5	2	1
3	3, 4	1, 3, 4, 5	3, 4	1
4	2, 3, 4	1, 3, 4, 5	3, 4	
5	2, 3, 4, 5	1, 5	5	

Table 5-4 Level partition table (2nd iteration)

Variable	Reachability set	Antecedent set	Intersection set	Level
1	1, 4, 5	1	1	
4	4	1, 4, 5	4	2
5	4, 5	1, 5	5	

Table 5-5 Level partition table (3rd iteration)

Variable	Reachability set	Antecedent set	Intersection set	Level
1	1, 5	1	1	
5	5	1, 5	5	3

5.2.2.3 ISM model construction (step 7)

After the ranking of the various variables into levels, the ISM model can be developed in the form of a digraph. A digraph is the graphical representation of the variables and their interdependence. Nodes and edges are used for visualizing the relationships. The partition table is the starting point for developing the digraph. Finally, the digraph is changed to an ISM model by substituting nodes of the factors with statements. Figure 5-1 shows the digraph that has been developed for the example worked so far.

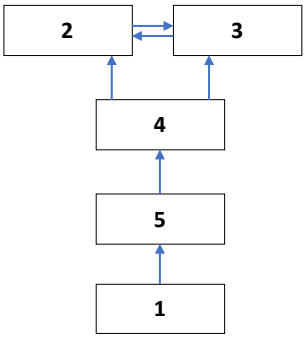


Figure 5-1 Digraph

5.2.3 MICMAC analysis

MICMAC analysis complements the ISM analysis, and in most of the papers reviewed it follows the ISM model. MICMAC stands for "Matriced' Impacts croises-multipication applique' and classment". MICMAC analysis allows identifying and quantifying the drive and dependence power of the variables considered in the analysis. The driving power is the count of all the variables that are within the reachability set, whereas the dependence power can be calculated by the count of all the variables in the antecedent set (Table 5-6).

Table 5-6 Reachability Matrix with driving and dependence power

Variables	1	2	3	4	5	Driving power
1	1	1	1	1	1	**5**
2	0	1	0	0	0	**1**
3	0	0	1	1	0	**2**
4	0	1	1	1	0	**3**
5	0	1	1	1	1	**4**
Dependence power	**1**	**4**	**4**	**4**	**2**	

As highlighted by Dewangan et al. (2015) however, since the relationship between the variables is not equal, some of them might be stronger or weaker than others. This can be addressed by employing the fuzzy MICMAC analysis approach. For using fuzzy MICMAC analysis, qualitative relationships can be quantified by mapping the qualitative terms in values within the scale 0 to 1. This is shown in Table 5-7.

Table 5-7 Possibility of relationship between variables i and j

No	Very Low	Low	Medium	High	Very high	Complete
0	0.1	0.3	0.5	0.7	0.9	1.0

The group of experts after they have agreed on the SSIM (Table 5-1) and the reachability matrix (table 5-2) has been derived, they are asked to rate the relationships based on the ranking provided in Table 5-7. The driving power is the sum of all points the variables that are within the reachability set have, whereas the dependence power can be calculated by the count of all the variables in the antecedent set. An example is shown in Table 5-8. It should be noted that the diagonal entries are converted to zero.

Table 5-8 Reachability Matrix using fuzzy possibilities with driving and dependence power (fuzzy marks are indicative for the sake of the example)

Variables	**1**	**2**	**3**	**4**	**5**	**Driving power**
1	0	.5	.7	.3	.7	2.2
2	0	0	0	0	0	0
3	0	0	0	.5	0	0.5
4	0	.5	.7	0	0	1.2
5	0	.7	.3	.4	0	1.4
Dependence power	0	1.7	1.7	1.2	0.7	

MICMAC analysis allows the graphical presentation of the variables by positioning them according to their driving and dependence power. In a scatter diagram, with X-axis the dependence power and Y-axis the driving power the variables are positioned, and clusters can be identified. The driving power and dependence power diagram for the example discussed till now is shown in Figure 5-2. In this figure the scores are for the full ISM analysis and not the fuzzy one.

The four clusters named as I to IV that are shown in Figure 5-2, allow the characterization of the variables. It gives an insight into the relative importance and interdependencies between these variables:

- The variables within cluster I are characterized as “autonomous” ones. These variables have less driving power and dependents and obviously have minor influence on the system. They are generally separated from the rest of the system, with which they have just couple of links.
- The variables within cluster II are characterized as “dependent” ones. They have low driving power and high dependence.
- The variables within cluster III are characterized as “linkage” ones. They have high driving power and high dependence power. These variables are unbalanced due to the fact that any activity on these will affect others and furthermore feedback on themselves
- Finally, the variables within cluster IV are characterized as “independent” or “driving” ones. The have strong driving power but weak dependence power.

Variables with extremely strong driving power are called the “primary variables” and fall into the group of independent or linkage criteria.

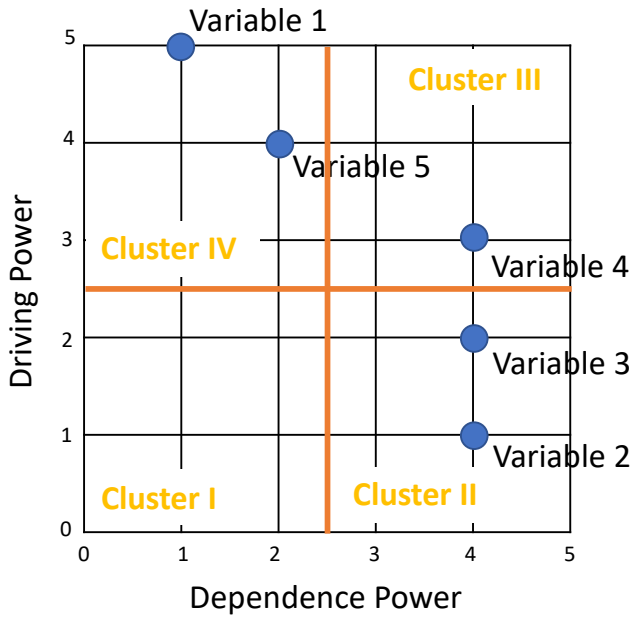


Figure 5-2 Driving power and dependence power diagram

5.3 ISM methodology application

5.3.1 Introduction

In chapter 2 the literature review presented identified the key success factors as well as the key barriers when implementing lean. These were then the basis for conducting the survey that was presented in chapter 4. As the survey in chapter 4 was distributed to a large number of companies in UAE, the information captured, although important, includes the views from companies and employees within these companies that are not necessary experts in the field. Thus, for better capturing the views of experts in lean manufacturing in UAE, the ISM was applied. In the following sections, the application of ISM is presented step by step.

5.3.2 Establishing the focus group for the completion of SSIM

As indicated in the introduction of the present chapter, the ISM is based on the coding of the experts' opinion into matrices. The experts are crucial in developing the structural self-interaction matrix (SSIM) of variables. Two workshops were organized, one for completing the SSIM and one after the analysis was completed for the presentation of the results and its validation. The selection of the experts

for participating in these workshops was based on their years of experience in implementing lean manufacturing in manufacturing companies in UAE. Initially 10 experts were selected. These were identified during the survey that was undertaken for the needs of chapter 4. After the initial communication with these experts, 5 accepted to participate in the analysis. Their profiles are presented in Table 5-9.

Table 5-9 Expert's profiles

Expert	Characteristics	Age	Years in lean manufacturing implementation
A	Continuous improvement manager	50	10
B	Operations manager	47	9
C	Technical director	55	7
D	Chief Operating Officer	54	15
E	Production manager	43	8

In the first workshop, the factors were presented to the experts and were discussed in detail. They were then asked to reach a consensus for every pair of variables, identifying the existence or not of the relationship between them. This information was used for the development of the SSIM matrices. In the same meeting, both the critical success factors and the lean implementation barriers.

5.3.3 Analysis of Critical Success Factors

The literature review (Chapter 2) revealed a wide range of factors (Critical success factors – CS) related to the successful implementation of Lean, that are summarized in the following list:

- (CS1) Organisational culture
- (CS2) Organisational readiness
- (CS3) Senior management commitment
- (CS4) Availability of resources for supporting the lean transformation
- (CS5) External support (employing consultants, lean experts etc)
- (CS6) Effective communication and engagement through the organisation
- (CS7) Strategic approach to improvements
- (CS8) Teamwork and systems thinking
- (CS9) Time planning for realistic change
- (CS10) Effective use of commitment and enthusiasm for change

5.3.3.1 ISM Analysis

In Table 5-10, the SSIM for critical success factors as these have been defined by the experts participating in the focus group is presented. The four symbols that have been used to denote the direction of the relationship between the variables (i and j):

- A: variable i has an impact on variable j;
- B: variable j has an impact on variable i;
- C: variable i and j have an impact on each other; and
- D: variable i and j are unrelated.

	(CS10) Effective use of commitment and enthusiasm for change	(CS9) Time planning for realistic change e	(CS8) Teamwork and systems thinking	(CS7) Strategic approach to improvements	(CS6) Effective communication and engagement through the organisation	(CS5) External support (employing consultants, lean experts etc)	(CS4) Availability of resources for supporting the lean transformation	(CS3) Senior management commitment	(CS2) Organisational readiness	(CS1) Organisational culture
	(CS10)	**(CS9)**	**(CS8)**	**(CS7)**	**(CS6)**	**(CS5)**	**(CS4)**	**(CS3)**	**(CS2)**	**(CS1)**
(CS1) Organisational culture	A	A	A	A	A	D	A	A	A	
(CS2) Organisational readiness	A	B	C	D	B	B	C	B		
(CS3) Senior management commitment	A	A	A	A	A	D	A			
(CS4) Availability of resources for supporting the lean transformation	B	D	A	D	D	A				
(CS5) External support (employing consultants, lean experts etc)	B	D	D	D	B					
(CS6) Effective communication and engagement through the organisation	A	A	C	A						
(CS7) Strategic approach to improvements	B	A	A							
(CS8) Teamwork and systems thinking	A	D								
(CS9) Time planning for realistic change	A									
(CS10) Effective use of commitment and enthusiasm for change										

Table 5-10 SSIM for critical success factors

Following the process as this has been presented in section 5.2.2, the initial reachability matrix was calculated, as presented in Table 5-11. After incorporating the transitivity as described in step (4) in section 5.2.2, the final reachability matrix is presented in

Table 5-12. Entries with an asterisk are included to incorporate transitivity. In the same table, the driving power and the dependence power for each critical success factor is also sown.

Table 5-11 Initial reachability matrix for critical success factors

	(CS1)	(CS2)	(CS3)	(CS4)	(CS5)	(CS6)	(CS7)	(CS8)	(CS9)	(CS10)
(CS1)	1	1	1	1	0	1	1	1	1	1
(CS2)	0	1	0	1	0	0	0	1	0	1
(CS3)	0	1	1	1	0	1	1	1	1	1
(CS4)	0	1	0	1	1	0	0	1	0	0
(CS5)	0	1	0	0	1	0	0	0	0	0
(CS6)	0	1	0	0	1	1	1	1	1	1
(CS7)	0	0	0	0	0	0	1	1	1	0
(CS8)	0	1	0	0	0	1	0	1	0	1
(CS9)	0	1	0	0	0	0	0	0	1	1
(CS10)	0	0	0	1	1	0	1	0	0	1

Table 5-12 Final reachability matrix for critical success factors and driving and dependence power

	(CS1)	(CS2)	(CS3)	(CS4)	(CS5)	(CS6)	(CS7)	(CS8)	(CS9)	(CS10)	Driving power
(CS1)	1	1	1	1	1*	1	1	1	1	1	**10**
(CS2)	0	1	0	1	1*	1*	1*	1	0	1	**7**
(CS3)	0	1	1	1	1*	1	1	1	1	1	**9**
(CS4)	0	1	0	1	1	1*	0	1	0	1*	**6**
(CS5)	0	1	0	1*	1	0	0	1*	0	1*	**5**
(CS6)	0	1	0	1*	1	1	1	1	1	1	**8**
(CS7)	0	1*	0	0	0	1*	1	1	1	1*	**6**
(CS8)	0	1	0	1*	1*	1	1*	1	1*	1	**8**
(CS9)	0	1	0	1*	1*	0	1*	1*	1	1	**7**
(CS10)	0	1*	0	1	1	0	1	1*	1*	1	**7**
Dependence power	**1**	**10**	**2**	**9**	**9**	**7**	**8**	**10**	**7**	**10**	

The level partition tables are presented afterwards (Table 5-13 - Table 5-17). Critical success factors 2, 4, 5, 7, 8 and 10 are ranked as a level 1 variables, as the reachability sets, and the intersection sets are identical. Critical success factor 9 is level, Critical success factor 6 is level 3, factor 3 is level 4 and factor 1 is level 5.

Table 5-13 Level partition table (1st iteration)

	Reachability	Antecedent	Intersection	Level
(CS1)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1	1	
(CS2)	2, 4, 5, 6, 7, 8, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	2, 4, 5, 6, 7, 8, 10	I
(CS3)	2, 3, 4, 5, 6, 7, 8, 9, 10	1, 3	3	
(CS4)	2, 4, 5, 6, 8, 10	1, 2, 3, 4, 5, 6, 8, 9, 10	2, 4, 5, 6, 8, 10	I
(CS5)	2, 4, 5, 8, 10	1, 2, 3, 4, 5, 6, 8, 9, 10	2, 4, 5, 8, 10	I
(CS6)	2, 4, 5, 6, 7, 8, 9, 10	1, 2, 3, 4, 6, 7, 8	2, 4, 6, 7, 8	
(CS7)	2, 6, 7, 8, 9, 10	1, 2, 3, 6, 7, 8, 9, 10	2, 6, 7, 8, 9, 10	I
(CS8)	2, 4, 5, 6, 7, 8, 9, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	2, 4, 5, 6, 7, 8, 9, 10	I
(CS9)	2, 4, 5, 7, 8, 9, 10	1, 3, 6, 7, 8, 9, 10	7, 8, 9, 10	
(CS10)	2, 4, 5, 7, 8, 9, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	2, 4, 5, 7, 8, 9, 10	I

Table 5-14 Level partition table (2nd iteration)

	Reachability	Antecedent	Intersection	Level
(CS1)	1, 3, 6, 9	1	1	
(CS3)	3, 6, 9	1, 3	3	
(CS6)	6, 9	1, 3, 6	6	
(CS9)	9	1, 3, 6, 9	9	II

Table 5-15 Level partition table (3rd iteration)

	Reachability	Antecedent	Intersection	Level
(CS1)	1, 3, 6	1	1	
(CS3)	3, 6	1, 3	3	
(CS6)	6	1, 3, 6	6	III

Table 5-16 Level partition table (4th iteration)

	Reachability	Antecedent	Intersection	Level
(CS1)	1, 3	1	1	
(CS3)	3	1, 3	3	IV

Table 5-17 Level partition table (5th iteration)

	Reachability	Antecedent	Intersection	Level
(CS1)	1	1	1	V

After the ranking of the various variables into levels, the ISM model was developed in the form of a digraph (Figure 5-3). The original digraph is presented in Appendix A. Finally, the digraph is changed to an ISM model by substituting nodes of the factors with statements. Figure 5-4 shows the ISM model that has been developed.

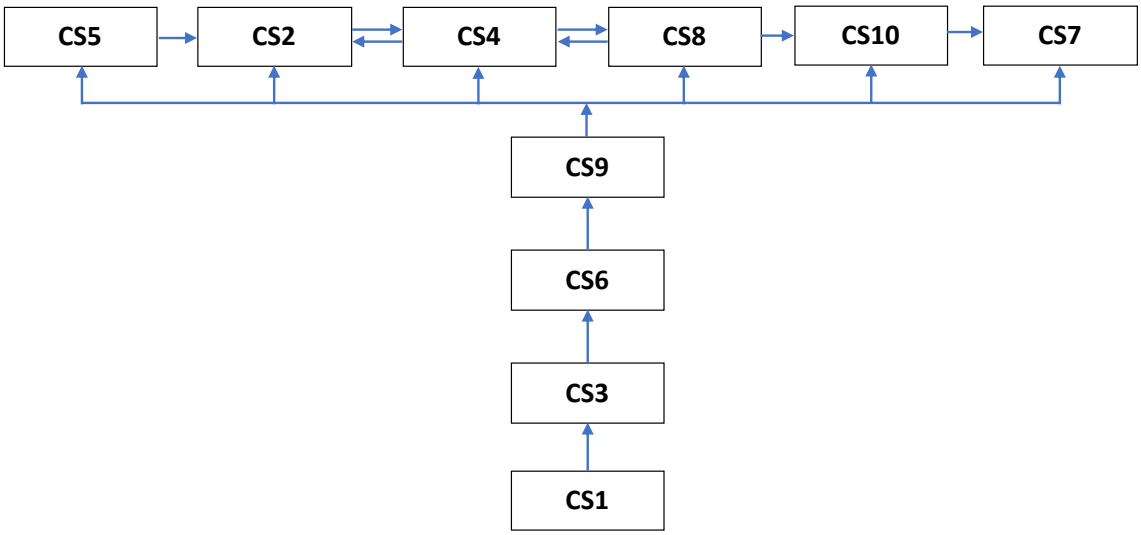


Figure 5-3 Digraph of critical success factors

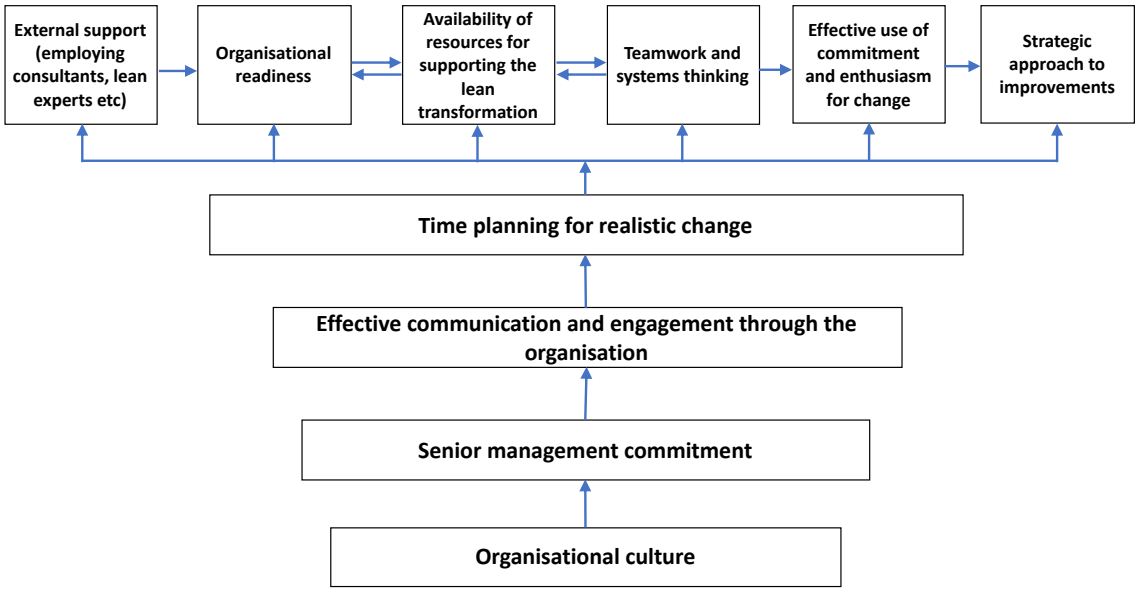


Figure 5-4 ISM model of critical success factors

5.3.3.2 MICMAC Analysis

MICMAC analysis allows identifying and quantifying the drive and dependence power of the variables considered in the analysis. The driving power is the count of all the variables that are within the reachability set, whereas the dependence power can be calculated by the count of all the variables in the antecedent set (Table 5-12). MICMAC analysis allows the graphical presentation of the variables by positioning them according to their driving and dependence power. In a scatter diagram, with X-axis the dependence power and Y-axis the driving power the variables are positioned, and clusters can be identified. The driving power and dependence power diagram for the critical success factors is shown in Figure 5-5.

(CS1) Organisational culture
(CS2) Organisational readiness
(CS3) Senior management commitment
(CS4) Availability of resources for supporting the lean transformation
(CS5) External support (employing consultants, lean experts etc)
(CS6) Effective communication and engagement through the organisation
(CS7) Strategic approach to improvements
(CS8) Teamwork and systems thinking
(CS9) Time planning for realistic change
(CS10) Effective use of commitment and enthusiasm for change

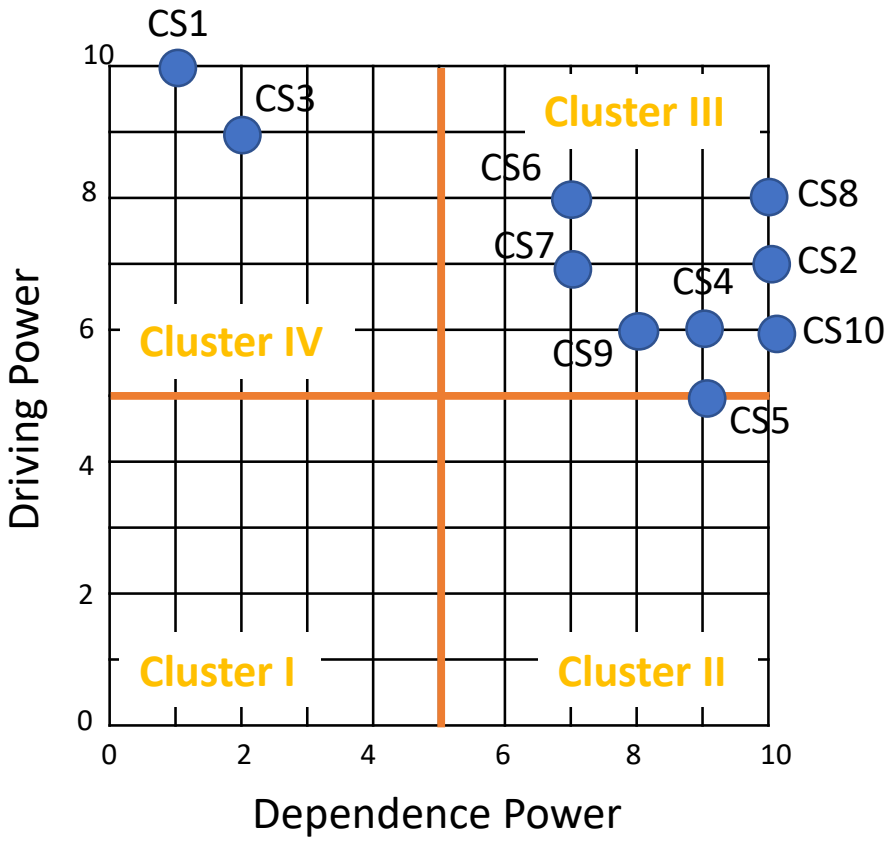


Figure 5-5 MICMAC analysis

5.3.3.3 Discussion of findings

A number of interesting conclusions can be drawn from the charts developed. The critical success factors that are in Cluster IV in the MICMAC analysis output, namely “organizational culture” and “senior management” are the ones that deserve the most attention. These are the ones the affect the other elements directly or indirectly. Looking at these at the ISM model, there are located at the bottom. These factors are the ones called “independent” or “driving” factors and, as mentioned at the beginning of this chapter, they have strong driving power but weak dependence power. From the framework to be developed point of view, these are the ones that need to be controlled as early as possible for having the maximum impact.

The rest of the factors all lie within cluster III. These are the “linkage” ones, and as mentioned before, they have high driving power and high dependence power. These variables are unbalanced due to the fact that any activity on these will affect others and furthermore feedback on themselves. These are quite sensitive and any change will have multiple effects. To make things even more complex, there is a “feedback” effect on them since they are interrelated.

The lack of any “autonomous” factors indicate that the system is quite robust and self-contained.

According t the analysis result from both the MICMAC analysis and the ISM model, “Organizational culture (CS1)” has the strongest driving power, as it influences all other variables. “Senior management commitment” has also high driving power. For both factors, this means that even a slight change within their performance will have a high impact in the whole of the system. Both these two variables have low dependence power, and as such they are not going to be largely affected by the rest of the factors. As mentioned before, these are the ones that need to be controlled early in the implementation of lean. This is in total agreement to the literature review findings reported in Chapter 2.

Factors “Effective communication and engagement through the organisation (CS6)” and “Teamwork and systems thinking (CS8)’ also have high driving power,

but at the same they have high dependence power as well. These are sensitive factors, as a change affecting these factors need to be very well planned, in order to account for feedback loops internally.

5.3.4 Lean implementation barriers

The analysis of the literature review also revealed the barriers (Lean Implementation Barriers – LIB) that have an negative impact on the implementation of lean manufacturing:

- (LIB1) Every day operational distractions
- (LIB2) Multiple production sites
- (LIB3) Difficulty in quantifying the benefits in advance
- (LIB4) Poor commitment of workforce due to fear of losing their job
- (LIB5) Poor commitment of workforce due to change inertia
- (LIB6) Poor commitment of workforce as change was not shared
- (LIB7) Poor commitment of workforce due to poor understanding of lean
- (LIB8) Lack of long-term senior management commitment
- (LIB9) Poor commitment of senior management due change inertia
- (LIB10) Poor commitment of senior management due to the poor belief on the approach
- (LIB11) Poor commitment of senior management due to poor understanding of lean
- (LIB12) Necessity of high capital investments

5.3.4.1 ISM Analysis

In Table 5-18, the SSIM for critical success factors as these have been defined by the experts participating in the focus group is presented. The four symbols that have been used to denote the direction of the relationship between the variables (i and j):

- A: variable i has an impact on variable j;
- B: variable j has an impact on variable i;
- C: variable i and j have an impact on each other; and
- D: variable i and j are unrelated.

	(LIB12) Necessity of high capital investments	**(LIB11)** Poor commitment of senior management due to poor understanding of lean	**(LIB10)** Poor commitment of senior management due to the poor belief on the approach	**(LIB9)** Poor commitment of senior management due to change inertia	**(LIB8)** Lack of long-term senior management commitment	**(LIB7)** Poor commitment of workforce due to poor understanding of lean	**(LIB6)** Poor commitment of workforce due to change not shared	**(LIB5)** Poor commitment of workforce due to change inertia	**(LIB4)** Poor commitment of workforce due to fear of losing their job	**(LIB3)** Difficulty in quantifying the benefits in advance	**(LIB2)** Multiple production sites	**(LIB1)** Every day operational distractions
(LIB1) Every day operational distractions	D	D	D	D	D	D	D	D	D	D	B	
(LIB2) Multiple production sites	A	D	D	D	D	D	D	D	D	A		
(LIB3) Difficulty in quantifying the benefits in advance	A	B	D	D	A	B	D	D	D			
(LIB4) Poor commitment of workforce due to fear of losing their job	D	B	B	D	D	B	B	A				
(LIB5) Poor commitment of workforce due to change inertia	D	B	B	C	D	B	B					
(LIB6) Poor commitment of workforce due to change not shared	D	B	B	C	B	B						
(LIB7) Poor commitment of workforce due to poor understanding of lean	D	C	B	D	B							
(LIB8) Lack of long-term senior management commitment	B	B	B	B								
(LIB9) Poor commitment of senior management due to change inertia	D	B	B									
(LIB10) Poor commitment of senior management due to the poor belief on the approach	B	B										
(LIB11) Poor commitment of senior management due to poor understanding of lean	B											
(LIB12) Necessity of high capital investments												

Table 5-18 SSIM for Lean Implementation Barriers

Following the process as this has been presented in section 5.2.2, the initial reachability matrix was calculated, as presented in Table 5-19Table 5-11. After incorporating the transitivity as described in step (4) in section 5.2.2, the final reachability matrix is presented in Table 5-20. Entries with an asterisk are included to incorporate transitivity. In the same table, the driving power and the dependence power for each critical success factor is also sown.

Table 5-19 Initial reachability matrix for lean implementation barriers

	(LIB1)	(LIB2)	(LIB3)	(LIB4)	(LIB5)	(LIB6)	(LIB7)	(LIB8)	(LIB9)	(LIB10)	(LIB11)	(LIB12)
(LIB1)	1	0	0	0	0	0	0	0	0	0	0	0
(LIB2)	1	1	1	0	0	0	0	0	0	0	0	1
(LIB3)	0	0	1	0	0	0	0	1	0	0	0	1
(LIB4)	0	0	0	1	1	0	0	0	0	0	0	0
(LIB5)	0	0	0	0	1	0	0	0	1	0	0	0
(LIB6)	0	0	0	1	1	1	0	0	1	0	0	0
(LIB7)	0	0	1	1	1	1	1	0	0	0	1	0
(LIB8)	0	0	0	0	0	1	1	1	0	0	0	0
(LIB9)	0	0	0	0	1	1	0	1	1	0	0	0
(LIB10)	0	0	0	1	1	1	1	1	1	1	0	0
(LIB11)	0	0	1	1	1	1	1	1	1	1	1	0
(LIB12)	0	0	0	0	0	0	0	1	0	1	1	1

Table 5-20 Final reachability matrix for lean implementation barriers and driving and dependence power

	(LIB1)	(LIB2)	(LIB3)	(LIB4)	(LIB5)	(LIB6)	(LIB7)	(LIB8)	(LIB9)	(LIB10)	(LIB11)	(LIB12)	Driving power
(LIB1)	1	0	0	0	0	0	0	0	0	0	0	0	**1**
(LIB2)	1	1	1	0	0	0	0	1*	0	1*	1*	1	**7**
(LIB3)	0	0	1	0	0	1*	1*	1	0	1*	1*	1	**7**
(LIB4)	0	0	0	1	1	0	0	0	1*	0	0	0	**3**
(LIB5)	0	0	0	0	1	1*	0	1*	1	0	0	0	**4**
(LIB6)	0	0	0	1	1	1	0	1*	1	0	0	0	**5**
(LIB7)	0	0	1	1	1	1	1	1*	1*	1*	1	1*	**10**
(LIB8)	0	0	1*	1*	1*	1	1	1	1*	0	1*	0	**8**
(LIB9)	0	0	0	1*	1	1	1*	1	1	0	0	0	**6**
(LIB10)	0	0	1*	1	1	1	1	1	1	1	1*	0	**9**
(LIB11)	0	0	1	1	1	1	1	1	1	1	1	1*	**10**
(LIB12)	0	0	1*	1*	1*	1*	1*	1	1*	1	1	1	**10**
Dependence power	**2**	**1**	**7**	**8**	**9**	**9**	**7**	**10**	**9**	**6**	**7**	**5**	

The level partition tables are presented afterwards (Table 5-21 - Table 5-26). Critical success factors 2, 4, 5, 7, 8 and 10 are ranked as a level 1 variables, as the reachability sets, and the intersection sets are identical. Critical success factor 9 is level, Critical success factor 6 is level 3, factor 3 is level 4 and factor 1 is level 5.

Table 5-21 Level partition table (1st iteration)

	Reachability	Antecedent	Intersection	Level
(LIB1)	1	1, 2	1	I
(LIB2)	1, 2, 3, 8, 10, 11, 12	2	2	
(LIB3)	3, 6, 7, 8, 10, 11, 12	2, 3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB4)	4, 5, 9	4, 6, 7, 8, 9, 10, 11, 12	4, 9	
(LIB5)	5, 6, 8, 9	4, 5, 6, 7, 8, 9, 10, 11, 12	5, 6, 8, 9	I
(LIB6)	4, 5, 6, 8, 9	3, 5, 6, 7, 8, 9, 10, 11, 12	5, 6, 8, 9	
(LIB7)	3, 4, 5, 6, 7, 8, 9, 10, 11, 12	3, 7, 8, 9, 10, 11, 12	3, 7, 8, 9, 10, 11, 12	
(LIB8)	3, 4, 5, 6, 7, 8, 9, 11	2, 3, 5, 6, 7, 8, 9, 10, 11, 12	3, 5, 6, 7, 8, 9, 11	
(LIB9)	4, 5, 6, 7, 8, 9	4, 5, 6, 7, 8, 9, 10, 11, 12	4, 5, 6, 7, 8, 9	I
(LIB10)	3, 4, 5, 6, 7, 8, 9, 10, 11	2, 3, 7, 10, 11, 12	3, 7, 10, 11	
(LIB11)	3, 4, 5, 6, 7, 8, 9, 10, 11, 12	2, 3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB12)	3, 4, 5, 6, 7, 8, 9, 10, 11, 12	2, 3, 7, 11, 12	3, 7, 11, 12	

Table 5-22 Level partition table (2nd iteration)

	Reachability	Antecedent	Intersection	Level
(LIB2)	2, 3, 8, 10, 11, 12	2	2	
(LIB3)	3, 6, 7, 8, 10, 11, 12	2, 3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB4)	4	4, 6, 7, 8, 10, 11, 12	4	II
(LIB6)	4, 6, 8	3, 6, 7, 8, 10, 11, 12	6, 8	
(LIB7)	3, 4, 6, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB8)	3, 4, 6, 7, 8, 11	2, 3, 6, 7, 8, 10, 11, 12	3, 6, 7, 8, 11	
(LIB10)	3, 4, 6, 7, 8, 10, 11	2, 3, 7, 10, 11, 12	3, 7, 10, 11	
(LIB11)	3, 4, 6, 7, 8, 10, 11, 12	2, 3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB12)	3, 4, 6, 7, 8, 10, 11, 12	2, 3, 7, 11, 12	3, 7, 11, 12	

Table 5-23 Level partition table (3rd iteration)

	Reachability	Antecedent	Intersection	Level
(LIB2)	2, 3, 8, 10, 11, 12	2	2	
(LIB3)	3, 6, 7, 8, 10, 11, 12	2, 3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB6)	6, 8	3, 6, 7, 8, 10, 11, 12	6, 8	III
(LIB7)	3, 6, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB8)	3, 6, 7, 8, 11	2, 3, 6, 7, 8, 10, 11, 12	3, 6, 7, 8, 11	III
(LIB10)	3, 6, 7, 8, 10, 11	2, 3, 7, 10, 11, 12	3, 7, 10, 11	
(LIB11)	3, 6, 7, 8, 10, 11, 12	2, 3, 7, 8, 10, 11, 12	3, 7, 8, 10, 11, 12	
(LIB12)	3, 6, 7, 8, 10, 11, 12	2, 3, 7, 11, 12	3, 7, 11, 12	

Table 5-24 Level partition table (4th iteration)

	Reachability	Antecedent	Intersection	Level
(LIB2)	2, 3, 10, 11, 12	2	2	
(LIB3)	3, 7, 10, 11, 12	2, 3, 7, 10, 11, 12	3, 7, 10, 11, 12	IV
(LIB7)	3, 7, 10, 11, 12	3, 7, 10, 11, 12	3, 7, 10, 11, 12	IV
(LIB10)	3, 7, 10, 11	2, 3, 7, 10, 11, 12	3, 7, 10, 11	IV
(LIB11)	3, 7, 10, 11, 12	2, 3, 7, 10, 11, 12	3, 7, 10, 11, 12	IV
(LIB12)	3, 7, 10, 11, 12	2, 3, 7, 11, 12	3, 7, 11, 12	

Table 5-25 Level partition table (5th iteration)

	Reachability	Antecedent	Intersection	Level
(LIB2)	2, 12	2	2	
(LIB12)	12	2,12	12	V

Table 5-26 Level partition table (6th iteration)

	Reachability	Antecedent	Intersection	Level
(LIB2)	2	2	2	V

After the ranking of the various variables into levels, the ISM model was developed in the form of a digraph (Figure 5-6). The original digraph is presented in Appendix B. This digraph was presented in the focus group for discussion. Based on the feedback received, the diagram was modified in order to account for their views. This will be discussed in more detail in the following paragraph.

Finally, the digraph is changed to an ISM model by substituting nodes of the factors with statements. Figure 5-7 shows the ISM model that has been developed.

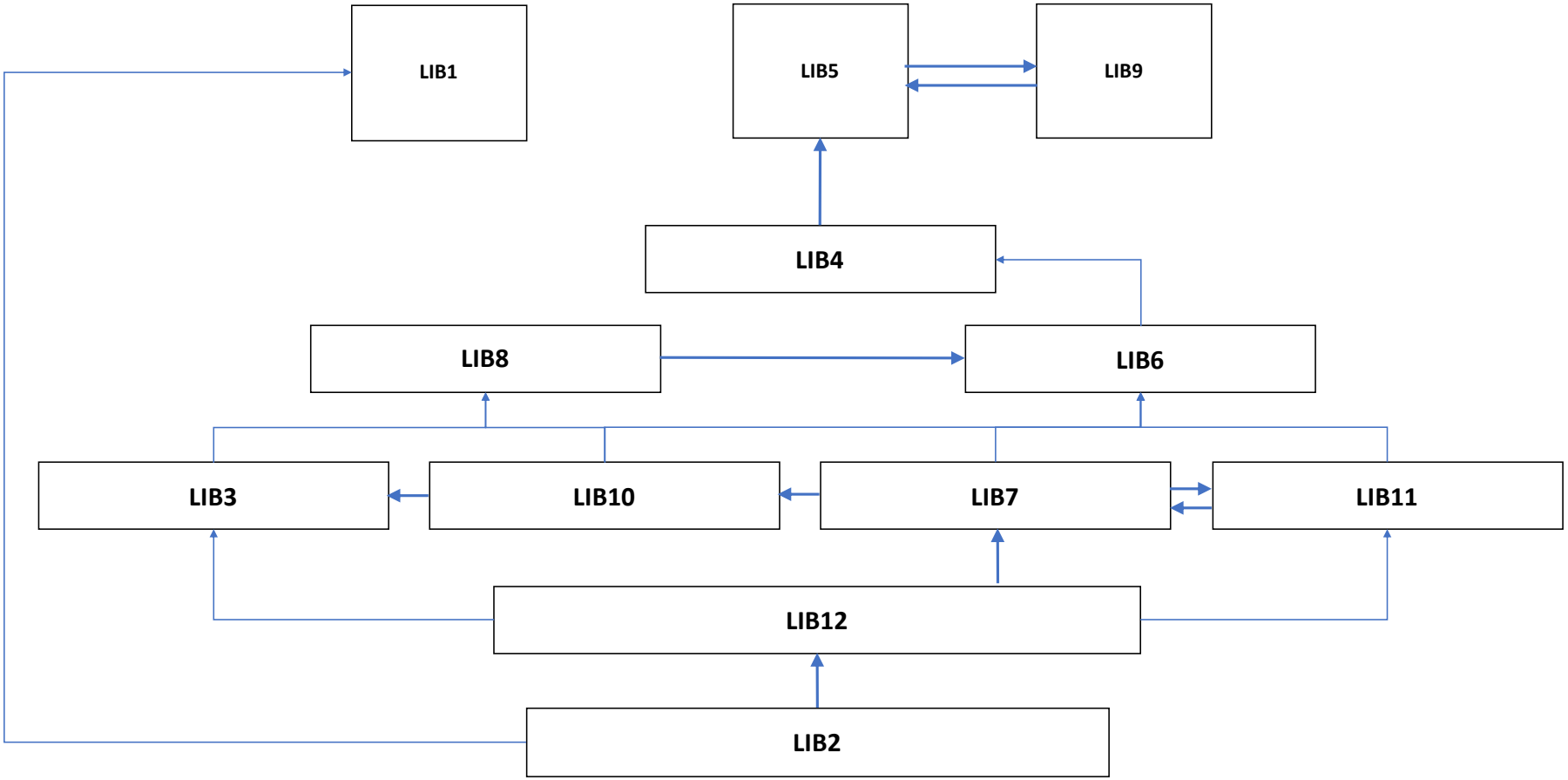


Figure 5-6 Digraph of lean implementation barriers

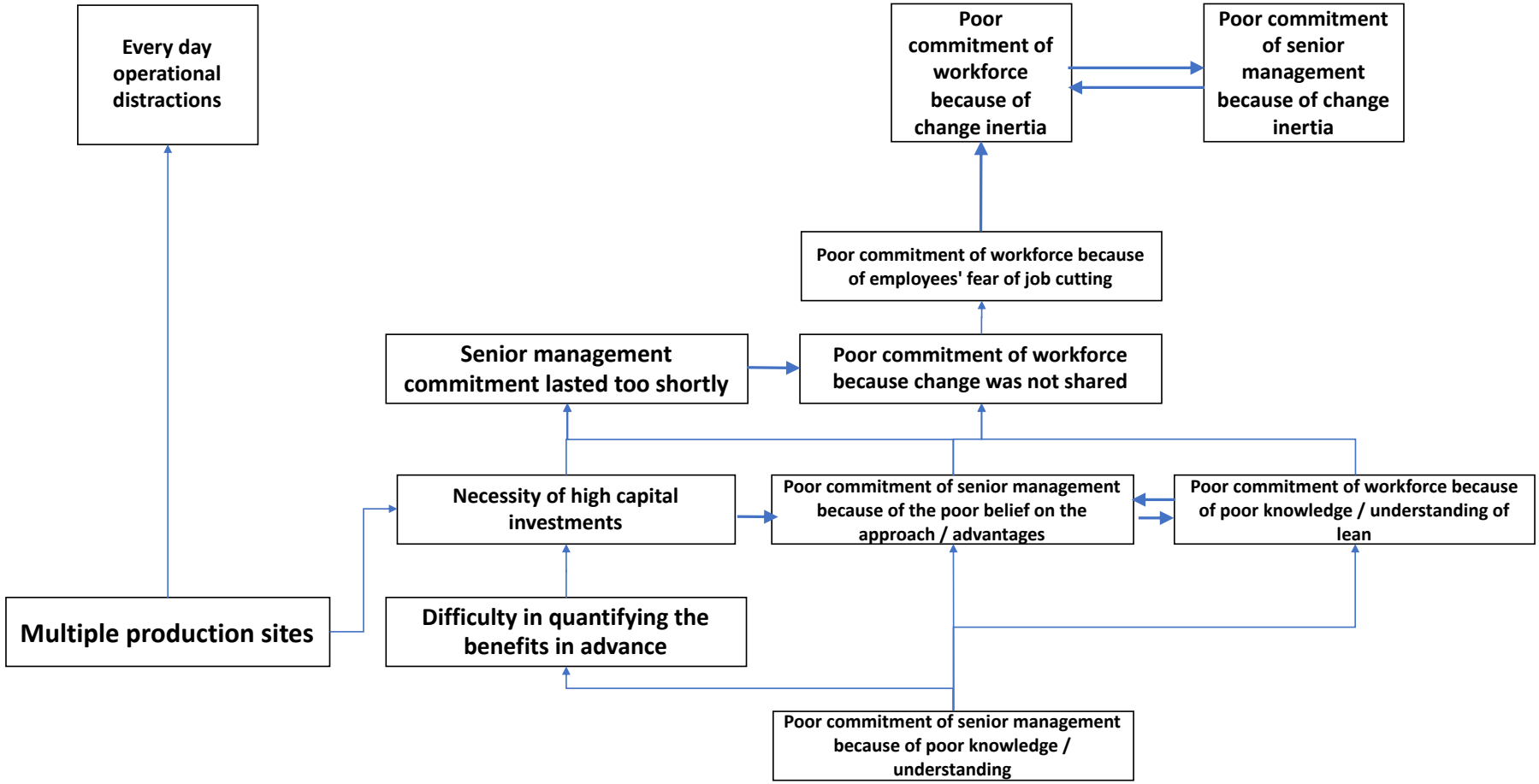


Figure 5-7 ISM model of lean implementation barriers

5.3.4.2 MICMAC Analysis

MICMAC analysis allows identifying and quantifying the drive and dependence power of the variables considered in the analysis. The driving power is the count of all the variables that are within the reachability set, whereas the dependence power can be calculated by the count of all the variables in the antecedent set (Table 5-20). MICMAC analysis allows the graphical presentation of the variables by positioning them according to their driving and dependence power. In a scatter diagram, with X-axis the dependence power and Y-axis the driving power the variables are positioned, and clusters can be identified. The driving power and dependence power diagram for the critical success factors is shown in Figure 5-8.

(LIB1) Every day operational distractions
(LIB2) Multiple production sites
(LIB3) Difficulty in quantifying the benefits in advance
(LIB4) Poor commitment of workforce due to fear of losing jobs
(LIB5) Poor commitment of workforce due to change inertia
(LIB6) Poor commitment of workforce due to change not shared
(LIB7) Poor commitment of workforce due to poor understanding of lean
(LIB8) Lack of long-term senior management commitment
(LIB9) Poor commitment of senior management due to change inertia
(LIB10) Poor commitment of senior management due to the poor belief on the approach
(LIB11) Poor commitment of workforce due to poor understanding of lean
(LIB12) Necessity of high capital investments

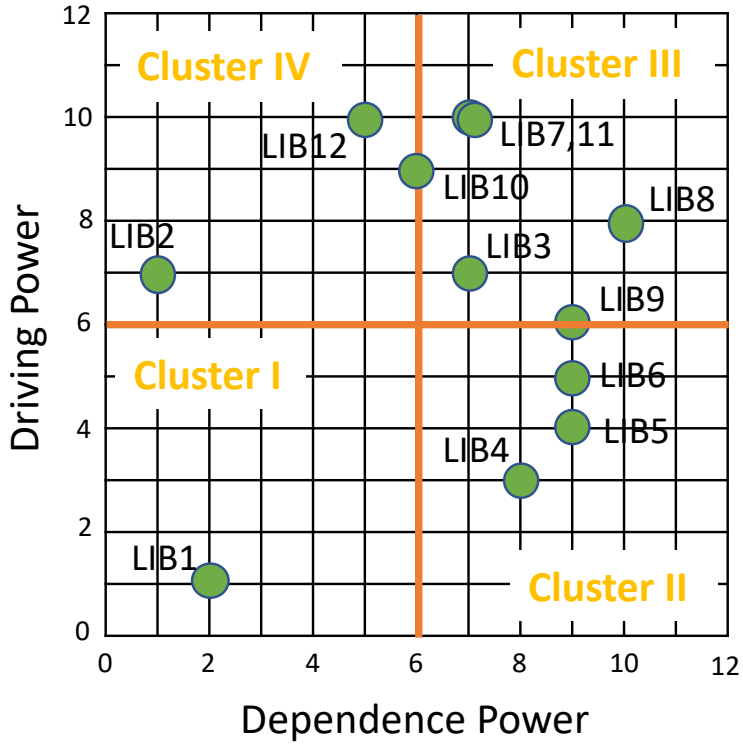


Figure 5-8 MICMAC analysis

5.3.4.3 Discussion of findings

The ISM of the lean barriers allows for the relationships between the various factors to be visualized, and at the same provides an indication of the relative importance they have. Further to this, MICMAC analysis and the driving and dependence power diagram allows to better characterize the factors in the four classifications mentioned already, namely: autonomous, dependent, linkages and drivers.

In any analysis of this type, the starting point is the discussion of the driving powers. Looking at the diagraph in figure 5-8, LIB12 (Necessity of high capital investments) and LIB2 (Multiple production sites) are the most driving barriers. This means that finding ways of overcoming these barriers can potentially improve the situation internally for the other barriers as well. For a better understanding of the relevant importance of these barriers, the ISM diagram (figure 5-6) should be analysed as well. It is obvious that these two barriers are at the bottom of the diagram and have the highest driving power. The focus group however, believed that the "root cause" is the senior management's "lack of knowledge" on lean that leads eventually to "poor commitment" from their side. This is depicted in the LIB11 (Poor commitment of senior management because of poor understanding of lean). MICMAC analysis shown in figure 5-8, does not reject this change, as LIB11 has the highest driving power, but at the same time is considered a "linkage" factor, i.e. a factor that is also driven by other ones.

There is one "Autonomous" barrier, with is the "Every day operational distractions" (LIB1). As can be seen from the ISM digraph, this barrier does not have an impact on the rest, and increases only with the increase of the number of sites. As an autonomous barrier, its impact to the rest is minimum, as well the impact of others. In order to handle this barrier, specific measures are needed that are not necessarily going to have an impact to the rest of the barriers.

Both financial related barriers (LIB3 "Difficulty in quantifying the benefits in advance" and LIB12 "Necessity of high capital investments") are closely interrelated. The difficult in quantifying both the benefits and the cost, that is due to lack of knowledge as per the ISM digraph, can lead to the perception that there

will be a need for high capital investments. This is a common perception, reported in the literature as well, and was also revealed in the survey with the lean practitioners in the UAE manufacturing sector.

All barriers related to workforce commitment (with the exception of the one related to their understanding), i.e. LIB4 (Poor commitment of workforce because of fear of job cutting), LIB5 (Poor commitment of workforce because of change inertia) and LIB6 (Poor commitment of workforce because change was not shared), are considered as dependent ones. This means that their driving power is relevantly low, but their dependence one is high. This practically indicate, that no direct measured are necessary as these will be addressed indirectly by the rest that have an impact one them.

An interesting and relatively important barrier, as indicated both from the MICMAC analysis and the survey in UAE is related to poor understanding of lean from the workforce that leads eventually to poor commitment (LIB7). "Poor understanding" barrier is probably one of the more easily ones to handle and fix, and the easy fix is providing training internally for revealing lean benefits and gains for both the individuals and the organization. This highlights the need for introducing training sessions very early in the lean transformation framework.

Finally, LIB8 (Senior management commitment lasted too shortly or Lack of long-term senior management commitment), LIB9 (Poor commitment of senior management because of change inertia) and LIB10 (Poor commitment of senior management because of the poor belief on the approach) are all "linkage" factors, and as such they have both high driving power, and high dependence power. These are sensitive factors, as a change affecting these factors need to be very well planned, in order to account for feedback loops internally

5.3.5 Validation and verification of models

Once the analysis was completed, the same focus group that helped in the completion of the SSIM in section 5.3.2 (Establishing the focus group for the completion of SSIM) was used for the validation of the models.

In a half a day workshop, the results were presented, and the focus group discussed their logic. The analysis presented satisfied the focus group, and there was a consensus among the group that the findings reflect and represent the reality. With regards the critical success factors the final ISM model was accepted as it was, with regards the lean barriers diagram, the initial one presented in figure 5-6 was changed to the one shown in figure 5-7, as discussed in the previous sections. As such the findings were considered approved and verified.

5.4 Chapter Summary

In the present chapter, the Interpretive structural modelling technique was presented and then used for identifying the interrelationships among the critical success factors and the lean implementation barriers.

The ISM hierarchy and the MICMAC results helped reveal these interrelationships. The critical success factors as well as the lean barriers with the highest driving power were revealed that will allow the framework to be developed in the next chapter to be address them.

In the following chapter, the results from the last two chapters and the literature review chapter will allow the formulation of the framework.

6 FRAMEWORK DEVELOPMENT FOR LEAN IMLEMENTATION

6.1 Introduction[4]

Research objective three has been set to develop a framework for implementing lean philosophy in the manufacturing companies in the GCC based on change management theory. Furthermore, research objective four is focused in the validation of the developed framework.

Based on the literature review presented in chapter 2, the analysis of the current state of lean manufacturing in the UAE that was revealed from the survey presented in chapter 4 and the ISM models developed from lean manufacturing experts in UAE that were presented in chapter 5, this chapter presents the framework that was developed (Figure 6-1).

The framework is based on change management theory for addressing the lean barriers and make an effective use of the key success factors. The ISM models developed in the previous section are a key starting point as well for deciding the sequence of the actions that an organization needs to successfully complete for introducing lean philosophy.

Finally, in sub-chapter 6.4, the validation of the framework is presented. For the validation, a focus group was established composed of seven experts, the framework was presented to the experts and then discussed in order to capture their views and feedback. Using experts' opinions for the validation of frameworks that their implementation duration would exceed the duration of the study is common and used by many researchers (Haq and Boddu, 2014).

[4] Parts of the work presented in Chapter 6 has been published into the following papers:

- Almanei M., Salonitis K., Tsinopoulos C. (2018) "A conceptual lean implementation framework based on change management theory", Procedia CIRP, Vol. 72, pp. 1160-1165
- Almanei M., Salonitis K. (2019) "Lean manufacturing implementation framework based on ISM and Change management" submitted for publication

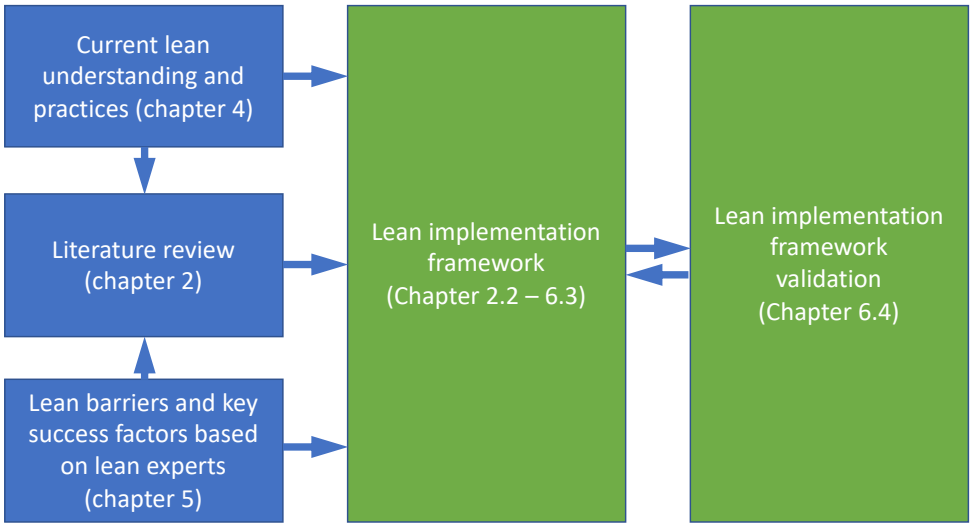


Figure 6-1 Chapter structure and input from previous chapters

6.2 Lean implementation framework

6.2.1 Framework development

A framework is defined as "*a guiding torch that helps a manager in providing necessary direction during the change management programmes that are implemented in an organization*" (Anand and Kodali, 2008). Furthermore, a conceptual framework is defined as "*a visual or written product, that explains, either graphically or in narrative form, the main things to be studied the key factors, concepts, or variables and the presumed relationships among them*" (Miles and Huberman, 1994). According to Maxwell (2005), building a conceptual framework is a structured process that can be developed using one (or a combination) of the following sources: experiential knowledge, existing research and theory, exploratory and pilot study and thought experiments.

For the development of the framework a logical sequence was followed, that consists of four phases: capturing of specifications, development of the conceptual framework, review of the framework and development of the finalized framework. These steps are illustrated in Figure 6-2 and then described in more detail the following sections.

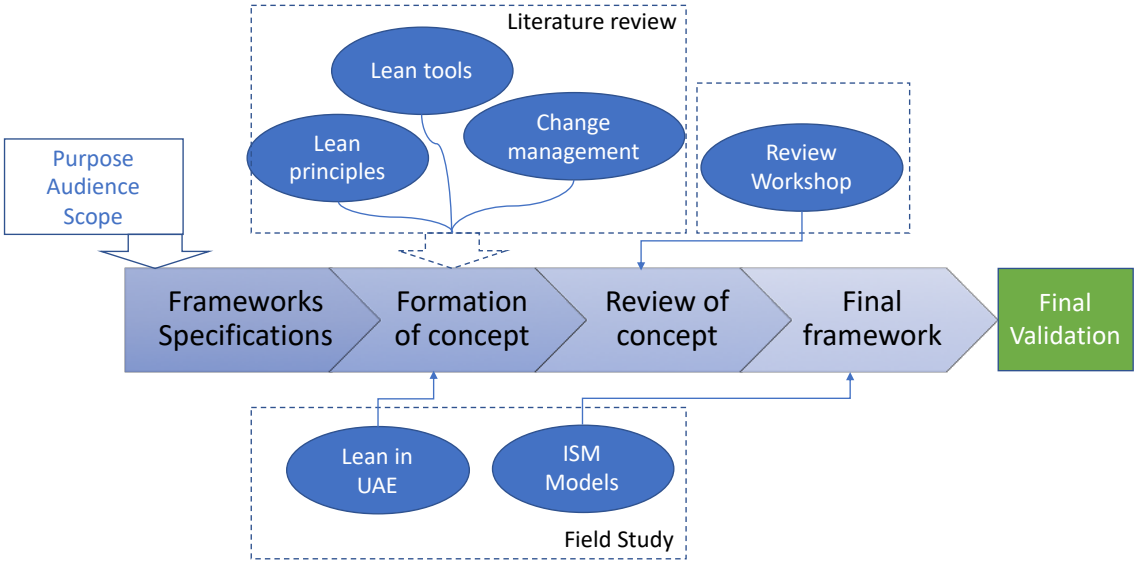


Figure 6-2 Lean implementation framework development process

6.2.1.1 Specifications phase

The starting point for building any framework is the clear definition on what this framework is expected to be able to do. Clarifying thus the purpose of the framework, the intended audience and what is within and outside the scope is important. These issues are indirectly addressed by considering the overall aim and the objectives of the present study. For clarification, answers to these questions are provided hereafter:

Purpose: The purpose of the framework is to assist the introduction of lean principles in the UAE manufacturing sector through a structured set of tools and steps that lean practitioners can adopt.

Targeted audience: Lean practitioners, operations managers and shop floor managers within manufacturing organizations

Scope: (1) provide a clear process that lean practitioners asked to introduce lean principles in an organization can adopt for making the change happen

(2) provide a sequence of implementation of lean tools for the practitioners in order to allow the better use of the available resources

(3) provide a communication tool for the organization's senior management to share the change both internally within the organization and externally with the shareholders

6.2.1.2 Development of conceptual framework phase

During the second phase, the content to be included in the framework is clearly defined. Two key sources of data were available to the researcher. Secondary data from literature, that however as highlighted in the literature review chapter (Chapter 2) are not discussing the UAE context. Primary data from the survey of lean understanding in UAE (Chapter 4) and the experts' view on the critical success factors and lean implementation barriers. Furthermore, the most appropriate way of organizing the framework was analysed, concluding that the basis of the framework should be the most appropriate change management model. As such the change management to be selected needs to be in sequential phases for simplicity. During this phase it was decided that the initial model will be developed based on the literature review findings and the survey on the understanding of lean in the UAE and the ISM models would be used for the final framework. This approach would allow the step-by-step integration of information from the available data and ensure that all data would be considered. The flow between framework steps was made consistent, and unnecessary activities were removed from the framework. In this phase, the most suitable representation of the framework that would suit its intended audience was also decided. Section 6.2.2 presents the initial framework developed.

6.2.1.3 Review of the conceptual framework phase

The third stage of the framework development was associated with reviewing the conceptual framework. The framework was presented to lean practitioners in the UAE (as will be discussed in section 6.2.3) and the contents of the framework were thoroughly reviewed to ensure sufficient information availability. Necessary amendments as well as new elements were introduced. As a result of this initial

review, a lean tools roadmap was developed (and will be presented in section 6.3) to complement the framework.

6.2.1.4 Development of final framework phase

In the final phase, using all the data captured from the initial workshop as well as the developed ISM models, the final framework was developed. For the use of the framework as a communication tool as well, it was developed as a graphical roadmap. An A3 sized landscape poster was developed, as well as a slide set to be used for the introduction or an organization to the framework. Both these supporting documents are included in the appendix of the present study.

6.2.2 Lean Manufacturing Implementation Framework for the manufacturing sector in UAE

As highlighted in the framework development process, the literature review was the starting point for identifying the key content to be included. The literature review (chapter 2) highlighted a specific gap: lean manufacturing implementation as any other change can benefit from the use of organisational change management theory and models.

Change is not something that happens only once, but rather a continuous process. Change affects both the people engaged in the change but the business processes as well. For the successful implementation of any change project, the business strategy needs to be aligned with the personal goals and objectives. Change management aims to help in achieving this alignment.

Both literature review and the survey revealed that lean implementation is accompanied by a change in the way the company values the different dimensions of work. Lean thinking and manufacturing in particular, requires change to happen in the structure of the organization, the system itself, the processes employed, and employee behaviour. A change framework thus can guide the practitioners on how to go about the lean implementation.

The literature review on change management helped construct a number of questions with regards the implementation the lean transformation, that answering them can allow decide which of the existing change management

models is the more appropriate to be adopted and adapted. These questions along with their rational are listed:

- Can lean transformation be classified as a “rapid” or an “incremental change”?
- What is the anticipated scale of the outcome of the lean transformation, can it be considered a “readjustment” or a “transformation”?

Answering these two specific questions allows the positioning of the change in the matrix proposed by Balogun and Hope Hailey (2008). To do so the nature of the proposed lean change must be understood and comprehended. Lean transformation, as highlighted both in the literature review, the survey and the ISM models, aims to change the culture of the company in order to accommodate the new system processes and requirements. One of the cornerstones is the way the organization manages the relationships with customers and suppliers. Such a change requires significant time and resources, that have a lasting impact on the organization’s culture. Based on this rational, the change is considered to be “incremental”. The impact of the change, after the completion of the whole transformation, is organization wide. As per by Balogun and Hope Hailey (2008), this is considered a “transformation”. Based thus on the classification of change, the change is considered to be “evolution”, since it is a large-scale change, with a long implementation timeframe (figure 6-3).

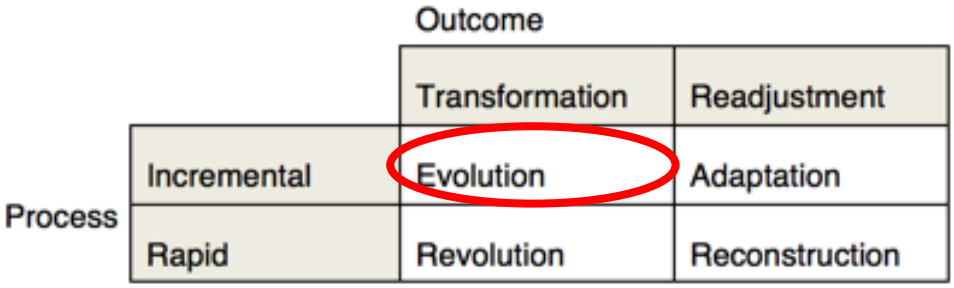


Figure 6-3 Classification of lean transformation according Balogun and Hope Hailey (2008) proposed classification.

Another set of questions will need to be answered in order for the framework to be developed to be as wholistic as possible. These are:

- How are the employees expected to cope with the lean transformation?

- Which model would be the most appropriate for leading the lean transformation?
- How can the practitioners learn from the (limited) reported failed change initiatives and failed lean transformations?

The discussion of the various models of leading change in chapter 2, resulted in in identifying their applicability as per their scope and scale (figure 2-17, repeated here for easy of reference as figure 6-4). Having identified the scope and scale of the lean transformation, Kotter's model for leading change is considered to be the more appropriate. Kotter's model, as a social model, fits better to the type of the change lean transformation brings about, as the behaviour of the employees and the organization as whole cannot be predicted and control during the lean transformation. This contradicts the basic assumption of the rational models. As shown in the literature review lean transformation is accompanied by uncertainties and disadvantages as well as benefits, that can result in resistance by those committed to existing methods and practices.

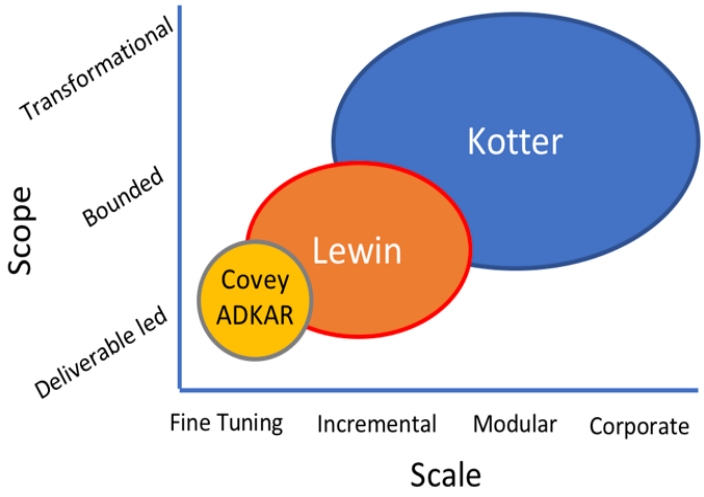


Figure 6-4 Change Theories and Project Scope

The framework proposed in the present study is based on mapping the lean transformation initiatives to Kotter's leading change model steps. Kotter's eight steps are grouped into three main classes as shown in Figure 6-5. The first phase, which is composed of steps 1 to 3, enable the creation of the necessary climate for change. The next phase, including steps 4 to 6, deal with the

engagement and enabling within the organization. The final phase of the suggested framework is composed of the two last steps, namely 7 and 8. In this phase the framework builds up on the early wins for the full deployment of lean tools and methods, and most importantly sustaining the change and the lean thinking. In the following paragraphs each phase will be described in detail.

In Figure 6-5, specific tools that have been already tried for the lean implementation are mapped into these steps and structured. The graphical representation of the framework highlights the purpose of each step and suggests key activities, in the form of a checklist, for a lean practitioner to engage into. It also suggests what is the expected duration of the step's activities, and the type of activities or deliverables that should be expected (whether it is a workshop, a training session, a report, etc.). An example of this graphical representation can be seen in Figure 6-6 for the first phase of implementation.

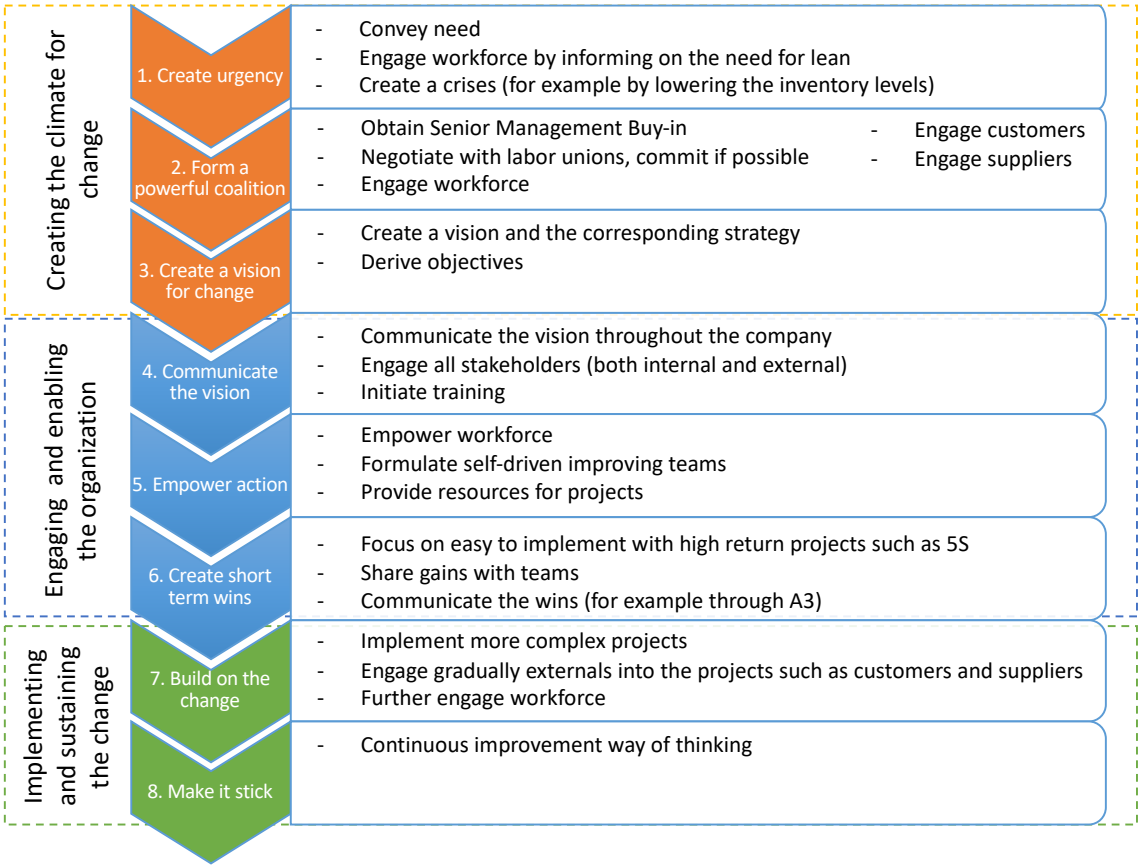


Figure 6-5 Lean implementation framework developed based on change management model

The activities proposed for each step are based on the literature review findings related to change management. These were discussed with the experts during the review workshop (figure 6-2) and agreed as being the ones that will have the highest impact for achieving the overall outcomes of each stage.

As indicated in the previous paragraph, the first phase is composed of steps 1 to 3 and tries to develop the necessary climate for change. In the literature about Kotter's model, usually this the step considered by most researchers as the most critical one. The success or not of the lean implementation depends largely on that. Leadership and management commitment are the key factors for the lean manufacturing implementation. This was confirmed for the case of UAE manufacturing organizations as well, as presented in the survey reported in chapter 4. Figure 4-17 revealed the relative importance of the lean barriers, and highlighted top management commitment as one of the key ones. It is obvious that strong leadership is required for leading the change to lean manufacturing. Acknowledging this requirement, this is integrated in the first phases of the change management programme. On the other end of the hierarchy, the engagement of the workforce is critical, as was shown in Figure 4-17 as well, and thus need to be considered from the very first stages. Following thus Kotter's change model, the first step is the creation of urgency internally that then can lead in better understanding internally of what is at risk. As can be seen in Figure 6-6, one of the first activities in the first step is for a change champion must be appointed. Kotter (2012) even suggests for appointing many change agents, and "not just the usual few appointees". This would help by sharing the responsibilities among a number of committed change and lean champions. The ultimate purpose of this step is to raise awareness internally through the simulation of critical situations. The framework took into consideration, especially after integrating the results of the ISM models, the significance of engaging all stakeholders, including both senior management and workforce. For this reason, the second step focuses in establishing coalition that expands from internal stakeholders to external ones such as the suppliers and the customers. For this reason the framework proposes setting a number of initial workshops / training sessions that will allow stakeholders to better understand the need for change.

Once the change champion(s) have established the need and formed both the formal and informal relationships, then they can work on setting a clear and understandable vision for the change, as well as the associated objectives, implementation workplans.

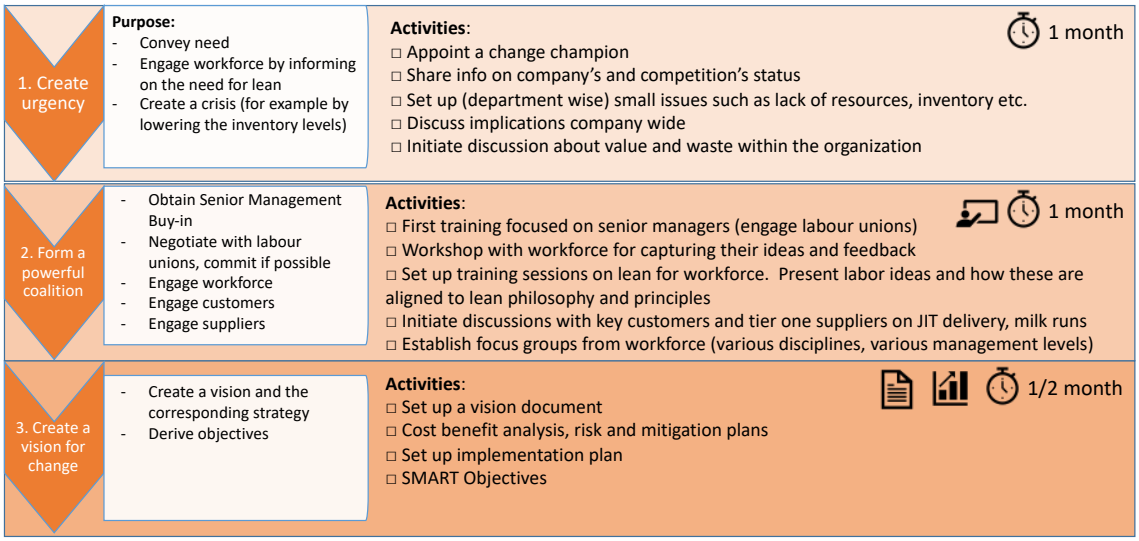


Figure 6-6 Phase I: Creating the climate for change

Phase two is focusing in engaging and enabling the organization to go through the proposed change (Figure 6-7). As per Kotter's model, the phase is composed of three steps, namely: (1) communication of the vision throughout the organization (step 4 in the overall framework), (2) develop and empower the implementation team (step 5 in the overall framework) and (3) create the first short wins that will strengthen the momentum internally (step 6 in the overall framework).

The focus of this phase is to establish the communication links internally within the organization. Having as a starting point the change vision developed in the previous step, the change managers have to communicate within the extended supply chain of the organization (from suppliers to customers). Regardless of how good the vision document and supporting material is, sharing and allowing for the time for the various stakeholders to understand the implications of the change and their role in the change is critical for allowing this to be successful. The communication needs to be augmented in every event that takes place

during the introduction and implementation of lean principles. The communication campaign should start well before the project kicks off.

Step five of the overall framework is focused on establishing the teams, in the form of quality circles, allows the delegation of the project tasks to teams and even more importantly the engagement of all stakeholders. Furthermore, these is a very suitable platform for capturing ideas from the employees, and thus enable change from the “bottom”. Quality circles thus need the resources and the time to prepare adequately for the task. Training is a key enabler, as well as their empowerment by giving them ownership and responsibility of the projects they decide to undertake .

Towards the final step of this stage, implementation of simple and small projects that can have easy wins (“harvest the low hanging fruits”) can dramatically increase the commitment of both the senior management and the workforce into the lean implementation change programme. Acknowledging and celebrating such noticeable gains will raise the confidence in the change and reinforce the position of the guiding coalition.

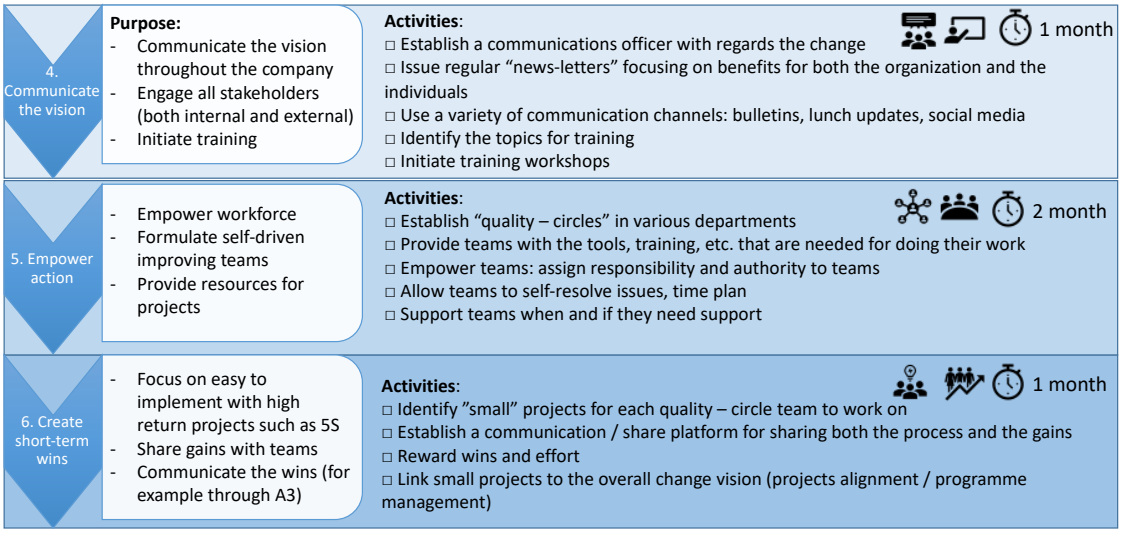


Figure 6-7 Phase II: Engaging and enabling the organization

The last phase of the framework focuses on the ramp up of the change programme through the implementation of more advanced lean projects and establishing the sustaining culture and processes for making the changes last

(Figure 6-8). This last phase is composed of two steps, namely: (1) the building on the change that has been succeeded in the previous phase (step 7 of the overall framework) and (2) the institutionalization of the strategic changes in the culture of the organization. This phase builds up on the early wins for the full deployment of lean tools and methods, and most importantly sustaining the change and the lean thinking.

In step 7, the quality circles, building up on the confidence they have gained as a team, can explore more lean opportunities that might require more advanced tools for implementation. Furthermore, during this phase, they can engage more stakeholders, even externals such as suppliers and customers, for maximizing the impact of their projects.

In the last step, the team will need to capture and document all lean project attempts, regardless of whether these are fully successful or not. These documents can serve as lessons for building some preventive measures and avoid mistakes when the next round of lean implementation starts. At this phase the successes need to become the new standards, shared in the organization and celebrated. After the first round of lean improvements, and actually at the end of each cycle, the vision and objectives set need to be reviewed and amended accordingly.

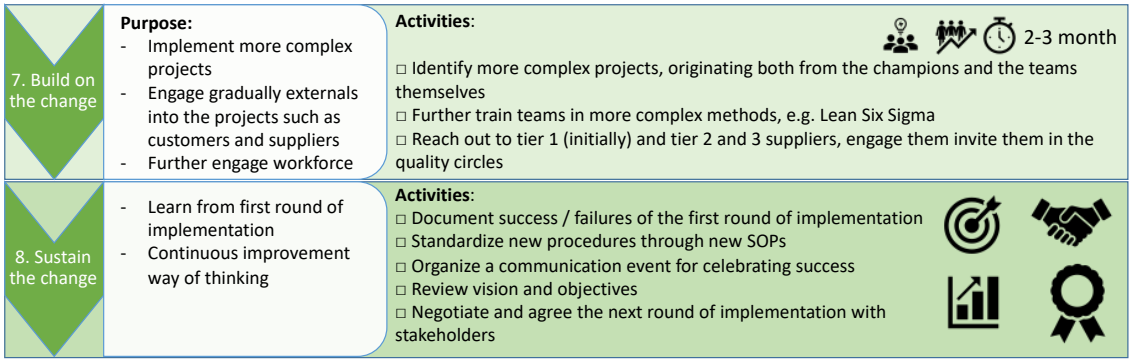


Figure 6-8 Phase III: Implementing and sustaining the change

Lean transformation, as any other change, is usually not an one off project. The framework is not supposed to be used as another change project, but rather introduce a different culture that welcomes, and exploits change. For this reason,

a timeframe that complements the framework was developed. This was one of the key feedback received during the validation of the initial conceptual framework. As can be seen in Figure 6-12, once phase 1 and phase 2 have been completed, then phase 3 can be repeated as many times needed in order to gradually increase the lean maturity of the organization and benefit from the gains of the transformation.

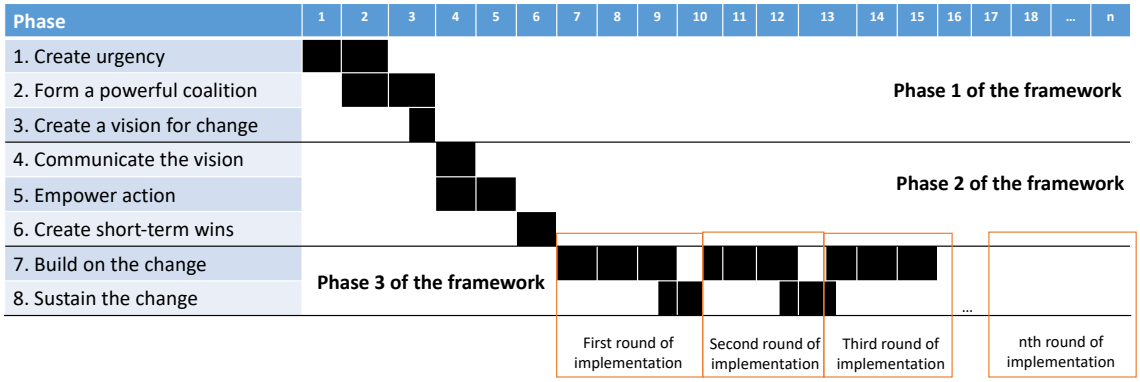


Figure 6-9 Timeline for implementing the lean implementation framework

6.3 Lean tools roadmap

The framework proposed highlights the key milestones in the lean journey. However, this does not provide details on the lean tools to be introduced, and focuses more on surpassing the change objections within the organization.

As shown in figure 6-5, the exact lean tools to be implemented in each phase are not prescribed. That was also highlighted as a key missing point during the validation of the initial conceptual framework. The conceptual framework thus had to be complemented by a lean tools / methods roadmap. The framework is focused in managing the change, whereas the various tools lean tools are expected to be implemented in steps 5, 6 and 7 of the framework. The training of the quality circles to such tools can be expected to be initiated earlier.

For selecting which tools to use first, the “house of lean” can be used (Figure 2-5). Starting with the foundations of the “house”, the focus should be in securing stability and setting up standards. Tools usually used during this phase include 5S, establishing TPM, visual aids, problem solving thinking, A3, “go to Gemba”

initiatives and SOPs. All these tools can be implemented during stage 6 of the conceptual framework in order to lead to quick wins. In a study presented by Salonitis and Tsinopoulos (2016) these specific tools were the ones identified as the more mature ones for companies that have recently embarked into their lean journey. The degree of understanding of lean tools can be also used in order to assign these into stages 6 and 7 of the conceptual framework. Further to this, the survey within the UAE highlighted which tools are most widely used in the manufacturing organization already, and as such it is better if these tools are implemented in the beginning of the transformation, as this will have a positive impact in the confidence of the practitioners. As shown in figure 4-14, lean tools related to operations and processes improvement are more widely understood, and as such the roadmap starts with 5S and SOPs that were most highly ranked in the survey.

A generic "lean implementation curve" can been suggested with the relevant tools ordered in the sequence to be applied. A proposal of such curve is shown in figure 6-10, mapping most of the lean tools to an implementation timeframe. The classification of these tools as per "house of lean" is also color coded. It should be noted that such a timeframe needs to be tailored to the needs and lean maturity of the organization to be introduced to.

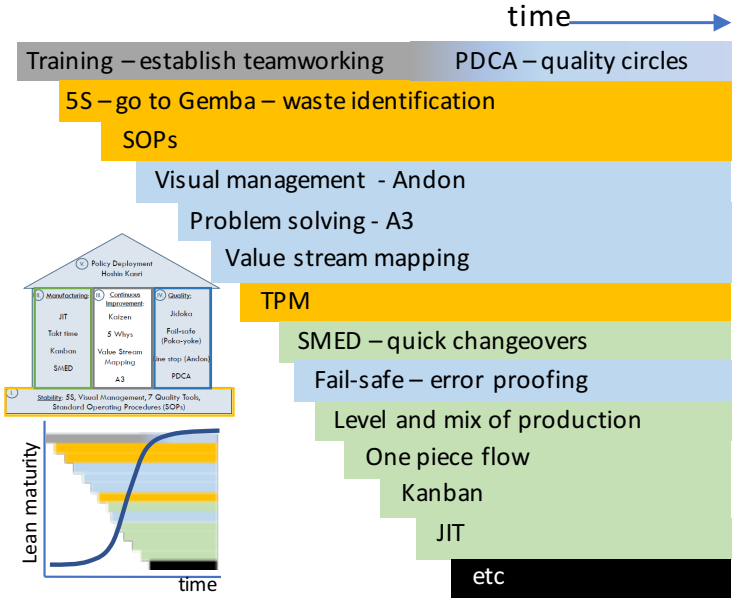


Figure 6-10 Lean tools roadmap

6.4 Framework validation

The Lean implementation framework was validated with experts in the field of lean implementation in manufacturing organizations in UAE. Five experts were interviewed for the validations. Their profiles are documented in Table 6-1. The validation process during each interview was:

- Presentation of the framework (with the slide set shown in annex D)
- Discussion of the framework with the interviewees, focusing in:
    - The logic and rationale of the framework
    - The potential applicability of the framework to the interviewee's organization
    - The user-friendliness of the framework
    - The completeness of the framework
    - The integrity of the framework to existing lean implementation schemes

The participants were requested to rate each of the themes from 1 to 5, with one representing the least favourable option and 5 as the highest achievable rating. Figure 6-11 illustrates the results from the study.

Table 6-1 Profiles of experts participated in the validation

Expert	Characteristics	Age	Years in lean manufacturing implementation	Manufacturing sector
A	Continuous improvement manager	50	10	Fabricated metal
B	Operations manager	47	9	Food & Beverage
C	Technical director	55	7	Food & Beverage
D	Chief Operating Officer	54	15	Wood & wood products
E	Production manager	43	8	Wearing apparel

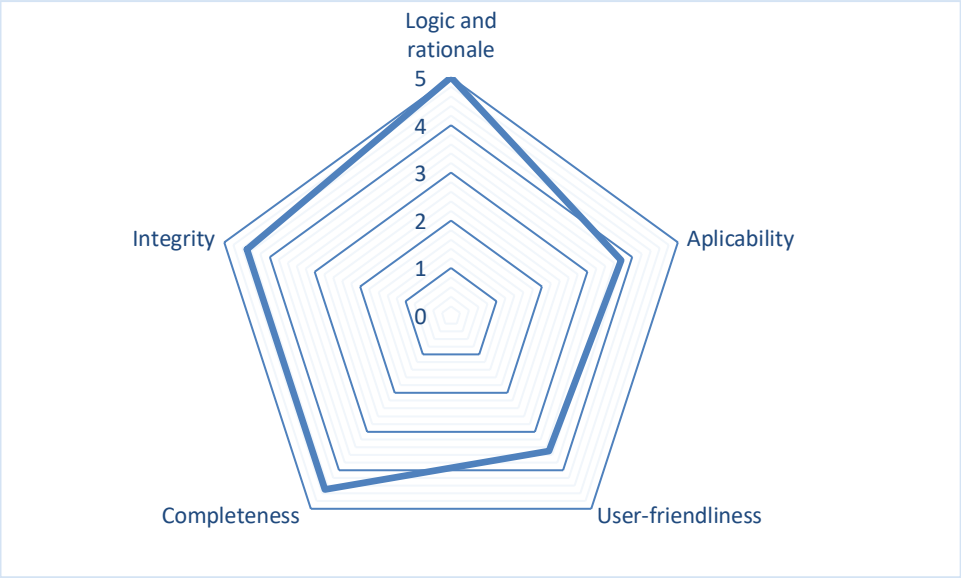


Figure 6-11 Framework assessment by experts' opinion

All experts agreed on the need for such a framework. The logic of using a change management model for the basis of the proposed lean implementation framework was highly appreciated by the experts. The mapping of the lean tools to Kotter's eight steps of change was confirmed by the experts as appropriate.

The experts were asked to rank the applicability of the framework to their own specific sector. Figure 6-12 presents the experts' ranking of the framework to different sectors within UAE, as per the classification of manufacturing companies in UAE. As shown the results averaged 3.75 (Figure 6-11), although the experts believe that the framework is more applicable to the manufacturing of discrete products, as is the case in the sectors of fabricated metal and wood products. In more continuous process production environments, as is the case of the food and beverage sector, the framework is not as easy to use. Experts suggested that the framework needs to be customized in such applications.

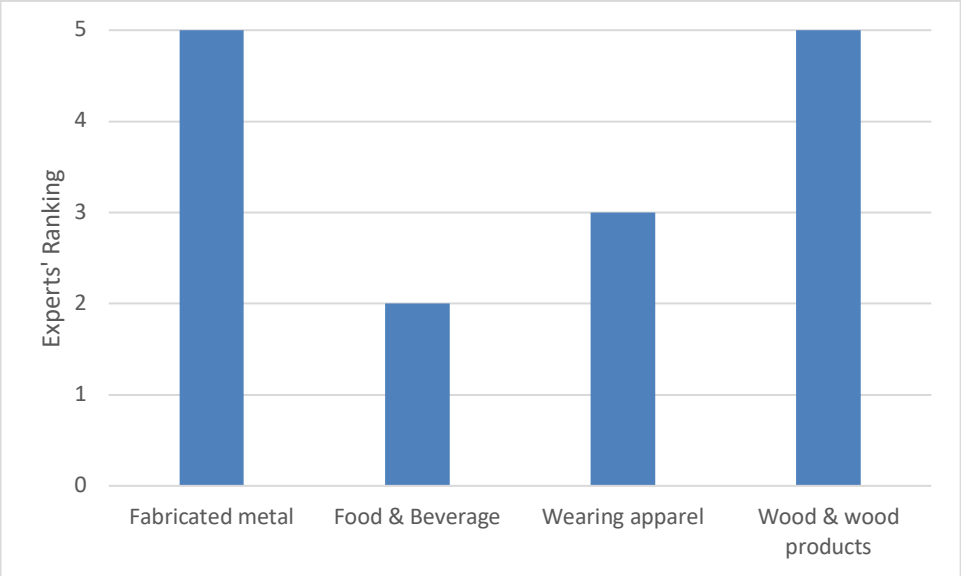


Figure 6-12 Applicability of the framework to different manufacturing sectros by experts' opinion

The possibility of integrating the framework for day to day lean implementation and continuous improvement was discussed during the validation interviews. As shown in Figure 6-11, the rating was very positive. All experts believe that the framework can be complementary to the existing lean transformations programmes that organizations might be running, further to use it for introduction of lean to a new organization.

The completeness of the framework developed was also discussed during the interviews. Experts were asked to assess whether the framework is complete and can stand on its own (with the complementary lean tools roadmap). All experts agreed that the framework includes all the required steps for completion. One expert highlighted, that the framework would be even more complete if a lean assessment tool would be included in order for the framework to be used for organizations that are not new to lean implementation. In that way, the lean practitioner would be able to assess the maturity of the organization before deciding with which step to start.

The last theme of discussion was on the user-friendliness of the framework. All experts agreed with the visual aids of the framework, although they would have liked a version in Arabic language, since this is to be implemented in UAE manufacturing organizations.

6.5 Chapter Summary

The chapter has presented the work relate to the third and fourth research objectives by presenting the Lean Implementation Framework. A thorough discussion on the Framework is presented, explaining each phase. Furthermore, the validation of both the framework and the lean tools roadmap that was based on experts' opinion is presented.

7 DISCUSSION AND CONCLUSIONS

7.1 Introduction

The overall aim of this study was to develop a novel lean implementation framework that would be able to bring about the transformation required in the organization. The framework needed to be tailored to the needs of the manufacturing sector in the Middle East, and specifically in the UAE. For achieving this aim, a research methodology was decided that was based on the interpretive research paradigm. The research presented is characterized as qualitative and the required data collection included both primary and secondary data.

The overall aim was achieved through a methodological investigation consisting of four phases. The first phase was focused on setting the research aim and objectives, after a thorough investigation of the research background that confirmed the validity of the research aim. The second phase was based on academic investigation of the existing literature on lean implementation frameworks, the variables that might have an impact, the barriers and the key success factors. Change management models and theories were also reviewed in detail. The third phase consisted of performing an industrial field study to identify the current understanding of lean principles at UAE. Furthermore, experts were consulted in order to identify the relationships among the key success factors and the lean implementation barriers. The final phase was focused on putting together all the content into a framework based on the change management theory. The framework was validated through an expert focus group.

The present chapter will highlight the key conclusions of the present study. Section 7.2 will summarize the research aim and objectives that were set in the beginning of the research. Sections 7.3 and 7.4 discuss the contribution to knowledge and to industry practitioners. Discussion on areas of future works in light of the thesis is presented in section 7.5 and finally in section 7.6 conclusions are drawn.

7.2 Overview of research aim and objectives

In chapter 1, the research aim and objectives were set for the present study. The aim of the present study was to develop a Lean Manufacturing framework based on the change management theory to enhance the productivity and performance of manufacturing companies focusing on UAE manufacturing sector.

In order to achieve this aim and to measure the level of achievement, four research objectives were set. The first research objective was to analyse the global current trends in lean thinking and the use of organisational change management theory in implementing lean through literature review. This research goal was addressed through a thorough literature review that was presented in chapter 2 and parts of it were presented into two conferences.

The second research was to assess the current practices with regards lean implementation in Middle Eastern countries and UAE in particular focusing in identifying (i) the success factors affecting organisational performance, and (ii) the enablers that smoothen the introduction and implementation of lean management. In order to achieve this objective, based on the literature review, two field studies were undertaken. The first one was based on a survey through a structured questionnaire for assessing the understanding of lean within UAE manufacturing sector, the maturity of the sector as well as the barriers and drivers of such transformations. The results of this survey were presented in chapter 4 as well as in one conference paper. Furthermore, in order to investigate “deeper” and understand the hidden relationships among the various variables, a focus group of experts was set up that contributed in the development of ISM models. The results of this work were presented in chapter 5 and published in one journal publication.

The third focus was to develop a framework for implementing lean philosophy in the manufacturing companies in the GCC based on change management theory, including the guidelines and the associated processes that has to be adopted by manufacturers. This was developed based on a structured approach and was presented in chapter 6 and in one journal publication. Finally, the last research

objective was to validate the framework based on experts' judgement that was also presented in the previous chapter.

7.3 Key research contribution

The research has been successful in providing contribution to knowledge in the following ways.

1- a novel framework based on change management for lean implementation has been developed that allows the introduction of lean philosophy and principles in a structured way
2- development of interpretive structural models for the lean implementation barriers and the key success factors that allowed the identification of the fundamental relationships among these factors
3- Illustrative guidelines based on the framework which provides the necessary information in order to systematically realise the lean manufacturing principles

Additional contributions to knowledge include:

- The industrial perspectives of lean manufacturing in the UAE manufacturing sector were revealed through a survey, and
- The lean implementation framework has been validated with the help of experts' opinion.

7.4 Contribution to industry and managers

As literature review and the survey indicated, lean is implemented in SMEs in a quite intuitive way. Most of the available frameworks focus on the tools' implementation and not on how to bring about the required change in the organization. The proposed framework takes a "systems" approach in the lean transformation, providing a list of tasks and activities that a lean champion can adopt in the organization for ensuring a successful and efficient lean transformation with lasting impact.

Therefore, the suggested implementation framework can be used as it is, or it can be tailored to the needs of an organization, without any supervision from an experienced researcher.

7.5 Research limitations

The proposed framework, as already mentioned, contributes to the body of knowledge on lean implementation as an alternative, more systems approach, to the transformation required. The key assumption is that the organization is new to lean philosophy, and as such the framework has been developed to cover this gap. However, this does not exclude this framework from using it for leading the change in an organization that has already had some experience in lean transformation. In that case the framework can be tailored to this, and complemented with additional tools as will be explained in the following section.

Another limitation of the present study is the fact that the framework could not be validated with a case study. This unfortunately cannot be addressed within the timeframe of this research. A lean transformation programme is quite dynamic and lasts quite some time that exceeds the available timeframe of the present study.

7.6 Recommendation for future research

There is an opportunity for further research based on the research findings and the research limitations discussed previously, which include:

- Expand the framework to be applicable for organizations that already have some experience in lean. For achieving this, the following complementary phases are foreseen to need to be included:
    - (1) A lean assessment framework, that is to be completed prior to the initiation of the updated framework. A lot of work has been presented by Oleghe and Salonitis (2016, 2018a, 2018b, 2018c). Specific tools such as multi-grade fuzzy logic can be used for assessing the leanness of an organization and its supply chain (Almutairi et al., 2019). This will provide a visual and numerical representation of the levels of leanness both for the whole

organization and specifically for the various departments within allowing for the ranking and prioritization of the follow up activities.
    - (2) provide alternative routes within the framework depending on the lean maturity of the organization
- Bridge the lean implementation framework with simulation. Oleghe and Salonitis (2018d, 2019) have presented a lot of work on how to assess the lean implementation initiatives using simulation, such as discrete event simulation and system dynamics (and combinations of the two). This would allow lean practitioners to experiment with different alternative lean projects and assess their potential impact in order to reach a decision of what is the most appropriate next project.
- Further testing and validation of the framework with industrial cases.

7.7 Conclusions

Concluding the results of research and the implications of findings, it can be concluded that the research has achieved its aim of developing a novel implementation framework for introducing lean based on change management model. The objectives set in the beginning of the research and stated in chapter 1 were all achieved. Furthermore, the following conclusions can be drawn from the present research:

1- Lean philosophy and management in manufacturing sector is still an open topic for research, especially when considering other developments such as the digitalization of manufacturing and the area of simulation
2- Lean philosophy, although applied extensively in the Japanese and the western manufacturing sectors, it is still not explored widely in the developing world
3- The size of an organization when implement lean is still a major issue, and companies and organizations need help in their implementation
4- The developed lean implementation framework can help SME organizations in the developing world to start their lean transformation

journey, as it helps them both with the management of the change and the introduction of the new lean tools

The aforementioned conclusions are drawn from the research presented in chapter 3 to 7. Conclusion 4 is primarily based on the experts opinion during the validation of the framework.

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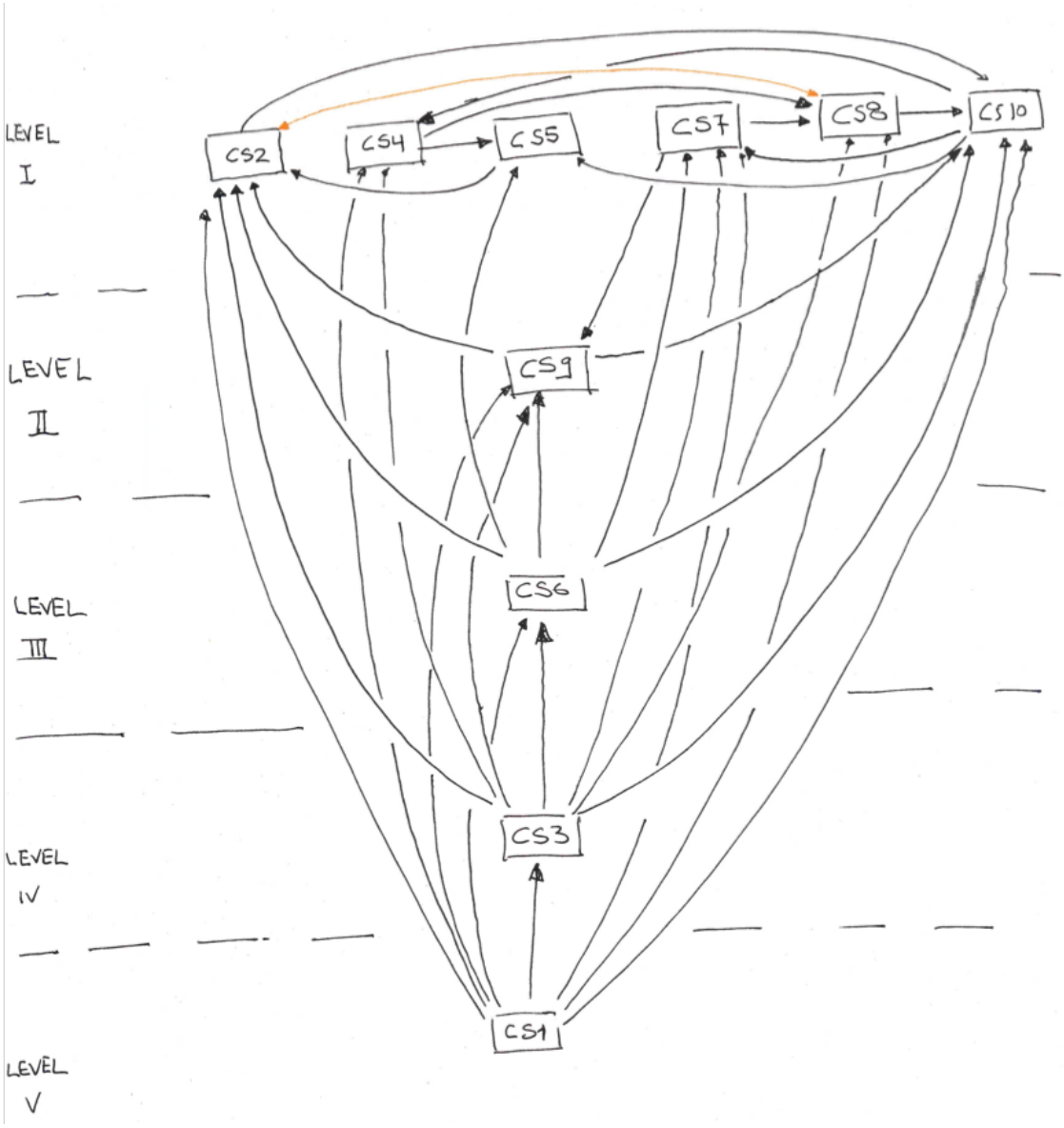
APPENDICES

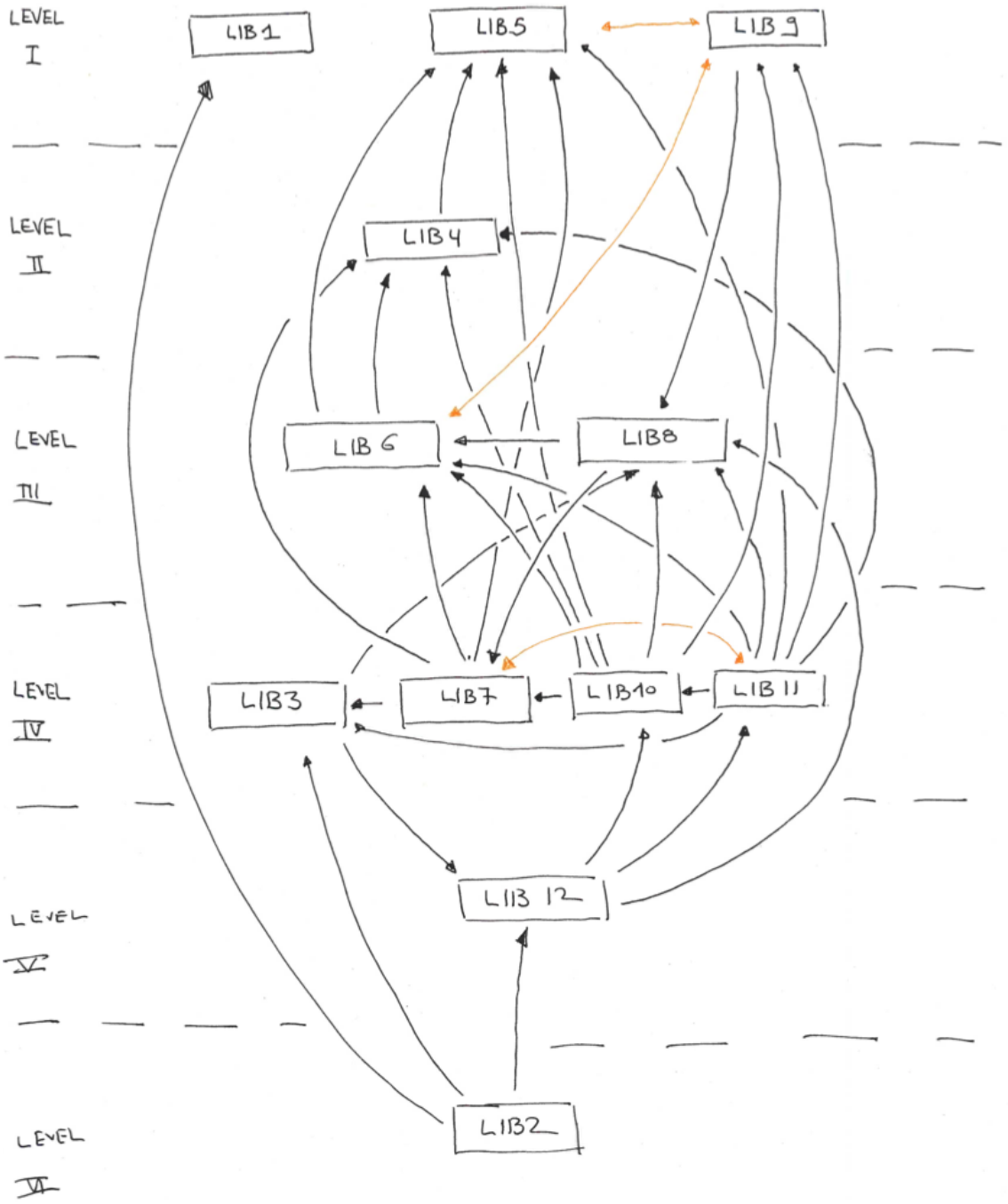
Appendix A Critical Success Factors Digraph

Digraph prepared during the ISM analysis for the critical success factors.



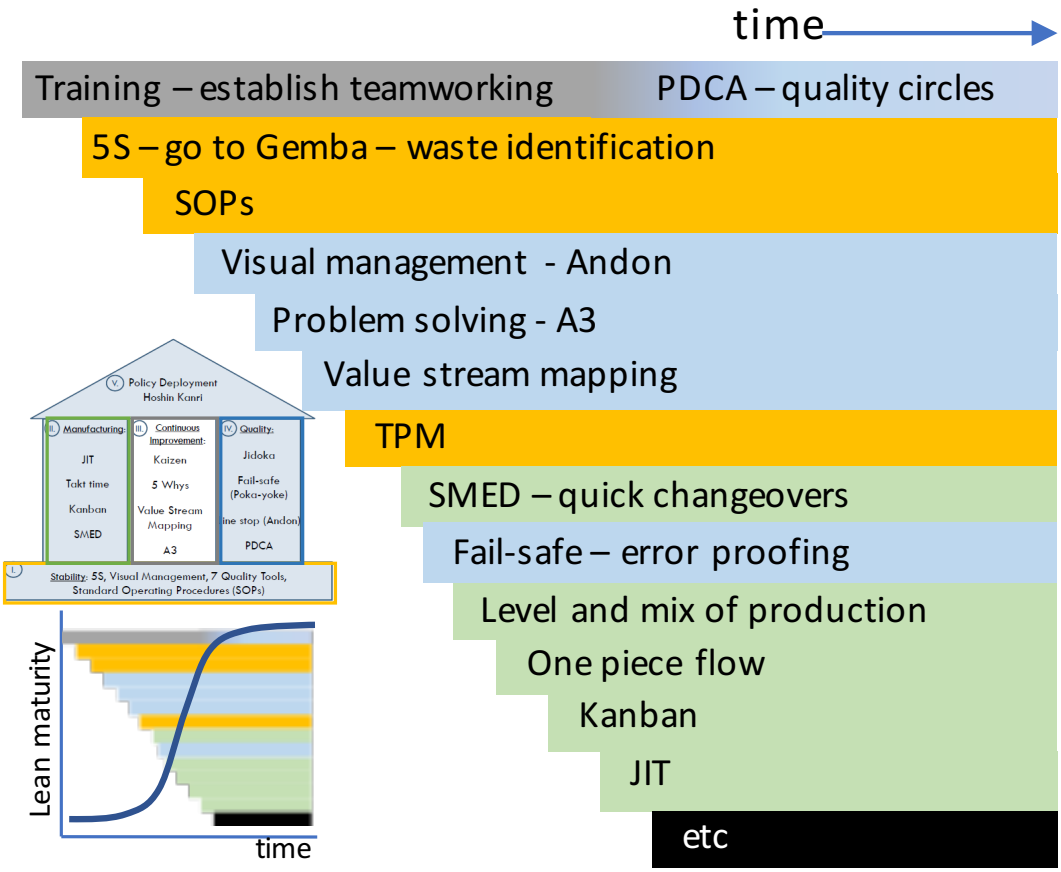
Appendix B Lean Implementation Barriers Digraph

Digraph prepared during the ISM analysis for the lean implementation barriers.



Appendix C Lean tools (based on Marcwinski, 2014)

Presentation of the lean terminology with regards the tools presented in the framework.



5S: a structured approach for improving the workplace practices. These are five terms beginning with the letter S: Sort, Straighten, Shine, Standardize, and Sustain.

A3: presentation of all data relative to a continuous project in an A3 sized paper. It usually includes the background, initial assessment, the method adopted and the implementation of the project

Andon: a visual management system indicating the status of machines, operations and equipment

Fail safe – error proofing (Poka Yoke): methods that prevent operators from making mistakes when undertaking a task, can be based on the shape or colour of a component.

Gemba: Japanese word for “actual place”, highlighting the ned for managers to frequently visit the shop floor where the real value for the organization is created

Just in time (JIT): Toyota's term for its own production system. The concept refers to producing or conveying only the components that are needed, when they are needed, and in the amount needed by the next process — with a minimum of inventory kept on hand.

Kaizen: “Continuous improvement," with the objective of identifying and eliminating waste in all areas, including production.

Kanban: a signalling method that directs the initiation of production or withdrawal of components from the location where inventory is kept.

Level and mix production (Heijunka): the idea of levelling the type and quantity of production over a period of time.

Muda, Mura, Muri: types of production waste that should be eliminated. Muda refers to any process that does not create value for the customer, Mura refers to unevenness in operations, and Muri to overburdening of equipment.

Plan Do Check Act (PDCA): Improvement cycle also referred to as Deming Cycle. It highlights the four stages of any improvement cycle, i.e. Plan of the improvement project, Do (implement) the changes, Check the results and finally standardize the change (Act).

Single Minute Exchange of Dies (SMED): a structured process for reducing the time that equipment is not adding value when changing from the production of one product to another

Standard Operating Procedures (SOPs): for every process, a standardized way of completing the required tasks is identified an documented eliminating in this way variation and variability

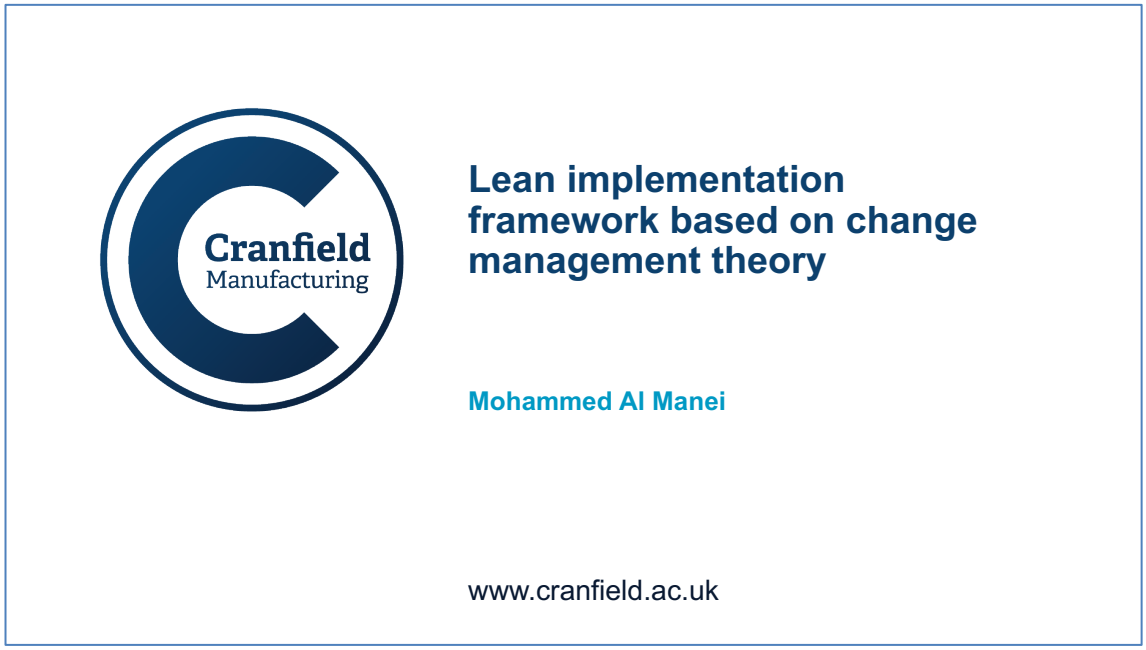
Total Productive Maintenance (TPM): complementary system to lean manufacturing focusing on maintaining and improving the integrity of production.

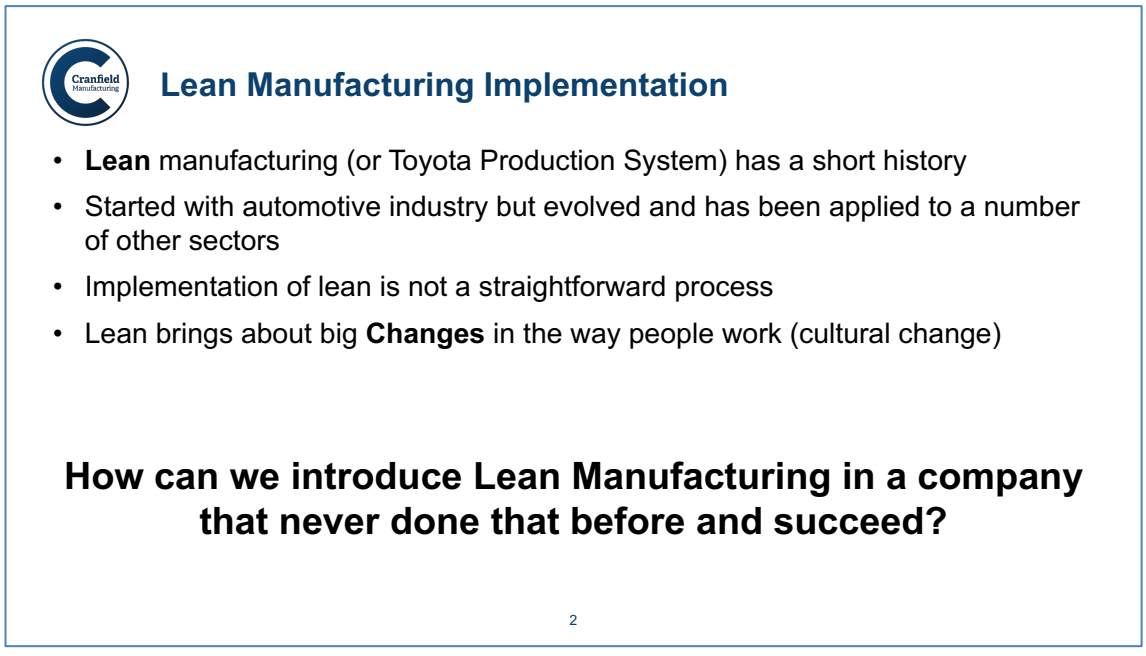
Value stream: The specific activities necessary to design, order and provide a specific product from concept through production, delivery, and post-delivery support.

Value Stream Mapping (VSM): an one page visual description of the production system for the manufacturing one specific family of products, following the product from the order request to satisfying the customer at delivery.

Appendix D Supporting presentation for introduction of the framework

The following presentation was prepared for introducing the framework to external interested practicioners.

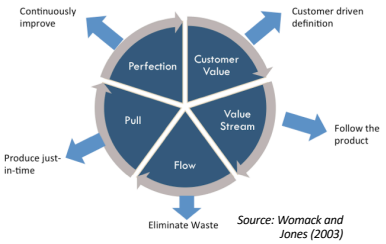




What is lean manufacturing?

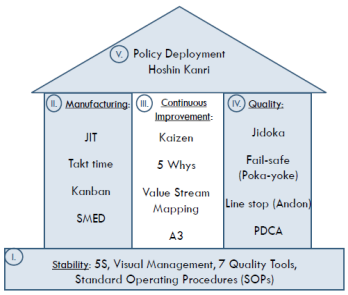
"Lean manufacturing is an integrated socio-technical system, whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability"

- Waste and value within Lean Manufacturing
- 5 principles of lean



Source: Womack and Jones (2003)

- House of lean

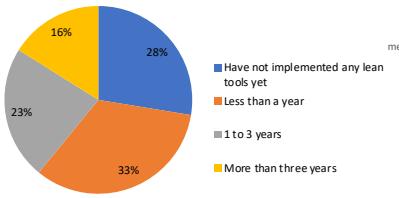


Lean in UAE

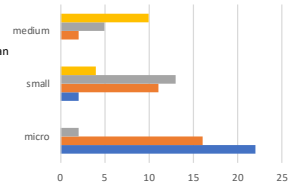
Survey in 2018

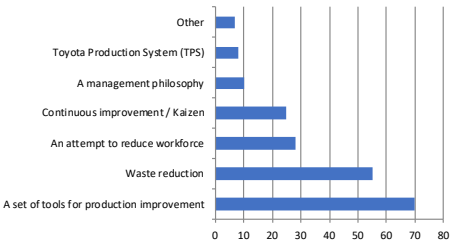
87 manufacturing SMEs from UAE participated

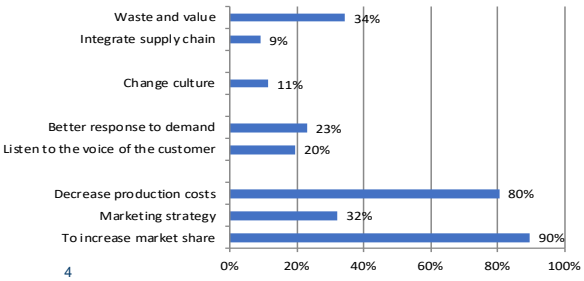
How many years has your company been implementing lean?



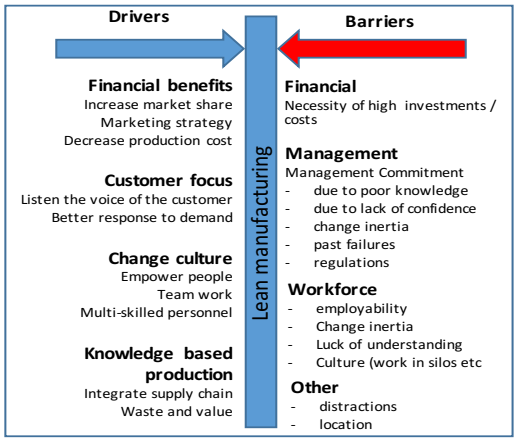
Lean implementation maturity

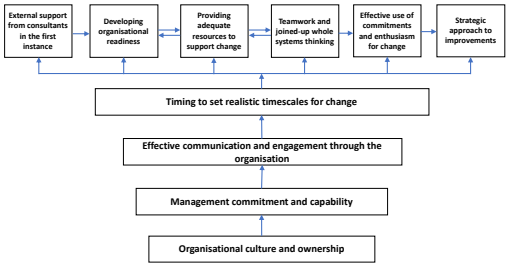






Lean Implementation: Drivers and Barriers





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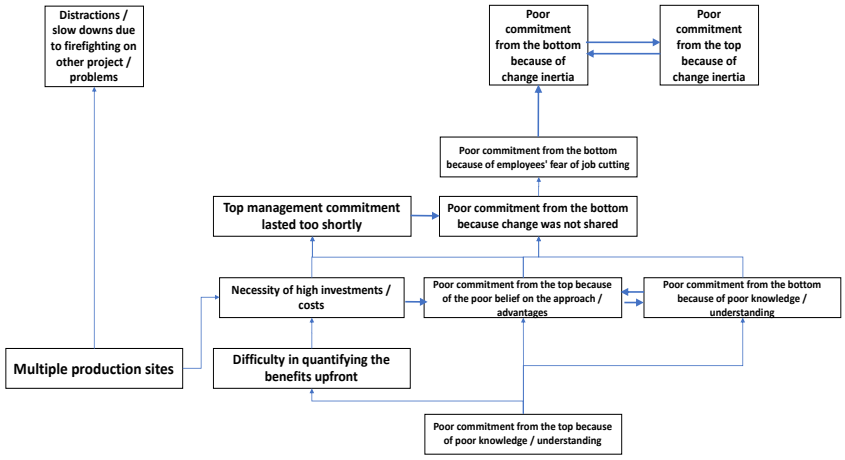
Critical success factors



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Overall framework

Phase I: Creating the climate for change

1. Create urgency

Purpose:
- Convey need
- Engage workforce by informing on the need for lean
- Create a crisis (for example by lowering the inventory levels)

Activities: 1 month
- □ Appoint a change champion
- □ Share info on company's and competition's status
- □ Set up (department wise) small issues such as lack of resources, inventory etc.
- □ Discuss implications company wide
- □ Initiate discussion about value and waste within the organization

2. Form a powerful coalition

- Obtain Senior Management Buy-in
- Negotiate with labor unions, commit if possible
- Engage workforce
- Engage customers
- Engage suppliers

Activities: 1 month
- □ First training focused on senior managers (engage labor unions)
- □ Workshop with workforce for capturing their ideas and feedback
- □ Set up training sessions on lean for workforce. Present labor ideas and how these are aligned to lean philosophy and principles
- □ Initiate discussions with key customers and tier one suppliers on JIT delivery, milk runs
- □ Establish focus groups from workforce (various disciplines, various management levels)

3. Create a vision for change

- Create a vision and the corresponding strategy
- Derive objectives

Activities: 1/2 month
- □ Set up a vision document
- □ Cost benefit analysis, risk and mitigation plans
- □ Set up implementation plan
- □ SMART Objectives

Phase II: Engaging and enabling the organization

4. Communicate the vision

Purpose:
- Communicate the vision throughout the company
- Engage all stakeholders (both internal and external)
- Initiate training

Activities: 1 month
- □ Establish a communications officer with regards the change
- □ Issue regular "news-letters" focusing on benefits for both the organization and the individuals
- □ Use a variety of communication channels: bulletins, lunch updates, social media
- □ Identify the topics for training
- □ Initiate training workshops

5. Empower action

- Empower workforce
- Formulate self-driven improving teams
- Provide resources for projects

Activities: 2 month
- □ Establish "quality – circles" in various departments
- □ Provide teams with the tools, training, etc. that are needed for doing their work
- □ Empower teams: assign responsibility and authority to teams
- □ Allow teams to self-resolve issues, time plan
- □ Support teams when and if they need support

6. Create short-term wins

- Focus on easy to implement with high return projects such as 5S
- Share gains with teams
- Communicate the wins (for example through A3)

Activities: 1 month
- □ Identify "small" projects for each quality – circle team to work on
- □ Establish a communication / share platform for sharing both the process and the gains
- □ Reward wins and effort
- □ Link small projects to the overall change vision (projects alignment / programme management)

Phase III: Implementing and sustaining the change

7. Build on the change

Purpose:
- Implement more complex projects
- Engage gradually externals into the projects such as customers and suppliers
- Further engage workforce

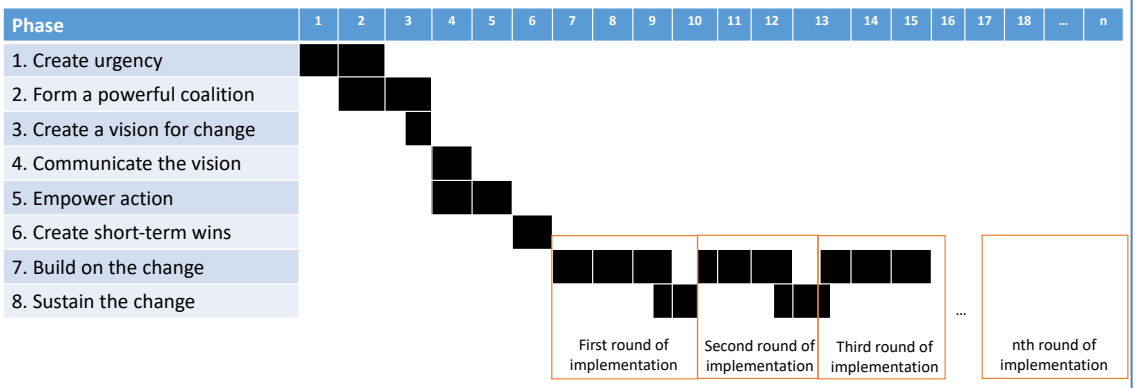
Activities: 2-3 month
- □ Identify more complex projects, originating both from the champions and the teams themselves
- □ Further train teams in more complex methods, e.g. Lean Six Sigma
- □ Reach out to tier 1 (initially) and tier 2 and 3 suppliers, engage them invite them in the quality circles

8. Sustain the change

- Learn from first round of implementation
- Continuous improvement way of thinking

Activities:
- □ Document success / failures of the first round of implementation
- □ Standardize new procedures through new SOPs
- □ Organize a communication event for celebrating success
- □ Review vision and objectives
- □ Negotiate and agree the next round of implementation with stakeholders

Implementation timeline



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Example of a timeline implementation

DELIVERABLES	1	2	3	4	5	6	7	8	9	10	11	12	RESPONSIBLE	REVIEW
CCF at Pacemaker														
Kaizen each c/t to <TT													Smith (IE)	Plt Mgr
Weld uptime to 100%														V.SMgr
c/o reduction to <TT														
Pull at Pacemaker													Jones (PC)	Plt Mgr,
FG = 2 days														MH Mgr
KB														V.SMgr
Mt'l handling														
Leveling Box														
Pull from Stamping													Jones (PC)	Plt Mgr
WIP = 1 day														MH Mgr
c/o < 10 min														V.SMgr
Pull from Supplier													Durham (Mt'l)	PC Mgr
Info flow														Plt Mgr
Daily delivery														V.SMgr
RM = 1.5 days														

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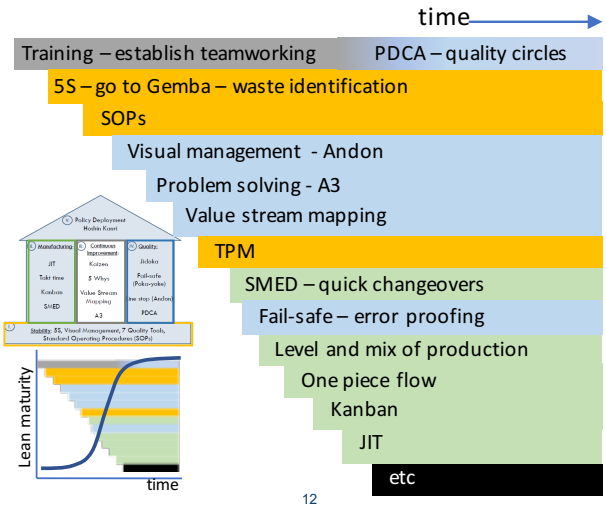
Key findings to date: Lean tools roadmap



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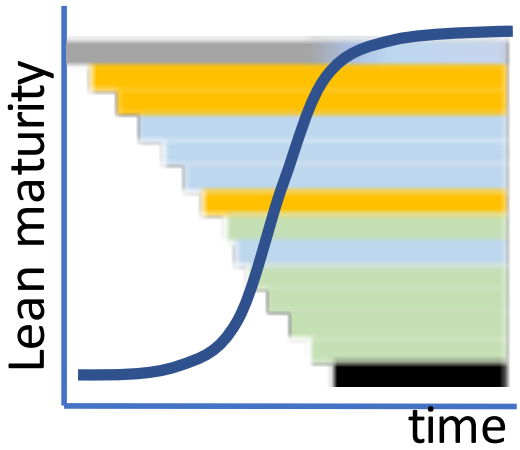
Lean maturity



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Thank you for your attention!

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