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Abstract

Lean philosophy developed and successfully practiced by Toyota with aim to deliver value, reduce waste through culture of continuous improvement. The philosophy has inspired both manufacturing and service industries to practice the lean work ethics. Because of its robustness and simplicity it is being implemented to inter alia health, education and information management sectors. Lean philosophy has helped companies to sustain growth at the time of financial crisis and shrinking economy.

Intrigued by successful implementation of Lean philosophy in service industry and knowledge work such as product development, the thesis is aimed to study implementation of Lean philosophy to procurement as a support function for complex project. For the purpose experts input from Equinor ASA are collected in a series of interviews dual with a desk-research and thorough analysis of previously published research papers. For a successful implementation of Lean to any process it is important to translate the lean propositions in proper logical manner to the frame of working of the process it is intended to be applied to.

The theory behind *Value* and *Waste* in procurement of complex project will be discussed with experts. And 7 types of wastes defined by Toyota Production System (TPS) will be compared with wastes in procurement. The thesis will also study the *Information Flow* in procurement. A successful implementation of Lean also needs a good relation with supplier, in this regard two working models with suppliers are discussed with experts in Equinor ASA.

The study finds an unequivocal definition of *value* proposition in procurement in complex projects. Quality and Cost efficiency are considered as salient factors for *value* deliverance in procurement. The concept of *waste* is also unambiguous in procurement but the context it is applied to differs from manufacturing . Among the 7 wastes defined by TPS only four remained pertinent to procurement. The study identified two major wastes in *Information Flow* namely *Overproduction of Information* and *Defective Information*, both the wastes can further cause waiting and delays. The thesis finds the digital tools used for communicating, retrieving information are functioning well in the organization. The thesis identified key elements which makes procurement in complex projects different from discrete manufacturing. These includes Risk, Uncertainty, Uniqueness, Complexity and Innovative nature of projects. A successful implementation of Lean to procurement in complex projects needs the organization has to become a learning organization.

The thesis finds *Organic model* is a good fit for supplier relation in procurement of complex projects. The model enables an enhanced understanding and trust between procurer and supplier, that will pave the path for successful implementation of Lean philosophy to procurement. But the *organic model* has also its limitations. In the end of the thesis some lean tools are suggested which are helpful in procurement in identifying wastes and eliminating them.

The thesis is based on Qualitative study for implementation of Lean in procurement. For further research Quantitative study using lean tool *Value Stream Mapping* is suggested. The tool maps the current flow of working to as detail as activity level and identifies concrete wastes in flow.

Preface

This thesis marks the end of 5 years study of Master of Science in Industrial Economics. And is written in fall semester 2020 at the University of Stavanger.

I start with thanking Tone Bruvoll for her knowledgeable insight and supervision. She has been generous with her time and patient with my style of thinking and writing. I am sincerely grateful for her contribution and support with the number of in person and virtual teams meetings.

I would like to thank all the Equinor ASA employees who took the time and shared their experiences and knowledge about the subject under study in the interviews.

The thesis advanced my understanding of Lean in Procurement and give me the opportunity to utilize my study background to from Project Management. I find the thesis interesting and thought provoking to work with.

Stavanger, January 05 .2021

Muhammad Mosa YaQoobi

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List of abbreviations

AP	Agile Project
DMAIC	Define, Measure, Analyze, Improve and Control
EPCI	Engineering, Procurement, Construction and Installation
GDP	Gross Domestic Product
IQ	Informatin Quality
JIT	Just in Time
NNVA	Necessary Non-Value Added
NVA	Non-Value Added
PD	Procurement Design
PDP	Procurement Design Process
PMBOK	Project Management Book of Knowledge
PMLC	Project Management Life Cycle
TPM	Traditional Project Management
TPS	Toyota Production System
TQM	Total Quality Management
Unk-Unks	Unknown-Unknowns
VA	Value-Added
WIP	Work in Progress

Keywords

[1]

Complex Project	The complexity is depending on both technical and organizational aspects. In this thesis for sake of simplicity the projects where the goal is partially/clearly known but the solution is not known is referred to as complex projects
Data	Data on their own may have no meaning, and only when contextualized (perhaps through interpretation by some kind of data processing system) may it take on meaning and become information
Information	Information is a message, something to be communicated from the sender to the receiver
Knowledge	Understanding something or being able to do something Knowledge is distinct from simple information
Lean Philosophy	A way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively.
Procurement	Procurement is the acquisition of systems, goods or services at the best possible total cost of ownership, in the right quantity, at the right time, in the right place for the direct benefit or use of the governments, corporations, or individuals generally via, but not limited to a contract.
Value	For a given stakeholder, value is the total and balanced perception, resulting from the various benefits delivered through the product/process life-cycle
Value Stream	An organizational construct that focuses on the flow of value to customers through the delivery of specific products or services
Waste	All elements of a process that only increase cost without adding value or any human activity that absorbs resources but creates no value; any activities that lengthen lead times and add extra cost to the product for which the customer is unwilling to pay

[1]The definitions are taken from PMBOK by Project Management Institute, Inc. and The Lean Product Design and Development Journey book by Marcus Vinicius Pereira and Luis Gonzaga Gonzaga Trabasso

Chapter 1

Introduction

Given the complex dynamics and distinguishing nature of projects in the project management landscape it has become increasingly difficult to apply any mechanical rule in an attempt to simplify Procurement Design (PD). With increasing focus on sustainability, competition among firms and strict quality demands have made it important for the organizations to have efficient PD plan. In Traditional Project Management (TPM) though the scope is clear and being repetitive, the risk factor can not be ignored. Agile and extreme projects carry risk from front end to the back, and risk is an eminent factor and needs to be managed in order to successfully carry out the projects. Procuring goods or/and services for risky projects need a flexible approach from both the procurer and the supplier sides.

Procurement is the acquisition of goods and services. It is important that the goods/services are appropriate and that they are procured at the best possible cost to meet the needs of the purchaser in terms of quality, quantity, time and location[31].

Procurement represents a very large fraction of total economic activity. The value of public procurement transactions in EU countries is about 16 percent of their GDP, while in the United States it is around 20 percent.1 In the private sector, the value of transactions is even larger and is steadily increasing, due to the current trend towards outsourcing all non-core business activities.[...] Unfortunately, there is not a one-size-fits-all measure for effective PD: the variety and complexity of situations in which procurement decisions are made means that appropriate purchasing procedures must take into account many aspects, and be tailored to each single situation. Nevertheless, some key driving effective procurement design are common to most procurement decisions, providing toolkit for how to taken them into account in different situations [14].

Integration of digital tools have improved communication and accelerated the process of procurement but it does not eliminate the risk/volatility of projects. Integration of Lean tools to procurement if not totally eliminate risk, it can improve the process and makes it agile to changing environment plus it makes the procurement quality robust and cost-effective.
Lean philosophy developed by Toyota with the purpose to eliminate waste and improving the quality of production. It is now extensively being applied to every part of supply chain. The approach is also being used in management science.

One area that has witnessed growing attention by scholars and practitioners as a way to reduce the costs associated with government procurement is lean thinking and the tools and techniques associated with lean principles. Generally lean thinking is not necessarily a new way of looking at increasing efficiencies in purchasing processes by eliminating waste and improving the flow of goods and services through the entire supply-chain. Over the years a number of similar approaches have been applied in practice (such as TQM, JIT, vendor stocking programs, and the like) that can claim similar successes, as well as similar failures. What makes lean thinking different as it relates to procurement is that it is generally considered a different way to view the management process, which was first introduced as the Toyota Production System (TPS). According to Schelie

and McCue (2011) lean thinking is not simply the adoption of lean tools, but a philosophy that becomes ingrained in the system that constantly looks at ways to reduce waste and increase customer satisfaction (notice how we have moved from tactical components of various analytical tools to a strategic orientation). For instance, as a result of lean thinking the TPS refocused their production process from looking specifically at how best to increase efficiency to looking to eliminate waste as goods and services moved along the entire production process.[50]

What makes lean thinking different from other approaches is that it is both a management philosophy and a set of tools and techniques that attempt to reduce waste and increase quality; where waste is defined in terms of non-value adding activities. When considering those entities who have successfully adopted lean thinking, as well as those who have successfully applied several of the techniques of lean, one thing becomes readily apparent: the key principle behind the lean doctrine is the identification and elimination of waste. Under the tenants of lean, waste is defined through the seven forms of *muda* which is best summarized as "any human activity which absorbs resources but creates no value" (Womack Jones, Lean Thinking, 2003, p.6). Also critical to this thinking is that value can be specified only by the ultimate customer for the process or activity concerned, and therefore any activity within the production process that does not create value for the customer is considered wasteful.[50]

Lean thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert muda into value. And, in striking contrast with the recent craze for process reengineering, it provides a way to create new work rather than simply destroying jobs in the name of efficiency.[51]

Complex projects are characterized by high risk, uncertainty and factors that are not known to procurer or supplier at the time of contract agreement. The thesis will study implementation of Lean to procurement of complex projects and will compare it with discrete manufacturing.

Concept of value and waste are central to implementation of lean to any process and is vital for its success. Both concepts will be further discussed in detail.

The thesis will study the *Value*, *Waste* and *Information Flow* in procurement of complex projects, experts‘s view from Equinor ASA and research papers on the subject of Lean and its implementation to procurement will be analyzed and studied.

1.1 Objective

The main title of thesis is:

Lean Procurement Design for complex projects

Since the Lean and Procurement Design are vast areas of study, in order to keep the thesis objective oriented, it is complemented by two sub-research questions which are formulated as follows:

RQ_1: *How Lean philosophy differs in Procurement of complex project compare to Manufacturing?*
(a study of implementing Lean philosophy to Procurement and comparing it to well established Lean principles in Manufacturing)

RQ_2: *How the information flow in Procurement be managed in complex projects using Lean philosophy?*
(a study of information flow in procurement compare to manufacturing)

In addition to the research questions above supplier relation and Lean tools and their applicability is also discussed in the thesis.

1.2 Procurement Design

With *Procurement Design* in this thesis is meant the underlying theory to forge an effective and efficient procurement through value driven processes, waste elimination, continuous improvement and building healthy supplier relation. In this regard three phases in procurement process are considered for study which are as follow:

1. Strategy development
2. Contract Establishment
3. Contract follow-up

1.3 Complex Project

The *Complex Projects* in this thesis is referred to the projects that are considered difficult to manage. In simple terms, complex and complicated are concepts often used to describe what is considered to be intricate or complicated.
Complexity within projects is a result of the organization‘s system behavior, human behavior, and the uncertainty at work in the organization or its environment. The three dimensions of complexity is defined as: [21]

System behavior: The inter-dependencies of components and systems

Human behavior: The interplay between diverse individuals and groups

Ambiguity: Uncertainty of emerging issues and lack of understanding or confusion.

1.4 Brief Plan

The thesis will study and analyze research papers, articles, books on lean in manufacturing and services industries, further experts‘s interview from Equinor ASA will remain central inputs for the thesis. Overleaf Latex a cloud-based editor program is used to write the thesis in addition Lean tools are studied, ClickCharts by NCH softwares is used to draw the diagram and charts.

Table 1.1 below shows a simplified road-map of the thesis.

Inputs	**Tools and Techniques**	**Output**
-Research papers	Lean Tools	
-Articles	Charts	Master’s thesis
-Books	Softwares	
-Interviews	Desk-research	

Table 1.1: Thesis plan

1.5 Structure

The thesis comprises of following chapters, with their brief description:

Chapter 1 Introduction:
Gives an introduction of the thesis and relate Lean to PD.

Chapter 2 Literature Review:
This chapter situates the thesis with the existing frame of knowledge with regard to Lean and PD. And gives an overview of the research previously done on the subject of Lean and PD.

Chapter 3 Theoretical Background:
This chapter provides a brief insight into the theory necessary to understand the basic concepts related to Lean, Lean tools and PD. Further its gives definition of TPM and AP.

Chapter 4 Methodology:
This chapter gives an overview of the research methods and techniques used in the thesis.

Chapter 5 Interviews:
This chapter presents the interviews from the experts to get a meaningful insight of Lean principles in procurement of complex projects.

Chapter 6 Discussion:
Presentation and discussion of the findings literature and interviews.

Chapter 7 Conclusions:
Conclusion based on the findings of the study and suggestion for further research.

Chapter 2

Literature Review

Toyota Production systems was originally engineered to eliminate non-value added activities in production processes. Due to its simplicity and robustness it is now applied in legal, economical, medical and management systems. Unfortunately Lean is adopted only at the time of financial distress/crisis and shrinking growth which compel the companies to apply austerity measure to sustain growth and survive the impact of the crisis.

For example the oil crisis in the fall of 1973, followed by a recession, affected government, businesses and society the world over. By 1974, Japan's economy had collapsed to a state of zero growth and many companies were suffering.
But the Toyota Motor company, although profits suffered, greater earnings were sustained in 1975, 1976, and 1977 than other companies. The widening gap between it and other companies made people wonder what was happening at Toyota.
Prior to oil crisis Toyota manufacturing technology and production system was little interested for other companies. When the rapid growth stopped, however, it became very obvious that a business could not be profitable using the conventional American mass production system that had worked so well for long [34].

The purpose of this chapter is to find relevant literature pertaining to Lean and Procurement, and synergy of Lean and Procurement that can be applied to Traditional and Agile projects.

2.1 Lean Thinking

Taiichi Ohno (1912-1990), the Toyota executive who was the most ferocious foe of waste human history has produced, identified the first seven types of muda described above and we've added the final one
It provides a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively. In short, lean thinking is lean because it provides a way to do more and more with less and less - less human effort, less equipment, less time, and less space-while coming to providing customers with exactly what they want.[52]

2.1.1 Five Lean Principles

Lean is lean since it provides a way to do more and more with less and less, that is to say less human effort, less equipment, less time and even less space while simultaneously producing products that customer really want. In this way it facilitates increasing value while decreasing waste at the same time[...] Waste means any human activity, which absorbs resources but creates no value. For instance, mistakes that require additional effort for rectification, production of items that nobody wants leading to inventories and remaindered products piling up, processing steps that are not required, movement of employees and transportation of goods from one place to another without

any purpose, people in a downstream process waiting because one of the upstream activities has not delivered on time, goods and services which do not meet customers needs.

Specifying Value

The critical starting point for lean thinking is value. Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) which meets the customer's needs at a specific price at a specific time.[...] Value is created by the producer. From the customer's standpoint, this is why producers exist. Yet for a host of reasons value is very hard for producers to accurately define.
Lean thinking must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. The way to do this is to ignore existing assets and technologies and to rethink firms on a product-line basis with strong, dedicated product teams. This also requires redefining the role for a firm's technical experts and rethinking just where in the world to create value. Realistically, no manager can actually implement all of these changes instantly, but it‘s essential to form a clear view of what‘s really needed. Otherwise the definition of value is almost certain to be skewed. In summary, specifying value accurately is the critical first step in lean thinking- Providing the wrong good or service the right way is muda.[52]

Identifying the Value Stream

The value stream is the set of all the specific actions required to bring a specific product (whether a good, a service, or, increasingly, a combination of the two) through the three critical management tasks of any business: the problem-solving task running from concept through detailed design and engineering to production launch, the information management task running from order-taking through detailed scheduling to delivery, and the physical transformation task proceeding from raw materials to a finished product in the hands of the customer.3 Identifying the entire value stream for each product (or in some cases for each product family) is the next step in lean thinking, a step which firms have rarely attempted but which almost always exposes enormous, indeed staggering, amounts of muda.[52]

The next step in lean thinking is to identify the actual value stream i.e. the whole set of activities required to produce the specific product independent if it is a good, a service or a combination of both. This is a kind of a door-to-door perspective applied to the three major fields of activity in any business (WOMACK JONES, 1996, p. 19):

- Problem-solving task: From concept through design and engineering to production launch
- Information management task: From order-taking through detailed scheduling to delivery
- Physical transformation task: From raw materials to the finished product of the customers

During the value stream analysis there will mostly appear three different types of actions along the value stream:

- Value adding activities (VA): Painting a car, assembling of a bolt
- Necessary but not value adding activities (NNVA): Inspecting painting to ensure quality
- Non value adding activities (NVA): Activities that can be eliminated instantly

The key of the value stream analysis is that you look at the entire value stream for each product or product family, beginning with the first supplier in the chain up to the ultimate customer. The potential of this procedure is based on a holistic view that goes beyond the single company. Once firms decide to do so they almost always reveal huge amounts of non value adding activities that is to say waste. In literature this kind of integral approach is called lean enterprise.[3]

Flow

Once value has been precisely specified, the value stream for a specific product fully mapped by the lean enterprise, and obviously wasteful steps eliminated, it's time for the next step in lean thinkingâ"a truly breathtaking one: Make the remaining, value-creating steps flow.[52]

The target of the flow principle consists in redefining the work of functions, departments and companies in a way that they positively contribute to value creation and to meet the real needs of the process participants at every point along the value stream so it is actually in their interest to make the value flow (WOMACK JONES, 1996, p. 24). To do this successfully not only requires to focus on the specific product or service, and to create a lean enterprise for each product but also to ignore or rather to rethink traditional boundaries of jobs, functions, departments, careers, companies, specific work practices and tools in order to eliminate backflows, scrap and stoppages of any sort and thus to make the flow more smooth. Once employees and managers begin with 'flow thinking' and learn to see it, it becomes also possible to apply flow to any activity performed. In principle, the procedure is in every case the same (WOMACK JONES, 1996, p. 64):[3]

- Concentrate on managing the value stream for the specific service or good
- Eliminate organizational barriers by creating a lean enterprise
- Relocate and right-size tools, and
- Apply the full complement of lean techniques so that value can flow continuously

Pull

Lean thinking however is not only concerned with the question how to provide the exact goods and services the customer really wants, but also how to provide it when the customer really wants it. The strategy behind is the pull principle, which means that you let the customer pull the product from your company as needed instead of pushing products onto the customer and so accumulating huge stocks of products that no one wants. Even though primarily looked at the end customer, this principle applies along the whole value stream and thus means that no upstream station should produce a good or service until the downstream station asks for it. An essential precondition for it is laid by the realization of the flow principle which can significantly reduce throughput times in product development, order processing and physical production by 50, 75 and 90 percent respectively (WOMACK JONES 1996, p. 24). This creates high flexibility and thus the ability to design, schedule and produce exactly what the customer wants and when he wants it. Furthermore, the short response time to customer demand makes it also possible to accelerate the return on investment and to reduce inventories to a minimum even in a complex production and value stream. According to WOMACK JONES (1996, p. 79) the secret for the latter can be seen in the ability to get parts resupplied very quickly from the next level of the system, which in turn enables to reorder in small batches. A special tool to control the resupply and to optimize inventories is kanban and JIT (Just in time).[3]

Perfection

The final principle in this row is striving for perfection which is some kind of reminder that there is no end in reducing effort, time, space, cost and mistakes while simultaneously producing more and more products which the customer really wants (WOMACK JONES 1996, p. 25). Indeed, the above mentioned four principles interact with each other in a way that improvements in one of these often lead to some improvements in the others. For instance, product teams which are in direct contact with customers almost always find better and better ways to define customer value more concisely and thereby also find some new ways to advance flow and pull techniques. Another aspect in this context concerns new technologies in manufacturing and other areas which often reveal new ways to increase value and eliminate waste that again redefines the prevailing picture of perfection a company has. Beside setting specific targets for improvement driven by kaizen, the

lean philosophy also uses impossible targets for the improvement process, and paints the picture of a perfect process situation for the people. Even if it might be impossible to get to there, just the imagination provides a great deal of inspiration and in particular direction to the people what is essential to making progress along the path and to pull together (WOMACK JONES 1996, p. 94).[3]

Perhaps the most important spur to perfection is transparency, the fact that in a lean system everyone-subcontractors, first-tier suppliers, system integrators (often called assemblers), distributors, customers, employees- can see everything, and so it's easy to discover better ways to create value. What's more, there is nearly instant and highly positive feedback for employees making improvements, a key feature of lean work and a powerful spur to continuing efforts to improve.[52]

2.2 Lean in Procurement

The main focus of any project whether Traditional or Agile, is to keep the the project within the constraints of time and cost while delivering the specified quality. In order to keep the track of all the constraints a PD process must be value driven process. Defining and managing value in PD process needs value management and Lean became an inevitable principle in the process.

[...] the purpose of value management is to develop a common understanding of the design problem and identify explicitly an agreed statement of the design objective by the project stakeholder[47].

Customer demand on procurement and supply chain overall is increasingly more diverse and complex. Procurement must be positioned to anticipate changes in business requirement, adapt to these changes, and accelerate implementation to capture opportunities ahead of the competition. The capability to align the customer segment with the right products/services and to develop adaptive supply chain are the core elements of the value added contributions that procurement is increasingly expected to deliver.[29]

In the coming section the thesis will go through the articles/research papers where lean in applied to procurement to build a research foundation.

The section follows will try to find definitions relating Lean to Procurement.

2.2.1 Definition

Lean Procurement analyses the steps within the procurement process to define what adds value, by reducing everything else (which is not adding value). Considering procurement‘s obsession with value, it is understandable that there is a strong synergy with the principles of Lean.[1]

Thinking Lean often involves utilising suppliers as often as possible (without paying too much of a premium) in order to free up internal resources to execute in core areas of the business. Striking the right balance between value-added services and the cost of goods and services can generate huge savings, in terms of both costs and time.[46]

Mirko Kleiner, the creator of Lean-Agile Procurement, embraces the values of Lean by incorporating waste reduction into his innovative lean-agile procurement methodology. Essentially, his new way of working which can slash complex sourcing times from six months to six weeks reduces waste by: [36]

- reducing preparation efforts as much as possible
- improving time to market dramatically
- reducing lengthy custom proposals to one-page documents
- reducing the number of procurement team members involved in the sourcing process.

Another definition of Lean Procurement follows as:

Lean in Procurement and Supply Management can be viewed as a way to:[22]

- Improve the procurement process and workflows, reducing time and eliminating waste
- Reduce/lower costs while improving the quality of products and services
- Improve the performance and responsiveness of suppliers
- Increase the focus on those activities that add value to the firm
- Enhance procurement‘s strategic rather than transactional focus

Lean procurement is based on three core principles that are derived from demand driven manufacturing and supply chain initiatives:[35]

1. Migrate from "push" to "pull"
2. Develop a flexible and responsive supply chain
3. Eliminate all waste in the procurement cycle

A procurement process can be viewed from at least two sides; in Figure 2.1 the client and the supplier side can be seen. The client and the supplier, or suppliers, goes on with their own activities but fairly often they have a need to communicate with each other.[15]

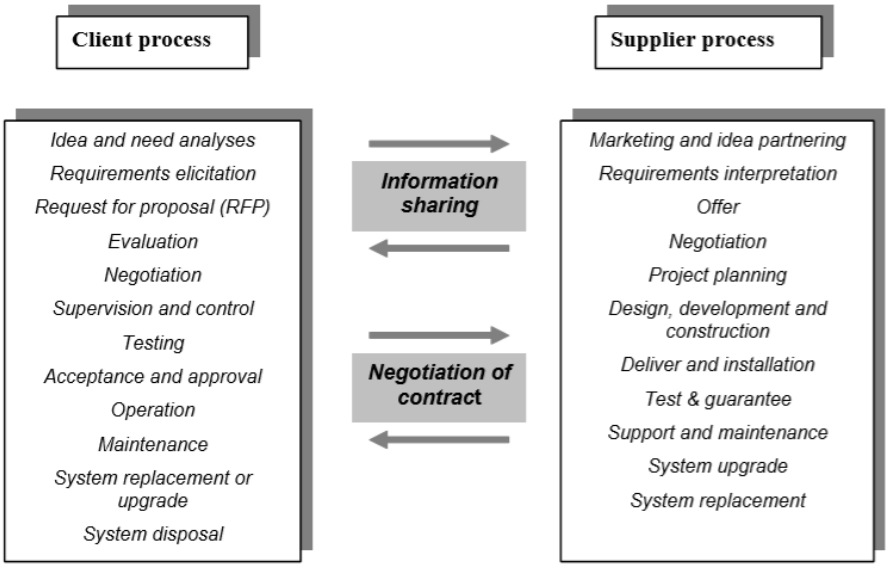

Figure 2.1: Activities in a Procurement Process
[15]

Each activity is initialized on either the client or supplier side or in some cases simultaneously on both sides. Depending on the goal of the project, different methods, tools and resources have to be used.[15]

The figure 2.2 shows that procurement encapsulate value network, supply and sourcing and is a broader term.

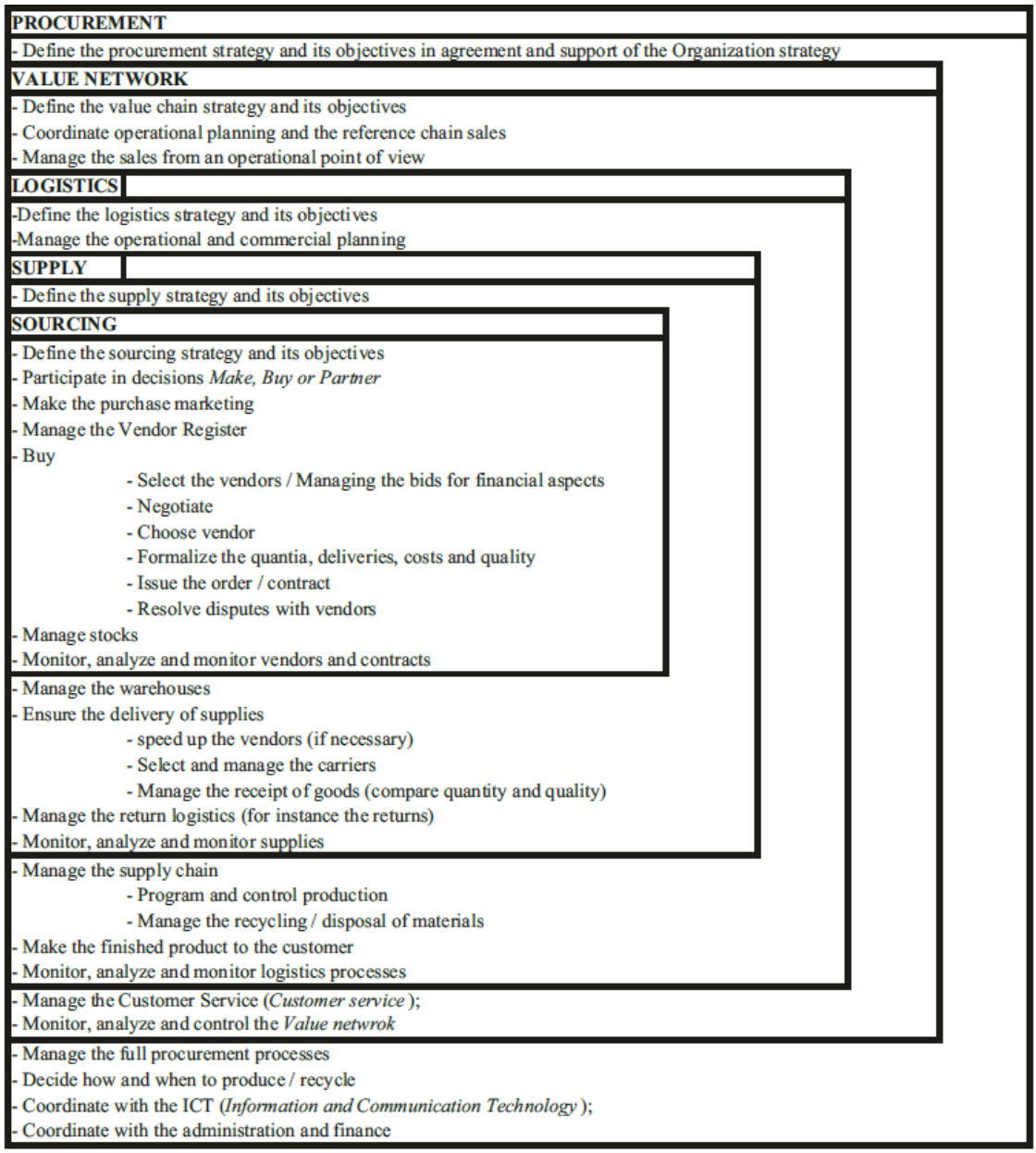

Figure 2.2: Procurement, Supply and Sourcing
[32]

2.2.2 Lean in Manufacturing vs. Procurement

Lean philosophy basically adhere to improvement of physical processes. Imitating it to knowledge work such as Procurement process may need some modifications. Identifying the procurement value stream, potential sources of waste, information variability are challenges in applying Lean philosophy to procurement.

Attempts to apply lean approaches to knowledge work have proved frustratingly difficult. Most in the business world believe that knowledge work does not lend itself to lean principles, because, unlike car assembly, it is not repetitive and can‘t be unambiguously defined. Consider a bank officer deciding whether to make a loan, an engineer developing a new product, and a social worker ruling on whether a child‘s environment is safe: In each instance the work involves expertise and judgment that depend heavily on tacit knowledge-knowledge locked inside the worker‘s head[...] In manufacturing, there is a common understanding of how to make an operation lean, and many of the same techniques can be employed in different organizations. This is not the case in knowledge work.[48]

What is unique with services and procurement in particular is that while a process might be exactly what is required to meet a customer‘s needs and expectations in an efficient and effective manner for that moment, those needs can vary considerably and change quickly and therefore have to be continually monitored and the related processes improved as required. For procurement these ongoing changes as far as customer needs and expectations are concerned could involve changes to the goals, objectives, or strategies of the departments that procurement is involved with, changing market conditions including availability or capability of suppliers, public preferences and or changes to the regulatory environment, just to name a few. As an aid to monitoring these changes the development of a measurement and control system directed at helping process owners identify ongoing opportunities for improvement is needed. [42]

Service processes are fundamentally different than manufacturing processes. Some of the factors that differentiate services from manufacturing are: the active participation of the customer into the delivery process, the place of delivery and the place of use of the service are often the same, the service intangibility and the impossibility of storing the services (Fitzsimmons and Fitzsimmons, 1994). It is also proved that service processes have not been as efficient as manufacturing processes (Lovelock and Gummesson, 2004). This implies that there is the opportunity to transfer in the world of services the practices commonly adopted in the manufacturing context (Smith and Waterman, 1981; Antony et al., 2005; Snee, 2004).[31]

In Procurement process it is the flow of information between work stations as compared to the material or products in case of manufacturing process. Similar to material, there are also some fundamental properties, which characterize information and simultaneously determine some advantages and shortcomings accompanied by information handling. This includes the following aspects.[3]

- Information is an intangible good that is not used up with repeated utilization
- Information is valuable for the user if he can realize it in his actions
- Information is no free good, thus information can be associated with a particular but often hard estimable price
- The value of information is dependent on the particular context and the time it is used
- The value of information can be changed by adding, selecting, concretizing and omitting; thus information is open-ended and condensable
- There are different attributes of information quality (IQ) such as accuracy, completeness, timeliness and reliability

- Information can be transported with speed of light even if the underlying objects (specified elements) cannot be transported with the same speed
- Buyer of information only get copies of the ordinary information, thus the enforcement of exclusive rights and in particular of property rights turns out as very difficult
- Information is transferred encoded which requires common standards for the exchange
- Copying of information is easy and cheap
- Obsolescence of information which is not caused by usage but by its timeliness at most
- Ambiguous ownership of information due to multiple possessors
- Almost arbitrary divisibility of information
- Identification of owner often is difficult; problems with protection of data privacy and data security
- Easy logistics of information, primarily electronic
- User-defined possible combinations; accumulation improves information value and quality

While lean thinking evolved out of lean production approaches, applied for the most part within manufacturing settings, other sectors public and private, including firms involved in the provision of services have adapted and successfully deployed lean thinking approaches (Radnor and Walley, 2008). Within the public sector, health care organisations have been found to be most frequently using lean (Radnor and Walley, 2008). Hospitals for example have implemented a variety of tools and techniques derived from the Toyota production system to extensively improve workflow and the quality and efficiency of all types of hospital services. Some of these tools and techniques included rapid improvement events, standardising systems, value-stream mapping and root-cause analysis (Silvester et al., 2004; Weber, 2006; Wysocki, 2004). By using rapid improvement events, value-stream mapping, everyday lean and other lean tools, the Virginia Mason Medical Center, an acute care hospital in Seattle, Washington, USA, reduced staff walking distance by 38%, inventory by 50% and patient lead time by 53% (Weber, 2006).[42]

In contrast to the manufacturing sector, in the area of information management, waste and value identification is more subjective and less perceptible. In fact, information management is not supported by a physical and visible system and, consequently, wastes are not so tangible and value flow is not directly visible.[7]

Table 2.1 below illustrate Lean principles in Manufacturing and Procurement process[1]:[3]

Lean Attributes	**Physical Manufacturing**	**Procurement**
Target	Degree of excellence	Cost, Quality and with in Time
Processes	Sequential Repetitive Non-iterative	Highly networked Sequential and parallel processes (Highly) iterative Not highly repetitive, Uncertainty, Risk Repeatable
Product	Physical Products	Data, specifications, instructions
Through put time	Days, Weeks, Months	Months, Years
Work Force	Skilled workers, Craftsmen	Engineers, Analysts, Consultants, Lawyers
Flow	Material/Product flow	Information flow
Flow Direction	Unidirections, loops and iterations not planned	Multidirectional, loops and iterations possible and planned
Potenial of Automation	Medium, High	Low
Value	Precisely defined at each step	Not well defined (Unk-unks)

Table 2.1: Lean attributes comparison

Lean is usually understood to be relevant to the 'operations' of a manufacturing enterprise, meaning those processes associated with material supply, component production, and delivery of products and services to the customer. It is claimed by Womack (1996) and others that 'Lean thinking'can be applied to great effect outside manufacturing operations, although examples of this such as applications in service-based enterprises are relatively rare. This is not to suggest that there is some inherent limitation with the Lean paradigm in this context, but it may be that since international comparisons of manufacturing performance are often easier and waste is more visible in factories, improved practices are more readily transferred around the world.[2]

In more general terms it is arguable that the principles of lean thinking and in particular the removal of waste and pursuit of perfection can be applied to any system where product flows to meet the demand of the customer, user or consumer (another system). These elements are certainly true for information management and systems for its management, where information flows and work is undertaken to add value to the information.[20]

Figure 2.2 shows analogy of a information system to manufacturing system.

[1]Logical modifications are made to the originally published table

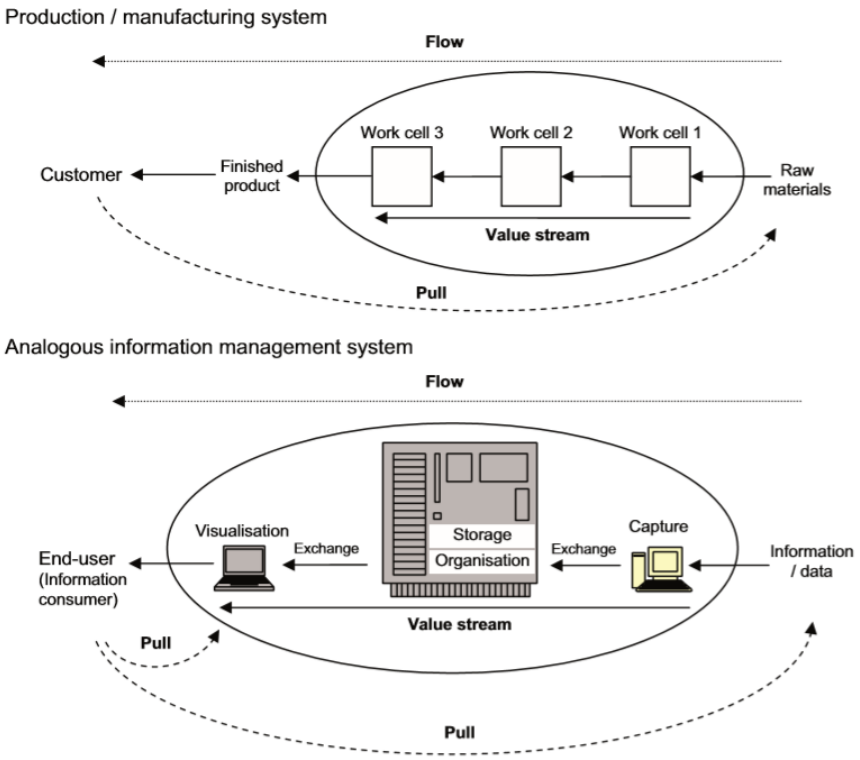

Figure 2.3: The value-flow model as applied to information management

2.3 Agile/Complex Projects

Simply put, Agile Project Management is a collection of Project management life cycles models that can be used to manage projects whose goals are clearly specified but whose solutions are not known at the outset of the project. These are what we call "complex projects."[...]
Its history stretches back a little more than 25 years. As recently as 2001, Agile software development was first codified through the "Agile Manifesto" put forth by Martin Fowler and Jim Highsmith There were 17 signers of the original Agile manifesto.[54]

Agile Mansifesto

"We are uncovering better ways of developing [products] by doing it and helping others do it. Through this work we have come to value: Individuals and interactions over processes and tools Working software over comprehensive documentation Customer collaboration over contract negotiations Responding to change over following a plan That is, while there is value in the items on the right, we value the items on the left more."

2.3.1 Risk in Complex Projects

Innovative project i.e. new product or new technology development possess risk and uncertainty. Complex projects have following characteristics:

Foreseeable Events

In foreseeable events we know that a certain event may take place(though we are not sure) and we can anticipate alternative course of action that we trigger when the event occur. [27]

Residual Risk

Residual risk er what is leftover after planning for foreseeable uncertainty.In may projects, there are simply too many foreseeable events, and planning for each even becomes impossible. While

many of these events, if small enough, may be captured in the project variation, some may have quite large impacts on the project.[27]

Variation

It is not possible to identify and proactively influence all risk factors (partly because no historical data are available on which to base the estimates). .... Variation in project performance makes the project outcome a non-deterministic event, a range of outcomes with probabilities. It is dangerous to pretend that this range of outcomes does not exist and to force teams to commit to deterministic targets. Forcing a deterministic answer to a stochastic problem often cause people to cover themselves and become overly conservative in their estimates.[27]

Complexity

Complexity stems from "large number of parts that interact in non-simple ways (such that) given the properties of the parts and the laws of their interactions, it is not a trivial matter to infer the properties of the whole. Complexity has two ingredients; system size (the number of parts) and the number of interactions among the parts. A large system is not complex if the parts don not interact - we can treat them in isolation and simply add the system‘s behaviour hard to predict from the behaviour of the parts.[27]

Unknown unknowns(Unk-unks)

Not all the project influence factors can be foreseen and planned for - some of them are not known by the project team at all. The same effect results if the project team is not aware of major interactions among influence variables and actions. They are not within the teams‘s horizon; they are outside its knowledge. Therefore, the team cannot plan for them. In addition, there are actions (relating to these unkown variables) of which the team is not aware. The decision theory and economics disciplines call this "unawreness" or "incomplete state space" and technology management scholars call it "ambiguity". Weick and Sutcliffe call unk unks "bolts from the blue", referring to events for which the team had no expectation at all, no hint, and no prior model.[27]

2.4 Contract design in Complex Projects

Large projects are rarely performed with one organization‘s internal resources alone: The resource commitment is too great, the risk becomes too high, and the range of specialized expertise areas goes beyond what exists in one company. Therefore, managing major projects typically in with partners. Collaboration with external parties poses a trade-off - the above advantages have to be weighed against multiple interests, which are never perfectly aligned and which cause possible interactions among multiple influences, or, in other words complexity.[...] A useful view of a contract is that of a business deal. The contract must, therefore, above all address the major contents of the business proposed. Specifications defined the business function of the project outcome, and price and schedule the investment, with payment terms determining the timing. Then there are multiple tools for mutual insurance, warranties, damages and limitations to them. The contract shapes the culture: first, because a project is not a permanent relationship in which the prospect of future interaction would discipline behavior, and second, because personnel turnover during the project is common. Thus, the contract is the key framework for setting standards of behavior and trust shown by others and, ultimately, the project‘s performance. The perceived fairness, realism, completeness, and transparency of the business deal are key elements in building up needed trust. Project management literature distinguishes three major contract forms: fixed price, cost reimbursable, and mixed incentive contracts. They differ in their appropriateness in allocating risks. Lump-sum turn-key fixed-price contracts allocate total risk to the contractor; they seem to have increased in importance over the years, as they clearly allocate responsibility to one major contractor who assumes most risk and can control the project execution, minimizing interface and working with more overlap.[27]

Figure 2.3 shows contract types.

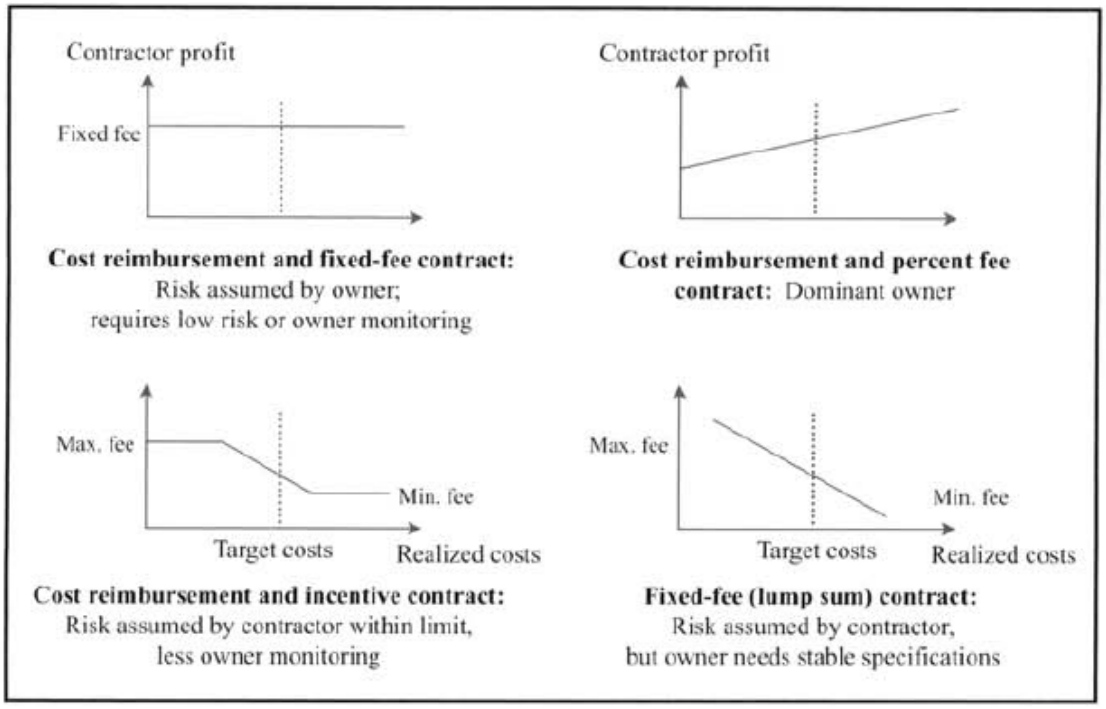

Figure 2.4: Contract types and risk allocation among parties
[27]

As the contract sets the tone of the collaboration, it is critical that the price is based on reasonable cost estimates for the project. While the price is a zero-sum game in the short term (the client wants to get the best deal while the contractor wants to make a living), deviating from the true cost in either direction is very dangerous. If the price is too low, the contractor will fell an irresistible temptation to shrink (there is no complex project in which the contractor cannot save costs by compromising on quality). If the price is too high, the client may not react this time but may find out and retaliate next time. Either side should avoid dictating contract terms and conditions, no matter how powerful he is; virtually always, both side have the opportunity of shrinking. This implies that contracts, especially fixed price lump sum turn-key contracts, should not be awarded on the basis of the lowest bid but based on identified risks, capabilities, and track records.
[27]
Although contracts are agreements among partners, they must include elements of a "hierarchy" (as if the parties were coordinated internally within one organization), in order to be operable during the myriad of small decisions to be taken during execution. These elements of hierarchy include command structures and authority systems, dispute resolution, procedures, standard operating procedures, and incentive systems.
[27]
There are eight business levers which represent the basis of risk identification - they are areas of high risk impact, and each area should be underpinned by careful estimates.

Table 2.2 gives the detail of the business levers in contract design:

Key Driver	**Definition/key Issues to be clarified**
Technical Specifications	Adequacy, completeness, and consistency of the description of the scope of work. Consistency between technical and commercial parts.
Price (quality of cost estimates)	Consistency of price and cost estimates with technical spcifications. Adequancy of contingency and profit margin.
Payment terms	Schedule of partial payments. This determines to what extent cash receipts by the contractor cover his cash expenses over the course of the project, defining the contractor‘s exposure from cash flow during the project.
Schedule	Achievability of key (intermediate and final) completion dates and consistency of their definitions. Impact of possible project delay/acceleration costs relative to contractual liquidated damages.
Performance guarantees	Acceptable tolerances of key performance measures; definition of preconditions for achievement of these performances; and liquidated damages that compensate for deviations from the performance tolerances.
Limitation of liability	What is the maximum extent of the contractor‘s liability toward the client under the contract (excluding tort or negligence)? Is it contractually clearly limited, and are indirect and consequential damages excluded?
Securities	How does the contractor ensure his performance toward the client? How does the client ensure his payment obligations toward the contract? For example, deposits, bonds, or guarantees by third parties.

Table 2.2: Definition of key drivers of contract business deal
[27]

2.5 Peter Kraljic Matrix

A company‘s need for a supply strategy depends on two factors: (1) the strategic importance of purchasing in terms of the value added by product line, the percentage of raw materials in total costs and their impact on profitability, and so on; and (2) the complexity of the supply market gauged by supply scarcity, pace of technology and/or materials substitution, entry barriers, logistics

cost or complexity, and monopoly or oligopoly conditions. By assessing the company‘s situation in terms of these two variables, top management and senior purchasing executives can determine the type of supply strategy the company needs both to exploit its purchasing power vis-a-vis important suppliers and to reduce its risks to an acceptable minimum.[24]

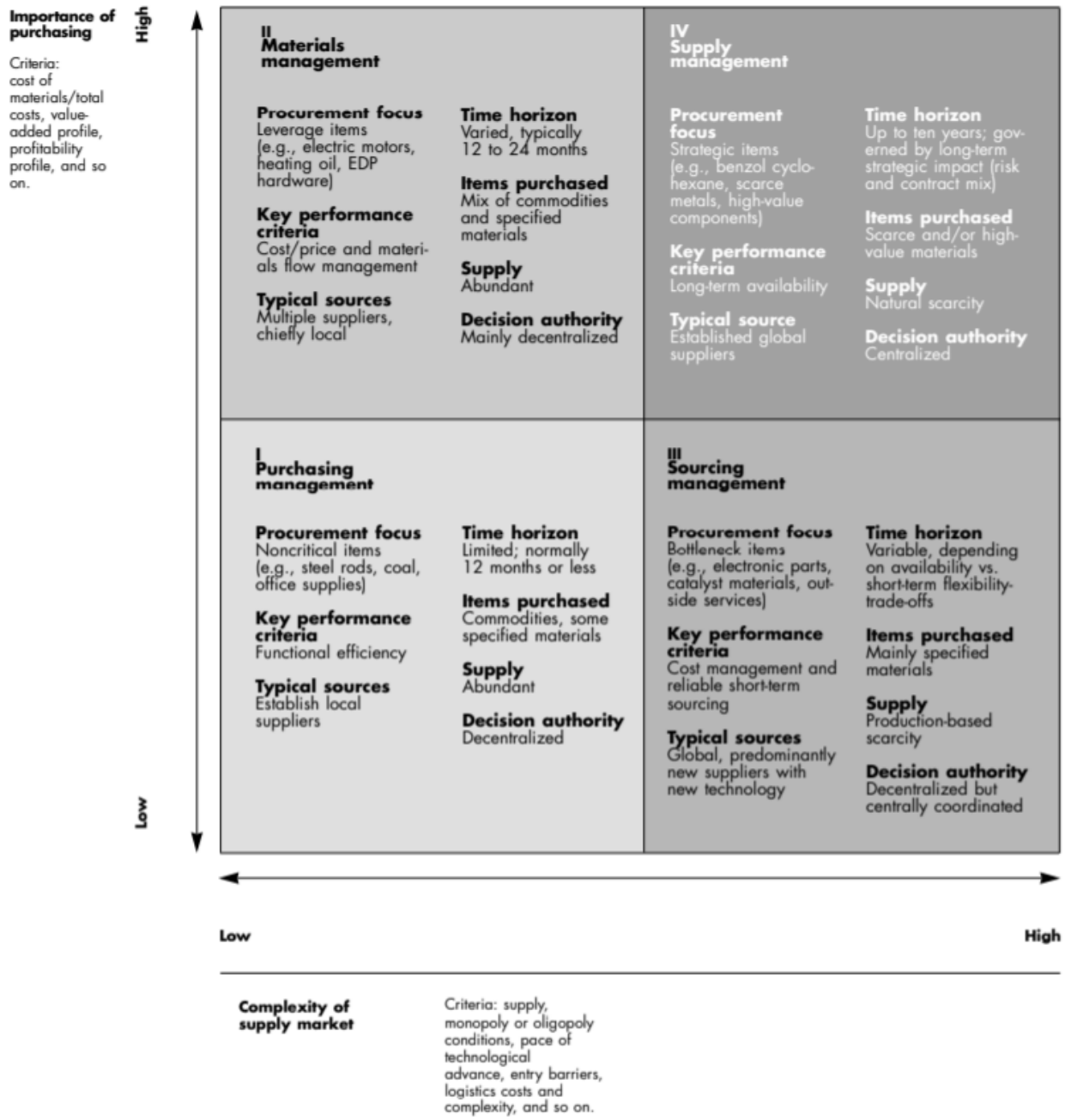

Figure 2.5: Stages of purchasing sophistication
[24]

2.6 Outsourcing

Outsourcing transfers some of what are traditional internal activities and resources of a firm to outside vendors, making it slightly different from the traditional make-or-buy decision. The vendor performing the outsourced service is an expert in that particular specialty. This leaves the outsourcing firm to focus on its key success factors and its core competencies. [19]

2.6.1 Six Sourcing Strategies

Having decided what to outsource, managers have six strategies to consider.

Many Suppliers

With the many-suppliers strategy, a supplier responds to the demands and specifications of a "request for quotation," with the order usually going to the low bidder. This is a common strategy when products are commodities. This strategy plays one supplier against another and places the burden of meeting the buyer‘s demands on the supplier. Suppliers aggressively compete with one another. This approach holds the supplier responsible for maintaining the necessary technology, expertise, and forecasting abilities, as well as cost, quality, and delivery competencies. Long-term âœpartneringâ relationships are not the goal.[19]

Few Suppliers

A strategy of few suppliers implies that rather than looking for short-term attributes, such as low cost, a buyer is better off forming a long-term relationship with a few dedicated suppliers. Long-term suppliers are more likely to understand the broad objectives of the procuring firm and the end customer. Using few suppliers can create value by allowing suppliers to have economies of scale and a learning curve that yields both lower transaction costs and lower production costs. This strategy also encourages those suppliers to provide design innovations and technological expertise.
Ford chooses suppliers even before parts are designed. Motorola evaluates suppliers on rigorous criteria, but in many instances has eliminated traditional supplier bidding, placing added emphasis on quality and reliability. On occasion these relationships yield contracts that extend through the product‘s life cycle. The British retailer Marks Spencer finds that cooperation with its suppliers yields new products that win customers for the supplier and themselves. The move toward tight integration of the suppliers and purchasers is occurring in both manufacturing and services.
As with all other strategies, a downside exists. With few suppliers, the cost of changing partners is huge, so both buyer and supplier run the risk of becoming captives of the other. Poor supplier performance is only one risk the purchaser faces. The purchaser must also be concerned about trade secrets and suppliers that make other alliances or venture out on their own. This happened when the U.S. Schwinn Bicycle Co., needing additional capacity, taught Taiwan‘s Giant Manufacturing Company to make and sell bicycles. Giant Manufacturing is now the largest bicycle manufacturer in the world, and Schwinn was acquired out of bankruptcy by Pacific Cycle LLC.[19]

Vertical Integration

By vertical integration, mean developing the ability to produce goods or services previously purchased or to actually buy a supplier or a distributor.

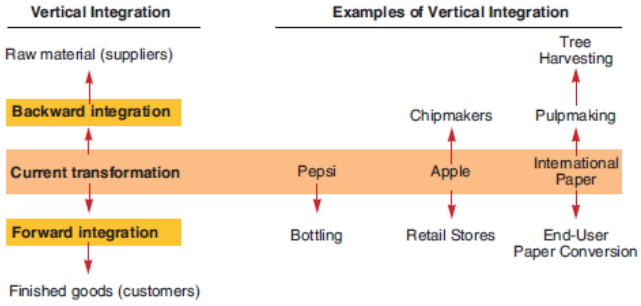

Figure 2.6: Vertical Integration can be Forward or Backword
[19]

Backward integration suggests a firm purchase its suppliers, as in the case of Apple deciding to manufacture its own semiconductors. Apple also uses forward integration by establishing its own revolutionary retail stores. Vertical integration can offer a strategic opportunity for the operations manager. For firms with the capital, managerial talent, and required demand, vertical integration may provide substantial opportunities for cost reduction, higher quality, timely delivery, and inventory reduction. Vertical integration appears to work best when the organization has a large market share and the management talent to operate an acquired vendor successfully.
The relentless march of specialization continues, meaning that a model of "doing everything" or "vertical integration" is increasingly difficult. Backward integration may be particularly dangerous for firms in industries undergoing technological change if management cannot keep abreast of those changes or invest the financial resources necessary for the next wave of technology. Research and development costs are too high and technology changes too rapid for one company to sustain leadership in every component. Most organizations are better served concentrating on their own specialty and leveraging suppliers‘ contributions.[19]

Joint Ventures

Because vertical integration is so dangerous, firms may opt for some form of formal collaboration. firms may engage in collaboration to enhance their new product prowess or technological skills. But firms also engage in collaboration to secure supply or reduce costs. One version of a joint venture is the current Daimler-BMW effort to develop and produce standard automobile components. Given the global consolidation of the auto industry, these two rivals in the luxury segment of the automobile market are at a disadvantage in volume. Their relatively low volume means fewer units over which to spread fixed costs, hence the interest in consolidating to cut development and production costs. As in all other such collaborations, the trick is to cooperate without diluting the brand or conceding a competitive advantage.[19]

Keiretsu Networks

Many large Japanese manufacturers have found another strategy: it is part collaboration, part purchasing from few suppliers, and part vertical integration. These manufacturers are often financial supporters of suppliers through ownership or loans. The supplier becomes part of a company coalition known as a keiretsu . Members of the keiretsu are assured long-term relationships and are therefore expected to collaborate as partners, providing technical expertise and stable quality production to the manufacturer. Members of the keiretsu can also have second- and even third-tier suppliers as part of the coalition.[19]

Virtual Companies

Virtual companies rely on a variety of good, stable supplier relationships to provide services on demand. Suppliers may provide a variety of services that include doing the payroll, hiring personnel, designing products, providing consulting services, manufacturing components, conducting tests, or distributing products. The relationships may be short - or long-term and may include true partners, collaborators, or simply able suppliers and subcontractors. Whatever the formal relationship, the result can be exceptionally lean performance. The advantages of virtual companies include specialized management expertise, low capital investment, flexibility, and speed. The result is efficiency.[19]

Chapter 3

Theoritical Background

This chapter consists of concepts and definitions of relevant theory, and explicitly presents the basic theory necessary to understand the Lean and is based on used in manufacturing industry. Theory behind Traditional and Agile projects and PD are also discussed.

3.1 Lean

The concept of "lean" is based on the principles of the Toyota Production System (TPS). TPS was developed with the objective of identifying and reducing wasteful activities in manufacturing processes through education and involvement of the workforce in order to better serve customers. While originally created for use in Toyota‘s manufacturing facilities, wasteful activities inhabit all processes inside and outside of manufacturing. Many companies are reducing wasteful activities in office business processes and streamlining operations to be more efficient in serving their customers better. Lean has spread to many industries - traditional manufacturing, logistics and supply chains, supermarkets, service providers, healthcare, banking, transactional processes, sales, marketing - because the basis is so fundamental to business success and has a foundation of common sense. Lean implementation has saved companies billions of dollars through reduction of waste activities[8].

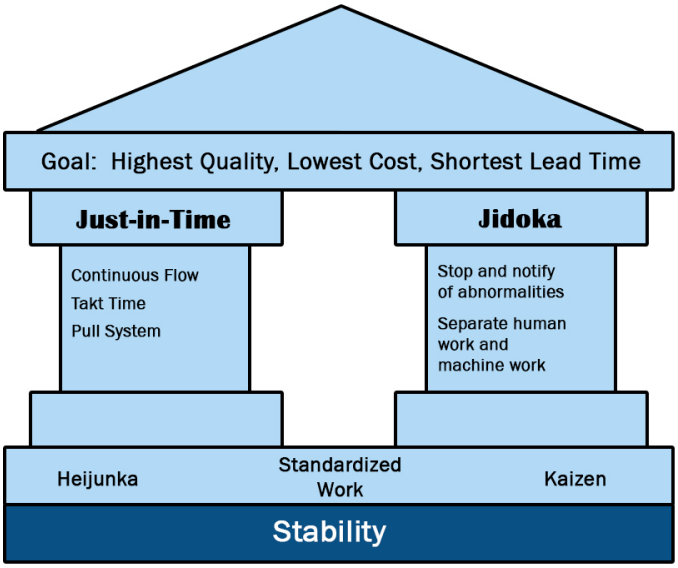

Figure 3.1: Toyota Production System House

3.1.1 Jidoka

The japanese word Jidoka (automation with a human touch) in the Toyota Production System means that the machines attempt to monitor when a process has broken down and stop the assembly line automatically. This allows one person to monitor multiple machines rather than one person for each machine. This translates into two quality control mechanisms:

1. Each production station contains a measurement device for the applicability quality metrics, and if the measurement is negative, the production station is not allowed to release it to the next downstream one

2. Each production station contains a "big red button" which stops the entire assembly line if an operator notices a quality problem. Assembly line workers were not only allowed to use the button, it was their responsibility if they saw quality problems being passed down the line. This came with mandatory training prior to working on the production line.

To accomplish Just-in-time and Jidoka, the three wastes are removed from the production system: Muri, Mura, and Muda.

3.1.2 Heijunka

It is a Japanese term that means "leveling." The Lean Lexicon 5th edition defines heijunka as: "*Leveling the type and quantity of production over a fixed period of time. This enables production to efficiently meet customer demands while avoiding batching and results in minimum inventories, capital costs, manpower, and production lead time through the whole value stream.*" The heijunka principle simply allows businesses to respond to changes in customer demand by establishing a standard or leveled flow of work.

How Heijunka works

There are three factors affecting the implementation of heijunka: Flexibility, Stability, and Predictability.

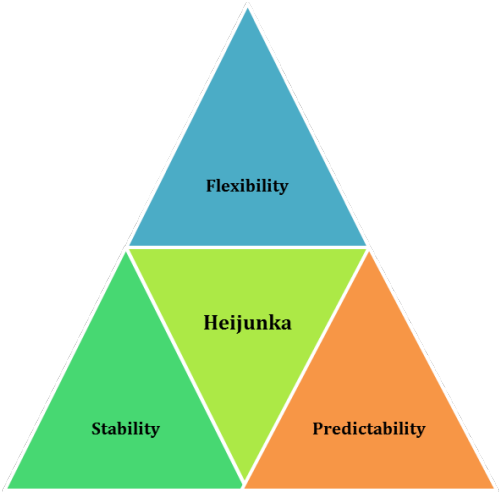

Figure 3.2: Heijunka Triangle

- **Flexibility** - Heijunka prescribes the production of various types of product in one timeframe. For example, in a 20-minute production period, the company needs to make 3 types of products using the same machine. Therefore, it will changeover twice within the 20-minute period. The time it takes for the machine to changeover to produce one product to another needs to be as fast as possible so that they can produce all 3 variants of the product within the time allotted.

- **Stability** - Setting the average amount of products in each type that needs to be produced in each lot allows the process to operate in a steady fashion. Companies would need to know their takt time or the time it takes for a product to get finished in order to meet customer demand in order to come up with their production schedule.

- **Predictability** - Companies need a way to forecast customer demand. It won‘t always be accurate, but it‘s still better to gauge how much of a product is really needed by the market and base the production schedule from there. This will make the production more predictable and manageable for the company.

Given these three factors, we can see that heijunka can actually be achieved with Just-in-Time already in place in the system. It also requires that the company has already analyzed and reviewed their value streams so that they can optimize it enough to actually make heijunka work.
While heijunka is not exactly rocket science, applying it to real-life production situations can be more complex than we can imagine. It may take a while before you actually get a hang of things. It is important to stay attuned to customer demand and adjust your process as needed. It should also be the company‘s priority to continuously improve and optimize their operations so that a more leveled workflow is established[9].

3.1.3 Kanban

Kanban is a visual system for managing work as it moves through a process. Kanban visualizes both the process (the workflow) and the actual work passing through that process. The goal of Kanban is to identify potential bottlenecks in your process and fix them so work can flow through it cost-effectively at an optimal speed or throughput.

Kanban, also spelt "kamban" in Japanese, translates to "Billboard" that indicates "available capacity (to work)". Kanban is a concept related to lean and just-in-time (JIT) production, where it is used as a scheduling system that tells you what to produce, when to produce it, and how much to produce.

A key reason for the development of Kanban was the inadequate productivity and efficiency of Toyota compared to its American automotive rivals. With Kanban, Toyota achieved a flexible and efficient just-in-time production control system that increased productivity while reducing cost-intensive inventory of raw materials, semi-finished materials, and finished products.

A Kanban system ideally controls the entire value chain from the supplier to the end consumer. In this way, it helps avoid supply disruption and overstocking of goods at various stages of the manufacturing process. Kanban requires continuous monitoring of the process. Particular attention needs to be given to avoid bottlenecks that could slow down the production process. The aim is to achieve higher throughput with lower delivery lead times. Over time, Kanban has become an efficient way in a variety of production systems.

The Kanban Method is a process to gradually improve whatever you do - whether it is software development, IT/ Ops, Staffing, Recruitment, Marketing and Sales, Procurement etc. In fact, almost any business function can benefit from applying the principles of the Kanban Methodology.

Kanban - The Concept

Kanban is a non-disruptive evolutionary change management system. This means that the existing process is improved in small steps. By implementing many minor changes (rather than a large one), the risk to the overall system is reduced. The evolutionary approach of Kanban leads to low or no resistance in the team and the stakeholders involved. The first step in the introduction of Kanban is to visualize the workflow. This is done in the form of a Kanban board consisting of a

simple whiteboard and sticky notes or cards. Each card on the board represents a task.

In a classic Kanban board model, there are three columns, as shown in the figure 3.3:

- **To Do**: This column lists the tasks that are not yet started. (aka "backlog")
- **Doing**: Consists of the tasks that are in progress.
- **Done**: Consists of the tasks that are completed.

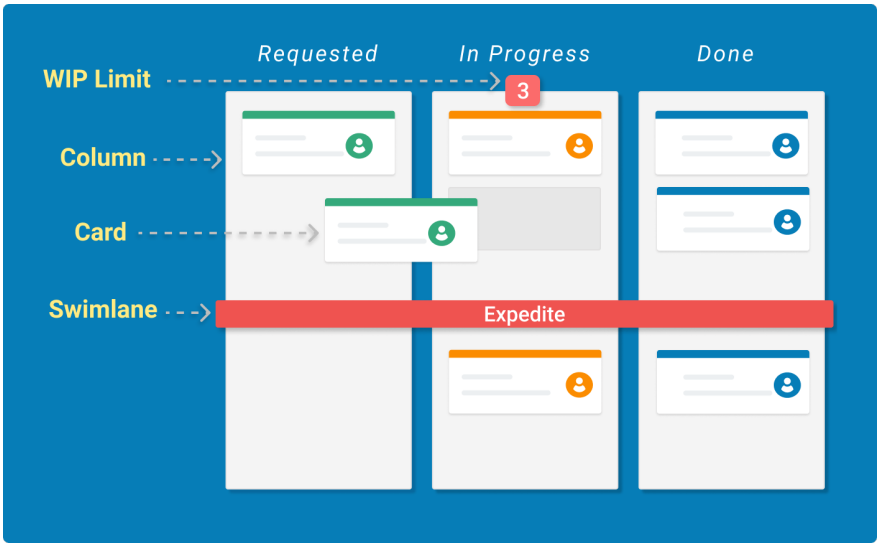

Figure 3.3: Kanban Board

This simple visualization alone leads to a great deal of transparency about the distribution of the work as well as existing bottlenecks if any. Of course, Kanban boards can show elaborate workflows depending on the complexity of the workflow and the need to visualize and examine specific parts of the workflow to identify bottlenecks in order to remove them.

The concept of FLOW

At the core of Kanban is the concept of "Flow". This means that the cards should flow through the system as evenly as possible, without long waiting times or blockages. Everything that hinders the flow should be critically examined. Kanban has different techniques, metrics and models, and if these are consistently applied, it can lead to a culture of continuous improvement (kaizen).
The concept of Flow is critical and by measuring Flow metrics and working to improve them, you can dramatically improve the speed of your delivery processes while reducing cycle time and improving the quality of your products or services by getting faster feedback from your customers - internal or external.

Kanban WIP Limits

A key aspect of Kanban is to reduce the amount of multi-tasking that most teams and knowledge workers are prone to do and instead encourage them to "Stop Starting! And Start Finishing!", a mantra coined by Dr. Arne Roock. WIP - Work-in-Progress - Limits defined at each stage of the workflow on a Kanban board encourage team members to finish work at hand and only then, take up the next piece of work.[13]

3.1.4 Kaizen

Kaizen is an approach to creating continuous improvement based on the idea that small, ongoing positive changes can reap significant improvements. Typically, it is based on cooperation and

commitment and stands in contrast to approaches that use radical or top-down changes to achieve transformation. Kaizen is core to lean manufacturing and the Toyota Way. It was developed in the manufacturing sector to lower defects, eliminate waste, boost productivity, encourage worker purpose and accountability, and promote innovation.

Kaizen is based on the belief that everything can be improved, and nothing is the status quo. It also rests on a Respect for People principle. Kaizen involves identifying issues and opportunities, creating solutions and rolling them out – and then cycling through the process again for inadequately addressed issues or problems. A cycle made up of seven steps can be implemented for continuous improvement and give a systematic method for executing this process.[44]

5 S of Kaizen

Five S of Kaizen is a systematic approach which leads to foolproof systems, standard policies, rules and regulations to give rise to a healthy work culture at the organization. You would hardly find an individual representing a Japanese company unhappy or dissatisfied. Japanese employees never speak ill about their organization. Yes, the process of Kaizen plays an important role in employee satisfaction and customer satisfaction through small continuous changes and eliminating defects. Kaizen tools give rise to a well organized workplace which results in better productivity and yield better results. It also leads to employees who strongly feel attached towards the organization. Let us understand the five S in Detail:

- SEIRI - SEIRI stands for Sort Out. According to Seiri, employees should sort out and organize things well. Label the items as "Necessary", "Critical", "Most Important", "Not needed now", "Useless and so on. Throw what all is useless. Keep aside what all is not needed at the moment. Items which are critical and most important should be kept at a safe place.
- SEITION - Seition means to Organize. Research says that employees waste half of their precious time searching for items and important documents. Every item should have its own space and must be kept at its place only.
- SEISO - The word "SEISO" means shine the workplace. The workplace ought to be kept clean. De-clutter your workstation. Necessary documents should be kept in proper folders and files. Use cabinets and drawers to store your items.
- SEIKETSU-SEIKETSU refers to Standardization. Every organization needs to have certain standard rules and set policies to ensure superior quality.
- SHITSUKE or Self Discipline - Employees need to respect organization‘s policies and adhere to rules and regulations. Self discipline is essential. Do not attend office in casuals. Follow work procedures and do not forget to carry your identity cards to work. It gives you a sense of pride and respect for the organization.[45]

Kaizen can be implemented in a seven-step cycle to create an environment based on continuous improvement. This systematic method includes:

- **Get employees involved**. Seek the involvement of employees, including gathering their help in identifying issues and problems. Doing so creates buy-in for change. Often, this is organized as specific groups of individuals charged with gathering and relaying information from a wider group of employees.
- **Find problems**. Using widespread feedback from all employees, gather a list of problems and potential opportunities. Create a list if there are many issues.
- **Create a solution**. Encourage employees to offer creative solutions, with all manner of ideas encouraged. Pick a winning solution or solutions from the ideas presented.

- **Test the solution**. Implement the winning solution chosen above, with everyone participating in the rollout. Create pilot programs or take other small steps to test out the solution.
- **Analyze the results**. At various intervals, check progress, with specific plans for who will be the point of contact and how best to keep ground-level workers engaged. Determine how successful the change has been.
- **Standardize**. If results are positive, adopt the solution throughout the organization.
- **Repeat**. These seven steps should be repeated on an ongoing basis, with new solutions tested where appropriate or new lists of problems tackled.[44]

The Kaizen process can be summarized down to just four steps:

- **Plan** - define your objective and how you'll achieve it.
- **Do** - implement the plan and make any changes required to ensure it works.
- **Check** - evaluate the results and identify opportunities for improvement.
- **Act** - make adjustments based on what's found in the previous step.

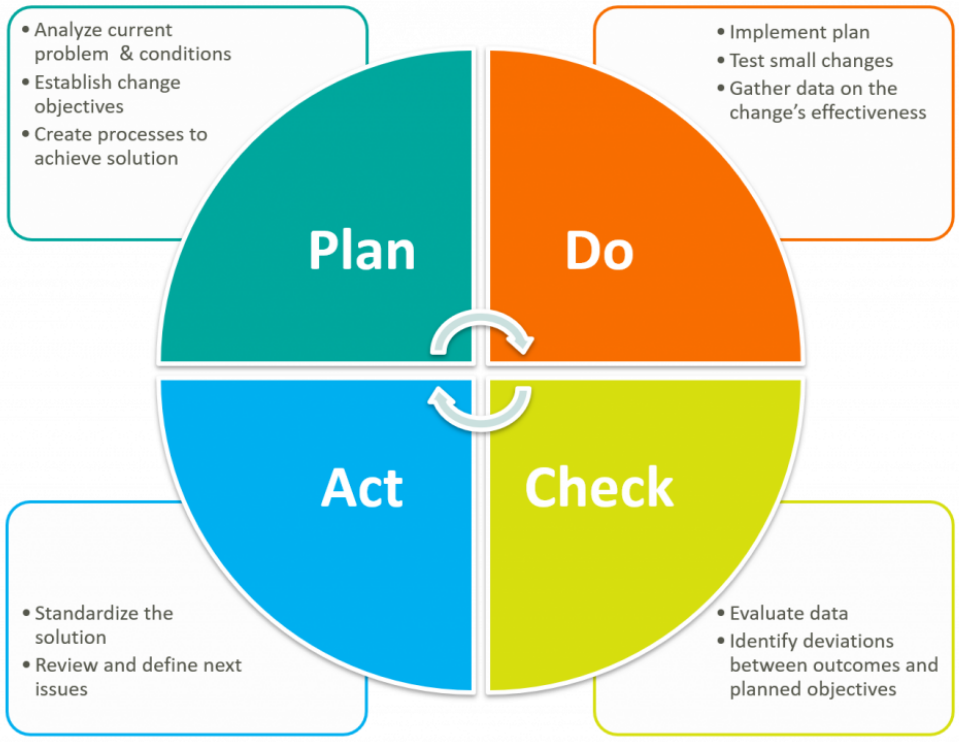

Figure 3.4: Kaizen-Continous Improvement Cycle

3.1.5 Muri - Design Out Overburden

The first of the objectives is to design out muri, which means beyond one's power, too difficult. Overburden results when a process is too complicated or difficult for the workers (or machines) to be able to perform reliably. The solution is to standardize the work. Each process should have a standard written procedure which eliminates variation and makes it clear to everyone what the worker is to do. For example, in non-Lean factories a worker might be given a task to place and tighten four bolts at their station. When the bolt inventory is low, they must call the supply department to replenish the inventory. In contrast, the Toyota Production System would create a written procedure which tells them which order to place the bolts, how far to tighten them, and how many seconds this action should take. When the bolts are depleted, the procedure specifies who to call, and they are tasked with replenishing the inventory.

3.1.6 Mura - Reduce Inconsistency

The second of the three objectives in the Toyota Production System is called mura, which means unevenness and irregularity. It is very harmful to plant productivity when the demand for its products is inconsistent. In fact, most plant managers would rather have low, steady demand for its products than wildly gyrating demand that is sometimes extremely high. The way to avoid mura is for the plant to operate on a "pull" basis. That is, each process in the system must request the components from the previous step. Hence, the parts do not get produced until they needed and the finished products are absorbed by the market as soon as possible. This is accomplished via kanban cards, which can be physical cards or electronic tracking mechanisms.

3.1.7 Muda - Eliminate Waste

The third of the three types of waste is also the one which is commonly associated with the Toyota Production System, probably because it is the easiest to implement and most intuitive to apply. The japanese word "muda" means "Futility, Uselessness, Wastefulness." Hence, this third concept within the Toyota Production System refers to the continuous improvement of the production system via the elimination of wasteful elements within the production cycle.
There are 7 types of waste that have been identified by Toyota engineers which receive the focus of production efficiency:

1. **Transport**
   The unnecessary transport of component parts, equipment, and machinery is a waste that should be eliminated. When parts are moved to interim locations, or more parts could be moved at one time, an element of waste occurs because the material did not have to be moved. The waste can be removed by minimizing the transport of materials. This category also includes things like transporting materials between plants and transporting equipment and machinery.

2. **Inventory**
   The unnecessary storage of inventory is a waste because it requires expenditures for floor space and the production of unsold products. When too much inventory exists, that is, excessive numbers of components stored at the production plant or too much finished product is produced, the storage of that inventory requires space which results in waste.

3. **Motion**
   The excessive movement of people and equipment to produce the products is a wasteful endeavor that should be eliminated. The total number of motions required to produce the products should be minimized. The number of people movements required to assemble the product must be minimized.

4. **Waiting**
   Delays incurred in a production step while waiting for a previous production step are wasteful. This is a common occurrence, and it results in a significant cost to the production facility.

5. **Overproduction**
   Producing too many end products requires that they sit idle until they are sold. In the meantime, the components must be purchased and the unsold products stored. All of these items have associated cost hence they are considered waste to the value stream.

6. **Overprocessing**
   When the process is poorly designed, excessive processing of the components during assembly is a waste that can be eliminated.

7. **Defects**
   Once production has completed, the process of repairing or replacing defective products suggests that the quality of production could be improved. The cost of repairing defects comes right off the bottom line. The process of managing defective product requires customer

service and maintenance personnel. And in addition, the reputation of the company suffers as a result of defective product. Hence, defective products are a waste to the value stream and should be minimized [6].

Lean operations supply the customer with exactly what the customer wants when the customer wants it, without waste, through continuous improvement. Lean operations are driven by workflow initiated by the "pull" of the customer‘s order. Just-in-time (JIT) is an approach of continuous and forced problem solving via a focus on throughput and reduced inventory[...] fundamentals of operations improvement: eliminate waste, remove variability and improve throughput. [19]

3.2 Lean Six Sigma (6σ)

Six Sigma is a rigorous, focused and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, Six Sigma aims for virtually error free business performance. Sigma, σ, is a letter in the Greek alphabet used by statisticians to measure the variability in any process. A company‘s performance is measured by the sigma level of their business processes. Traditionally companies accepted three or four sigma performance levels as the norm, despite the fact that these processes created between 6,200 and 67,000 problems per million opportunities! The Six Sigma standard of 3.4 problems per million opportunities.[41]

The phrase "lean Six Sigma" is used to describe the integration of lean and Six Sigma philosophies. Six Sigma complements lean philosophy in as much as providing the tools and know-how to tackle specific problems that are identified along the lean Journey: "Lean eliminate ‘noise‘ and establishes a standard.[...] Six sigma focuses project work on the identified variation from the proposed standard, which in itself does not entirely focus on the customer requirements, instead it is sometimes a cost-reduction exercise that can lose sight of the customer if not implemented alongside lean. [38]

Lean	**Six Sigma**
Establish methodology for improvement	Policy deployment methodology
Focus on customer value stream	Customer requirements measurement, crossfunctional management
Use a project-based implementation	Project management skills
Understand current conditions	Knowledge discovery
Collect product and production data	Data collection and analysis tools
Document current layout and flow	Process mapping and flowcharting
Time the process	Data collection tools and techniques, SPC
Calculate process capacity and Takt time	Data collection tools and techniques, SPC
Create standard work combination sheets	Process control planning
Evaluate the options	Cause-and-effect, FMEA
Plan new layouts	Team skills, project management
Test to confirm improvement	Statistical methods for valid comparison, SPC
Reduce cycle times, product defects, changeover time, equipment failures, etc.	Seven management tools, seven quality control tools, design of experiments

Table 3.1: Synergy between Lean and Six Sigma

Table 3.1 summarises the key lean implementation steps, along with the Six Sigma tools that can be used as an aid to achieve each task.

Motorola was the first organization to use the term six sigma in the 1980s as part of its quality performance measurement and improvement program. Six sigma has since been successfully applied in other manufacturing organizations such as General Electric, Boeing, DuPont,Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instruments, Sony, etc. The reported benefits and savings are composed and presented from investigating various literatures in six sigma.
In the business world, six sigma is defined as a 'business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations. The six sigma approach was first applied in manufacturing operations and rapidly expanded to different functional areas such as marketing, engineering, purchasing, servicing, and administrative support, once organizations realized the benefits. Particularly, the widespread applications of six sigma were possible due to the fact that organizations were able to articulate the benefits of six sigma presented in financial returns by linking process improvement with cost savings[...] Six sigma is more comprehensive than prior quality initiatives such as Total Quality Management (TQM) and Continuous Quality Improvement (CQI). The six sigma method includes measured and reported financial results, uses additional, more advanced data analysis tools, focuses on customer concerns,and uses project management tools and methodology, which can be summarized the six sigma management method as follows:

6σ = TQM+Stronger Customer Focus+Additional Data Analysis tools+Financial Results+ Project Management

Table 3.1 presents the key steps of six sigma using DMAIC process. DMAIC is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applies technology for continuous improvement.[25]

Six Sigma Steps	**Key Processes**
Define	Define the requirements and expectations of the customer Define the project boundaries Define the process by mapping the business flow
Measure	Measure the process to satisfy customer's needs Develop a data collection plan Collect and compare data to determine issues and shortfalls
Analyze	Analyze the causes of defects and sources of variation Determine the variations in the process Prioritize opportunities for future improvement
Improve	Improve the process to eliminate variations Develop creative alternatives and implement enhanced plan
Control	Control process variations to meet customer requirements Develop a strategy to monitor and control the improved process Implement the improvements of systems and structures

Table 3.2: Key Steps of Six Sigma using DMAIC process
[25]

3.3 Projects

A project is a sequence of unique, complex, and connected activities that have one goal or purpose and that must be completed by a specific time, within budget, and according to specification.[53]

Another definition is given by the British Standards Institution:

A project is unique set of coordinated activities, with a definite starting and finishing point, undertaken by an individual or organization to meet specific objectives within defined schedule, cost and performance parameters.[17]

A project is a temporary endeavor undertaken to create a unique product, service, or result. Fulfillment of project objectives may produce one or more of the following deliverables:

- A unique product that can be either a component of another item, an enhancement or correction to an item, or a new end item in itself (e.g., the correction of a defect in an end item);
- A unique service or a capability to perform a service (e.g., a business function that supports production or distribution);
- A unique result, such as an outcome or document (e.g., a research project that develops knowledge that can be used to determine whether a trend exists or a new process will benefit society); and
- A unique combination of one or more products, services, or results (e.g., a software application, its associated documentation, and help desk services).

[26]

Characteristics of Projects

There are three primary characteristics of projects that set them apart from other activities. Projects are temporary, unique and require progressive elaboration. In addition to the three primary characteristics of projects, there are several other traits that projects often exhibit. For example projects tends to:

- Carry risk and uncertainty
- Be organisationally complex, requiring the interaction of many people, departments and other organisations
- be managed against time, budget and human resource plans
- suffer conflicts due to competition for resources required by other projects and non project work
- have single point responsibility provided by project manager
- required teamwork and the ability of participants to use effective leadership skills

[17]

Organizational leaders initiate projects in response to factors acting upon their organizations. There are four fundamental categories for these factors, which illustrate the context of a project:

- Meet regulatory, legal, or social requirements;
- Satisfy stakeholder requests or needs;

- Implement or change business or technological strategies; and
- Create, improve, or fix products, processes, or services.

Table in figure 3.5 illustrates how example factors could align with one or more of the fundamental factor categories.

Specific Factor	Examples of Specific Factors	Meet Regulatory, Legal, or Social Requirements	Satisfy Stakeholder Requests or Needs	Create, Improve, or Fix Products, Processes, or Services	Implement or Change Business or Technological Strategies
New technology	An electronics firm authorizes a new project to develop a faster, cheaper, and smaller laptop based on advances in computer memory and electronics technology			X	X
Competitive forces	Lower pricing on products by a competitor results in the need to lower production costs to remain competitive				X
Material issues	A municipal bridge developed cracks in some support members resulting in a project to fix the problems	X		X	
Political changes	A newly elected official instigating project funding changes to a current project				X
Market demand	A car company authorizes a project to build more fuel-efficient cars in response to gasoline shortages		X	X	X
Economic changes	An economic downturn results in a change in the priorities for a current project				X
Customer request	An electric utility authorizes a project to build a substation to serve a new industrial park		X	X	
Stakeholder demands	A stakeholder requires that a new output be produced by the organization		X		
Legal requirement	A chemical manufacturer authorizes a project to establish guidelines for the proper handling of a new toxic material	X			
Business process improvements	An organization implements a project resulting from a Lean Six Sigma value stream mapping exercise			X	
Strategic opportunity or business need	A training company authorizes a project to create a new course to increase its revenues			X	X
Social need	A nongovernmental organization in a developing country authorizes a project to provide potable water systems, latrines, and sanitation education to communities suffering from high rates of infectious diseases		X		
Environmental considerations	A public company authorizes a project to create a new service for electric car sharing to reduce pollution			X	X

Figure 3.5: Examples of Factors that Lead to the Creation of a Project

[26]

Robert Wysocki introduced a the concept of Project Management landscape, that gives a helpful guide in categorizing project and managing them accordingly. His categorizing model revolves around two important elements *Goal* and *Solution*. Every project has a goal and to achieve that goal solution are needed.

Every project that ever existed or will exist falls into only one of these four quadrants at any point in time. This landscape is not affected by external changes of any kind. It is a robust landscape that will remain in place regardless. The quadrant in which the project lies will provide an initial

guide to choosing a best-fit project management life cycle (PMLC) model and adapting its tools, templates, and processes to the specific characteristics of the project.[53]

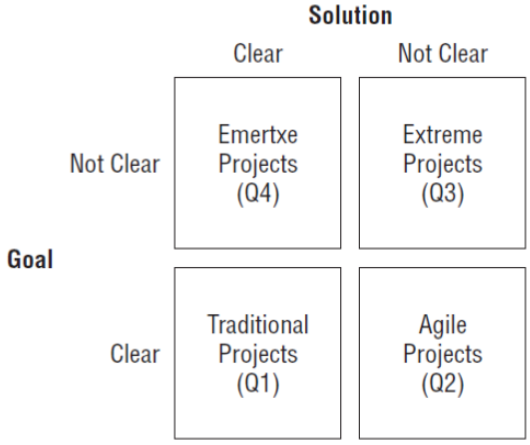

Figure 3.6: The four quadrants of the project landscape

3.3.1 Tradtional Projects [54]

This is the simplest of all possible project situations, but it is also the least likely to occur in today‘s fast-paced, continuously changing business world. Perhaps they are similar to projects that have been done several times before. There are no surprises. The client has clearly specified the goal, and the project team has defined how they will reach that goal. Little change is expected. These projects are change intolerant.They are focused on delivering according to time and budget constraints, and rely more on compliance to plan than on delivering business value. The plan is sacred, and conformance to it is the hallmark of the successful project team. That has proven to be misdirected.
The projects that remain in the Q_1 in figure 3.6, are those which have been done many times before and well-established templates are probably in place. In addition to a clearly defined goal and solution, projects that correctly fall into the Q_1 have several identifying characteristics which are as below:

Low Complexity

Other than the fact that a low-complexity project really is simple, this characteristic will often be attributable to the fact that the project rings of familiarity. It may be a straightforward application of established business rules and therefore take advantage of existing designs and coding. Because these projects have been done many times, they will often depend on a relatively complete set of templates for their execution. To the developer, it may look like a cut-and-paste exercise.

Requires few changes

Every scope change request requires that the following actions be taken:

- Someone needs to decide if the request warrants an analysis by a project team member.
- The project manager must assign the request to the appropriate team member.
- The assigned team member conducts the analysis and writes the Project Impact Statement.
- The project manager informs the client of the recommendations.
- The project manager and client must make a decision as to whether the change will be approved and if so how it will be accomplished.

- If the scope change request is approved, the project scope, cost, schedule, resource requirements, and client acceptance criteria are updated.

All of this takes time away from the team member‘s schedule commitments. Too many scope change requests and you see the effect they will have on the project schedule. Furthermore, much of the time spent planning the project before the request was made becomes non-value-added time.

Well understood technology infrastructure

A well-understood technology infrastructure is stable and will have been the foundation for many projects in the past. That means the accompanying skills and competencies to work with the technology infrastructure are well grounded in the development teams. If the technology is new or not well understood by the project team, there are alternative strategies for approaching the project.

Low risk

The requirement for Q_1 projects is that their environment is known and predictable. There are no surprises. All that could happen to put the project at risk has occurred in the past, and there are well-tested and well-used mitigation strategies that can be used. Experience has rooted out all of the mistakes that could be made. The client is confident that they have done a great job identifying requirements, functions, and features, and they are not likely to change. The project manager has anticipated and prepared for likely events (not including acts of nature and other unavoidable occurrences). There will be few unanticipated risks in Q_1 projects. That doesn‘t mean you can skip the risk management process in these projects. That will never be the case, regardless of the quadrant the project occupies.

Experienced and Skilled Project Teams

Past projects can be good training grounds for project teams. Team members will have had opportunities to learn or to enhance their skills and competencies through project assignments. These skills and competencies are a critical success factor in all projects. As the characteristics of the deliverables change, so does the profile of the team that can be most effective in developing the deliverables.

Plan-driven Project Management

Because all of the information that could be known about the project is known and considered stable, the appropriate Project management life cycle model would be the one that gets to the end as quickly as possible. Based on the requirements, desired functionality, and specific features, a complete project plan can be developed. It specifies all of the work that is needed to meet the requirements, the scheduling of that work, and the staff resources needed to deliver the planned work. Q_1 projects are clearly plan-driven projects. Their success is measured by compliance and delivery to that plan.

3.3.2 Agile Projects [54]

Cases where what is needed is clearly defined but how to produce it isn‘t at all that obvious, these are complex projects and occupy a space in the landscape somewhere between traditional and extreme projects. Projects that correctly use a Q_2 in figure 3.6, approach have several defining characteristics as briefly identified in the sections that follow.

A Critical Problem without a Known Solution

These are projects that must be done. The only approaches that make sense are those that enable you to discover an acceptable solution by doing the project. These projects fly in the face of all of the traditional practices of project management. Executives are uncomfortable with this situation

because all of the valid agile approaches have variable scope. Resources are being requested without knowing what final product will be delivered and if it has the requisite business value.

A Previously Untapped Business Opportunity

In these types of projects, the company is losing out on a business opportunity and must fi nd a way to take advantage of it through a new or revamped product or service offering. The question is what is that business opportunity and how can you take advantage of it? Here very little of the solution is known.

Change-driven Agile Projects

Q_2 projects cannot succeed without change. APM projects utilize just-in-time planning models. They don‘t waste resources and are "lean" in that sense.

Meaningful Client Involvement Is Essential

The solution will be discovered only if the client and the development team meaningfully collaborate in an open and honest environment. For the client this means fully participating with the project team and a willingness to learn how to be a client in an agile world. For the development team this means a willingness to learn about the client‘s business and how to communicate in their language. For the project manager this means preparing both the client team and the development team to work together in an open and collaborative environment. It also means that the project manager will have to share responsibility and leadership with a client manager.

3.4 Difference between Traditional and Agile methodology

The benefits of Traditional and Agile approaches are tabulated in table 3.3 below:

Benefits of Traditional Approach	**Benefits of Agile Approach**
Clearly defined objectives	Flexible prioritization
Controllable processes	Early and predictable delivery
Clear documentation	Predictable costs and schedules
More accountability	Improves quality
	More transparency

Table 3.3: Benefits of Traditional and Agile approaches

[23]
As discussed earlier, this methodology isn‘t a fan of sudden changes and avoids them strictly as it would take the team back to square one. Agile could be your best bet in terms of managing big and complex projects. Whether your project has multiple interconnected phases or one stage is dependent on many others, choose agile as it is a better fit for complex projects.
The table 3.4 shows the major differences between the traditional and agile project methodology.[23]

Characteristics	**Agile Approach**	**Traditional Approach**
Organizational structure	Iterative	Linear
Scale of projects	Small and medium scale	Large-scale
User requirements	Interactive input	Clearly defined before implementation
Involvement of clients	High	Low
Development model	Evolutionary delivery	Life cycle
Customer involvement	Customers are involved from the time work is being performed	Customers get involved early in the project but not once the execution has started
Escalation management	When problems occur, the entire team works together to resolve it	Escalation to managers when problem arise
Model preference	Agile model favors adaption	Traditional model favors anticipation
Product or process	Less focus on formal and directive processes	More serious about processes than the product
Test documentation	Comprehensive test planning	Tests are planned one sprint at a time
Effort estimation	Scrum master facilitates and the team does the estimation	Project manager provides estimates and gets approval from PO for the entire project
Reviews and approvals	Reviews are done after each iteration	Excessive reviews and approvals by leaders

Table 3.4: Traditional and Agile approaches

3.5 Procurement

Procurement refers to the participation in the development of requirements and their specifications; managing value analysis activities; conducting supply market research; managing supplier negotiations; conducting traditional buying activities; administering purchase contracts; managing supplier quality; buying inbound transportation.[5]

Procurement is the business management function that ensures identification, sourcing, access and management of the external resources that an organisation needs or may need to fulfil its strategic objectives.
Procurement exists to explore supply market opportunities and to implement resourcing strategies that deliver the best possible supply outcome to the organisation, its stakeholders and customers.
Procurement applies the science and art of external resource and supply management through a body of knowledge interpreted by competent practitioners and professionals.
Procurement includes activities and events before and after the signing of a contract as well as the general management activities associated with a range of contracts:[28]

- pre-contract activities such as planning,needs identification and analysis,and sourcing
- post-contract activities such as contract management,supply chain management and disposal,and
- general activities such as corporate governance, supplier relationship management,risk management and regulatory compliance

An effective procurement is key for streamlining processes and reducing costs for organizations. It reduces the risk of supply and enhance the quality and innovation in businesses.

Procurement is more than just purchasing goods and services for an organization. An effective procurement process involves in-depth understanding of requirements by all business units, identifying the right supplier for meeting those requirements, periodically evaluating supplier performance, and negotiating contracts that can provide the highest value at minimum cost. There are seven steps to design a effective procurement process:[37]

Step 1: Identify the requirement for goods and services from all business units

The procurement cycle starts when any of the business units in an organization needs obtaining goods/services from an external supplier. Hence, the first step of the procurement process entails identifying and consolidating the requirements of all business units in an organization. This provides visibility into the spend areas and categories to identify areas for cost savings through spend analysis.

Step 2: Identify and evaluate a list of suppliers

Once the business units identify their requirements, the next step is to identify a list of potential vendors who may supply the goods/services. The objective of this process is to evaluate relevant suppliers. Evaluation metrics include pricing, quality of service, industrial reputation and recognitions, warranty and guarantee provisions, and customer service. After the assessment is complete, the supplier who offers maximum value and the best market pricing earns the deal.

Step 3: Negotiate the contracts with the selected supplier

After selecting a supplier to fulfill the requirements of an organization, the contract process begins. Contracting is a crucial step for any organization for maximum value creation and stimulating buyer-supplier collaboration. This process involves assessing critical factors like pricing structure, the scope of work, terms and conditions, timelines of delivery, etc. Detailed analysis and negotiation of contracts give insights into more cost savings opportunities, including dynamic discounting.

Step 4: Raise a purchase requisition and release the purchase order

After an organization finalizes its contract with a supplier, the next step is to raise a purchase requisition (PR). A PR includes a description of the good/service, pricing and quantity, supplier information, and the approval workflow. Once a PR is approved, the finance team releases the purchase order (PO) to the supplier that documents information like the PO number, payment terms, supplier information, etc.

Step 5: Complete the payment process upon receiving an invoice

Once the supplier receives a PO, he sends an invoice mentioning the price for requested goods/services. Once the organization gets the PO, and they invoice, the procurement team matches them to ensure quality and quantity. Depending on the payment terms established between the organization and its suppliers, the payment is released pre- or post-delivery.

Step 6: Receive and audit delivery of requested goods/services

Based on payment and contractual terms, the supplier delivers the goods/services. On receipt, companies should audit to ensure the suppliers have met quality expectations.

Step 7: Maintain proper records of invoices

After receiving the delivery, as a best practice, it is important to effectively store all invoices to track spend and the various expenditure categories within the organization.

Chapter 4

Methodology

In the pursuance to sought answer to the research questions, research methodologies are perused by the author in order to find the best-fit methodology for the thesis. There are numerous possible research methods available, of which two main distinctive categories are **Qualitative** and **Quantitative** methods.

Qualitative research and **Quantitative** research is framed in terms of using words (qualitative) rather than numbers (quantitative), or better yet, using closed-ended questions and responses (quantitative hypotheses) or open-ended questions and responses (qualitative interview questions). A more complete way to view the gradations of differences between them is in the basic philosophical assumptions researchers bring to the study, the types of research strategies used in the research (e.g., quantitative experiments or qualitative case studies)[12].

- *Qualitative research* is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant‘s setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data. The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honors an inductive style, a focus on individual meaning, and the importance of reporting the complexity of a situation.[12]

- *Quantitative research* is an approach for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results, and discussion. Like qualitative researchers, those who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative or counterfactual explanations, and being able to generalize and replicate the findings.[12]

Lean philosophy is based on inducting a working culture of banishing waste and doing more with less and recurring improvement. Applying Lean to a company whether manufacturing or knowledge-based work, requires acquaintance of cultural background, working environment, cross-discipline synergy of people and departments in the company and therefore it becomes evidently natural to choose the **Qualitative** research method for the thesis.

A comparison of contrasts between Quantitative and Qualitative research methods makes it best understandable. A comparison of contrasts are tabulated in table 4.1 below:

Quantitative	**Qualitative**
Numbers	Words
Point of view of researcher	Point of view of participants
Researcher distinct	Researcher closed
Theory testing	Theory emergent
Static	Processes
Structure	Unstructured
Generalizing	Context understanding
Hard reliable data	Rich in depth
Macro	Micro
Behaviour	Meaning
Artificial setting	Natural setting

Table 4.1: Contrasts between Quantitative and Qualitative research methods [10]

There were numerous good theses/research articles written on the subject of Lean and digitization of procurement process, this thesis differs in the context that it takes in account applicability of Lean principles in information management and comparing Lean principles from manufacturing vs. procurement.

The flow chart in figure 4.1 gives a illustrates the methodology mechanism of the thesis.

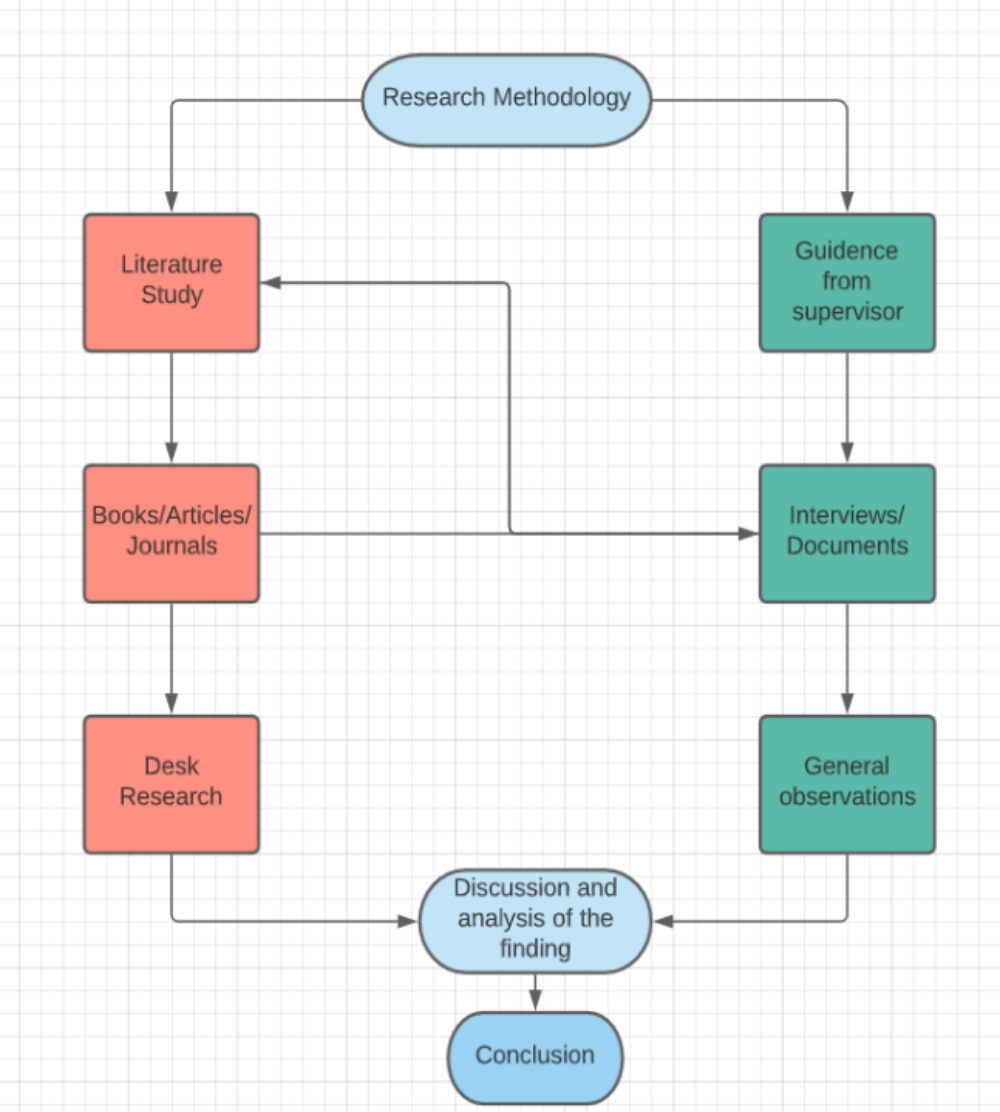

Figure 4.1: The thesis methodology

4.1 Research Design

Research design provides a framework and mechanism to answer the research question-s. The nature of research questions put the thesis in the premises of exploratory research method i.e. exploring the ways in which Lean philosophy can be referred and implemented to procurement and exploring where the potential wastes may be hidden in the process. The purpose of the research design is to provide a road map to simplify the equivocally dispersed information, and give it a convergent form useful for the research.

The flowchart in figure 4.2 illustrates the research design of the thesis. What is mentioned as case study in the flowchart is the semi-structured interviews based on a procurement project. Based on the literature and interviews this thesis will explore the ways in which the Lean philosophy differs from manufacturing to procurement process. And how the Lean tools can be implemented to procurement from manufacturing. Part of the research question will be to find potential wastes in information flow through the interviews.

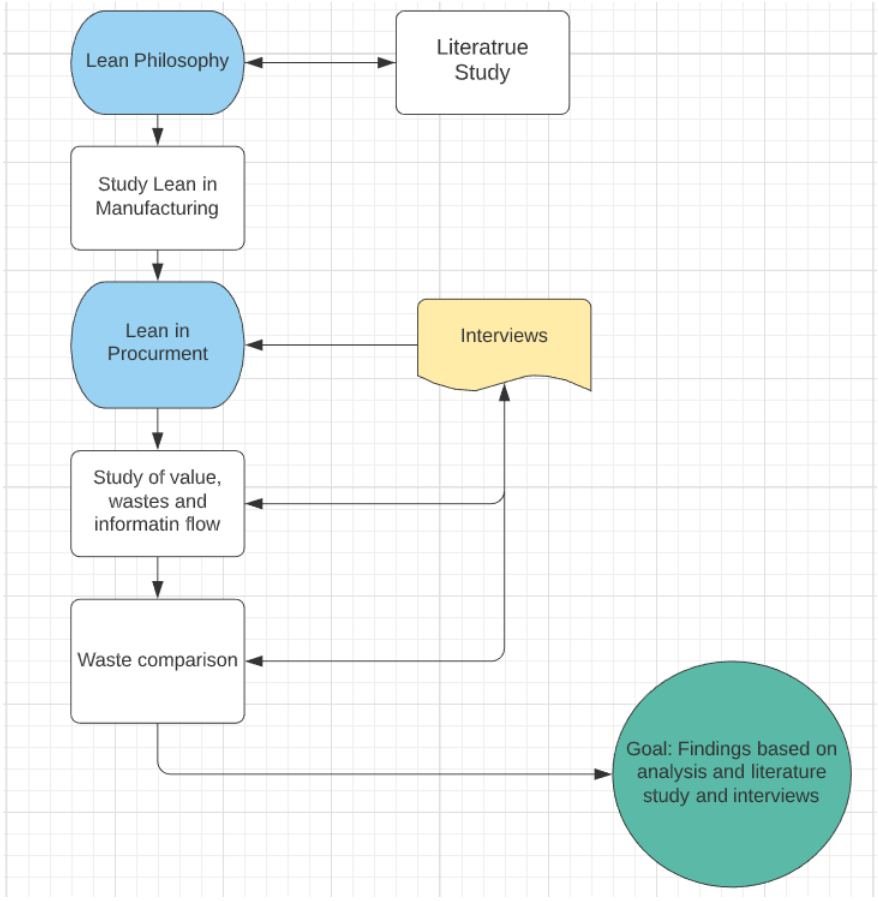

Figure 4.2: Research design

4.2 Technique for the Literature Review

In order to find the relevant literature pertaining to the subject of Lean and procurement a comprehensive search plan is made to find and select the literature which can act as a framework to the thesis. The relevant literature found on the various web-site were evaluated, summarized and filtered for study in the thesis. The following steps are carried out in the process:

1. Literature review work began with identifying key words, which remained useful in locating materials.
2. The most used key-words were Lean, Procurement Design, Lean manufacturing, Lean Procurement, Complex Projects, Agile Projects.
3. Based on the key-words search are made on digital sites e.g. ScienceDirect, ResearchGate, UiS Brage . Google Scholar and Google Books are used as search engine in finding the preliminary articles/books.
4. Initially more than 50 books/articles/research journals are located and skimmed for study of which only 40 are selected and remained useful to the topic.
5. Relevant literature are organized thematically in the thesis and referenced

Table 4.2 below shows the search made using the key-words and most relevant books/article/journal hit.

Key words searched	Number of books find	Number of articles hit
Lean + Procurement	10	5
Lean + Manufacturing	13	8
Procurement + Design	-	2
Complex + Projects	6	8
Agile + Projects	5	12

Table 4.2: Literature Review Key-words search results

4.3 Data Collection

The data collection steps include setting the boundaries for the study through sampling and recruitment; collecting information through unstructured or semi-structured observations and interviews, documents, and visual materials; as well as establishing the protocol for recording information.[...] The collection procedures in qualitative research involve four basic types and their strengths and limitations: [11]

- A qualitative observation is when the researcher takes field notes on the behavior and activities of individuals at the research site. In these field notes, the researcher records, in an unstructured or semi-structured way (using some prior questions that the inquirer wants to know), activities at the research site. Qualitative observers may also engage in roles varying from a nonparticipant to a complete participant. Typically these observations are open-ended in that the researchers ask general questions of the participants allowing the participants to freely provide their views.
- In qualitative interviews, the researcher conducts face-to-face interviews with participants, telephone interviews, or engages in focus group interviews with six to eight interviewees in each group. These interviews involve unstructured and generally open-ended questions that are few in number and intended to elicit views and opinions from the participants.
- During the process of research, the investigator may collect qualitative documents. These may be public documents (e.g., newspapers, minutes of meetings, official reports) or private documents (e.g., personal journals and diaries, letters, e-mails).
- A final category of qualitative data consists of qualitative audiovisual and digital materials (including social media materials). This data may take the form of photographs, art objects, videotapes, website main pages, e-mails, text messages, social media text, or any forms of sound. Include creative data collection procedures that fall under the category of visual ethnography (Pink, 2001) and which might include living stories, metaphorical visual narratives, and digital archives (Clandinin, 2007).

Lean is an organisational culture of relentless improvement, adapting technology to fit people and process and aligning the organization through simple, visual communication. In order to capture the data a semi-structure interview approach is selected.

Type	**Options within type**	**Advantages**	**Limiations**
Interviews	• Face-to-face, one-to-one interview • Telephonic interview • Email, Skype, Zoom interview	• Useful when participants can not be directly observed • Participants can provide historical information • Allow researchers control over the line of questioning	• Provide indirect info through the view of interviewees • Provide info in the designated place rather than natural field settings • Researcher‘s presence may bias responses • Not all people are articulate or perceptive
Documents	• Minutes of meetings • Power point presentations • Journal, letter, reports	• Enable a researcher to obtain the language and words of participants • Can be accessed at time convenient to researcher • As written evidence it saves researcher time and expense of transcribing	• Maybe the protected info be unavailable to public and private access • Require researcher to search the material in hard-to-find places • Materials maybe incomplete • The documents may not be authentic or accurate

Table 4.3: Advantages and Limitation of Interview and Documents in semi-structured method [11]

Table 4.3 gives a brief account of advantages and limitation of semi-structured interview method.In addition the advantages and limitations of documents are also annexed in the table.

In addition to semi-structured interviews **Desk Research** is actively used during the research process of the thesis. Desk research remained a helpful tool in getting a deeper insight and knowledge of the subject. Desk research provided with insightful journals, previously done research papers and providing with useful data.

4.4 Research Limitation

Procurement is a complex and vast area of study, and studying it in lean context differs greatly compare to conventional manufacturing processes. There are some limitations imposed to the study, which are as follows:

1. **Procurement Process** - Only three phases of procurement process namely, Strategy Development, Contract Establishment and Contract follow-up are chosen for study. And keeping track of all the activities during the procurement process is a subtle task and requires time and very detail study of cases which is beyond the scope of this thesis

2. **Lean Attribute**- Of the 5 Lean attributes namely Value, Waste, Flow, Pull and Perfection only first three important attributes are taken up in this study

3. **Uniqueness** - Each procurement project has some degree of uniqueness compare to previously carried out projects. And the analysis and conclusion drawn may not as best fit for all procurement cases, but a guide to improvement for future projects

4. **Inter-disciplinary**- Procurement is inter-disciplinary process, where the client and the contractor are the main stakeholders. There are number of other stakeholders involve, and catching up all the data and views may not be possible in this thesis

As an example, by comparison of two procurement processes a number of differences can be observed. An illustrative example can comparison between a oil rig offshore and and a car manufacturing and assembly line.

An offshore oil rig consists of high-tech components, of which the main components are usually delivered by one or a few suppliers. As a complement to the main suppliers, some installation/service work may need to be done. The lifetime for the offshore oil rigs are calculated in decades at the time of the investment. The oil rigs are maintained/serviced and modified throughout its lifetime. The organisation procuring different components usually has experience of similar technology but does not necessarily perform all of the technological development by themselves. The main organisational activities are operation and administration.

While procuring for manufacturing of assembly line for cars large numbers of suppliers are needed. Assembly line for cars have short lifetime. The production line may perhaps also have a demand for high flexibility. The company that is going to produce the cars are themselves highly involved in advanced engineering work.[15]

This example above illustrates how the procurement for the different industries varies, and defies the one-size-fit-all formula. Context and reference Lean philosophy is applied to differs from one industry to other, and depends on the nature of the work the industry is performing. Therefore, the findings of the thesis may not exactly be the same if it would have carried out in another industry.

4.5 Research Quality

Maintaining the research quality throughout the thesis is a challenging task. It is hence essential to have grasp of what quality is? One way to measure the quality is how well a research performed to

answer the questions using the appropriate methodology. From lean context the research quality can be considered as how well it performed to the end customers satisfaction i.e. how well the end customer find the research useful. Does the research meet its objectives is a simple way of the measuring the quality of the research.

Throughout the research the core focus remained to explore the knowledge around the research questions and, search and sort literature that are pertinent to the subject and can impart novelty to the subject under study.

The two parameter are important to measure the quality of a study.

1. Reliability
2. Validity

4.5.1 Reliability

The reliability refers to a measurement that supplies consistent results with equal values [Blumberg et al., 2005]. It measures consistency, precision, repeatability, and trustworthiness of a research [Chakrabartty, 2013]. It indicates the extent to which it is without bias (error free), and hence insures consistent measurement cross time and across the various items in the instruments (the observed scores). Some qualitative researchers use the term 'dependability' instead of reliability. It is the degree to which an assessment tool produces stable (free from errors) and consistent results. It indicates that the observed score of a measure reflects the true score of that measure. It is a necessary, but not sufficient component of validity [Feldt Brennan, 1989]. [30]

The finding thesis is based on the interviews and on the research previously done on the subject, and has not any pre-determined plan to bias the findings. In Qualitative studies the reliability maybe some what difficult to measure. But it provides a edifice to build upon further research and analysis.

4.5.2 Validity

The precision and accuracy of correlation of data with conclusion comprises the validity of any research.

Validity is often defined as the extent to which an instrument measures what it asserts to measure [Blumberg et al., 2005]. Validity of a research instrument assesses the extent to which the instrument measures what it is designed to measure (Robson, 2011). It is the degree to which the results are truthful. So that it requires research instrument (questionnaire) to correctly measure the concepts under the study (Pallant 2011). It encompasses the entire experimental concept, and establishes whether the results obtained meet all of the requirements of the scientific research method. Qualitative research is based on the fact that validity is a matter of trustworthiness, utility, and dependability [Zohrabi, 2013]. Validity of research is an extent at which requirements of scientific research method have been followed during the process of generating research findings. It is a compulsory requirement for all types of studies [Oliver, 2010]. [30]

Lean philosophy is highly dependent on the domain of working culture and organizational setup that varies from organization to organization. The pattern studied in one organization maybe different from other, this makes it difficult to engineer generalizations based only on one organization. The beauty of Lean lies in its adaptiveness to the situations where it is applied. The thesis may exhibit characteristic similar for other Lean studies but may also differ considerably.

Chapter 5

Interviews

This chapter presents interviews of expert practitioners having extensive knowledge and meaningful insight in the fields of project management and procurement. The interviewees remained involved in procurement of complex projects in Equinor ASA. Interviewees are treated anonymously so that they can express their subjective and impartial views on the topic under study. In addition no sensitive/classified information from Equinor ASA is shared in the thesis or otherwise elsewhere. Prior to conduct the interviews an *Interview Guide* is worked out to give the interviewees a brief introduction to the scope of the work. A list of 40 questions are formulated supplemented with key words (see appendices A and B) this gives the interviewees a brief introduction to the scope of the thesis, and remained helpful through out the interview process.

Table 5.1 below gives a brief account of the interviewee‘s background, date and duration of the interviews conducted. The interviewees are given number from 1 to 4.

Interviewee No.	**Interviewee ‘s background**	**Location and Date**	**Type of interview**	**Duration**
1	Procurement (with more than 10 years of experience)	Bergen 21.10.2020	Teams meeting	81 minutes
2	Procurement/ Project Development (with more than 10 years of experience)	Stavanger 29.10.2020	Teams meeting	57 minutes
3	Procurement (with more than 10 years of experience)	Stavanger 02.11.2020 05.11.2020	Teams meeting	108 minutes
4	Procurement (with more than 10 years of experience)	Bergen 04.11.2020	Teams meeting	75 minutes

Table 5.1: A brief overview of experts interviewed

The information collected through the interviews are presented in the sections below.[1]

[1]Word interviewees and experts are used interchangeably throughout the thesis and means the same

5.1 Value, Waste and Information Flow

Of the 5 Lean attributes Value, Waste, Flow, Pull and Perfection only the three important attributes are taken up in the interviews. Interviewee‘s views are stated with their interviewee number in table 5.2 below:

Lean Attribute	**Interviewee‘s view**	**Observation**
Value	1. A good Procurement Strategy is important to ensure value, and value is achieved through competitive agreement with suppliers	Though different wording being used, Quality and Cost-efficiency are the decisive factors for value deliverance in procurement of complex projects
	2. Ability to deliver a task that is required within given time and minimum use of resources	
	3. Finding solutions which are not only best in procurement perspective but also in life cycle perspective	
	4. Process which costs minimum and deliver the required quality	
Waste	1. Activities which do not gives value	There exists a common ground with different wording for waste definition
	2. Processes which increases cost without adding value	
	3. When the same mistakes which can be corrected happens again we have waste (absence of improvement cycles and experience transferring)	
	4. Not make use of the previous experience	
Information Flow	1. There is no problems with technology but how the information flow is managed is important, it is the human factor	Human factor (not working with Lean principles), information overload, too many information sharing tools and absence of a common system for everyone involved in procurement are the factors for hampering information flow
	2. There is tendency for information overload, many good solutions but it can be alot	
	3. There are too many tools available to share, retrieve information, having them all integrated in one will improve the understanding of information	
	4. There is always room for improvement, a common system can ensure swift flow	

Table 5.2: Expert‘s view on Value, Waste and Information Flow in Procurement in Complex Projects

5.2 Lean in Procurement

Interviewees/experts 's views were asked about the implementation of Lean in procurement and what are challenges in implementation of Lean in Procurement compare to a traditional manufacturing process. The findings are presented as below in table 5.3:

Element Discussed	**Interviewee's view**	**Observation**
Lean in Procurement	1. Lean is important in procurement for making an organization competitive	There exists a consensus about the Lean in Procurement, but it implementation in procurement may not be as linear as in manufacturing
	2. It requires training and efforts to implement Lean in Procurement	
	3. Lean is important for making good templates, routines and standards to work effective with procurement	
	4. We must find the shortest/best way to goal and Lean can be helpful tool	
Challenges	1. Many misunderstand the concept of Lean and confuse it with knowledge transfer	The challenging part in implementation of Lean to procurement of complex projects is the non-repetitive and complex nature of the solutions required. A good grasp of Lean concepts require training in the organization
	2. Lean in Procurement may not be applied necessarily in the same way as it does in manufacturing	
	3. In procurement in complex projects the Lean does not exactly applies as good as it does in repetitive processes	
	4. Leadership must show it practically (walk and talk) and be good role models. For workers the challenge is to adapt to continuous change	
Organizational Culture	1. Organization culture is important	It is being endorsed by the experts that Organizational Culture is very important for successful implementation of Lean in Procurement
	2. Organization culture is important. A Project organization is very adaptive to deliver on new parameters all the time. A flat organization is more effective. Context is important	
	3. All the factors organizational culture, leadership, human factor all are important for successful implement of Lean	
	4. Organizational culture is important to implement Lean	
Digitalization	1. Digitalization is important but it is not enough, we must have the ability to see value through the whole supply chain	Digitalization can be very helpful in procurement of repetitive standard products/services. But in procurement of complex projects it may not be the same
	2. Digitalization alone is not Lean but it is a part of Lean	
	3. We don't have high degree of digitalization in Project Procurements, despite the product we procure has high degree of digitalization	
	4. Despite we have good templates and digitalized procurement, we must know what we are doing and where is the potential to improve. Procurement of high risk projects needs more attention and just digitalization in not enough for complex project to be Lean	

Table 5.3: Implementation of Lean in Procurement Expert's views

5.3 Supplier‘s Engagement

Experts were asked about what approach the organization shall adopt with suppliers in complex projects. Shall it be more Organic or Mechanistic or a hybrid of both. Before presenting the experts‘s view on this topic it is important to highlight the difference between the two types of structure. Table 5.4 shows the major differences between the approaches.

Mechanistic Structure	**Organic Structure**
High horizontal and vertical differentiation - a hierarchical structure of authority and control.	High/complex horizontal and vertical integration - a network of authority and control based on knowledge of the task.
High formalization - the definition of roles, responsibilities, instructions, and job methods is stable	Low formalization - tasks and responsibilities are redefined depending on the situation
Centralization-decisions made at the top of the hierarchy	Decentralization-decisions made by those closest to and most knowledgeable about the situation, and/or by those with responsibility for implementation.
Standardization through written rules, procedures, SOPs	Mutual adjustment and redefinition of tasks and methods through joint problem solving and interaction
Close supervision with authority and prestige based on position.	Personal expertise and creativity without supervision. Prestige attached to expertise
Vertical (superior-subordinate) communication in the form of instructions.	Frequent lateral communication, often in the form of consultation between people from different departments

Table 5.4: Comparison of the characteristics of mechanistic and organic organization [18]

In organic forms systems and people are more proactive and adaptable to changing circumstances. In rapidly changing environments, where organizations need to innovate to survive, teams of knowledgeable employees working together to anticipate and respond quickly to shifting environmental demands are needed.
Whereas in mechanistic form high levels of hierarchical control, clearly defined roles and tasks, and centralized decision making all impede flexibility and creativity. Likewise formalization interferes with innovation because change requires rewriting policies and rules and disseminating the revisions to supervisors who must then implement the new rules and ensure that others comply with them. They concluded that, whenever innovation is needed for adaptation or responsiveness to changes in the environment, mechanistic structures hinder performance. [18]

The Organic setup can be think of a more trust based setup, whereas mechanistic is more controlled based setup.

Experts's views on this topic are presented as below in table 5.5:

Interviewee No.	**Interviewee's view**	Observation
1	It depends on the nature of the project. We have good coordination with the main suppliers	Mechanistic Approach fits well for procurements having repetitive/standard pattern, while experts 's views have a consensus on having organic approach in procurement of complex projects
2.	Having both the models in your toolbox is important	
3.	In complex projects as for example for UPP (Unmanned Production Plateform) project organic model fits well. But there should be a balance to share risk if things go in wrong direction. But I mean organic approach is good for complex projects	
4.	We want more organic (trust based) approach with our suppliers, but we are not yet there	

Table 5.5: Experts's view on Mechanistic vs. Organic approach with supplier

This is also been mentioned by one of the experts that building a trust based relation with suppliers needs sharing of sensitive information and financial commitment which makes it risky.

5.4 Wastes in Procurement phases

Wastes related to three phases in procurement **Strategy Development, Contract Establishment** and **Contract Follow-up** are discussed with the experts the finding are tabulated in table 5.6:

Procurement Phase	**Expert's view on Waste in Procurement**	**Observation**
Strategy Development	1. Waiting and overproduction of information, there are pages and pages of information than needed	Waiting, Overproduction, overprocessing are mentioned as major wastes in Strategy Development phase
	2. Concept of wastes from discrete manufacturing may not necessarily applied in same in procurement and oil and gas industry. For example inventory is not applicable in procurement	
	3. All these seven waste do not fits our of working environment exactly but waiting can be relevant, but re-work due to uncertainty are not waste	
	4. Re-work, Waiting if we don't plan good it cause waiting for others, Unnecessary details, defective information	
Contract Establishment	1. Overproduction of information, waiting and rework	The same waste types remain visible in interviews in Contract Establishment phase
	2. Waiting, overproduction of information	
	3. Waiting and over-production of information	
	4. Re-work, waiting, over-production of information	
Contract Follow-up	1. Waiting, over processing, overproduction	Human factor (not working with Lean principles), information overload,
	2. Overproduction, waiting	
	3. Waiting, overproduction of information	
	4. There are too many unnecessary meetings, re-work (over-processing)	

Table 5.6: Wastes in Procurement phases

Chapter 6

Discussions

In this chapter the findings from both literature review and interviews are evaluated, analyzed , discussed and presented. The literature review is compared against the information collected in the interviews. As mentioned earlier in the introduction chapter of the thesis, the main focus of the study is two-fold. One is study of implementing and comparison of Lean in procurement with that of manufacturing, two study of applicability/implementing of Lean philosophy in information flow in procurement, considering complex project environment. Keeping in view the objective of thesis the main elements from the research relevant to the objective are addressed in this chapter.

In Lean philosophy the concise definitions of *Value* and *Waste* must be established before it is applied to a system in an organization. During the desk-research the author find a handful of research in past is being done in relation to Lean information flow in procurement. But numerous good research articles/theses/journals were written regarding digitalization of procurement. To start the discussion it is important to mention the main differences between procurement in complex projects and manufacturing.

6.1 Procurement in Complex Projects in comparison with Traditional Manufacturing

The main differences between Procurement and Manufacturing are taken up in table 2.1. A traditional manufacturing follows repetitive and linear pattern, which makes it favourable to implement lean principles. Procurement in complex projects for example in oil and gas industry has a complex network of stakeholders and needs a comprehensive plan and rigor efforts to implement Lean, figure 6.1 illustrates the customer-supplier interaction. The general example illustrated in figure involves EPCI.

It can be seen in figure 6.2 interaction between the customer and the supplier has simple linear setup, where the customer puts an order to the manufacturing company and received the order from the manufacturer. The manufacturer knows exactly what the scope of the demanded order is and makes the necessary orders for materials and parts need to suppliers in Just-in-Time manner, the setup being repetitive is highly compatible for Lean implementation.

In complex procurement in complex projects for example EPCI in Oil and Gas industry the purchaser in the standard contract is typically a Operator acting on behalf of a production license called "Company" (Mentioned as Licensee in figure 6.1) while the other party whom are supplying the services and/or goods to the Company are called "Contractor" (Mentioned as Main Contractor in figure 6.1).
The scope of work under an EPCI contract contains Engineering, Procurement, Construction and Installation. This normally means a long-term commitment for the parties that are involved, and a certainty of variations throughout the commitment. For that reason, projects that are under an EPCI Contract require a detail regulated Contract, as well as flexibility in relation to the perfor-

mance of the work. None the less, unforeseen occurrences will take place and in spite of detailed contracts, disputes can arise when one of the Contract parties is unable to fulfill its Contractual obligation.[33]

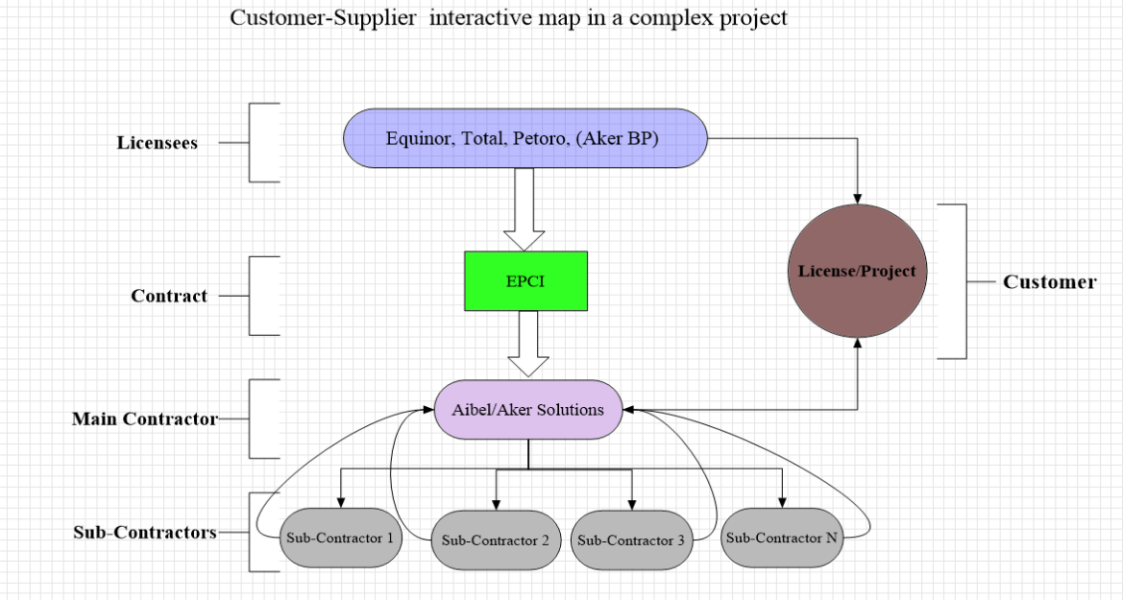

Figure 6.1: Customer-supplier interaction in Procurement in Complex Project in Oil and Gas Industry

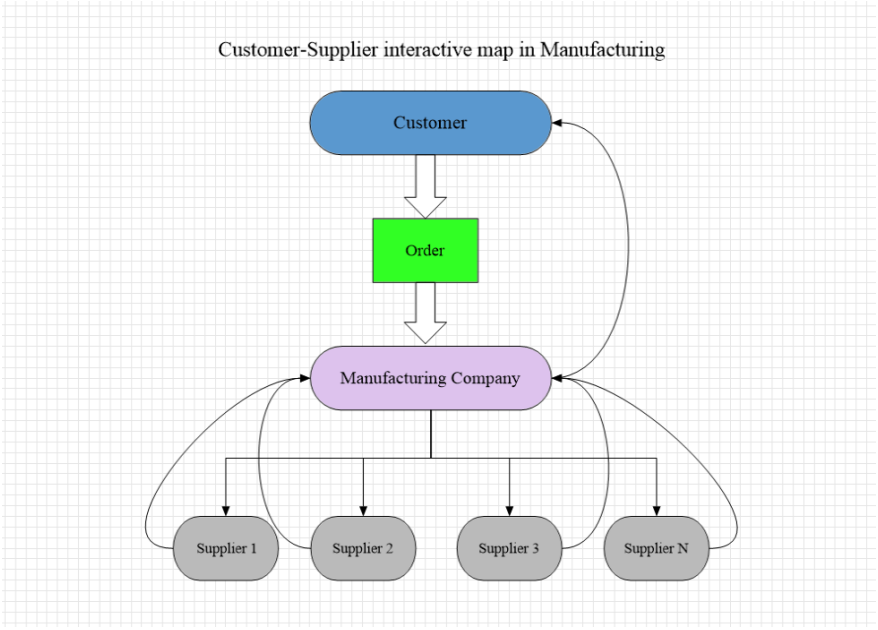

Figure 6.2: Customer-supplier interaction in manufacturing

Despite detailed specifications in contract in complex project uncertainty and risk makes it difficult to have an well known scheduled plan as in case of manufacturing. The goals in procurement of complex projects are emergent. The uniqueness of the projects makes it laborious to imitate the Lean principles in procurement. In complex project as EPCI project the contractor is asked to suggest a technical solution based on the specifications and needs provided by licencee. And the main contractor is responsible for delivering the detail engineering design after the contract is awarded.

In broad terms it may be argued that the situation is; a premature project, tender commit to

and promise of functional result of his work at a firm price, but when making his commitments contractor does not know what he actually has commmited to deliver as it depend and result from the detail design and engineering which is yet to be performed.[33]

In manufacturing the manufacturer exactly knows what he is going to deliver to the customer, but this is not the case in complex projects. The main differences between manufacturing and procurement are shown in table 2.1. It is confirmed by the experts during the interviews that Lean philosophy may not exactly be applied in same way as it does in manufacturing. It needs a comprehensive study and good working models and examples to justify the knowledge worker involved in procurement that lean works in procurement. One of the experts shared his view as follows:

In those short Lean courses they show examples that does not exactly match the kind of work we are doing, and the staff working with procurement thinks this does not apply to our work so they proceed with the same as before.

Procurement of repetitive and standard parts having low level of complexity lean principles can be implemented with considerable degree of ease. As they are repetitive and being done many times previously and carries low uncertainty or risk factor.

Despite the clear differences between manufacturing and procurement the experts interviewed think that the organization can reap the rewards from lean in procurement but it needs a clear understanding and training and may not be that simple as in manufacturing.

6.2 Value

In complex projects such as one involving EPCI contract the notion of value is amorphous. The high risk, involvement of many organizations/suppliers, technical specifications, disciplines from different academic background make it difficult to have an unambiguous and unanimous definition of value. In any process value can only be defined by the ultimate end-user. An analysis together with query with the end-user in order to apprehend what their specific needs are will be helpful in establishing a consensus for understanding value. Once the definition of value is agreed upon it becomes easier for the supplier of information/goods/services to provide a with quality.

In previously research literatures there is a lack of a coherent definition of value in complex projects. In one such articles a study of the previously research work is carried out and one of the findings are as below:

[...]it established that the concept of value is undoubtedly a cornerstone of the contemporary production system and supply chain constructs, but that this concept suffers from a pronounced interpretive viability issue within the academic literature, just as we found within the practitioner literature evaluated[...] [16]

They identified four areas that contribute to this:[16]

- Lack of theoretical rigour
- Lack of definitional rigour
- Plethora of different value related terms
- Variety of linguist usages embodied

There are various definitions of value in different disciplines within an organizations based on the nature of their work in a project. As a result there is not a equivocal understanding of value in complex projects.

According to Lean Philosophy, value can only be seen by the eye of the beholder [...] no real value can be pushed but only pulled through the value chain.
Even though it is easy to understand the previous statement, it is hard to put into practice: [40]

- We often have scarce time to invest in understanding what is expected from our internal and external stakeholders. We tend to use preconceived ideas and wishful thinking to define the value.
- Even when we have the time and resources, understanding the stakeholders is not an easy task, particularly because their vision of reality might be quite different from ours. Standing in somebody else‘s shoes is not trivial.
- The real value is subtle and normally not verbalized, thus it cannot be heard, but only felt.

The definitions of value perceived from different disciplines is given as follow: [1]

Discipline of origin	**Definition of Value**
Project Management	In traditional projects, the value is a consequence of the execution of activities and generation of results, so greater efficiency should create more value
Marketing/Economy	Value is based upon utility theory (after Jevons 1970), which argues that the value (price) of a good or service is explained by the degree of utility, usefulness or satisfaction that is derived by the consumer from its consumption
Engineering	Value is a function of the obtained benefit by its related cost
Lean Philosophy	The value for a particular stakeholder is the sum of all benefits perceived by him, through the development results, which, in addition to the final product, includes all the intermediate results, the use of which composes this experience
Procurement	Acquisition of goods or services that meets the project needs, that is having the right quality and is cost effective through its whole life-cycle

Table 6.1: Value definitions

From the table 6.1 it is evident that the underlying theory of value differs from discipline to discipline, which makes it difficult to come up with a single unanimous rigour definition of value in complex projects which involves many disciplines with different academic backgrounds.

Procurement as a support function has to served the needs of the project. The definition of *value* provided in table 6.1 is formulated after the experts interviews. According to the experts Quality and Cost-efficiency of the deliverable are the main determinants of the *value* in procurement. From Lean context the customer for a procurement process is the project, a procurement process shall deliver value to the project. But internally in an organization the term customer is not well befitted. The author is of the view to use the term end-user internal in organization. Internal in a organization the value shall be pulled by the end-user from the producer to avoid waste.

[1]The definition of value for Project Management, Engineering and Lean Philosophy is taken from the The Lean Product Design and Development Journey book by Marcus Vinicius Pereira and Luis Gonzaga Gonzaga Trabasso Page 58

6.3 Waste

In traditional manufacturing/production materials and physical parts flow through different processes and is transformed into a final product demanded by the customer/end user. In procurement of complex projects mostly information flows through different work stations. Ambiguity, risk and uncertainty is high in complex projects, which results in creation of waste in the procurement process. The wastes in procurement due to uncertainty, risk and complex nature of the projects can not be eliminated but they can be reduced. In order to reduce wastes it is important to identify them. During the interviews with the experts in Equinor ASA, the author observes that general waste definition from Lean manufacturing can be translated to procurement domain i.e.

Waste refers to all elements of a process that only increase cost without adding value, or any human activity that absorbs resources but creates no value [43]

Having established the definition for waste in procurement, the following can go wasted and will negatively impact a project: [2]

- **Resources** : Knowledge workers involved in procurement in complex projects are highly skilled project managers, engineers, lawyers and workers having financial background. If for example defective information is passed for any decision making, it has to be re-worked and corrected, this all process consumes resources, and may delay the project.
- **Time** : This aspect is tightly related to the precedent factor. Various team meetings like quality or steering circuits often are an integrated part of a person‘s assigned task. Poor communication discipline, bad preparation and purposeless procedure make meetings unproductive and require additional ones. This obviously wastes people‘s time.
- **Information/Knowledge**: Working with information is central in procurement. Processing and creating right information is important for a project to be successful. Lost knowledge, deficiencies in information quality and poor information sharing due to less powerful information and knowledge management systems just mean waste. Levels of information or of knowledge once gained during previous projects should not be lost again.
- **Opportunity/Potential**: The oversight of people, tool and technology potential, which could be used to better achieve the specific project targets with less effort and resources, constitutes another example for waste.
- **Money/Investment**: Finally, the entire project effort in respect to spent resources and materials is assessed in money. Money used for hiring consultants with low utilization rates, unnecessary software tools, and strategies based on vague and unreliable preliminary studies cost the project in terms of monetary value. A good strategy and optimal use of resources in procurement can reduce this waste.

In manufacturing with known scope and right information available things that can go wasted can easily be sort out and corrected with Lean tools at hand for example use of Jidoka. But Jidoka may not precisely fits the Procurement process, automation as in manufacturing may not be applied exactly in procurement of complex projects. In procurement of complex projects strategies shall be worked out by experienced and knowledgeable work force, and throughout the process a close supervision of experts is needed in each phase, human errors may cause wastes.

[2] Logical changes are made based on the literature study and interviews to the list provided in Lean Product Development: Making waste transparent Christoph Bauch

During the interviews with experts the 7 wastes established by TPS and their comparison in manufacturing and procurement is discussed and the finding are tabulated as below:

	Waste	**Manufacturing**	**Procurement**
1	**Waiting**	Material and Physical parts	Knowledge workers waiting for information
		Maintenance	Information waiting for people
		Tools	Waiting for data, answers, requirements, specifications, test results, approvals, decisions, review sections, signatures
		Operators	
		Queue for further Operations	
2	**Defects**	Components, materials, sub-assembling or products that do not have required quality	Information with deficient quality
		Defective parts produced	Wrong information, Poor quality, lacking accuracy and details
3	**Overproduction**	Producing more than ordered by client	Producing too many solutions
			Information over-load
		To produce before order	Redundant tasks
			un-synchronized processes (produced early and at high rate before the end user‘s need)
4	**Over processing**	Over-design of products that is not necessary	Unnecessary features and details
			Excessive accuracy
		Producing products with extra precision and features that the client is not willing to pay for	Over working with solutions
			Extra process loops (unnecessary paper work)
5	**Transport**	Excessive and unnecessary movement of materials, pieces and products	Not Applicable
5	**Motion**	Unnecessary motion of operators/workers during production, changing of tools	Not Applicable
7	**Inventory**	Capital locked in material	Not Applicable
		Semi-finished products	
		Storage between work stations	
		Finished products in storage awaiting order to be supplied	

Table 6.2: 7 Wastes comparison Manufacturing and Procurement

Experts‘s views are in line with the literature studied. Wastes such as Transport, Motion and Inventory can be treated as non-relevant for Procurement. Taking transport waste, due to improvement in information and communication technology it is not costly to transfer information from one work station to another even at long distances within in matter of seconds. Waste due to motion is little relevant in procurement context as knowledge workers mostly communicate through communication softwares and the office setup is not a problem for small teams of project managers, engineers and all involved in procurement to access each other. And the improvement in technology makes it very easy and cheap to store information.

The wastes in procurement are not as visible as it is in manufacturing. Since information is intangible, to assess its quality and flaws needs a meticulous study of the processes involved.

6.4 Information Flow

In manufacturing physical parts flow through the processes and is transformed into final product. The concept of *Pull* in lean manufacturing helps to reduce the amount of inventory and unnecessary use of labor hours. The work station needing material/parts pulls it from the work station upstream. Manufacturing involves both information and product flow, but the information is scheduled, planned and well known to manufacturer. Whereas in procurement in complex projects products needed for the projects possess high degree of risk and uncertainty because of its uniqueness and innovative nature and the information at hand may not be certain and changes can arise as the project progress, which neither the procurer nor the supplier has information about at the time of contract. They are discussed in the sections below.

6.5 Properties of Information

Before start of discussion of information flow, it is important to have a look at its properties. Similar to material, there are also some fundamental properties, which characterize information and simultaneously determine some advantages and shortcomings accompanied by information handling. This includes the following aspects :[4]

- Information is an intangible good that is not used up with repeated utilization
- Information is valuable for the user if he can realize it in his actions
- Information is no free good, thus information can be associated with a particular but often hard estimable price
- The value of information is dependent on the particular context and the time it is used
- The value of information can be changed by adding, selecting, concretizing and omitting; thus information is open-ended and condensable
- There are different attributes of information quality (IQ) such as accuracy, completeness, timeliness and reliability
- Information can be transported with speed of light even if the underlying objects (specified elements) cannot be transported with the same speed
- Buyer of information only get copies of the ordinary information, thus the enforcement of exclusive rights and in particular of property rights turns out as very difficult
- Information is transferred encoded which requires common standards for the exchange
- Copying of information is easy and cheap
- Obsolescence of information which is not caused by usage but by its timeliness at most
- Ambiguous ownership of information due to multiple possessors
- Almost arbitrary divisibility of information
- Identification of owner often is difficult; problems with protection of data privacy and data security
- Easy logistics of information, primarily electronic
- User-defined possible combinations; accumulation improves information value and quality

6.5.1 Manufacturing

Figure 6.3 below illustrates a general example of material and information flow in manufacturing. In the general example shown in figure 6.3, a customer puts an order to manufacturer and the manufacturer makes the necessary plan to produce the order and orders the materials/parts needed from the suppliers, and the information of the order is communicated to all in-house work stations to make the necessary arrangements for the production. The round arrows between the work stations shown at the bottom of the figure 6.3 are pull arrows, where the value is pulled from upstream. The information flows upstream illustrated by green arrow in figure 6.3 and the material parts flows downstream illustrated by blue arrow. With known specification of physical product demanded by the customer, its relatively easy to keep track of the value and communicate the right information regarding the product demanded, which in results in a smooth stream of information and products in manufacturing.

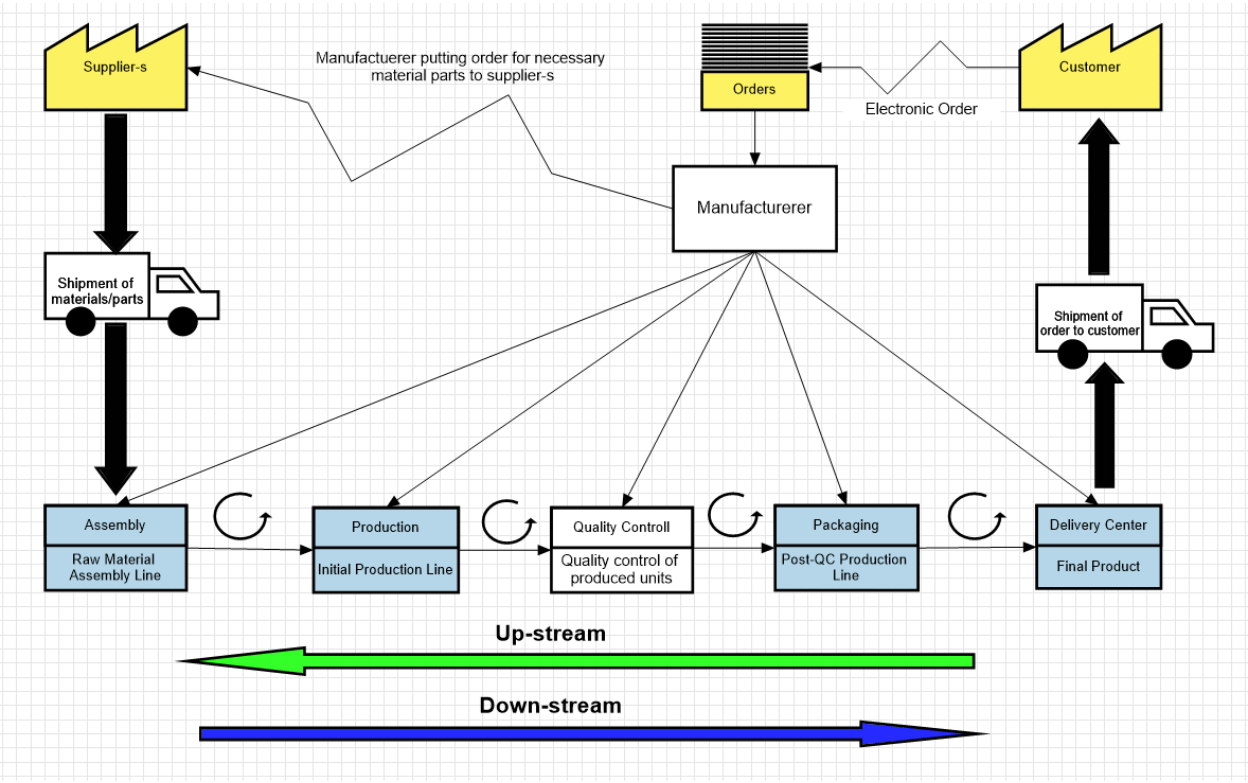

Figure 6.3: Flow of materials and information in manufacturing

A simplification of the general flow of information and materials is illustrated in the figure 6.4:

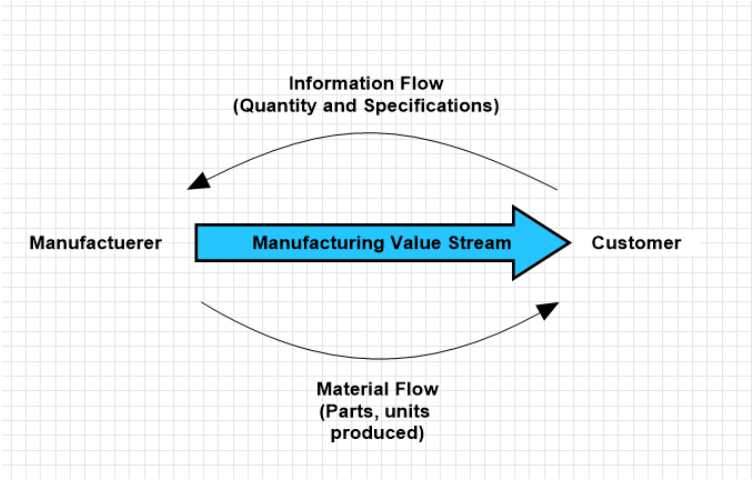

Figure 6.4: General representation of Flow of information and Materials and value in manufacturing

6.5.2 Procurement

In complex projects changes and iterations are certain to happen. The changes need a flexible procurement strategy and managing flow of information becomes crucial for the successful deliverance of project deliverables. The quality of information and direction of its flow if manage well are decisive to reduce waste in procurement. The direction of information flow shall be towards the end user who ask for it, and the quality of information is the efficient use of knowledge to produce exactly what is demanded by end-user. This means Lean principles can be imitated to knowledge work and hence in procurement. The concept of *Pull* can be a guiding principle to reduce the waste in this regard.

During the interviews with experts the author find consensus of views on training of knowledge worker for successful implementation of Lean in an organization. An organization mostly working with knowledge where the physical products are replaced by intangible products and goals become emergent, the role of information management and use of knowledge management becomes key for the success of projects.

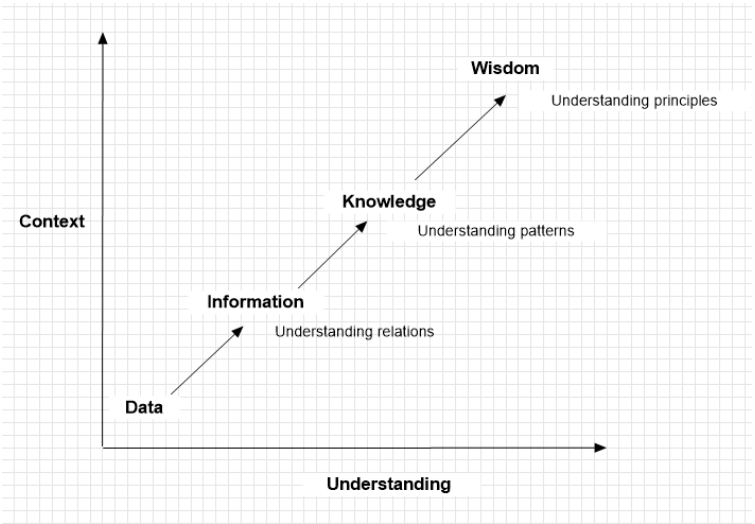

Figure 6.5: From Data to Wisdom

A lean organization is a true learning organization transforming data is to wisdom in most efficient way. Figure 6.5 shows how understanding for a context increasing as data is transformed to

wisdom.[39]

Information itself is defined as the knowledge of circumstances and procedures and always has a particular purpose within a certain context. Only by incorporation, linkage and transfer of information, knowledge can be generated which in turn can be seen as the entirety of all parts of knowledge and abilities the individual uses for problem solving. An essential precondition for the accurate transition of information to knowledge consists in the interpretability of information by the recipient. This is especially true as knowledge per se cannot be transferred directly from person A to person B, but has to go the way via data and information. Another point that has to be mentioned is that not everything that begins with data and information will necessarily end up in knowledge. Furthermore, the built up of new, accurate and useful knowledge is essentially affected by the information processing abilities of the respective person itself but also by the quality of incoming information. [4]

In order to truly implement lean to manage information flow, it is important that the organization and the workers are willing to make the organization a learning organization, this in long run will reduce waste that can appear as rework, unevenness and overburden.

As put by one of the experts during the interviews:

Problem in organization is although many think they understand the concept of Lean they don't, they think its knowledge building, but Lean is not just about knowledge building. It need training of the employees to get the Lean implemented truly.

Flow of information within the organization in procurement is shown in swim lane diagram 6.6:[4]

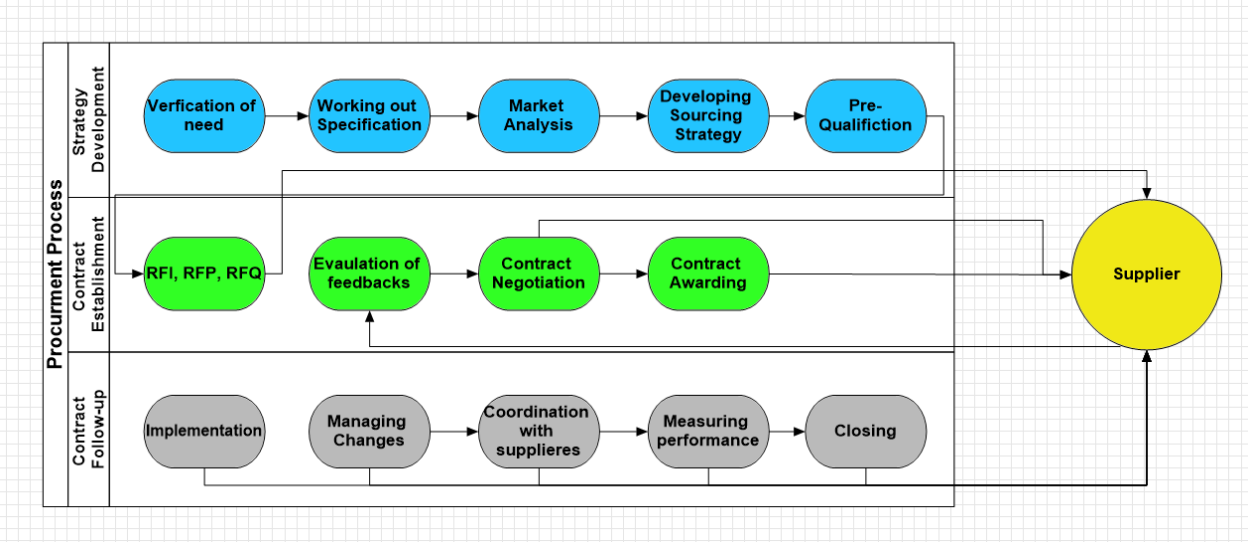

Figure 6.6: General Procurement Information Flow

The quality of information is dependent on how the information is organized and presented to the end user. In lean philosophy the quality of the information and hence its value must increase as it flows from the producer to the end-user. The information flow within the organization is shown in swimlanes and information flow out-side the organization with supplier is presented with yellow circle. Information flow in procurement of complex project compare to manufacturing is not as good known and scheduled. As an example at the beginning of a complex project the procurer may not have exact information necessary to fully describe what technical features and properties the end-product should have. Lacking in information when the contract is awarded there a potential for scope enlargement and changes along the way as project develops. Experts

[4]The steps mentioned in the Procurement phase are taken from lecture notes IND610-1, Professor Tone Bruvoll

the author have interview have confirmed the presence of waste in information flow in different phases of procurement. Two major reason are mentioned which hamper the streamline flow of information:

1. Overproduction of information
2. Defective information

The first one is concerned with producing too much unnecessary details/specifications, which take time for both the producer of information and the end-user in and out-side the organization to process the information, and causing waiting and delays.

The second one is related with producing defective information due knowledge barriers or not knowing what the end-user needs. This results in extra communication within and out-side organization and is time and resource costly.

Complex projects have an intricate stream of information flow. And it is subtle to generalize the flow in up and downstream as in the case of manufacturing. But the support functions in complex projects can be generalized for example in procurement. Figure 6.7 shows the flow of information value in procurement to a project.

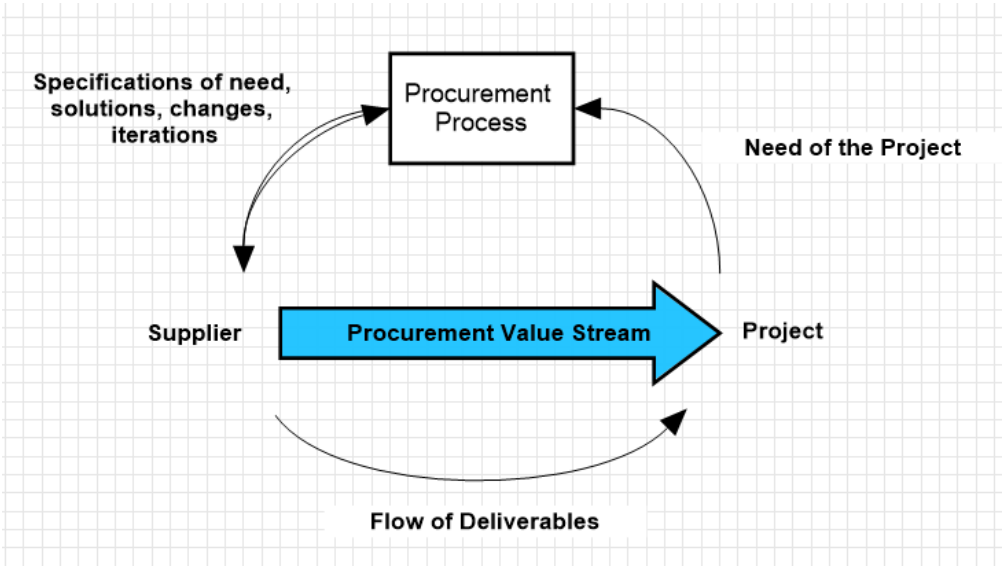

Figure 6.7: Generalize form of information flow and value in procurement in complex project

Information which is not known to the procurer or supplier at the time of contract awarding due to innovative and complex nature of a project, needs a healthy understanding relation between the procurer and supplier to work out solutions as changes emerge. Planed iteration or rework due to scope changes which are not known to procurer and supplier may not be regarded as waste but learning. In dealing with lack of information a Agile Project Management life cycle discussed in section 2.3 is helpful tool for projects where the solutions are not known due to lack of information. But to work in agile fashion willingness and support from both procurer and supplier is needed. Sourcing models discussed in sub-section 2.6.1, the Joint-Venture or Keiretsu Network sourcing models can help the procurer to model the nature of relation with the supplier in complex project.

The digital tools used by the organization to communicate information is functioning well. Digital tools such as **Polarion, Kontiki, SAP, Office 365 package, Teams, Sharepoint** have make it easier to share, retrieve and communicate information with suppliers. But communicating the right, accurate and precise information through these digital channels is human work.

6.6 Lean Tools in Procurement

Tools and practices like kanban, JIT, mistake proofing were copied by many companies and widely understood as the secret of the TPS. Quite contrary, Toyota itself calls them ‘countermeasures‘ and considers them rather as temporary responses to specific problems used as long as a better approach is found or conditions change [...] They are supposed to counter very specific categories of problems occurring and to provide the system with some kind of "built-in tests" to display problems immediately when and where they occur.[4]

Compare to manufacturing the applicability of lean tools in procurement need a understanding of the contextual factors. As describe by Toyota these tools are countermeasure to support the value adding efforts, driving out waste and streamlining processes. The processes in manufacturing differs from procurement as a support function in projects and hence the applicability of the tools requires a careful calibration for its successful implementation.

From the interviews with experts and the literature studied, the author finds four important areas for successful implementation of Lean principles.

1. Leadership
2. Organizational Culture
3. Employees Involvement
4. Education/Training of the employees

Lean tools are supporting pillars of lean principles. The factors mentioned above applies equally to the implementation of lean tools in an organization. In manufacturing lean tools are mostly used on production floor, where the workers are mostly involved. Application of Lean tools in procurement in addition to the factors above requires a meaningful supplier involvement. Based on interviews and literature studied, following lean tools and their applicability in procurement and challenges related to them are briefly tabulated in table 6.3.

- Kaizen
- Value Stream Mapping (VSM)
- 5S
- Kanban
- PDCA

These Lean tools are selected because of their relevancy to information management related work and robustness. There are many tools in lean which may not perfectly applied to procurement of complex projects such as Jidoka which is related to automation of processes.

6.6.1 6 Sigma

In addition to above Lean tools 6 Sigma tool **DMAIC** is a strong tool for continuous improvement of the processes and for eliminating wastes, but it is argued that "the implementation of Six-Sigma is not a short-term, quick fix improvement. A committed and charismatic leadership is essential in coaching and guiding the adoption of this holistic, long-term, and continuous improvement methodology. There are seven key principles that will ensure that companies can reap benefits from Six-Sigma [49]

1. A committed leader is needed to ensure successful Six-Sigma implementation.

2. Six-Sigma efforts must be integrated with existing business strategies and key performance measures.

3. Successful Six-Sigma efforts must be supported by the framework of a business process.

4. Six-Sigma requires disciplined customers and market intelligence.

5. Six-Sigma projects must produce real savings or revenue.

6. Six-Sigma projects must be led by thoroughly trained full-time team leaders, who are known as Champions, Master Black Belts, Black Belts, and Green Belts. A Champion is a quality leader in the organization and is responsible for developing and implementing strategy, setting objectives, allocating resources, and monitoring progress. Master Black Belts have a more managerial role, in that they are often responsible for all Six-Sigma work in a particular area or function. Black Belts have a more operational role. In most cases, a Black Belt is a leader of a team that is working on a problem. People who are trained and committed to a Six-Sigma project as part of their regular jobs are referred to as Green Belts (Hoerl, 2001).

7. Six-Sigma projects must be supported by the continuous reinforcement and reward of leaders.

Two important factors for successful implementation of 6-sigma are committed leadership and coaching of the team members involves in a project. Successful implementation of Lean and Six Sigma is a long term commitment and can not be achieved overnight. The theory behind 6-Sigma tool **DMAIC** discussed in section 3.2. In procurement DMAIC tool has potential of improving the quality of the processes. It also requires a meaningful supplier engagement. Six Sigma tools are engineered by Motorola to find the cause of problems and prevent their recurrence. In procurement of complex projects it can be very helpful in minimizing costs and managing risk.

Lean tool	Purpose	Applicability in Procurement	Challenges
Kaizen	Kaizen means a continuous, incremental improvement process for process flow and workmanship with the goal to create more value with less waste.	Kaizen in procurement in complex projects is a helpful tool to make continuous improvement over time	Needs commitment from Leadership and and meaningful supplier involvement
VSM	Mapping method to identify all the specific activities and process steps along the value stream of a specific product or product family	Value stream mapping is effective tool to analyse and visualize the waste and its sources to the activity level and is relevant in procurement	Cooperation of the knowledge workers. People don‘t like to be measured even though VSM is not about measuring people‘s performance but processes
5S	Related to making work place efficient by the use of 5S which are Sort, Set in Order (organize), Shine, Standardize an Sustain	A stong tool that can be applied with ease in every information management related work including procurement	Basic training of knowledge workers involved in procurement
Kanban	Kanban is a visual system for managing work as it moves through a process. Kanban visualizes both the process (the workflow) and the actual work passing through that process	Useful in procurement to keep account of bottlenecks in the process and communicate with team members	Leadership‘s commitment and training of the employees
PDCA	Lean Management tool used to operationalize continuous improvement. Involves steps Plan, Do, Check and Act/Adjust	This is a applicable tool in procurement in complex projects. It is an enabler for accelerating improvement cycle	Leadership‘s willingness to commit to training and education of the employees and employees willingness to get it implemented

Table 6.3: Lean tools in Procurement

Chapter 7

Conclusions

The objective of this thesis was the study of applicability of Lean philosophy in procurement in complex project environment. And through literature published, experts interviews and analysis to find the answers to following research questions:

RQ_1: *How Lean philosophy differs in Procurement of complex project compare to Manufacturing?*
(a study of implementing Lean philosophy to Procurement and comparing it to well established Lean principles in Manufacturing)

RQ_2: *How the information flow in Procurement be managed in complex projects using Lean philosophy?*
(a study of information flow in procurement compare to manufacturing)

In addition to the research questions above topics which are not directly related to the implementation of lean to procurement but important for its success such as good supplier relationship was also discussed with experts during the interviews. Conclusion based on literature studied and experts 's interviews are presented in sections below.

7.1 RQ_1

The basic core principles of lean philosophy based on *Continuous Improvement and Respect for People* are the underpinnings of a successful implementation of lean philosophy to any process. The third principle of *Standard Work Practices* may not be exactly applicable to complex project, but it rather favours agile work practice. The study identified 5 key element which makes procurement in complex projects different from manufacturing.

1. Risk
2. Uncertainty
3. Uniqueness
4. Complexity
5. Innovative nature

A successful implementation of Lean in procurement of complex projects needs addressing the aforementioned elements. And for the purpose Agile Project Management model of working is a good match, where learning, knowledge building and environment of trust are crucial factors for success of a complex project. Since the complex projects are non-repetitive the standardization of procurement is almost impossible, but use of continuous improvement and learnings from each project can be a good guide for future projects. This needs a systematic work for accumulating

data, information and building knowledge through experienced work-force. In order to get lean implemented successfully in procurement for complex project an organization must transforms its self to true learning organization.

The proposition of *Value* and *Waste* in procurement is also discussed in details with experts. The authors find an unambiguous interpretation of *Value* in procurement, but different wording been used by the experts. In the definitions provided Quality and Cost efficiency of the deliverable remained decisive domains for *value* deliverance in procurement. Working within the organization *value* should be producing information/requirement as asked and needed by the end-user. *Value* in procurement in project context can be defined as:

Acquisition of goods or services that meets the project needs that is having the right quality and is cost effective through its whole life-cycle.

The concept of *Waste* is well-established. And is defined as:

Every activity or process that only increases cost and does not adds/creates value is waste

Further of the seven types of waste in lean manufacturing only 4 are relevant in procurement, the fact is supported by both literature studied and the experts interviewed. Information and communication technology makes it possible to communicate information within matter of seconds to any end on globe. And the cost related to information storage are much less than in physical manufacturing. Waste due to motion in procurement is also trivial.

Table 7.1 shows the applicability of seven waste in manufacturing and procurement.

Type of Waste	**Applicable in Manufacturing**	**Applicable in Procurement**
Waiting	✓	✓
Defects	✓	✓
Overproduction	✓	✓
Overprocessing	✓	✓
Transport	✓	N/A
Motion	✓	N/A
Inventory	✓	N/A

Table 7.1: Waste Applicability in Procurement and Manufacturing

Transferring lean philosophy from manufacturing to procurement needs training and education of staff involve in procurement. It needs leadership‘s commitment and willingness of staff to get lean

implemented successfully in procurement. With expets‘s interviews it can be concluded that the organization culture in Equinor ASA is favourable for lean implementation. Short courses on lean where examples and learnings from manufacturing is used are little convincing for the staff and hence little effect for change and implementation of lean in procurement.

7.2 RQ_2

It is argued that streamline follow of information is central in procurement of complex projects. Information is intangible and thus keeping track of value along its stream needs meticulous study of details. In manufacturing flow of product and information can be mapped in up-stream and down-stream flow. But information flow in procurement in complex projects have a stream of iterative loops, where information in the organization and out-side with supplier exchanges frequently via mails, meetings and telephonic. The study conclude two potential waste areas which hampers the stream line flow of information in procurement:

1. Overproduction of information
2. Defective information

The overproduction of information is concerned with producing too much unnecessary details, and the defective information waste is due to knowledge barrier or not knowing exactly what the end-user needs. Both the wastes further generate delays. Addressing these two waste can significantly improve the quality of flow of information. Planned iteration due to complexity and unk-unks (unknown-unkowns) lack of information are not regarded as waste but learning. Information flow in procurement can be streamlined with lean philosophy but it needs leaderships commitment and training of the staff involved in procurement. The concept of *Pull* in information flow is an effective way to reduce waste. The softwares used to communicate and retrieve information are functioning well within the organization, but human factor to avail from these tools and producing information with value is dependent on good training of the staff involved in procurement. Despite the differences from automobile industry lean philosophy is still applicable for managing information flow in procurement. Lean in manufacturing is a result of decades of research and learning. In procurement the concept is relatively younger.

Lean tools such as **Kanban, VSM, 5S, Kanban, PDCA** are recommended in procurement because of their robustness and simplicity of adaptiveness to processes. These tools may not bring change overnight but can help the organization to reduce their waste in the long run.

7.3 Supplier Relation

Two organizational models *Mechanistic* and *Organic* are studied and discussed with the experts regarding the supplier relation. The author is of the view that a successful execution of lean in procurement of complex projects needs a meaningful supplier relation. Through the literature and experts ‘s interview and analysis it is concluded that the *Organic model* is a good fit for working with suppliers in complex projects but it needs environment of trust and years of working relation to build that trust. Sharing of strategic sensitive information with suppliers sets boundaries for the procurer in *organic model*. Whereas *Mechanistic model* is well fitted for manufacturing where flow is repetitive and plans are known, in other words a it is top-down approach.

7.4 Further Research

In this thesis a Qualitative Study of applicability of lean philosophy in procurement is carried out, and similarities and differences in manufacturing and procurement are discussed. A Quantitative study involving practical examples supported by numerical improvement through use of *Value*

Stream Mapping and other lean tools is suggested. The further research will be a practical demonstration of the applicability of lean philosophy in procurement, it will advance the organizations understanding for lean and help improve its processes through waste elimination.

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Appendix A

Interview Guide

Hello,

My name is Muhammad Mosa, I am student in Industrial Economics at the University of Stavanger, and presently writing my M.Sc. thesis on the subject of 'Lean Procurement Design for Complex projects' the main objective of the thesis is to study the applicability of Lean philosophy to Procurement process and study the flow of information in Lean context. The questions formulated in this interview are semi-structured and open-ended. The interview answers will be treated anonymously, and no classified/sensitive information will be published/shared in the thesis from the interviews/ documents. There are not right or wrong answers to the questions formulated, therefore more concise and accurate answers will enable me to draw correct conclusions and come up with precise improvement suggestion. It is worthwhile to mention that the study is not the measure of the working quality of the organization but an study to compare Lean from manufacturing context to procurement context. If you consent, I may take audio record of the interview and that will not be share with anyone and will be deleted right after the transcription. The questions will be related to three phases of procurement:

1. Strategy Development
2. Contract Establishment
3. Contract Follow-up

The questions are mostly related to **Value, Waste** and **Information Flow** in procurement.

I will be greatly thankful for your time and answers.

Regards,

Muhammad Mosa YaQoobi,
Student Industrial Economics

Keywords

Complex Project	Complexity is depending on both technical and organization aspects i.e. complex project include: Involvement of many teams and stakeholders. Complex project refers to projects that include ambiguity or uncertainty. The projects where the goal is partially/clearly known but the solution not known
Information	Information is a message, something to be communicated from the sender to the receiver
Lean Philosophy	A way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively.
Procurement	Procurement is the acquisition of systems, goods or services at the best possible total cost of ownership, in the right quantity, at the right time, in the right place for the direct benefit or use of the governments, corporations, or individuals generally via, but not limited to a contract.
Value	For a given stakeholder, value is the total and balanced perception, resulting from the various benefits delivered through the product/process life-cycle
Waste	All elements of a process that only increase cost without adding value or any human activity that absorbs resources but creates no value; any activities that lengthen lead times and add extra cost to the product for which the customer is unwilling to pay

Appendix B

Questions

Preliminary

The interview questions are supplemented on the previous page with keywords and their meaning taken from PMBOK (will be further explained during the interview if needed) in order to help conveying the explicit and precise meaning of the questions to the interviewees. The **General Questions** section is related to generic procurement process of the organization, the **Specific Questions** section is related to a single complex project.

B.1 General Questions

1. Introduction
2. How will you define a project?
3. How well acquainted is the organization to **lean philosophy**?
4. How will you define **value** in project context?
5. How well informed the project stakeholder (internal/external) are to the term **value** while working on a project?
   (the internal stakeholders are the departments of the organization involved, and the external stakeholders are outside the organization. Value in terms of Lean is defined in the above in keywords section)
6. What do you think of lean in procurement?
   (Do you think it will be easy or it will require a lot efforts/training to apply lean in procurement?)
7. How will you define **waste** in procurement context?
   (Waste is defined as process-s which only increases cost without adding value)
8. What do you think the possible **wastes** are in performance of activities in procurement?
9. What can be the possible source-s/reasons of **waste** in different phases of procurement?
10. Can the digititalization only makes the procurement process Lean?
11. What communication tools (software program) are used to share **information**?
    (Do you think the ways in which the information is shared/communicated, needs to be improved?)
12. What do you think about the applicability of **Lean philosophy** in procurement?
13. What do think will be the challenging part in implementing Lean to Procurement process?
    (Is it the organization culture, the human factor, the leadership?)

14. What approach of engagement do you think with supplier shall be adopted in procurement of complex project?
(Shall it be more Organic or more Mechanistic or hybrid of both?)

B.2 Specific Questions

In this section questions are related to a single specific project.

Questions related to Strategy Development, Contract Establishment and Contract Follow-up

B.2.1 Strategy Development

1. What are the steps involved in Strategy development phase?
   (A generic strategy development process involves process such as Verification of need, Working out specification, Market analysis, Developing sourcing strategy and Pre-qualification)

2. What is the most efficient way to manage information flow within the organization and outside in this phase (Strategy Development)?
   (Is it meetings, software to share information or other ways?)

3. In Lean manufacturing there are defined seven wastes. Do you think the wastes are analogous when it comes to information flow in procurement?
   (The seven wastes in lean manufacturing are Unnecessary transportation, Inventory, Motion, Waiting, Over-production, Over-processing and Defective products)

4. What are the typical wastes one can come across while working on strategy development?

5. How well acquainted are the members of the Strategy development team to Lean information management?

6. How effective is the existing software programs for sharing, retrieving, and communicating information within the organization and outside?

7. What are the possible challenges in implementing Lean philosophy to the Strategy development phase?

8. Do you have any suggestion how the information flow can be better managed than the existing one?

B.2.2 Contract Establishment

1. What are the steps in Contract Establishment phase?
   (Generally the Contract Establishment involves preparation of RFI, RFP, Evaualtion of feedbacks, Negotiation and Awarding of contract)

2. For information sharing what digital tools are used within Equinor and outside the organization?

3. Are the wastes in this phase is analogous to seven waste in manufacturing?

4. Can you mention some of the typical wastes in this phase?

5. How effective is the existing software programs for sharing, retrieving and communicating information within organization in this phase?

6. What are the challenges in implementing Lean philosophy to the Contract Establishment phase?

7. Can you describe the issues related to information flow within organization and with the supplier in this phase?

8. Are there delays caused due to unavailability of information?

9. How important is stream-lining the flow of information in this phase?
   (Streamlining is the process used to simplify or eliminate unnecessary work-related tasks to improve the efficiency of processes in businesses or organizations)

10. Do you think Lean philosophy can impart a role in managing information flow?

11. What will be the challenging part in implementing Lean philosophy to the contract establishment phase?

12. Do you have any suggestion how the information flow can be better managed than the existing one in this phase?

B.2.3 Contract Follow-up

1. Can you describe the procedure for Contract Follow-up in the project?
   (Generally Contract Follow-up phase comprises of Implementation of the procurement, Managing changes, Coordination with suppliers, Measuring the performance and Closing)

2. What are the typical wastes in this phase?

3. Do you think the wastes in this phase are analogous to that of manufacturing?

4. How effective is the existing software programs for sharing, retrieving and communicating information within organization and outside in this phase?

5. What are the challenges in implementing Lean philosophy to Contract Follow-up phase?

6. Do you have any suggestion how the information flow can be better managed than the existing one in this phase?