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Company-specific Production System in a Multi-plant Company

Developing the Framework for Design and
Implementation of XPS

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Summary

Success story of Toyota had many followers, however not all of them succeed. Contingency theory suggest that there is no universal improvement approach that fits to all organizations. Each improvement programme has to be contingent on certain situation. As a respond to that issue, there has been observed recently a noticeable trend among multi-plant companies in developing company-specific production systems that are often customized versions of Toyota Production System. Company strategically selects tools and best practices from the improvement programmes such as just-in-time, Total Quality Management or Six Sigma and fit them into the organization's unique characteristics, objectives and local contingencies. The company-specific production system is termed XPS. The "X" stands for the company name and "PS" usually for the production system. The XPS is a corporate improvement programme that is developed at headquarter and applied to all subsidiaries within a manufacturing network to improve simultaneously their performance. XPS creates a common platform for all the plants within an organization and allows transferring the best practices across them.

However, there is a risk that by applying one common improvement programme, local resources, capabilities and unique characteristics of subsidiaries may not be utilized. If headquarter utilizes equal management approach toward all plants without considering their unique characteristics, it might provide a compromised system where some of the subsidiaries are not managed properly. Although many cases of successful XPS implementation of XPS are documented, the concept has received rather limited attention from an academic perspective. There is a lack of established methods and guidelines for design and implementation of multi-plant improvement programmes.

The objective of this study was to develop a framework to support design and implementation of XPS in a multi-plant company that takes into consideration unique characteristics of each plant. To achieve this objective four research questions have been answered:

(1) What is the content of XPS?

(2) What are the benefits of XPS?

(3) What factors should be considered whether to standardize best practices across subsidiaries or adapt them at each subsidiary?

(4) How to manage an implementation of XPS in multi-plant company?

This research present a number of relevant findings to the multi-plant improvement programme theory such as new typology of XPS.

The framework was developed based on the findings from qualitative literature study. The framework consists of three phases: (1) conceptual, (2) design and (3) implementation. Each phase contains several technical stages and corresponding organizational factors that must be considered before moving to the next phase. As a part of the framework, a tool for XPS design was developed. The tool allows mapping of company's current situation, competitive priorities and improvement objectives. It considers subsidiary's characteristics such as product, manufacturing processes and demand to support a choice of best practices and decide whether to standardize practices across subsidiaries or adapt them to respond to the unique characteristics of subsidiaries. The new XPS typology was proposed that consider the degree of best practices standardization and the way in which XPS is managed.

In order to test and validate the framework, a case study at the Norwegian furniture manufacturer Ekornes was performed. Through the tool for XPS design, a set of practices that address the Ekornes' improvements objectives was developed. It was concluded that due to the unique characteristics of subsidiaries, some practices have to be adapted first in order to fit the local context. Based on the number of internal determinants, research suggested that Ekornes should employ decentralized approach to manage its XPS.

Preface

In the last semester of the Master of Science in Engineering program at the Norwegian University of Science and Technology (NTNU), the students are required to write a master thesis. This thesis accounts for 30 ECTS-credits.

This master project was carried out in the spring semester of 2017 by student Tomasz Adam Bielec at the Department of Mechanical and Industrial Engineering, as part of a two-year master program in Global Manufacturing Management.

I would like to express my great appreciation to my supervisor Erlend Alfnes and thank for insightful discussion, engagement and constructive suggestions throughout the years at NTNU. It was a great honour working with him.

I would like to also thank you my co-supervisor Sven-Vegard Buer for his enthusiastic encouragement and his valuable advices. His assistance have helped me to complete this master thesis.

I want to thank Ekornes that welcomed me in their factory and for providing me a possibility to conduct a case study.

I would like to thank you to my colleagues from NTNU for all the productive discussions and for the good times we have spent together at the Department. I will miss them.

I would like to offer my special thanks to my girlfriend and her endless support and love. I love you.

I cannot finish without thanking my family.

I warmly thank you my parents. Accept my thankful wishes for everything that you have done to help me to reach my graduation. I am highly blessed to have such an amazing parents and grateful for all the skills they have instilled in me.

Thank you to my brother. Although you are my little brother, you taught me how to work hard and follow my dreams.

Thank you to my beloved grandmother for their motivation and love. I would not be able to finish this master thesis without you. You have been always my best friend and teacher. I love you “Babciu”.

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Abbreviations

AMPS	Aluminum Metal Production System
ATO	Assemble-to-Order
BOM	Bills of Material
BRP	Business Process Reengineering
BTO	Build-to-Order
CODP	Customer Order Decoupling Point
EBS	Elkem Business System
ERP	Enterprise Resource Planning
ETO	Engineer-to-Order
EVSM	Extended Value Stream Mapping
HPS	Hyundai Production System
HVLV	High Variety-Low Volume
IMVP	International Motor Vehicle Program
JIT	Just in Time
JOS	Jotun Operations System
LM	Lean Manufacturing
MTS	Make-to-Stock
ATO	Assemble-to-Order
NTNU	Norwegian University of Science and Technology
SC	Supply Chain
SMED	Single-Minute Exchange of Dies
STO	Ship-to-Order
SWOT	Strengths-Weaknesses-Opportunities-Threats
TOC	Theory of Constraints
TPS	Toyota Production System
TQM	Total Quality Management
VSM	Value Stream Mapping
WIP	Work in Progress

1. Introduction

Chapter 1 aims to:

1. Establish the context for the master's thesis by providing a research background and motivation.
2. Introduce main objective, research questions and limitations.
3. Present a structure of the thesis and demonstrate how chapters and sections are organized.

This chapter introduces a background and a motivation behind conducting this research. Secondly, a research problem is described. Thirdly, main objective of this thesis is presented together with supportive research questions and limitations. Fourthly, the section depicts a thesis structure in a graphical form and briefly explain the content of each chapter. The last section summarizes a chapter to ensure that aims of the chapter outlined in the frame box above are fulfilled.

1.1. Background and motivation

Today's market is noticing effects of globalization, such as disruptive technological changes, innovation in manufacturing, information technology and increasing number of multinational companies (Henrik Jørgensen et al., 2009). This led to rapidly changing environment and pressing market situation that force manufacturing companies to optimize manufacturing processes and constantly increase operational performance in order to stay competitive (Karim and Arif-Uz-Zaman, 2013). The recent growth of low-cost economies is progressively pressing manufacturers in high-developed countries such as Norway, to become more flexible, innovative (Powell et al., 2013) and deliver better quality products (Bhamu and Singh Sangwan, 2014). Hence, companies need to constantly look for improvement opportunities and continuously eliminate waste to increase the productivity. Lean manufacturing, that evolved from Toyota Production System (TPS), has been a supposedly an answer for these challenges (Womack et al., 1990). Lean manufacturing is an improvement programme that aims to eliminate waste by using less human effort, less time and less space to become highly responsive to the customer demand and to deliver high quality products in the most efficient way (Karim and Arif-Uz-Zaman, 2013).

The success story of Toyota had many followers, however not all of them succeed. There has been reported that a big number of improvement programmes fail (Henrik Jørgensen et al., 2009). A lack of clear and widely acknowledged implementation methodology (Behrouzi and Wong, 2011), insufficient employees involvement (Liker, 2004) ,lack of alignment between the operational management practices and competitive strategy (Tatikonda and Tatikonda, 1996) and ambiguous corporate goals and objectives are often reasons of failure. Pertusa-Ortega et al. (2010) claimed that implementations fail particularly due to lack of perspective on resources and capabilities available in the organization. This is in line with a contingency theory that emphasizes that no improvement programme can fit to all organizations and their unique characteristics (Lee and Jo, 2007).

There has been observed recently a noticeable trend among multi-plant companies to deploy a company-specific production system. These systems are often customized version of Toyota Production System (Netland, 2013). Company designs its own system through strategical selection of tools and best practices such as JIT, TQM and Six Sigma and fit them to organization's unique characteristics, objectives and local contingencies. This company-specific production system is termed XPS (Netland and Aspelund, 2014) where the letter "X" stands for the company name and "PS" usually for the production system. XPS is a multi-plant improvement programme that is developed in headquarter and applied further to all subsidiaries to improve simultaneously a performance of all facilities within a manufacturing network. An objective of XPS is to align all plants within the network by adopting the same set of principles and best practices in multiple plants to increase competitiveness and leverage knowledge (Netland and Sanchez, 2014). XPS creates a common platform for all plants within an organization and allows transferring the best practices across the network (Netland and Sanchez, 2014). A number of Norwegian companies, such as Elkem, Kongsberg, Hydro, Jotun and Madshus have developed their own company-specific production systems to address the challenges of the competitive market. Improve of an efficiency helped them to survive a financial crisis in 2007. XPS developed at Hydro achieved a significant cost savings at the level of 1,5 bn. NOK per year, what had a major influence in overcoming a dramatic aluminum price fall from 3000 US-dollar per ton to 1300 US-dollar per ton within less than one year (Norsk HYDRO ASA, 2014). Netland (2013) studied over 100 examples of implemented company-specific systems, and claimed that XPS can simultaneously improve performance of multiple plants and can provide a company competitive advantage – but only if XPS is implemented properly.

Even though XPS is popular among manufacturing companies, it is a relatively new phenomenon in academic literature. Hence, the clear literature stream has not been established yet. This new literature stream has been introduced and is still very strongly rooted at the Norwegian University of Science and Technology in Trondheim – the mother University of a researcher. It is worth mentioning that a term XPS has been first introduced at the NTNU, by Torbjørn Netland and has been further cited and acknowledged by many international researchers.

1.2. Problem description

Although many cases of the successful implementation of XPS are well documented, this concept has received rather limited attention from the academic perspective (Netland and Aspelund, 2014). It leaves a few important aspects still to be explored. Despite the increasing number of multinational corporations, the academic literature is focused more on single-plant improvement programs, rather than a multi-plant perspective (Netland and Aspelund, 2014).

The purpose of any improvement actions is the best use of available resources and capabilities of the particular plant (Keating et al., 1999). There is a risk that by applying one common improvement programme across all subsidiaries, some of the plants would be not managed properly due to their unique, local characteristics. The academic literature recognizes this as an important issue, but does not provide a clear answer to what degree companies should standardize practices across their subsidiaries to create a common platform and when should practices be adapted locally to respond to subsidiaries' unique characteristics (Netland and Aspelund, 2014, Beckman and Rosenfield, 2008). This dilemma is relevant especially to companies with plants within a network that produce different types of products for different customers and the unique productions systems consists of different processes. This problem was pointed out by Netland and Sanchez (2014) through a case study of the Volvo Production System's. In one of the Volvo's fabric in South Africa, this problem is being solved only through a pragmatic approach, where managers see XPS only as a guideline and do not implement all modules.

An explicit distinction between when subsidiaries should adopt the standardized, global programme and when subsidiaries should adapt it to their characteristics needs more research (Netland and Aspelund, 2014). It is important to analyze what are the factors that decide whether headquarter develops one, global XPS that encompasses all plants or let each subsidiary adapt the practices locally. In addition there is lack of research how to manage effectively XPS from headquarter perspective. It is necessary to consider the aspect of decision-making autonomy between headquarter and subsidiaries, and decide who “owns” and manage XPS.

Past researches on improvement programmes focused mostly around the content of Lean manufacturing. The literature on Lean implementation still brings confusion due to the number of various implementation frameworks that differ in regards to a scope and methods (Karim and Arif-Uz-Zaman, 2013). In addition, most of the frameworks consider only aspect of improvement programme implementation in a single plant, while the number of multi-plant companies is still increasing (Henrik Jørgensen et al., 2009). Therefore, there is a need for an unambiguous, systematic approach for the improvement programme implementation is multiple subsidiaries simultaneously.

Despite growing interests in multi-plant improvement programmes, there is still very little available research on how to manage improvement programmes itself to sustain the competitive advantage (Netland and Aspelund, 2014). Dynamic environment and increasingly competitive market require dynamic capabilities that have to be constantly developed to sustain the competitive advantage (Eisenhardt and Martin, 2000). Therefore, a static XPS might only hinder a continuous improvement instead of increasing a performance. Therefore, there is a need for a method that support the continuous improvement of the programmes itself (Netland and Aspelund, 2014).

This research is important due to the high capital intensity of corporate improvement programmes (Netland and Aspelund, 2014) and the relatively small number of successful implementation (Bjørge Timenes et al., 2005).

1.3. Scope

1.3.1. Objectives

The previous, introductory section has shown that there is a need for more research about the multi-plant improvement programmes, principally in regards to the design and implementation and the aspect of best practice standardization and adaptation to the contextual factors of subsidiaries. This composed a primary objective of this thesis - **To develop a framework for design and implementation of XPS in multi-plant company that considers the subsidiaries unique characteristics.**

1.3.2. Research Questions

In order to support achieving the research objective, research questions have been formulated. Defining research questions is fundamental to research process as they guide conducting this thesis. First two research question aim to explore the XPS as a concept and to establish a solid theoretical foundation for this thesis. Questions 3 and 4 are related to the particular literature gap that was outlined in the introduction.

1. What is the content of XPS?

This research question seeks to explore and define what constituents build the XPS.

2. What are the benefits of XPS for multi-plant company?

This research question aims to specify reasons for the XPS development and the advantages companies can achieve by developing one.

3. What factors should be considered whether to standardize best practices across subsidiaries or adapt them at each subsidiary?'

This research questions is related to a particular literature gap. Academic literature does not provide a clear distinction between the best practices standardization and best practices adaptation. As it has been recognized, the best practice standardization across the subsidiaries may provide a common platform that gives advantages such as common language. However, standardized practices might not always fit to subsidiaries' characteristics. Therefore, this research question aims to fill this gap by defining factors and determinants that should be considered before the company decide to either standardize or adapt best practices across its subsidiaries.

4. How to manage an implementation of XPS in multi-plant company?

This questions seeks to fill the literature gap in regards to how the XPS is managed from headquarter perspective. It includes the aspects of the XPS design, implementation and management of the improvement programmes itself to sustain the competitive advantage. This research question is interrelated with the previous question and aims to consider whether the way of managing XPS varies as the degree of standardization and adaptation of best practices changes.

1.3.3. Limitations

To have a full overview of the research scope, besides explaining what is going to be achieved in this thesis, it is also important to consider its limitations. The main three limitations have been recognized:

Research focus

Does not consider the cultural and human aspects of best practices transfer.

Literature

This master thesis considers only the literature in English. There has been identified a few research papers about the XPS in automotive industry written in German, however they have not been included in the literature study. The literature used was limited to the NTNU's library and online database.

Time

This master project was conducted in a period of 20 weeks. This time constraint led to some limitations on how comprehensive the project is. Time constraint also effected the case study and its extensiveness.

1.4. Organization \ Structure

This section presents the structure of this thesis in a graphical form and aims to introduce briefly each chapter.

The organization of the thesis is visually presented in the figure 1. The chapter 2 - methodology is applied to chapter 3, 4 and 5. Chapters 3 and 4 are theoretical part, while chapter 5 is empirical part of research.

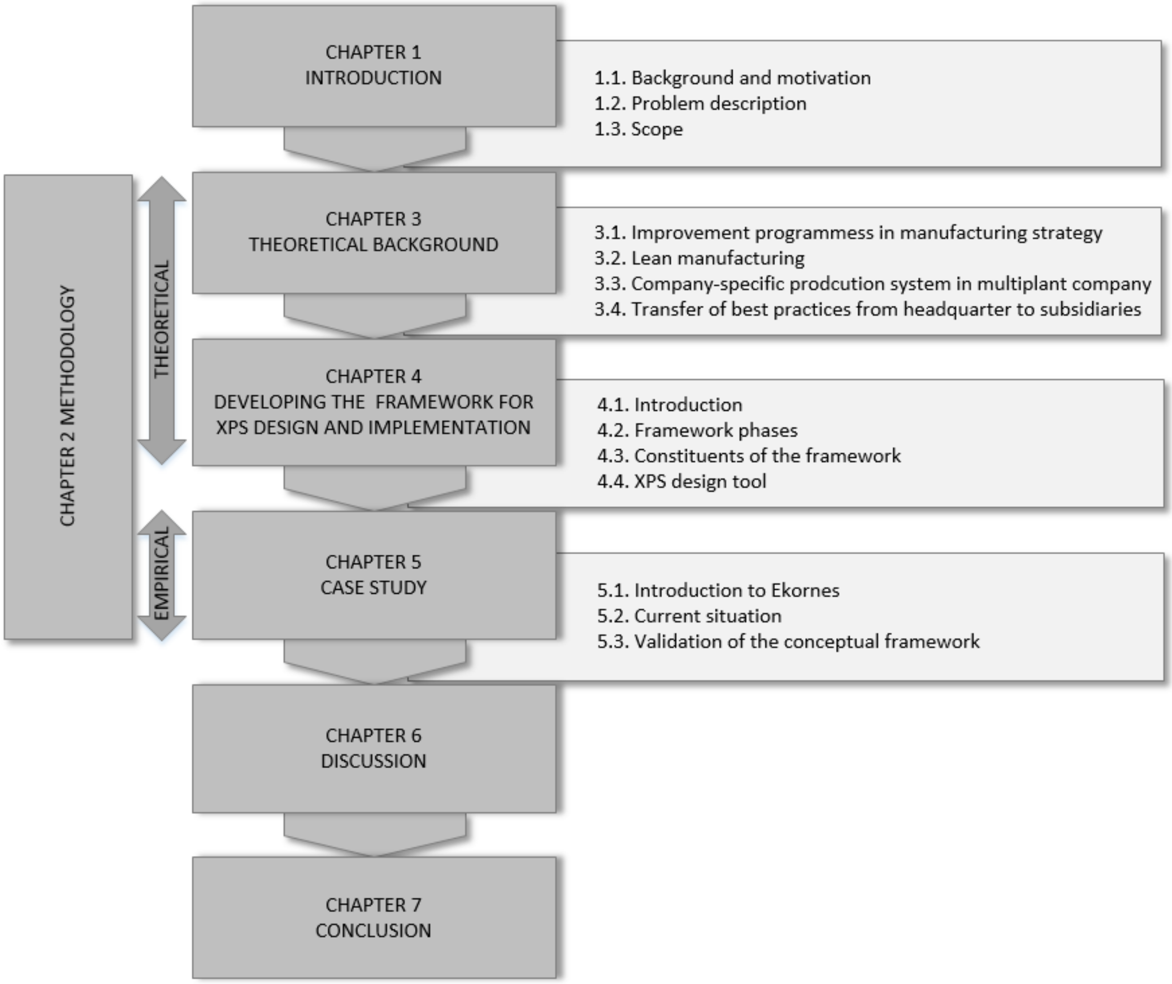


Figure 1 Structure of the master thesis

Chapter 1 *introduce*s the research problem by bringing a background information that contributes to formulation of research objective and research question that are presented in the section 1.3. In addition, the limitations and the thesis structure are depicted.

Chapter 2 describes a *methodology* that is utilized in this master thesis. First, the research design is presented that is followed by various research methods that supported conducting this research.

Chapter 3 presents a *theoretical background* of this research. The chapter is divided into 4 main sections. The first section aims to put the research topic into a broader context of *the operations strategy*. The second section introduces *Lean manufacturing*, while the third sections presents *XPS*. The last, fourth section of a literature review puts forward the aspect of *best practice transfer from headquarter to subsidiaries*. Each section is further summarized in order to assure that all the section aims are achieved and to depict the important findings from a literature. Those findings are further used to develop the framework.

Chapter *4 develops the framework for design and implementation of XPS in the multi-plant company* based on the synthesis of findings from the literature review. The framework consists of three phases; (1) conceptual, (2) design and (3) implementation that contain several technical stages and organizational factors. Each of the elements that bulling this framework is described thoroughly in the chapter. In, addition the supportive tool for XPS design as an integrative part of the framework was developed. The tool is described in the section 4.3.

Chapter 5 evaluates and validates a conceptual framework through *the evaluative singe case study*. The chapter begins with a short introduction of a factory that is followed by an explanation of current practices in regards to the multi-plant improvement programs. Subsequently the framework is applied to develop XPS of the company.

The next chapter *discusses* all findings from the theoretical part and a single case study. This chapter have an essential role to check whether all research questions are answered and the research objective is achieved.

The thesis is *concluded* in the last chapter. The chapter ends up by providing suggestions for a future research, describing the theoretical and practical contribution and depicting research limitations.

1.5. Summary

The chapter 1 framed a context for the master's thesis and presented a content of the research. A theoretical background of the XPS has been introduced together with a motivation of the research. In regards to the identified literature gaps, four research questions have been formulized to support achieving a research objective. The limitations in regards to research focus, literature, time and case study have been commented. The structure of the thesis has been introduced first in a graphical form to get a clear overview of the research architecture and later each chapter has been briefly explained.

2. Methodology

Chapter 2 aims to:
Thoroughly explain the research methods that are used in this thesis.

In chapter 2, research methods and procedures that build a methodology are presented. First, the research design is outlined and depicted in an illustrative form. The next section gives a detailed explanation of each research method that is utilized in this thesis together with a goal and the reasoning behind choosing the particular methods.

2.1. Research design

In order to solve any scientific problem it is important to choose a research approach that will be utilized and to define the main steps that will be followed (Rajasekar et al., 2006). Two main approaches to the research that use different tools and have a various outcome can be differentiated: (1) Quantitative approach that uses numbers and applies mathematics and statistics. The goal is to evaluate the evidence and the results are often depicted in form of graph and tables. This approach is non-descriptive, conclusive and usually seeks to answer the “what, where and when” questions (Rajasekar et al., 2006). (2) The qualitative approach is, descriptive and non-numerical. It applies reasoning and uses words, and is often exploratory. The goal it so describe a situation and to get the meaning (Rajasekar et al., 2006). Thesis states the exploratory questions “how” and “what” which according to Yin (2014) can be answered trough conducting a qualitative approach. Therefore, this approach has been chosen in this thesis.

The project was divided into six phases. Five phases are subsequent while the sixth, project follow up, was performed continuously throughout the project to ensure the successful project delivery. The function of the *project definition, literature study, developing the conceptual framework* was to explore the theory and build a framework. *The single case study phase* aims to test and validate the framework and together with *discussion and conclusion* phase constitute the theory-testing part of this thesis. Project follow-up has a control function.

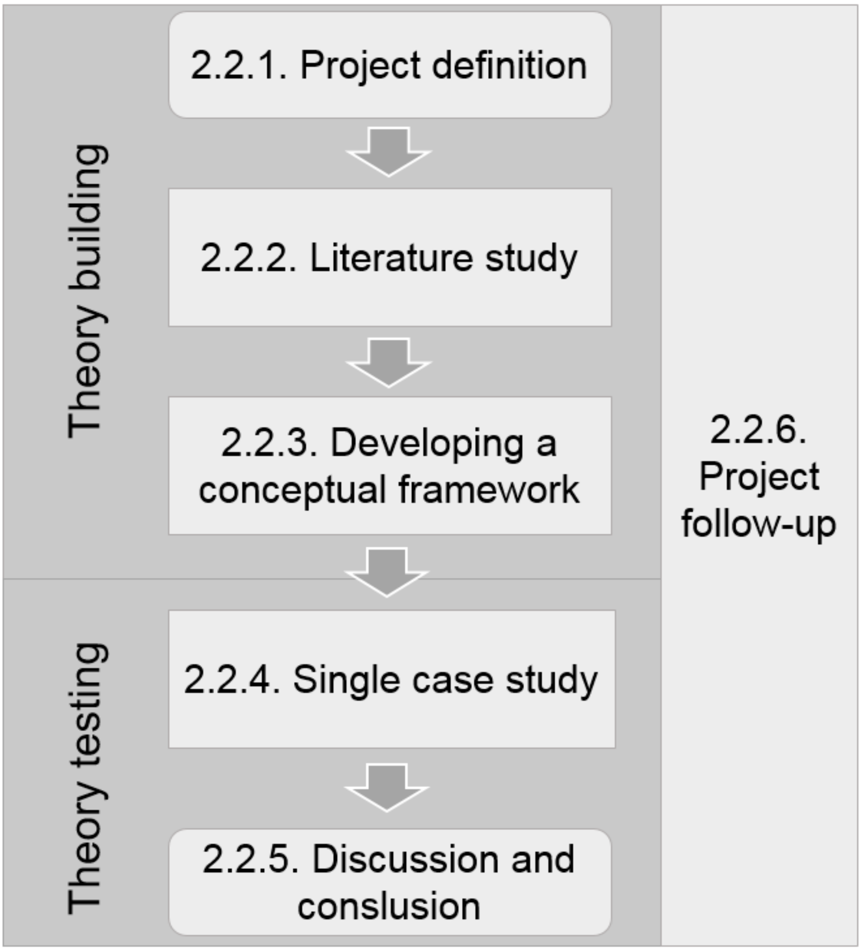


Figure 2 Phases of the research methodology

2.2. Research methods

This section explains in detail the research phases illustrated in the figure 2 and discusses goals and the reasoning and motivation behind choosing particular research methods.

2.2.1. Project definition

The initial phase aimed to select a research topic and define a research problem together with a scope. The research problem was developed through the brainstorming and consultations with supervisors. The project definition took into consideration a recent industry trend, which was not explored in detailed manner in academic literature yet (Netland and Aspelund, 2014). It gives the significance of the problem for the advancement of science (Rajasekar et al., 2006). The important factors that are recommended by Rajasekar et al. (2006) were followed while choosing a topic: topic should be suitable for the research and a researcher should have an interest in the research area. While defining a scope a possibility of data collection and a time contingency were taken also into consideration. After the problem and topic were formulated, the additional assessment was performed according to the five questions based on Rajasekar et al. (2006) regarding the problem.

(1) Is problem interesting to the research and the community?

(2) Is the problem significant to the current status of the topic?

(3) Is there sufficient guidance?

(4) Can the problem be solved within a 20 weeks timeframe?

(5) Will it be possible to collect all necessary data?

It has resulted in a few reformulations and rewordings of the prior chosen problem.

2.2.2. Literature study

The methodology of literature study utilized in this master thesis is based on the methodology proposed by (Boell and Cecez-Kecmanovic, 2014). Authors presented a framework for literature review that consists of two major circles; (1) *search and acquisition* and (2) *analysis and interpretation*. The framework is presented in the figure 3. The literature review is a part of a research report that examines and assesses an existing knowledge of a particular problem. It allows identifying phenomena that are understood poorly and enables developing assumptions and theoretical claims. In addition, literature review plays a very important role in knowledge development (Boell and Cecez-Kecmanovic, 2014). Literature review in this thesis was conduced in order to explore and synthetize existing research concerning improvement programmes such as Lean manufacturing and company-specific production system in multi-plant company and the best practice transfer.

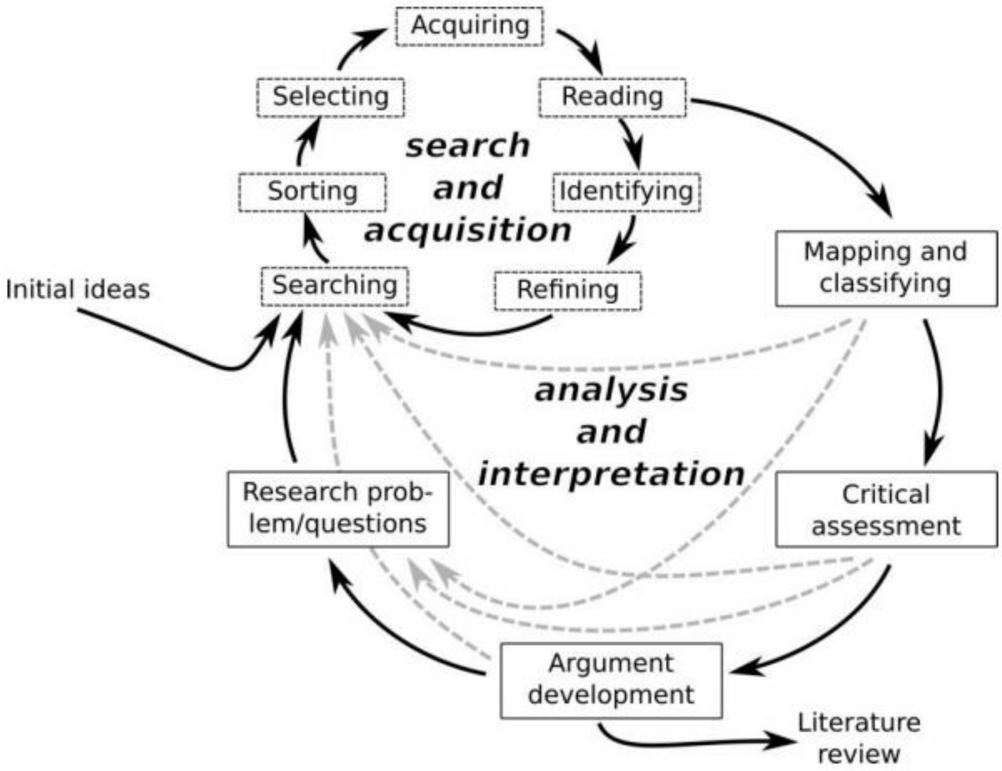


Figure 3 Framework for the literature review (Boell et.al, 2014)

Analysis and interpretation

The wider circle starts with a rather clear idea about the research problem and topic. However, it continues within the „search and acquisition" circle, which might lead to revising a research problem. Research usually repeats the circle several times. Stages of a wider circle are as follows:

Reading – Researcher often has some basic understanding based on the experience or previous readings. Reading begins first with an orientation reading to get an initial understanding of the publication and to narrow the down a number of relevant researches. It should be performed in a structured and organized way. Gradually, researcher begins with an analytical reading that aims to interpret and understand research articles. It begins with the interpretation of individual publication first and later seeks to relate them one to another. Reading leads to understanding of the publication that is necessary to contrast its findings with other articles and to set the contribution into the wider context of knowledge. Taking down notes of ideas that appearing is here recommended.

Mapping and Classifying – This separated activity aims to analyze and finally systemize findings and ideas from the reviewed publication to develop a classification that depicts major views, contributions and sources.

Critical assessment – This stage aims to make an analysis and evaluation of existing level of knowledge regarding a research problem and to identify aspects that are left unclear or are contradictive.

Argument development – Previous stages build a foundation for identifying a research gap and problematization of current state of knowledge. This stage creates a motivation for a future research. It is essential to understand why the identified research gap is important to be addressed.

Research problem and questions – Through the repetition of circles, researcher increases his knowledge what might lead to redefinition of a research problem. Research problem is translated into research questions that are more specific. Researchers repeats circles until the satisfactory state of literature review that includes research questions and problem is achieved.

Search and acquisition

Searching – This is a stage that aims to identify the further publications. Boell and Cecez-Kecmanovic (2014) suggested focusing on a narrow number of highly relevant publications than on a big number of articles that relevance is unsure. Searching is an integrated part of research process that teaches researcher about specialized terms, concept and expressions and deepen and understanding that facilitate and improve the search approach.

Sorting – This stages aims to categorize and prioritize searched publications by its relevance. It might by undertaken with methods such as ranking algorithms in databases, number of citations or publication dates.

Selecting – Individual publications are selected after the results of search are sorted. Reading an abstract to get an overview of the scope, aims, methods and findings is a useful method for relevance assessment. Boell and Cecez-Kecmanovic (2014) claimed that the framework allows focusing on a small number of articles first because through a several iterations of circles, it will be possible finding additional articles that were not identified first

Acquiring – Is a stage that aims to acquire the full text of article

Identifying - Based on reading, researcher is able to identify more articles, through new terms, authors, journals or citation tracks which is known as a „snowballing"

Refining – Individual search strategies can be developed to improve and systemize the literature search.

The knowledge building process is never-ending. However, researchers are often time-constrained. Therefore, it is important to achieve a comprehensive literature study in the available time. Literature study can be assessed as comprehensive and saturated when researcher realizes that arguments or findings of new publications are similar and do not introduce anything new. Researcher can also decide to finish a review by his pragmatic judgment.

2.2.3. Developing a framework

Based on the findings from a literature review a framework has been developed. The framework aims to support the design and implementation of the company-specific productions system in the multi-plant company. Framework was developed based on a science validity and focus on practical relevance.

2.2.4. Case study

Case research is recognized as one of the most powerful methods, especially for developing a new theory (Voss et al., 2002). The XPS is a relatively new phenomena in the industry and the explicit and unambiguous literature stream has been not established yet (Netland and Aspelund, 2014). In addition, the case research can generate new and sometimes creative insights and can acquire the high validity with the end user of the research – practitioners (Voss et al., 2002). The case research conducted at the organization site gives an opportunity to face the real industrial issues and the input from the employees at the different organizational levels of the company can greatly contribute to knowledge building process of the researcher (Voss et al., 2002). Various authors have defined a term case study differently. Thomas (2011) studied over 30 definitions and based on this research developed an aggregated definition that will be used in this research. He emphasized the importance of the two elements that case study has to comprise: The subject, which is a “practical, historical unity”, and an object that refers to the “analytical and historical frame”. The term case study is described by Thomas (2011) as:

“Analysis of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods. The case that is the subject of the inquiry will be an instance of a class of phenomena that provides an analytical frame-an-object- within which the study is conducted and which the case illuminates and explicates”

In addition to the subject and a purpose, Thomas (2011) suggests further choice of approach, methodologies and processes as a further step in distinguishing classification of the case study. He proposed a typology that is illustrated in figure 4 and will be later applied to categorize the case study employed in this research.

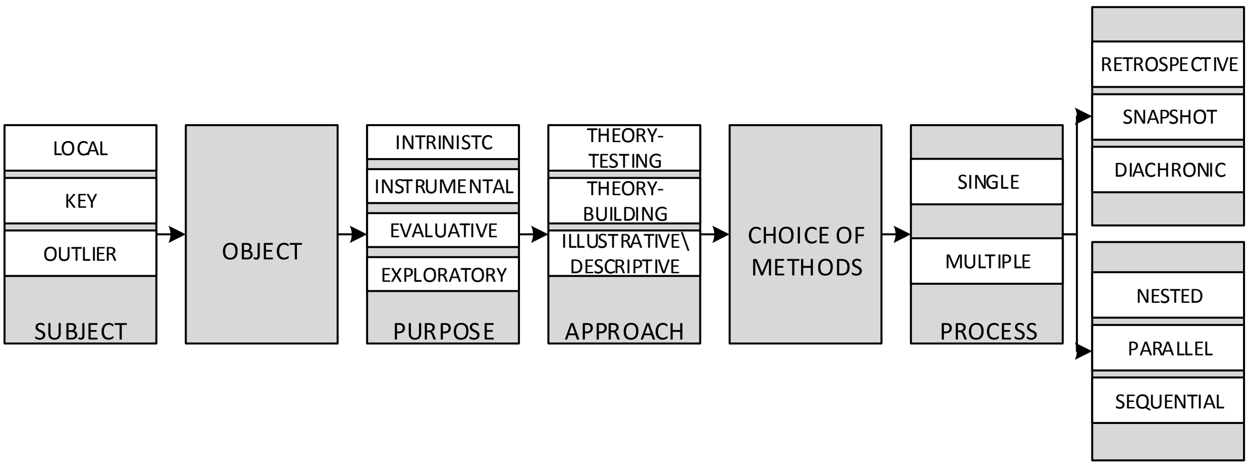


Figure 4 A typology of the case study (Thomas, 2011)

The *subject* of the case study represents an item that is researched through a case study and can be identified either through researcher's knowledge in a form of *the local knowledge case*, as an inherent interest in form of *key case* or as an *outlier,* the reasons of its difference.

The *object* represents an analytical focus of the study and a frame within the case study is viewed.

The *purpose* of the study can be *intrinsic* that refers to the exploration, *instrumental, evaluative or exploratory* that depicts the reason behind doing the study.

The next staged is an *approach* to the study and can be categorized as a *theory testing, theory building or illustrative.* After setting an approach, the choice regarding the *methods* has to be undertaken. However, it significantly varies between the different researches - therefore we will not go deeper into it.

In the *process* stage, the choice about the operational processes is being made and the decision about the number of elements studied. If the study is conducted on one element, we categorize it as a *single* case and if more than, it is termed *multiple.* Further this choice lead to the multiple variety of the processes; *retrospective, snapshot, diachronic, nested, parallel, segmental.* Only processes that are applied in this research will be further explained and discussed in the next section (Thomas, 2011).

Categorization of the case study

The typology presented in the figure 4 (Thomas, 2011) is used to categorize the case study conducted in this master thesis.

The *subject* of the study is Norwegian furniture producer Ekornes. The company was chosen since it owns multiple facilities and managing improvement to increase the performance of all plants simultaneously is challenging. It is categorized as a *key case* study.

The *object* of this case study is to investigate the current practices regarding the improvement programmes and validate the conceptual framework.

This case study is conducted with two *purposes.* The first purpose is *evaluative* since it analyzes the current situation at the Ekornes regarding the improvement practices in its manufacturing network and is *instrumental* since it aims to check the validity and applicability of the proposed framework.

Two *approaches* are appropriate to this type of case study. The first approach is theory-testing that refers to framework validation, while the evaluative part of current situation is *descriptive* since it seeks to objectively describe the Ekornes improvement practices

This single case study is supported by a *methodology* proposed by Yin (2014) and is described in the next subsection.

The case study is conducted on one manufacturing company – *single* case study. It involves collecting the data from the past and in addition the current situation that is being examined. Therefore, this case study encompasses both *retrospective* and *snapshot* category.

Case study methodology.

After the case study is categorized, a particular approach to planning and carrying of the study has to be established in order to assure a delivery of desired outcome. Through an analysis and data triangulation as the use of multiple sources it was aimed to achieve the most explicit and authentic picture of the event. To support that, a well-known methodology developed by Yin (2014) is applied in the research. Methodology is illustrated in the figure 5 and further described in this section, together with explanation how those steps were applied to the context of this master thesis.

The methodology consists of six subsequent stages. The first stage is *plan*ning that aims to identify research questions or other rational for conducting a case study. A rational for conducting a case study in this master thesis is to test and validate developed framework for design and implementing XPS is multi-plant company. Yin (2014) recommended comparing case study with other research methods to decide whether it is relevant to use that opposed to others methods' strengths and limitations. As the XPS is relatively new concept, Voss et al. (2002) recommended a case study as an appropriate method.

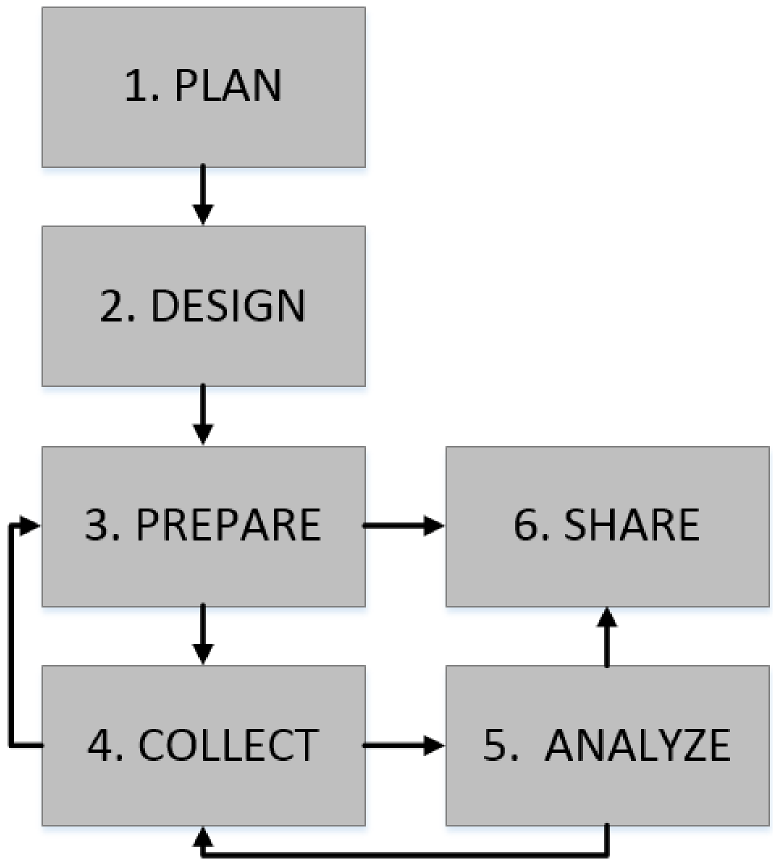


Figure 5 Stages of the case study (Yin, 2014)

Next stage, *design* aims to create a logical plan for the transition from set of questions to set of conclusions. Stage aims to determine the tools and approaches to gather data. Those tools and approaches must be used systematically and properly to assure the construct validity, internal and external validity and reliability (Yin, 2014).

Internal validity concerns establishing the right cause-and-effect relationships. External validity is a degree to which findings are applicable to other setting or groups. Reliability is the extent the data would be similar if collected another time.

It was planned to collect data from the multiple sources and utilize tools such as interviews, documentation reviews and observations.

Preparation is a next stage that ensures that researcher is well prepared before the case study is commenced. Study protocol as a useful tool for preparation, should be developed at this stage to define all procedure that will be undertaken. Yin (2014) emphasized that researcher should perform the final screening of case companies to find a right candidate.

Ekornes was recommended by a supervisor as an appropriate and suitable case company for the research problem. Before the case study was conducted, researcher created a protocol to that was discussed first with the co-supervisor and the contact person from the case company. It contained a necessary data to obtained, the methods how the data will be extracted and the expected outcome of the case study. Few adjustments have been made as results of discussions.

The fourth stage, *collect* aims to gather a necessary data and information depicted in the case study protocol. Researcher used a multiple sources of evidence to maintain a high quality and validity of data. Yin (2014) recommended use of case study data base, but as the single case study was conducted, it was decided to not develop one.

Data was collected through an observation at the company site, semi-structured interviews and correspondence through an email. Researcher took field notes during the observation and notes during every meeting. A meeting report in the end that was further accepted by the interviewer. Short focused interviews were further conducted to verify the observations and gather missing data.

The fifth stage aims to *analyze* data obtained and to draw conclusions for answering the research questions. Since the data was only qualitative, no analytic strategy was needed to develop.

Data obtained through the observation and interviews where further examined in order to find linkages between the research objective and the outcome, having in mind research questions.

Sixth and the last stage is to *report.* The goal of the written report is to describe the complex problem in a way that can be understood and questioned. It is important to present enough evidence to make researcher confident that the research problem has been explored extensively.

This master thesis presents a report by first introducing the case company to make a reader familiar with the case object. Later, the current situation of the case company is described and critically assessed. Further, the conceptual framework is validated and findings are discussed.

2.2.5. Discussion and conclusions

Both findings and developed prior framework were discussed. It includes critical reflection on each steps of the framework. This phase also discuss limitations of this research. Findings and both theoretical a practical contribution is further summarized in form of conclusions.

2.2.6. Project follow-up

The project follow-up was performed continuously along the process to ensure achieving thesis objective, through conducting the comprehensive research in a defined time-constraint of 20 weeks. A gantt chart method were utilized in order to follow the process and update the status.

3. Theoretical background

Chapter 3. aims to:
Provide the theoretical background for this master thesis.

This chapter provides a theoretical background for this master thesis through structured literature review. The theory part is divided into four sections; (1) improvement programmes in manufacturing strategy, (2) Lean manufacturing, (3) company-specific production system and (4) best practice transfer from headquarter to subsidiaries.

3.1. Improvement programmes in manufacturing strategy

Section 3.1. aims to:

Set a research topic into a broader context of a manufacturing strategy.

Terminology

The term *improvement programme* is used throughout this thesis and the working definition of this term has been developed based on definition from (Netland and Aspelund, 2014)

“Improvement programme is a systematic process of creating, formalizing and diffusing better operational practices with the aim of improving company’s performance and increasing competitiveness”

Best practices are defined as:

“Superior organization’s use of knowledge that is being the most effective” (Jensen and Szulanski, 2004)

The traditional process improvements aim to identify local and single efficiencies. Even though a single process increases its performance, it does not necessarily have a positive impact on the entire value stream (Liker, 2004).

Improvement programmes look at the value chain as a whole of processes and seek improvements that affect its performance, e.g. Lean manufacturing aims to reduce waste in value chain by reducing a large number of non-value added processes (Liker, 2004), theory of constraints aims to reduce bottlenecks that constraints the whole production process (Goldratt et al., 2004), Six Sigma aims to achieve the quality improvement of all processes (Eckes, 2002).

A very limited deliberation of strategic level thinking in Lean manufacturing could be a reason of lack of sustainability of Lean program (Hines et al., 2004). Different stakeholders perceive the improvement opportunities differently what makes the multi-plant improvements programmes very challenging. Therefore improvement programmes should be integrated with the business and manufacturing strategies (Johnston and Menguc, 2007) and should be encompassed in one holistic approach (Challis et al., 2002).

Before a particular improvement programme is implemented, company should consider whether the programme fits into the company' strategy, in order to maintain the long-term focus of the implementation effort and achieve the expected results (Näslund, 2008). Next section seeks to explore the strategic perspective on the choice and implementation of corporate improvement programmes.

3.1.1. Strategic perspective on the improvement programme implementation

What is a strategy?

There is no agreement on a single, widely accepted definition of strategy. The term itself developed from strategy of war as strategic ploy that was first time mentioned over 2000 years ago (Beckman and Rosenfield, 2008). Mintzberg (2003) sees a strategy as an intended action to deal with a certain situation. Mintzberg and Waters (1985) defined a strategy as a pattern that is a consistency of behavior. The strategy can be also a position that concerns company positioning within an environment and strategy as a perspective that refers to the way of perceiving the world (Mintzberg, 2003).

The strategy as a plan and pattern can be independent, thus plans are not always realized, while patterns can appear without any presumptions. Therefore, the *planned* strategy is termed *intended* while the part that is actually made is called *realized*

(Mintzberg, 2003). From the practical perspective, this is difficult to realize the whole intended strategy (Beckman and Rosenfield, 2008).The part of the intended strategy that is realized is being termed *deliberated strategy*, while the part of strategy that is developed without the intentions is *emergent.* That part of strategy that is never realized is called *unrealized* (Mintzberg, 2003). The firms often follows the many path of strategies. Beside have a plan, organizations often experiments and learn to adapt itself to the dynamic environment (Beckman and Rosenfield, 2008).The figure 6 shows the different paths the strategy.

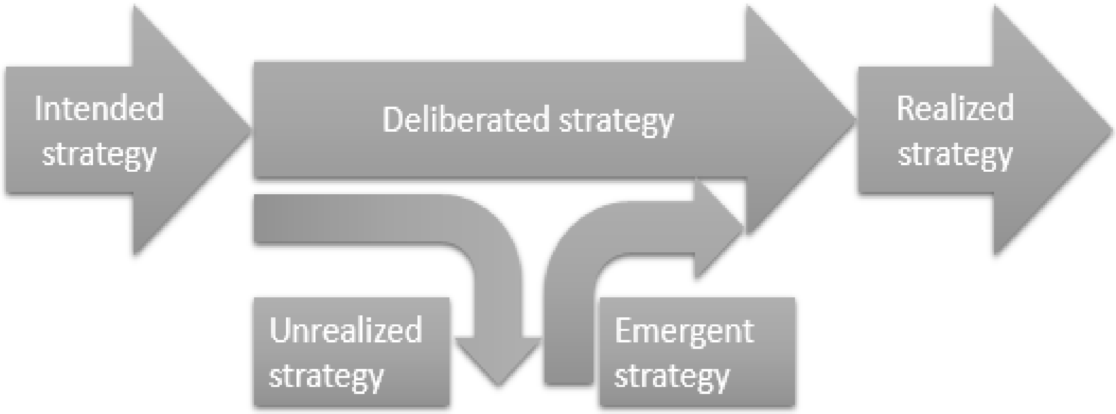


Figure 6 Types of strategies (Beckman and Rosenfield, 2008)

Strategy is a big picture of how the organization is going to compete (Beckman and Rosenfield, 2008). Strategic planning encompasses three hierarchical level of the firm: corporate level, business unit level and functional strategies such as manufacturing strategy (Fine and Hax, 1985). The first who advised the manufacturing enterprises about the importance of alignment between the manufacturing and business strategy was Skinner (1969). This alignment is decisive for the overall success of the business (Skinner, 1969). The manufacturing strategy can become a “competitive weapon” for the company, but if there is no link between the levels of strategies, it may lead to many drawbacks in manufacturing performance. Number of researchers supported the early work of Skinner (1969) and the approach where a corporate strategy is an input into the business strategy and further drives a formulation of manufacturing strategy (Fine and Hax, 1985, Hayes and Wheelwright, 1984, Leong et al., 1990).

Corporate level strategy

At the highest level in the organization, decisions regarding the choice of the industry and market that company wants to compete in. The general scope of the company is being decided. Financial strategy is an important part where strategists at this level manage the company's portfolio and make an investment decisions (Beckman and Rosenfield, 2008).

Business level strategy

Business strategy defines decisions that are being made at the strategic business unit level, which aim to support the corporate goals (Brown and Blackmon, 2005). Business strategy specifies how company plans to achieve and maintain the competitive advantage within its industry. At this level, decisions regarding the market positioning and what capabilities company aims to utilize to be competitive and fulfill the customers' requirements are made. This strategy, in order to succeed has to be aligned with all business functions (Rusjan, 2005).

Functional level strategies

Functional level strategies such as manufacturing, marketing, resource & development determine business functions and should assist in achieving the business strategy goals (Rusjan, 2005). This research focuses on manufacturing strategy and the rest of functional strategies are out of the scope. However, it is important mentioning that in order to succeed, functional strategies need to be aligned together and form an internal fit (Beckman and Rosenfield, 2008).

Manufacturing strategy

Manufacturing Strategy is a pattern of decisions about how the capabilities and resources will be used in order support the business strategy (Hayes and Wheelwright 1984), with the goal of gaining advantage over its competitors (Skinner, 1969), termed competitive advantage (Dyer and Singh, 1998). Resources are defined as observable assets such as technologies, methodologies and skills that company owns and utilizes with the aim of achieving a competitive advantage (Beckman and Rosenfield, 2008). Lowson (2002) classified resource into tangible (technology, financial, physical), intangible (reputation, brands, information) and human (skills and knowledge, motivation). Capabilities as opposite to the resources cannot be valued and traded and are always intangible, such as activities, processes or functions. Company's capability is the ability to achieve its objectives. Capabilities are developed based on the firm's experience and focus over time (Beckman and Rosenfield, 2008). Competences encompass knowledge such as know-how, innovation, experience that the company owns and can utilize them if have a certain capabilities (Lowson, 2002). "Manufacturing strategy refers to exploiting certain properties of the manufacturing function as a competitive weapon" (Skinner (1969). Hill (1986) suggested that manufacturing strategy is a coordinated approach that aims to achieve a consistency between capabilities, policy and competitive advantage, in order to operate successfully in the marketplace. Miller and Hayslip (1989) defined a manufacturing strategy as that "a projected pattern of manufacturing choices formulated to improve fundamental manufacturing capabilities and to support business and corporate strategy" and this formulation will be followed in this research.

The content of manufacturing strategy is clearly established in the literature, however, the literature about how the firms should adopt and operationalize the manufacturing strategy is rather limited (Rusjan, 2005, Kim and Arnold, 1996). Operationalizing refers to the decisions that manufacturing executives have to make to implement successfully the manufacturing strategy (Kim and Arnold, 1996).

Vickery (1991) proposed three-stage strategy model that links the business strategy with the manufacturing strategy through the choice of competitive priorities. Model is in line with Wheel Wright (1984) that claimed that manufacturing strategy should reflect the priorities of the business strategy. The first step of the Vickery (1991) model refers the competitive priorities identification based on a business strategy. Secondly, company sets objectives for the performance measures to each competitive priority and further defines and implements the structural and infrastructural decisions coherent with the competitive priorities.

Kim and Arnold (1996) researched the coherence between the manufacturing strategic task and the allocation of resources to diverse improvement programmes. They argues that the competitive priorities should be linked directly with the choice of the improvement programmes. The identification of competitive priorities that are key capabilities that company aims to develop to gain a competitive advantage, starts the manufacturing strategy formulation. The next step is to determine the performance measures that support the competitive priorities. Rather than focusing on the traditional costs accounting measures, company should chose the various operational measures linked manufacturing objectives. Eventually, the choice of the future improvement programmes based on the particular objectives and expected results is made.

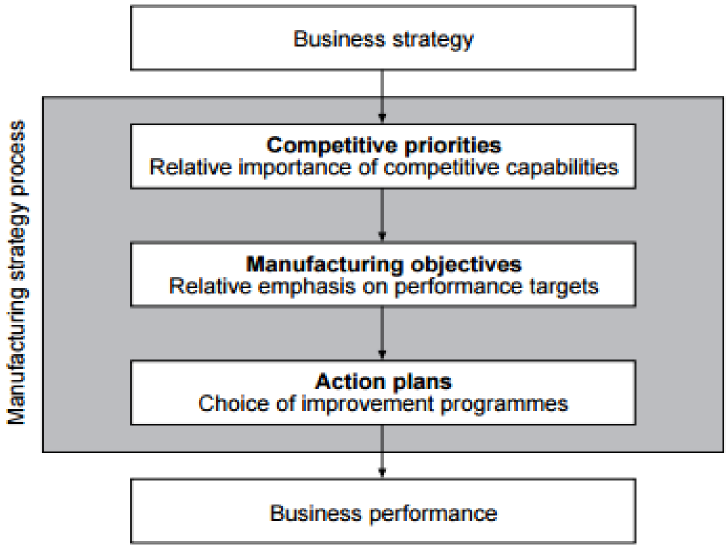


Figure 7 Manufacturing strategy process (Kim and Arnold, 1996)

Competitive priorities as an input to improvement programme

Kim and Arnold (1996) and Hines et al. (2004) suggested that improvement programme is a central element of manufacturing strategy. Therefore, company should focus at the right choice of programme that improve the organization competitive priorities. Therefore, it is essential to consider how the improvement programmes are related to the competitive priorities (Anand and Rambabu, 2009).

Competitive priorities are an important input into the manufacturing strategy for that reason that they define the improvement goals (Kim and Arnold, 1996, Cagliano and Spina, 2000) and future performance requirements (Vickery, 1991). Skinner (1969) early defined three basic competitive priorities: cost, quality and delivery. However literature encompasses; cost importance, quality importance, delivery time importance and flexibility importance (Ward et al., 1998, Vickery, 1991, Ferdows and De Meyer, 1990). In the more recent researches the innovativeness in products and services

(Leong et al., 1990) and sustainability (Kleindorfer et al., 2005) have been recognized as another important competitive priorities. Vickery (1991) proposed a term manufacturing competitive priorities that includes cost, flexibility (volume, product mix), quality (design and conformance) and delivery (dependability and speed).

Table 1 A review of the competitive priorities

Reference \ Competitive priorities	Cost	Quality	Delivery	Flexibility	Dependability	Service	Innovation	Sustainability	Responsibility
Skinner (1969)	•	•	•						
Hayes and Wheelwright (1984)	•	•	•		•				
Ferdows and De Meyer (1990)	•	•	•	•					
Leong et al. (1990)	•	•	•	•			•		
Chase et al. (1990)	•	•	•		•	•	•		
Vickery (1991)	•	•	•	•					
Garvin (1993)	•	•	•		•	•	•		
Kim and Arnold (1996)	•	•	•	•		•			
Ward et al. (1998)	•	•	•	•					
Mills et al. (1998)	•	•	•	•			•		
Kleindorfer et al. (2005)	•	•	•	•				•	
Miltenburg (2009)	•	•	•	•	•		•		
Netland and Frick (2017)	•	•	•	•	•	•	•	•	•

Netland and Frick (2017) compared different competitive priorities of European manufacturers based on the International Manufacturing Strategy Survey databases across 20 years. The results show that quality and dependability have still the highest priority for European manufacturers. The lowest priority have social responsibility and sustainability and while the flexibility and innovation getting more attention in the recent years. Cost priority changes the most and is highest at the economic crisis period. In addition, the importance of speed is increasing while companies losing the attention around the service. This research although performed only on the European manufacturers, shows clearly the recent trends and what should be taken into account while developing capabilities to achieve a competitive advantage. Table 1 summarizes the review of competitive priorities.

The operations strategy literature suggest two main opposite approaches in regards to the competitive priorities development. Skinner (1969) suggests that a company should focused and develop only those capabilities that support the strategy. Hill (1997) in his definition recognized the importance of exploiting the core competences in gaining the competitive advantage. The approach suggests that a company has to choose the capabilities to develop because it cannot achieve the high performance for number of dimensions. The reason is that the improvement in one dimensions decreases the performance of other. It is known as a trade-off theory that is supported by number of researchers (Boyer and Lewis, 2002) .In contrast to this, De Meyer and Ferdows (1990) suggested that companies should develop the multiple dimensions simultaneously. The concept of cumulative capabilities known as a sandcone model (Flynn and Flynn, 2004, Ferdows and De Meyer, 1990) suggests that strong foundation of quality has to be developed first before a delivery, flexibility and cost effectiveness can be achieved subsequently. The model is presented in the figure 8.

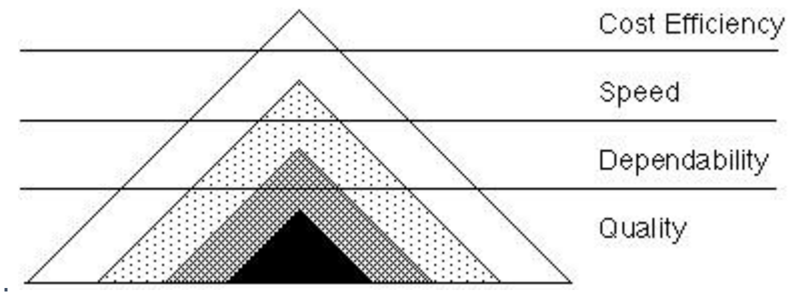


Figure 8 The sandcone model (Ferdows, 2004)

The model evolved after a number of Japanese manufacturers had managed to successfully develop two or more capabilities, without considering the trade-off between them (Nakane, 1986, Ferdows and De Meyer, 1990). Netland and Frick (2017) confirmed that the way companies develop their competitive priorities nowadays, supports the cumulative model. However, the results shows that the cost is higher prioritized than a flexibility, what is in line with the Nakane (1986) model but is in contrast to the sandocone model developed by Ferdows and De Meyer (1990).

Singh et al. (2014) presented four additional views on capabilities development. (1) In the treshold model, company achieves the excellence of one capability, developing the satisfactory level of other capabilities. This model is therefore in contrast with a Porter (1996) trade-off model. However, the similarities to the Hill's (1995) Hill and Hill (2009)framework can be observed. Hill and Hill (2009) defined aspects that separate the company from the others as order winner, while aspects that make company competitive as order qualifiers. Hence, according to the threshold model, company should be an order winner in one capabilities, while being the order qualifiers on the. In the next model, (2) multiple capabilities are developed without any pattern. It can be observed in the companies that are in a transition, postpone a strategic decision or are unable to deal with the complexity. (3) Author proposed an average model for the organizations that reach the average level of all capabilities. The choice either is intended because of e.g. high cost of developing certain capabilities or if reached level is acceptable. (4) Non-competitive model represents a company that has a level of capabilities worse than expected. This situation might occur under certain unexpected conditions in the environment.

The above literature review of the recent research on competitive priorities does not confirm the universal use of any of the models. It might rather suggest that development of competitive priorities follows the contingency approach (Schroeder et al., 2011) and that companies adapt them to current market requirements (Netland and Frick, 2017). This is in line with a concept of dynamic capabilities (Eisenhardt and Martin, 2000) that is highly recognized in the literature, but not always included in the manufacturing strategy implementation frameworks. These are "behavioral orientation constantly to integrate, reconfigure, renew and recreate its resources and capabilities and, most importantly, upgrade and reconstruct its core capabilities in response to changing environment to attain and sustain competitive advantage" (Wang and Ahmed, 2007). Therefore, dynamic capabilities should be considered when company implement the improvement programme.

3.2. Lean manufacturing

Section 3.2. aims to
1. Introduce origins of Lean manufacturing. 2. Explain Lean manufacturing content. 3. Investigate Lean implementation frameworks. 4. Review methods for measuring the Lean implementation. 5. Discuss the applicability of Lean in different production environments.
Terminology
Due to the continuous development of Lean manufacturing concept, there is no one, widely acknowledged definition in the academic literature. Therefore, for the purpose of this thesis, a definition that is a synthesis of various definitions (Womack et al., 1990, Liker, 2004, Shah and Ward, 2003, Hallgren and Olhager, 2009, Powell et al., 2014) depicted in section 3.2.1. has been proposed. *“Lean manufacturing is a philosophy, structured approach and a set of principles, best practices, techniques, methods and tools that aims to increase the efficiency of operations through the continuous elimination of waste, continuous improvement sustained by the commitment of all employees.”* The term *Lean manufacturing* is used interchangeably with the term *Lean* in this thesis.

This section presents Lean manufacturing as an improvement programme. The reason of choosing this aspect as a second section of a literature review is because Lean manufacturing is the foundation to development of company-specific production system XPS (Netland and Aspelund, 2014). Findings from this section are further utilized to support development of a framework for design and implementation of XPS.

The next section introduces origins of Lean manufacturing that is followed by section that depicts Lean principles and tools. Further, various Lean implementation frameworks are presented. The next section reviews how the Lean implementation is measured. Lastly, the applicability of Lean manufacturing in different production environment is discussed.

3.2.1. Origins of Lean manufacturing

Lean manufacturing evolved from the Toyota Production System (TPS) originated in Japanese's shop floor and particularly at Toyota Motor Corporation (Ohno, 1988). The way of Toyota manufactured their automobiles was developing an efficient and effective production system that required fewer resources, while was creating better quality products for the lower costs. Toyota turned their operational excellence into a strategic weapon (Liker, 2004). This system focused on the elimination of waste and maintaining a continuous improvement (Papadopoulou and Özbayrak, 2005) through full utilization of all employees to minimize cost (Sugimori et al., 1977). Waste is referred to every activities which are not adding the value (Melton, 2005) or the activities the customer is not willing to pay (Karlsson and Ahlstrom, 1996). Continuous improvement is a culture within the organization that everyone is involved and aligned to eliminate waste through both radical or incremental improvements and a philosophy that has a goal to reduce failures and increase a success (Bhuiyan and Baghel, 2005). Toyota Production System included concepts such as just-in-time (JIT), one-piece flow, jidoka or heijunka (Hines et al., 2004, Liker, 2004) that will be further explained in this section. Successful implementation of these tools however, was only possible due to the business philosophy that was focused on understanding of employees and their motivation to develop an ability to cultivate leadership, teams, culture and maintain continuous learning (Liker, 2004).

The term Lean was used the first time by Krafcik (1988) to describe the system that uses less resource and were later popularized in the book "The machine that changed the world" written by Womack et al. (1990). The book was an important outcome of the International Motor Vehicle Programme (IMVP) ran at the Massachusetts Institute of Technology that aimed to close the performance gap between the Japanese and Western automotive industries (Bhamu and Singh Sangwan, 2014). Womack et al. (1990, p.13) described Lean manufacturing as a production system that *"uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever grooving variety of products".* After the 1990, focus of Lean expanded from the shop-floor and highly prescriptive practice approach, to the level of value stream and an approach that aims to continuously increase the value to customer by further removing waste, broadening a project portfolio or adding feature to products (Hines et al., 2004). Lean manufacturing requires focus to make the one-piece product flow only with value-adding processes without any interruption, a pull system that replenishes components only when the downstream operations needs it and cascades backwards to the beginning of the manufacturing process to meet a customer demand and a culture of continuous improvement (Liker, 2004). This approach was perceived as a "one best way" for cost reduction and increasing a productivity. Several studies confirmed that Lean manufacturing besides providing a better quality and higher productivity, gives a better customer responsiveness (Krafcik, 1988). Later, the focus of Lean manufacturing spread beyond a single enterprise and encompassed the entire value chain from the supplier of raw material to the end customer (Rother and Shook, 2003). Through the years of development Lean manufacturing expanded from Toyota's production toolkit to the complex Lean business system (Stålberg and Fundin, 2016).

The long-lasting Lean manufacturing evolution brought a confusion regarding its definition. The disagreement regarding definition exists due to the confusions about what Lean in fact includes and encompasses and what does not (Hines et al., 2004, Bhamu and Singh Sangwan, 2014, Shah and Ward, 2007). According to the researchers Lean is a process of change (Womack, 1990), a philosophy that reduces the time from a customer order to delivery by reducing waste (Liker, 1996). It is a multi-dimensional approach that contains just-in-time, quality systems, work teams, cellular manufacturing and supplier management (Shah and Ward, 2003), is a management philosophy focused on identifying value and waste elimination throughout entire supply chain, is a program that aims increasing the efficiency of operations (Hallgren and Olhager, 2009), and a philosophy and set of tools that targets to identify and eliminate waste (Powell et al., 2014).

For the purpose of this research the definition of Lean has been developed, which includes the principles the most researchers are agreed on:

"Lean manufacturing is a philosophy, structured approach and a set of principles, best practices, techniques, methods and tools that aims to increase the efficiency of

operations through the continuous elimination of waste, continuous improvement sustained by the commitment of all employees."

3.2.2. Lean Manufacturing principles and tools

The constant development brought unambiguity concerning also the content of Lean (Bhamu and Singh Sangwan, 2014). Womack et al. (1990) proposed the set of fundamental Lean principles that further evolved into various Lean manufacturing models that discuss the content of Lean (Shah and Ward, 2007, Åhlström and Karlsson, 1996). Womack et al. (1990) depicted those fundamental principles in a highly acknowledged sentence - " Specify value, line up value-creating actions in the best sequence, conducts these activities without interruption, whenever someone requests them, and perform them more and more effectively" (p.15) Womack et al. (1990). Table 3-4 outlined those Lean principles.

Table 2 Lean Principles (Womack and Jones, 1990)

Principle	Description
Value	"Capability provided to customer at the right time at an appropriate price, as defined in each case by the customer" (p311) Value must me expressed in terms of a specific product.
Value Stream	Set of activities required to create a product from its concept launch until the products is delivered to the end customer. In order to create a value stream, all stages must be defined. There can be defined three types of activities: - Value-added: activities creating value - Types One Muda: No value-added activities but they are unavoidable - Type Two Muda: No value-added activities, can be avoid Muda – Japanese word for waste
Flow	Quick changes, right sizing and sequential steps instead of traditional batch-and-queue system to achieve the flow of product with no stoppages, backflow or scrap.
Pull	System of organizing production in which nothing is produced by the upstream supplier until it gets a signal from downstream supplier that there is a need for product. This system avoids the building-up inventory and allow being responsive to the customer.
Perfection	The elimination of muda so there are only value-added activities along the value chain. Striving for perfection is a never-ending process, where the end-state cannot be achieved.

Bhamu and Singh Sangwan (2014) reviewed 209 research papers concerning Lean manufacturing and claimed that scope of techniques and methodologies is constantly expanding. In addition, tools and techniques have multiple names and some of them are even overlapping or particular tools might have a different method of implementation that is proposed in different articles. For the purpose of clarity, this thesis uses a model of Toyota Production House (Liker, 2004) to discuss further a content of Lean manufacturing. The Toyota House is presented in the figure 9.

Figure 9 The Toyota Production House (Liker, 2004)

The analysis of the Lean elements starts from its fundaments: *philosophy*, visual *management, stable and standardized processes and Heijunka.* Next, the middle pillar with *people, continuous improvement and waste reduction* is presented. Further, two side pillars, *just-in-time and jidoka* are discussed*.* Roof of the Toyota House represent goals of Lean such as best quality, lowest cost, shortest lead-time, best safety and high morale.

Figure 9 The Toyota Production House (Liker, 2004)

Philosophy

The bottom of the fundament consists of Toyota Way *philosophy*. The core of the philosophy is that “the culture must support the people doing the work” (Liker, 2004).

Philosophy as a basic way of thinking contains elements such as; customer first, focus on people, learning and continuous improvement.

Visual management

Visual management is a communication device (Motwani, 2003) and techniques that give visual suggestions whenever the abnormal situation appears. It can be applied to machine, line, arrangement of good and tools or inventory (Ohno, 1988). Motwani (2003) suggested that the 5S is proper technique to start. Hence, it makes a foundation for other elements. 5S is a waste reduction tool that focuses on an effective organization of workplace and the standardization of work procedures. 5S includes elements such as

- *Sort:* sort and keep only what is needed
- *Straighten*: everything is kept is its place
- *Shine*: is a cLeaning process that exposes abnormal conditions that could hurt a quality.
- *Standardize*: develop procedure to maintain first three Ss.
- *Sustain:* continuous improvement that aims to maintain a stabilized workplace

Stability and standardization of processes

Stability and standardization are fundaments of Toyota house that are essential to achieve operational excellence. Standardization aims to create processes and procedures that can be repeatable (Bicheno and Holweg, 2009) so they can be continuously improved. It is however important that the rigidity of the standards allows to be innovative and creative while being specific enough to provide a useful guidelines. Standards should be specific enough to function useful guidelines, but still allow for certain degree of flexibility. It is important, that all the employees that work close to processes continuously improve these standards. Therefore, standardization builds a foundation for continuous improvement, innovation and growth of employees (Liker, 2004). Next to the standardization, TPS requires a stability that can be achieved through the tools and techniques such as visual management or heijunka,

Heijunka

Heijunka is a production technique to level a demand by volume and product mix that allows to keep the production level constant and stable, and to balance the use of labor and machines (Liker, 2004). The total order volume for a certain period is divided and levelled, so that the same amount and product mixed is appointed for each day and the big batches are avoid. Small batches that are run more frequently highlight early problems and does not hide quality issues (Bicheno and Holweg, 2009). The buffer stock is being hold in order to meet the demand, if the demand is fluctuating (Liker, 2004) or there has been a production stoppage. Heijunka provides a flexibility to produce what customer wants and when he wants it, hence it reduces a risk of unsold products.

Continuous improvement

Continuous improvement is a center of the Toyota House, hence the perfection is a goal (Åhlström, 1998). It is a continual search for the improvements in quality, cost, delivery and design (Bhasin and Burcher, 2006). Bhuiyan and Baghel (2005) defined the continuous improvement as a culture, which involves everyone in the company in order to eliminate the waste, through both incremental and radical improvements. Japanese word for improvement is kaizen and it teaches how to work effectively in small groups, how to solve problems, collect, document and analyze data to improve processes. It gives a power of proposal making to shop-floor workers and any decisions requires open discussion and consensus before is implemented (Liker, 2004).

People

Most of researchers agreed that *people* are critical to the implementation of Lean and they are a heart of the Lean organization (Womack et al., 1990), because only through people, operations can achieved needed stability (Liker, 2004). It is important that the Lean philosophy be shared by all employees at all organizational levels. Regular training is required to enable a faster respond to changes in products and processes (Zhou, 2016) and solve problems at the root (Liker, 2004). Motwani (2003) summarized that the crucial is “pulling the entire organization together on a common journey with a common language.” People are engaged in decision/making and through the suggestions programmes employees are engaged in continuous improvement.

Waste reduction

Eliminating of waste, or in Japanese muda can exists according to Ohno (1988) “seven” forms: (1) overproduction – manufacturing products that there are no orders for, (2) waiting –waiting for the next process, tools or part due to the stock out, delay, equipment breakdown or bottleneck, (3) transport – such as moving material, carrying work in process (WIP) or finish goods to the storage, (4) inventory – excess raw material, WIP, finished goods etc., (5) over processing – processing that is unneeded due to the e.g. bad quality tool or poor product design (6) motion – any movement that employees make during the process, (7) defects – manufacturing of defective parts, rework, scrap etc. Liker (2004) suggested eighth waste in form of unused employee creativity such as skills, ideas or learning opportunities.

Just-in-time

Just-in-time is one of the pillars TPS and is described by Sugimori et al. (1997, p.555) as a method whereby “the production lead time is greatly shortened by maintaining the conformity to changes by having all processes produce the necessary part at the necessary time and have on hand only the minimum stock necessary to hold the processes together”. It aims to eliminate all forms of waste and respond quickly to daily shifts in customer demand (Liker, 2004). Two main sources of wastes are work-in-process (WIP) inventory and delays in flow time. JIT reduces production lot sizes, through production leveling (Ohno, 1988) that are produces with short lead time (Liker, 2004). Shah and Ward (2007) claimed that JIT requires practices such as cycle time reduction, quick changeover time to decrease WIP and cellular layout and bottleneck reduction to decrease flow time delays.

Takt time planning is a concept that represents a uniform rate of how the products progress throughout the production stages to satisfy a demand. It synchronize the rate of production to the rate of sales (Womack and Jones, 1996). If the process is faster than a takt time, it overproduces, while if it is slower, it creates a bottleneck (Liker, 2004). Takt time is fundamental for the mapping and achieving a flow. It represents an available work time divided by an average demand per day (Bicheno and Holweg, 2009).

Continuous flow aims to move from a batch production to a one-piece flow, meaning that a single unit moves between processes. Production is organized in cells that consists of people, machines or workstations closely arranged where one unit at the time flows through operations at a rate that is determined by the customer needs. (Liker, 2004). It focuses on stability, continuity and reduction of waste such as waiting, move, scrap to achieve the continuous flow - without any queue or delays between steps (Bicheno and Holweg, 2009, Womack and Jones, 1996) and helps to identify inefficiencies in a system (Liker, 2004). Liker (2004) claimed that one-piece flow brings number of benefits. It gives a better quality since every operator inspects a product before sending it to the next operation. It creates flexibility since a lead time is short and a changing to different product mix can be done rapidly. It gives higher productivity since one-piece flow reduces non-adding value activities and it is visible which workers or machines are free and idle. Achieving a flow frees up floor space due to the close distances between the machines in the cell setting and reducing space needed for inventory. It improve safety due to the less movement and transporting heavy products, morale since workers can see effects of their work and reduces costs of inventory .

Pull system is categorized as one of the ten dimesons of Lean system (Shah and Ward, 2007). It is a material replenishment system that is initiated by a consumption and is an important principle for achieving just-in-time (Liker, 2004). The Pull system is the scheduling principle, means that the upstream process does not start until the downstream process requires it. It is a system based on consumption at the previous process (Bicheno and Holweg, 2009). Pull can be driven through the pull mechanisms such as Kanban. (Womack et al., 1990, Bicheno and Holweg, 2009). Kanban can have a form of signs, boards, card, box that is sent to the upstream process to signalize a need of replenishment and trigger production and delivery. Kanban includes a number and information of parts and its location. Kanban system can include small inventory or parts buffers that can occur due to the natural breaks in flow (Liker, 2004)

Quick changeover time. Success of Toyota Productions System was achieved due to the inter alia Shingo's and Ohno's methods to reliably reduce a changeover time. It is a change of the production process from processing the current product to prosessing the next one. Method, termed Single Minute Exchange of Die (SMED) was first introduced on big stamping presses for producing the side panels where dies had to be changed for each model. Toyota aimed to reduce the changeover time from more than twelve hours to ten minutes, to achieve a goal of reducing the economic lot size to below the one car (Bicheno and Holweg, 2009, Ohno, 1988).

Integrated logistics aims to agree with suppliers more frequent delivery, so the JIT can be achieved. Suppliers need to have ability to deliver high-quality products.

Jidoka

Jidoka as a second TPS pillar is a quality approach that aims to make the problem immediately visible as it occurs, what prevents for moving the problem downstream. It often referred as autonomation that includes the equipment with a degree of human intelligence the automatically stops the production when the problem is detected. As Lean requires the minimum levels of inventory, Jidoka focuses on making the right thing at the first time. Jidoka uses a light signal in a form of andon to signalize whenever help is needed, so workers can quickly resolve a problem and resume production (Liker, 2004). Methods such as 5 whys helps to find and analyze a source of the problem and chose a right solution. Jidoka uses also Poka-yoke which is a fail proofing devices that prevent defects through e.g. process will not start if the step is forgotten, or if there is irregularity in the material, or if there is a working mistake (Ohno, 1988).

3.2.3. Lean manufacturing implementation

The number of organizations that implemented Lean programmes have increased rapidly in the recent years (Bhamu and Singh Sangwan, 2014). Many studies have confirmed positive relation between an operational performance and the implementation of improvement programs such as Lean (Netland et al., 2015). However, still many implementations fail due to the reason such as lack of understanding Lean (Shah and Ward, 2003). The academic literature does not provide any general accepted framework or guideline for the implementation. The number of frameworks is diverged, due to the continuous development of Lean concept and different perspectives on definition and scope. Therefore, a question how to implement the improvement program is still valid and not fully answered. As the implementation methodology in the literature is divergent, it is therefore difficult to generalize (Papadopoulou and Özbayrak, 2005). Certain researches propose complete frameworks in forms of roadmaps, model or assessment initiatives (Mostafa et al., 2013), while other focus on the particular elements, components, techniques and tools (Papadopoulou and Özbayrak, 2005). The review below aims to point out the fundamental and common elements of the implementation.

Lean implementation frameworks

Womack and Jones (1996) suggested a four-stage implementation process where each stage is related to a certain time period - Lean leap: (1) *get started* which lasts the first six months, is the challenging phase due to the organization's inertia. At this stage, Lean agent should be appointed and a core of Lean knowledge should be established. First phase includes also mapping a value stream and introducing kaikaku as a radical change to value-creating activities, starting with the ordering system in facilitates producing results. (2) *Create a new organization*, lasts from six months to the second year. It refers to organizing the firm by a product family and expanding the improvement to the rest of organization. It requires creating a mind-set of continuous improvement by all employees. (3*) Install business systems*, lasts from year three to year four and focuses on sustaining the improvement through teaching, rewards, keeping scores and mechanisms that allow prioritizing further improvements. (4) *Completing the transformation* takes time and usually ends by the end of fifth year.

Åhlström and Karlsson (1996) suggested that Lean manufacturing contains five elements: Lean product development, procurement, manufacturing, distribution and Lean enterprise. Authors proposed a framework that is based on following aspects of Lean: elimination of waste, continuous improvement, zero defects, just-in-time, pull instead of push, multifunctional teams, decentralized responsibilities, integrated functions and vertical information systems. Based on the framework authors investigated an impact of Lean aspect on remuneration system.

Karlsson and Ahlstrom (1996) developed also an assessment model that investigates a company changes towards Lean. Authors defined number of determinants within each Lean manufacturing principle proposed earlier by (Womack and Jones, 1996). These determinants are measurable and intend to reflect the changes toward Lean. Authors emphasized that Lean is direction rather than a state. Therefore, implementation focus should lie on the changes within each determinant. This model is recommended as a tool for practitioners to follow the progress in achieving Lean production.

Sanchez and Perez (2001) proposed an implementation framework that similarly assesses changes toward Lean. Authors developed a checklist that consists of total 36 indicators that are categorized by the principles: elimination of zero-value added activities, multifunctional teams, and continuous improvement. JIT production and delivery, integration of suppliers and flexible information system. Each indicator asses the contribution towards Lean manufacturing and performance improvement.

Anvari et al. (2011) constructed a dynamic model for a Lean roadmap. It contains five, main phases. First phase starts with assessing the company regarding the existing situation, commitment of management and Lean knowledge. When these determinants are achieved, company moves to the second, preparation stage that includes strategic planning and establishing a Lean office. The next, pilot phase begins with creating a value stream mapping (VSM) that is followed by obtaining a continuous flow, stability, flexibility and pull systems. Further, company expands the scope to the whole system and seeks a perfection through a measurement and continuous improvement.

Mostafa et al. (2013) proposed a four-phase implementation framework that begins with the conceptualization phase, in which company selects and trains all the employees that have a responsibility for an implementation. Implementation design phase consists of current situation analysis using questionnaires, SWOT and VSM and aims to identify waste. Based on the current state and gap analysis company generates a future state VSM and transformation plan. The implementation and evaluation phases are merged together. The evaluation is an iterative process that aims both standardize and validate the implementation results. The complete Lean transformation ends as the Lean practices are expanded and standardized. Throughout all phases constant monitoring and controlling is performed to deliver the expected results. Each phases consist of a milestone that if achieved gives a signal that company can move to the next stage.

Nordin et al. (2012) developed a framework that comprises two main circles, readiness for change and implementing change. Before the readiness is achieved, company has to establish the urgency needs. Each of the circle consist of few drivers of change that has to be communicated across the organization and established by the top management. Top management ensures that all employees understand a vision and goals of the implementation. The readiness for changes circle contains phase such an understanding of a need for change, leadership and direction and creating change agent team as a system that assists the translation of the change process. The next circle, implementing a change is critical and can be only achieved when the implementation is aligned in the organization, so all employees are aware of the value their impact can have on a Lean change and understand how this changes can be made. Nordin et al. (2012) also stressed that the implementation is dynamic since the Lean implementation is direction rather than state. Implementation is driven also by the empowerment by the means of training, motivation and rewarding system. The last driver is a system and control that assess efforts and the implementation progress towards Lean.

Bhasin and Burcher (2006) viewed the Lean implementation as a long journey where the continuous improvement approach has to be adopted in order to achieve the high degree of Leanness. Authors agreed that Lean manufacturing consists of technical and cultural requirements. They included ten Lean tools that are included in technical aspects, such as kaizen, cellular manufacturing, kanban, process mapping, SMED, single piece flow, kaikaku, supplier base reduction, 5S, value, seven waste and visual management. Authors emphasized the need of implementation all tools due to their interconnectedness, rather than a single tool use.

Jina et al. (1997) proposed a diagram that is suit to the high variety and low volume production. Diagram includes elements such as product design geared to logistics and manufacture, organizing manufacturing along Lean principles and integrative supplier relationships. The center of a framework contains Agile, process-oriented organizational capabilities.

The progression of Lean implementation is an important discussion and lack of ambiguous implementation sequencing and direction are according to Bhasin and Burcher (2006) major barriers to implementation. Motwani (2003) emphasized that the full potential of Lean can be achieved only if all Lean initiatives are implemented. Hayes (1998) argued that some of the practices such as scheduling systems and reduction of set-up time are interrelated and therefore cannot be implemented separately. Anand and Kodali (2010) stated in line with Hayes (1998) that not all the practices have to be applied in order to benefit from the Lean improvement. He pointed out however, that some of the practices has to be implemented in a step-by-step approach as for example, lot reduction and kanban can be only successful if the setup time has been reduced and the quality level of the assembly lines has been increased. Authors also pointed out the lack of focus in academic literature concerning the sequences of implementation.

Lean implementation sequence

Marodin and Saurin (2013) reviewed 102 Lean related studies and inferred that Value Steam Mapping (VSM) is a common beginning step of the Lean implementation. VSM is a tool that developed by Rother and Shook (2003) based on the initial work made by Hines and Rich (1997) which was a response to the seven types of waste identified by Ohno (1988). VSM allows visualizing the performance and conditions of production system. VSM visually present both value-added and non-value added activities during the process of transformation the products. The mapping process consists of creating the current state map and the future map on the initial part of the project. VSM often includes time in process, waiting buffer, time in the inventory but it underestimate the relevance of quality, cost and customer satisfaction (Wan et al., 2007).

While the VSM that is performed at the facility level it is always concerned with the overproduction as the worst waste (Ohno, 1988), processing, defects, waiting and motion (Rother and Shook, 2003). When the flow of products and information is seen from the manufacturing network perspective that encompasses all subsidiaries, it also looks at the overproduction due to the inconsistent information flows between facilities. However, it mainly focuses on the unnecessary inventories and transportation (Jones et al., 2003). Better management of information flows and logistics that aims to optimize performance of all subsidiaries simultaneously rather that an individual plant can be achieved through extended value stream mapping (EVSM) (Jones et al., 2003).

Åhlström (1998) investigated sequences of the improvement activities implementation and claimed that the zero defects systems and the delayering are being important to adopt at the early phase. Quality systems give better results if the customer is involved from the beginning, while delayering improves decision-making and communication. Elimination of waste, pull scheduling and the multifunctional teams are interconnected core principles, hence they require a vast resources and management effort throughout the entire implementation. Vertical information and team leaders have supportive function to core principles, thus contribute to the increase of performance. They require resources and efforts throughout the entire process of implementation. At the later stage, more resources has to be involved in maintaining a continuous improvement (Åhlström, 1998).

As the review of implementation framework confirmed, there is no clear agreement concerning the implementation of Lean, neither on classification of phases nor steps and elements. However, researchers are aligned that the Lean manufacturing implementation must consists of both *technical elements* such tools or methods and the *organizational elements* such as employees' involvement. This review does not include existing Lean implementation framework but is a representative sample that aims to compare and depicts most used and common elements of framework. Reviewed framework tend to be universal (with notable exception of (Jina et al., 1997)) and does not consider any contextual factors. In addition, frameworks do not focus on the simultaneous implementation of Lean in multi-plant company, where some of the plants may operate in different production environments.

3.2.4. Organizational factors of Lean implementation

The importance of organizational factors in successful Lean implementation is widely accepted in the academic literature. Bhamu and Singh Sangwan (2014) emphasized the *Lean awareness program* should be first established to make all the employees familiar and conscious to the Lean approach. The goal of awareness program is to *align all employees* across organizational levels and assure the common understanding of Lean *vision* and goals. It facilitates building an organizational *culture* that support workers doing their work (Liker, 2004) and proactive approach that sustains an improvement (Saad et al., 2006). Building a *common platform* for the Lean implementation begins with a high level of *committed top management*. Lean tools cannot be effectively implemented without the right management (Liker, 2004). Top management should be able to identify effectively Lean drivers and barriers to develop an effective implementation and post-implementation plan. Top management have to understand the processes at the shop floor through genchi genbutsu (or gemba) which means "to go and see" the actual situation for full understanding (Liker, 2004). Nonetheless, the committed top management is able to facilitate the integration of infrastructure only if possesses *strong leadership* abilities. Those abilities enhance acquiring and developing capabilities and knowledge among employees. Strong leadership and skills are one of the critical success factors that allows gaining a maximum outcome from Lean implementation maintaining the vision and keeping employees motivated (Saad et al., 2006, Nordin et al., 2012).

Motwani (2003) suggested that *training* should start with the top-management to create Lean *experts* through seminars outside the organization. He sees Lean as a corporate vision, hence senior management support is critical. Manville et al. (2012) emphasized however that the vital is that middle management get a bigger role in performance improvement and strategy formulation. The focus *on effective communication, common language and training* increase the employee awareness of the Lean journey and maintain *commitment* to attain the long-term benefits (Motwani, 2003, Bhamu and Singh Sangwan, 2014, Nordin et al., 2012). Karlsson and Ahlstrom (1996) pointed out that the miscommunication leads to the misleading of Lean concept and is an essential barrier to implementation. Effective communication can be achieved by information transparency, sharing of knowledge, learning and evaluation of Lean efforts (Nordin et al., 2012).

Netland et al. (2015) investigated relations between the control practices and implementation of Lean. They emphasized that the choice of certain control practices, that control input, process and output can enhance or hinder the improvement program implementation. They documented that the organizations that have the *dedicated implementation team* as an input control practice have more extensive implementation of Lean. This view is consistent with Kotter (2007) who suggested that a *dedicated and proactive team* that includes employees from all the organizational level and have a supportive role could enhances the implementation of Lean. Netland et al. (2015) argued that having a cross-organization dedicated team can secure that the all levels of firm have an equal awareness of Lean and it can provide a coordination platform function. In addition, dedicated team is often well trained and can provide a relevant knowledge and support to shop-floor workers for searching the shop-floor level improvements. However, the opposite view of Boppel et al. (2013) who argueed that the dedicated team does not necessarily enhance the implementation, because it can perceived by the shop-floor as an indicator that Lean is an only project, not a journey and continuous improvement process, hence can hinder the implementation. Netland et al. (2015) suggested also the nonfinancial *rewards* has a positive impact on the

Lean implementation. Introducing reward and recognition system may help to keep high level of employee's engagement in Lean journey.

3.2.5. Lean performance measurement

The implementation of the improvement programmes such as Lean is never-ending process, since the approach is based on continuous improvement Therefore, the performance progress must be constantly monitor (Liker, 2004). This section reviews the different views on how to measure the Lean implementation.

Performance measurement

Performance measurement is a process of quantifying action, which leads to change in performance. It relates the decisions what to be measured, how to measure and ultimately how to react to the measurements' results (Sjøbakk et al., 2015). The two fundamental dimensions of performance are effectiveness and efficiency. Greater efficiency and effectiveness is a key to the success to achieve the organization goals. Effectiveness shows to which extent the customer requirements are met, while efficiency mirrors the way in which the resources are utilized when delivering a product/service with a certain level of customer satisfaction. The level of performance that company can achieve is a function of the effectiveness and the efficiency of the action it performs, and can be represent by set of performance (Neely et al., 1997, Sjøbakk and Bakås, 2014). The goal of measuring the shop-floor performance is to encourage employees to be responsible for improving their activities in order to support the strategic goals (Bond, 1999).

The literature around the performance measurement is broad and diverse, because of the different aspect focus. In the earlier years, the performance was measured mainly in terms of financial ratios (Behn, 2003, Sjøbakk and Bakås, 2014). However, those costing and accounting systems have been lacking both the strategy focus, short-term goals priority and have been not considering the external factors and they have not been enhancing the continuous(Bhasin, 2011, Kaplan and Norton, 1996). In response to those cons, the mutli-dimensional and more balanced approach between non-financial and financial measures has been established(Norton and Kaplan, 1993, Bhasin, 2008). Number of substitute methods have been introduced, in order to handle with the limitations of the traditional, financial PMS.

Performance measurement of Lean implementation

The many Lean performance measurement systems are built upon the model developed by Karlsson and Ahlstrom (1996) that assesses the changes towards the Lean manufacturing. The model is limited to the factors related to the manufacturing part of the company and work organization within it. Authors defined the nine indicators based on the main Lean principles; (1) elimination of waste, (2) continuous improvement, (3) zero defects, (4) JIT, (5) pull, (6) multifunctional teams, (7) decentralized responsibilities, (8) integrated functions and (9) vertical information system. The determinant are indicators representing changes that have been used further to determine operationalized measurements and the desired direction of indicator towards Lean. Authors recognized a difference between the determinants and the performance of Lean production system. Factors - increase of productivity, shorter lead times, reduce cost are the goals of Lean production implementation, hence they can assess the overall performance of Lean system. Thus, the changes, implemented principles and actions taken are determinants, which are carried in order to reach the desired performance Karlsson and Ahlstrom (1996). Model assumes that Lean is a direction not a state, so it takes into account the change of determinants, not the values (Karlsson and Ahlstrom, 1996, Womack and Jones, 1996). The model is focused however on the single changes rather than the overall level of Leanness, which can be treated as a weakness of this method.

Gulshan and Singh (2012) proposed a survey that defines the status of Lean manufacturing. The status can be assessed from the response to the questions, which framed nine parameters created by (Karlsson and Ahlstrom, 1996). Questionnaire contains 53 questions with the seven point Likert scales (from strongly disagree to strongly agree). The parameters were not assessed equal. The weight to each parameter was determined by the analytical hierarchy process. The most important parameter was elimination of waste and followed by JIT deliveries and multifunctional teams. The result shows that the all parameters are complementary to each other, means that if there is improvement made in any of the parameters the others also get improved and the overall Lean performance is increasing. It has been shown that the JIT deliveries is a main driver influencing the Lean manufacturing performance. Continuous improvement and multifunctional teams are following. (Gulshan and Singh, 2012) However, companies are still overlooking the importance of Elimination of Waste as a most important Lean parameter as it is utilize the resources and maximize the productivity of an organization (Motwani, 2003). Soriano-Meier and Forrester (2002) carried a survey on 30 firms based on 9 variables from Karlsson and Ahlstrom (1996) to determine the degree of Leanness.

Manotas Duque and Rivera Cadavid (2007) also adapted the dimensions from Karlsson and Ahlstrom (1996), but they defined the relationship between Lean activities and Lean metrics. They narrowed down dimensions to elimination of waste, continuous flow and pull-driven systems, continuous improvement, multifunctional teams and information system. Authors defined metrics inside those dimensions. The weakness is that the framework has been not confirmed with any data, survey or a case.

Bhasin (2011) developed an audit that allows to assess in what stage of Lean journey company currently is. He defined twelve categories and respective 104 indices. Later, the scoring system was divided among seven phases from the planning level to the Ideological, which is a tantamount level. Audit was performed in 20 organizations (Bhasin, 2011).

Behrouzi and Wong (2011) proposed a self-benchmarking for assessing the Leanness. They used a fuzzy membership functions, where Lean measures are quantified by comparing current performance to the benchmark from historical data. Lean performance attributes have been defined and performance metrics for each attribute. Waste elimination as quality, cost and time, JIT as a delivery performance in addition to Continuous improvement which should happen at all stages. The weakness of the method is that it does not concert any aspect of the human resources and the quality is represented only with the one measure of number of scrap.

Bayou and de Korvin (2008) and Bhim et al. (2010)developed a relative measure used a fuzzy logic as well. The first authors stated the Lean is a matter of degree and defined attributes as a JIT, kaizen and quality control. They have tested the model by comparing the Leanness of GM and Ford, using Honda as a benchmark. They are taking into account only few determinants of Leanness, which is a weakness of this approach.

Fullerton and Wempe (2009) stated that is crucial to take both non-financial and financial measures to assess the performance of Lean. They discussed four categories of hypotheses that were tested further in a survey on 121 manufacturing companies. First category considered link between shop-floor involvement to setup time reduction, production quality improvement and cellular manufacturing. The second category discussed the relationship between non-financial manufacturing performance and Lean activities. The third category contained relationships between profitability and Lean activities and the least category checked the links between financial and non-financial performances. They have proved that non-financial measures convey the relationship between financial performances and other Lean practices

Wan et al. (2007) proposed a methodology to measure quantitatively the overall Leanness of a VSM. VSM allows visualizing the performance and conditions of production system, but the measure of overall Leanness is not visible. Research aims to propose a methodology to measure the overall Leanness of a VSM represented by input variables: Cost, Time and Value as an output. Since the VSM does not provide the information of product value or costs, that information must be collected in addition to time-related data. The overall score illustrated how Lean the company is and the slack values can give a possibility for improvement (Wan et al., 2007). However it does not exactly determinate the source of waste but only how much waste currently exists in the system. In addition, the method does not focus on the quality and has not been supported by any of the cases studies, what contests its reliability.

Azharul and Kazi (2013) argued that feedback loop for continuous improvement was not presented in the previous researches They defined a methodology for Leanness evaluation metric using continuous performance measurement CPM – Leanness evaluation metric of both efficiency and effectiveness attribute of manufacturing performance (Azharul and Kazi, 2013). The methodology does not cover the continuous improvement aspect.

In another research, Pakdil and Leonard (2014) argued available frameworks and created the LAT – Leanness assessment tool to measure the effectiveness and efficiency of the Lean implementation throughout entire business. This was the first tool, which is using both quantitative and qualitative approaches. They defined eight quantitative performance dimensions, which use ratio-based approach and fuzzy logic- along with detailed sub-performance indicators – related to the seven types of waste (Pakdil and Leonard, 2014). Further, author utilized the radar charts to immediate to the strong areas and areas, which need to be improved. However, the tool is very complex and requires a vast amount of data.

3.2.6. Applicability of Lean in different production environments

Lean manufacturing and its constituents such as planning and production method just-in-time from early years was recommended for repetitive manufacturing which is "a *repeated production of the same discrete products or families of products. Repetitive methodology minimizes setups, inventory and manufacturing lead-time by using production lines, assembly lines, or cells. Products may be standard or assembled from modules" (Cox and Blackstone, 1988 cited in Papadopoulou (2013).* Production that represents a non-repetitive manufacturing is often associated with job-shop – a production setting with a functional layout that by having similar purpose machines grouped together produces high variety products in low volume. This production environment is termed High Variety-Low Volume (HVLV) and the application of Lean manufacturing in this production environment has been discussed recently in the academic literature (Powell et al., 2014, Matt, 2014, Buetfering et al., Alfnes et al., 2016).

Production environment has various definitions, however many of them are related to the positioning of the customer order decoupling point (CODP) as a main factor to distinct the environment (Gosling and Naim, 2009, Olhager, 2003, Powell et al., 2014, Hoekstra and Romme, 1992). CODP is a point that separates those stages of supply chain that is driven by a forecast planning and anticipated demand, from that part driven by the customer order. This point has a strategic buffer function to respond to the variability in demand. It also helps to schedule the standardized parts while responding to the orders uncertainty. All products and information flows below CODP are pulled, while products and information flows above are driven by speculation and forecast (Gosling and Naim, 2009, Naim and Gosling, 2011, Olhager, 2003)

The common taxonomy contains four different production situations; Make-to-stock (MTS), Assemble-to-order (ATO), Make-to-order (MTO) and Engineer-to-order (ETO) differentiated by the CODP placement, (Olhager, 2003, Amaro et al., 1999, Sjøbakk et al., 2015, Bertrand and Muntslag, 1993, Wortmann, 1992). Make to Stock (MTS) is when finished goods are made based on forecast and receipt of customer order results in withdrawal of the product from the inventory (Hill,1993). Assemble-to-order (ATO) is a production situation where the products are customized to certain degree, but they are assembled from the standardized parts. This gives a possibility to assemble them in different options or configurations. Order triggers the assembly process, but the customized parts are purchased or manufactured according to the anticipated demand. Make-to-order (MTO) is the production situation where the most of the processes are triggered by the receipt of the customer order. There is a higher degree of product customization then in the ATO (Olhager, 2003). In engineer-to-order (ETO) environment, products are customized to meet the customer requirement, thus the unique engineering design is needed with each order (Amaro et al., 1999, Olhager, 2003). Other researcher suggested more detailed distinction, claiming the proposed taxonomy is not precise (Amaro et al., 1999). Buetfering et al. (2016) depicted six production environments by adding ship-to-stock (STS) and buy-to-order (BTO). The figure 10 presents different production situations by illustrating a position of CODP. Figure 10 shows that the HVLV includes ETO, BTO, MTO and part of ATO, while other part of ATO, MTS and STS are included in low variety, high volume (LVHV) production environment (Buetfering et al., 2016).

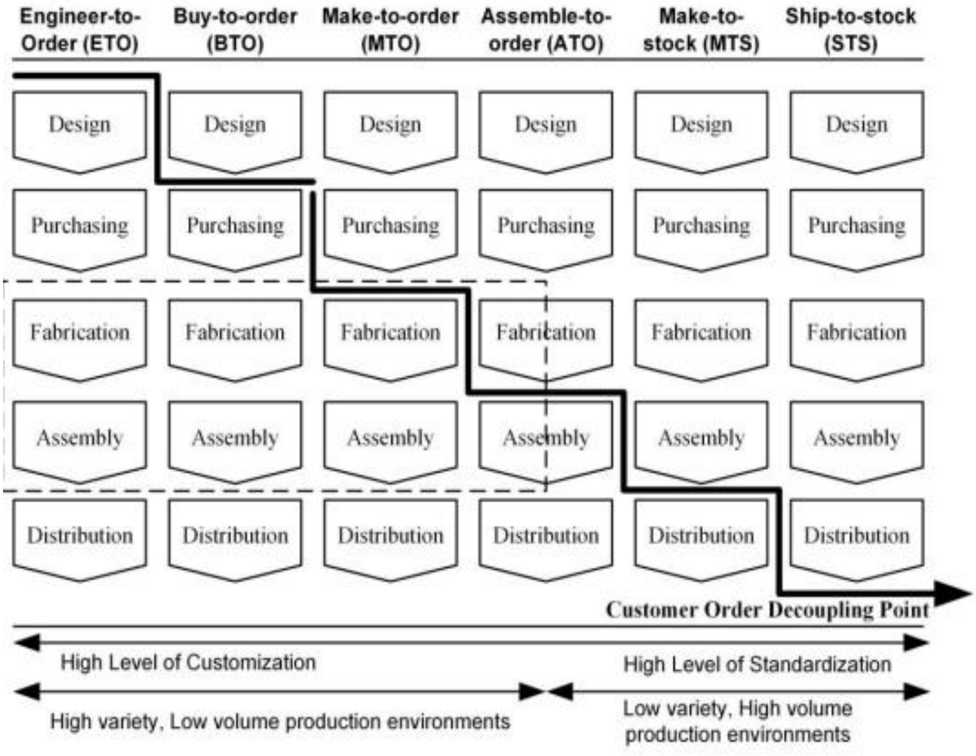


Figure 10 Supply chain structures (Buetfering et al.2016)

Powell et al. (2014) proposed a new set of ten principles for the Lean implementation in HVLV and validated them through a multiples case study. Birkie and Trucco (2016) suggested that Lean can be adapted to all types of production situations including HVLV since some of the Lean tools are universal. This is in line with other scholars that suggested that Lean can be applied in HVLV environment, but only if some tools are readjusted (Matt, 2014, Jina et al.1997, Naim and Gosling, 2011). Azadegan et al. (2013) claimed that due to the instability and unpredictability of the HVLV production setting, it is difficult to decrease the inventory levels and create the process flow.

Jina et al. (1997) described three main obstacles associated with the implementation of Lean in HVLV. Firstly, there is not a clear definition and scope of HVLV, since companies with different level of industry structures and SC relationships that manufacture products in different volumes and complexity are categorized within the HVLV. This might make a formulating a common Lean manufacturing strategy even more arduous. Secondly, the turbulence is identified as a next challenge, which is encountered in the bigger degree in HVLV than in typical Lean manufacturing repetitive industry. The turbulence occurs when the variability and uncertainty of inputs affect the company's behavior, which makes it more difficult to obtain the required output. The turbulences appear mostly because of the changes in the schedule, product mix, volume and design changes. Thirdly, the impact on the manufacturing system and an inability to separate the internal and outbound SC, as it can be made in repetitive environment by levelled schedules with some determined and flexible parameters. Those four challenges require, according to the author, the necessary adjustments in Lean Manufacturing principles if implemented in LVHV.

Portioli-Staudacher and Tantardini (2012) claimed that kanban does not give much benefit for the products designed according to customer specification and this is very difficult to pace production by the takt time. However, other practices such as streamlining processes, reduction of setup time, reduction of lot sizes, 5S and employees involvement are highly applicable it HVLV environment.

Matt (2014) researched an applicability of Value Stream Mapping (VSM) in ETO environment based on a case study of craft-product oriented enterprise. Author claimed that due to the variability of sequences and lead times, the VSM has to be adapted. He considered a high level of customer involvement as another obstacle, which required a certain degree of adaptation. In the large project's environment, the crossing of material flow can result in non-value-added activities as e.g. buffers of material or unnecessary movement. In addition, the uniqueness of every project can limit the waste reduction.

Alfnes et al. (2016) proposed a framework for flow design in HVLV and claimed that the VSM is applicable only in low turbulence settings. In the medium turbulence environment, the modified version of VSM is required. Companies with the high level of turbulence should try to decrease the turbulence in order to be able to apply the modified VSM

Applicability of best practices to various product, demand and manufacturing process characteristics

Discussed articles do not provide an explicit classification of Lean practices and their applicability in different environments. In addition, reviewed articles took into consideration the aspect of CODP placement, while did not considered other characteristics such as demand or manufacturing process characteristics that may be required to explicitly map the characteristics of an environment.

In order to consider an applicability of different Lean tools from subsection 3.2.4. , the characteristics proposed by (Jonsson et al., 2003) are used. Authors categorized seven characteristics in three groups; (1) product, (2) demand and (3) manufacturing process characteristics.

(1) Product characteristics

- *Products (BOM) complexity* – Number of levels in the bill of material and the number of items at each level.
- *Degree of value added at order entry* (Production situation) – Extent to which products are finished before the customer order arrives, such as MTS, ATO, MTO, ETO.

(2) Demand characteristics

- *Volume\frequency* – annual volume and the number of times products are manufactured: Few\Large, Several\Large, Large\Large, Large\Medium, Call-offs.

(3) Manufacturing process characteristics

- *Production process* – average size of the production run: Mass, Continuous, Batch, One-off.
- *Shop floor layou*t – How the shop floor is organized; functional, cellular or line layout: Fixed, Functional, Cells, Continuous Line.
- *Batch sizes* – typical order quantity: Order quantity, Small, Medium, Big
- *Throughput times* – typical throughput time in the production e.g. time that a product go through all production processes: Short, Medium, Long.

The table 5 below, presents how different Lean tools and practices that were discussed in section 3.2.4. are applicable to companies with different products, manufacturing processes and demand characteristics

Table 3 Applicability of different Lean practices to environments with different characteristics

Characteristics / Lean Practices	Product characteristics							Demand characteristics				Manufacturing process characteristics															
	Product Complexity			Production situation				Frequency\Volume				Production process				Shop floor				Batch Size				Through-put times		
	High	Med-ium	Low	MTS	ATO	MTO	ETO	Few\ Large	Sever-al\ Large	Large\ Medium	Call-offs	Mass	Conti-nuous	Batch	One-off	Fixed	Funct-ional	Cells	Continuous Line	Order qty.	Small	Medium	Big	Short	Medi-um	Long
Visual Management	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Standardized processes	●	●	●	●	○	○	○	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●
Stability of processes	●	●	●	●	○	○	○	○	●	●	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●
Level production \ Heijunka	●	●	●	●	○	○	○	○	●	●	●	●	●	●	○	●	●	●	●	●	●	○	○	●	●	○
Just-in-Time	●	●	●	●	○	○	○	○	●	●	●	●	●	○	○	○	○	●	●	●	●	○	○	●	●	○
Takt-time planning	●	●	●	●	○	○	○	○	●	●	●	●	●	○	○	○	○	●	●	●	●	○	○	●	●	○
Continuous flow	○	●	●	●	○	○	○	○	●	●	●	●	●	○	○	○	○	●	●	●	●	○	○	●	●	○
Pull system\Kanban	○	●	●	●	●	○	○	○	●	●	●	●	●	○	○	○	○	●	●	●	●	○	○	●	●	●
SMED	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
CI \ Kaizen	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Waste reduction\ Gemba	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
People & Teamwork	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Jidoka \ Autonomation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

3.2.7. Summary of the section

The section 5.3. was focused around the Lean manufacturing concept. This section first introduced Lean manufacturing and its origins. It has been concluded that due to the constant development of Lean, there is an ambiguity around its both definition and content. Therefore, the working definition has been developed. The Toyota Production House developed by Liker (2004) supported systemizing Lean tools and practices in section 5.3.2. It has be considered that there is no commonly accepted implementation guideline for Lean. The review of the number of framework conducted in section 5.3.3. concluded that Lean implementation process has to consider both technical elements and organizational factors simultaneously in order to be successful. It has been found out the Lean implementation frameworks do not discuss the multi-plant implementation aspect. The number of organizational factors have been identified in section 5.3.4. As the Lean manufacturing seeks for the continuous improvement, it was derived that the performance measurement plays an important role in the process that allow monitoring the current status and progress. Review of Lean measurement in section 5.3.5. presented various methods that encompassed both operational and financial measures, and are associated with the competitive priorities. The next section 5.3.6. sought to discuss the Lean applicability in different production environment. As the need of adaptation of some Lean practices is recognized in the academic literature, this section considered in addition the different product, demand and manufacturing processes characteristics and their impact on the Lean applicability. Table 3 has shown the practices such as standardized processes, stability of processes, level production, just-in-time, takt-time planning, continuous flow and pull system need a adaptation against certain characteristics or are not beneficial. This summary confirmed that aims of this section have been achieved.

3.3. Company-production system in multi-plant company

Section 3.3. aims to
1. Explain what XPS is. 2. Discuss the benefits of XPS implementation. 3. Analyze a content of XPS.
Terminology
The term multi-plant improvement programme used in this chapter is defined as a: *"Systematic processes of creating, formalizing and diffusing better operational practices in the intra-firm production network aim of increasing competiveness" (Netland, 2013).*

Following the example of Toyota Motor Company, number of manufacturers developed their own production systems constrained to social and organizational factors (Lee and Jo, 2007). Those production systems are tailored and specific to unique characteristics of manufacturers, and are often based on Lean and are inspired by Toyota Production System (Netland, 2013). Company-specific production system is "an own-best way approach to the one-best-way paradigm" (Netland, 2013). These company-specific production systems are termed XPS, where the "X" stands for company name and "PS" often for production system. However, the industrial XPSs have different names such as Kongsberg Way, Jotun Operations System, Volvo Production Way, Elkem Business System.

First, industrial examples of Norwegian manufacturers that developed their XPS are presented. Then we examine why companies develop their XPS from the two perspectives: as a company-specific production system and as a multi-plant improvement programme. Thirdly, tools and principles that are most often used in XPSs are presented. Fourthly, we discuss the synthesis of the different improvement programmes that can build XPS. Fifthly, popular improvement programmes are shortly presented and compared.

3.3.1. Industrial examples of the XPS

The development and implementation of XPS is an indubitable phenomenon in the manufacturing industry. This section aims to depict some of the examples of industrial XPSs implemented by companies with headquarters in Norway that were collected by (Netland, 2014).

Elkem

Elkem is a manufacturer of carbon and earth minerals silicon with headquarter in Oslo. Is the first company in Norway that have successfully developed and implemented their own XPS termed The Elkem Business System (EBS). EBS is grounded strongly in Lean principles and methodologies. *The fundament* of EBS consists of five principles such as leadership close to the process, management by objectives, stable processes, 5s, involvement and training. The next level encompasses *the rules in use* that consists of *standardized work processes, customer/supplier relations, simple* and *direct flow and systematic improvement*. The center of the EBS are empowered people, between the pillars that refers to right supply and quality. The goal of the EBS are *EHS, customer focus & innovation and waste elimination.*

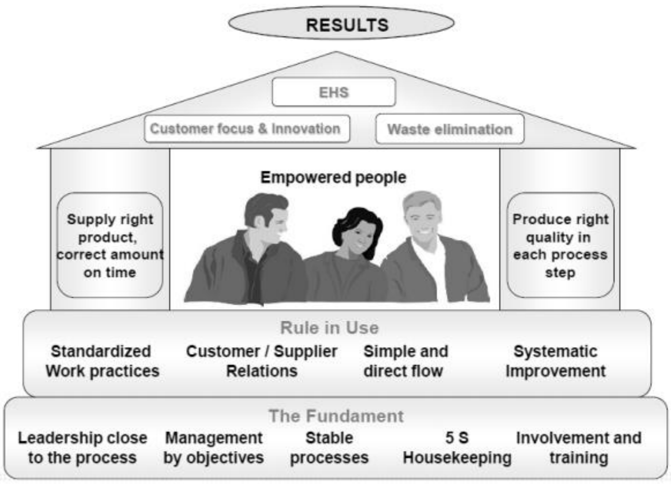


Figure 11 Elkem Business System (Netland, 2014)

Hydro

Hydro Primary Material division that produces aluminum metal launches its Aluminum Metal Production System (AMPS) based on Lean principles as a common platform for improvement in 2007. AMPS consists of principles such as standardized work processes, defined customer-supplier relations, optimized flow, dedicated team and visual leadership. Each of the principles contain standard and common tools. In addition, AMPS takes into account the local characteristics of the plant and allows for the local adaptation. System is highly focused on the all levels employee's involvement. The AMPS office has been established in headquarter that aims to support the implementation across the facilities and standardize the AMPS documentation.

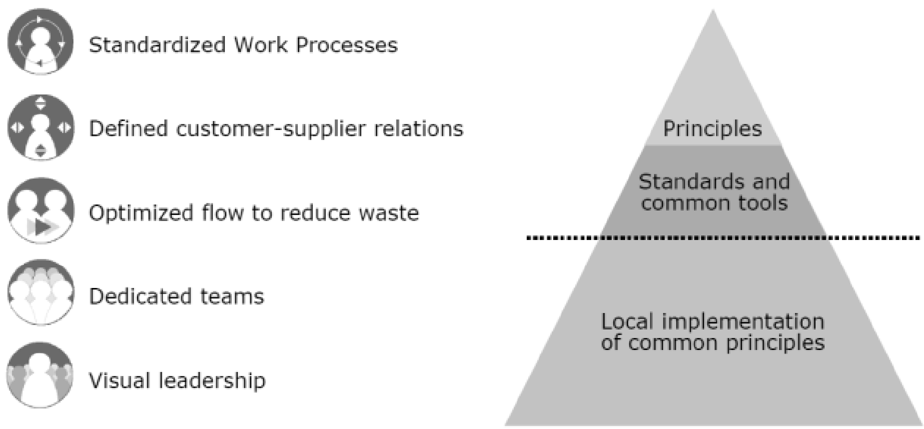


Figure 12 Hydro's Aluminum Production System (Netland, 2014)

Jotun

Jotun produces paints and proactive coating and operates in 43 countries. Jotun have started to develop its own Jotun Operations System (JOS) in 2007 that contains four may elements; results, continuous improvement and competence development as two pillars, process management of best practices and foundation built with operational principles such as stable processes, HSE, management by objectives, maintenance and JIT. Jotun has established the JOS office that performs audits and trains the employees. Each of the subsidiary in addition has a Lean coordinator.

Figure 13 Jotun Operations System house (Netland, 2014)

3.3.2. Benefits of implementing XPS

The XPS is seen in the literature from two perspectives that are not preclusive, but rather show that XPS is a holistic approach that can improve performance of entire manufacturing network (Netland and Aspelund, 2014).

First perspective sees XPS *as a company-specific production system* that means that each firm tailors the improvement principles to its own needs. The content of XPS consists of principles, techniques and tools of the well-known improvement programmes that are tailored to the company needs and characteristics. Since the system is developed within the organization boundaries, it often leads to the bigger employees' engagement because of the common platform and belongingness feeling (Netland and Aspelund, 2014).

The second perspective sees XPS as *a multi-plant improvement programme.* The XPS is considered as an improvement programmes that is set in a corporate level and applied further to all subsidiaries of the organization. XPS is common for the global production network rather than local solution. XPS creates a common platform for all plants within an organization. It also allows transferring the best practices between the plants and creates a common language (Netland and Aspelund, 2014).

Companies combine the earlier plant-specific improvement programmes and creates one improvement programme that encompasses all facilities. XPS is a lasting strategic programme, not a project. XPS aims to sustain the focus across all the plant within the manufacturing network. It requires the constant top management evolvement and a managerial attention. Single plants instead of developing their own improvement programmes separately, deploy a common system developed by headquarter (Netland and Aspelund, 2014).

3.3.3. The constituents of XPS

As the section 3.3.3. shown, the reviewed examples of Norwegian XPS's are strongly influenced by the Toyota Production System and contain number of tools and best practices that have been depicted in the section 3.2.4. Netland (2013) compared 30 industrial XPS's and confirmed that XPS is strongly influenced by Lean principles, which builds a foundation of XPS. However, none of the XPS's was the same, what verifies the uniqueness of the XPS. His research also depicts that the companies today are setting more focus on technical aspects of Lean then on soft principles as it used to be. Author however emphasizes the lack of focus on the modern manufacturing aspects such as automation or ERP. The table 4 depicts the list of principles that have been included in thirty industrial XPS cases studied by Netland (2013). It shows that almost all companies set a focus on standardized work and continuous improvement. Total quality, pull system and flow is also among the most used principles.

Netland (2012) also investigated how the program management theory can successfully support managing the XPS. He studied 15 company that implemented XPS to develop a program management framework. The concept of XPS has been described by the use of content, structure and process as main constituents of XPS.

XPS structure consists of organizational and technical elements. It is first develop at the corporation level and then each plant develop its own structure that supports the implementation. Those structures has been called super- and support-structure. It describes organizational functions in regards to the XPS ownership and roles, and establishes supportive tools such as best practice databases as a part of technical structure. XPS process specifies actions that must be deployed to successfully implement the XPS. It consists of organizational mechanisms that varies between the level of organization and firms.

Table 4 The prioritized list of XPS principles. (Netland , 2013)					
Rank	Best practice	% of XPS	Rank	Best practice	% of XPS
1	Standardized work	93	24	Communication	13
2	CI\Kaizen	83	25	Organizational design	13
3	Total quality	77	26	Quick change-over	13
4	Pull system	70	27	Design for manufacturing	10
5	Flow orientation	67	28	Profit-making	10
6	Value stream	67	29	Innovation	10
7	Employee involvement	63	30	Inventory management	10
8	Visualization	60	31	Jidoka\Autonomation	10
9	Customer focus	57	32	Product Development	10
10	Stability	50	33	Reduction of batch size	10
11	Workplace management	50	34	Automation	7
12	Just-in-Time	47	35	New effective technology	7
13	HSE	43	36	OEE	7
14	Teamwork	43	37	Payment	7
15	Heijunka	40	38	Sales	7
16	Leadership	40	39	Competitive benchmarking	3
17	Takt time	40	40	ERP	3
18	Maintenance	37	41	Optimized manning	3
19	Lead supply chain	30	42	Order and material planning	3
20	Performance measurement	30	43	PLC management	3
21	Cross-functional training	27	44	Real-time response	3
22	Flexibility	20	45	Transport on wheels	3
23	Vision, culture and values	17	46	Focused factory	0

The 1st phase *establishment* begins together with a decision at the corporate level to develop an organization's XPS. Netland (2012) sees the need of project management techniques at this stage. The *reengineering* as a 2nd phase contains often radical changes as a change in facility layout or standards work place management as for example 5S. This phase gives an opportunity to establish new factory standards that would support vulnerable just-in-time production. In the phase 3, company focuses on the *continuous improvement.* In this phase constant employees and top management involvement is very important and should be built around the organizational culture. Because the XPS is shared between many plants, it leads to the higher uncertainty and ambiguity. The last 4th phase is very hard to reach and not easy to maintain, because the firm has to *constantly innovate* in order to increase a performance. There is an importance of constant learning and competence building to be able to succeed with process innovation as competitors and their practices cannot be followed anymore.

3.3.4. Synthesis of Lean with other improvement programmes

An importance of a choice of the right set of best practices and tools is imperative. A majority of publications that investigate relationships between the improvement programmes and an operational performance focuses only on a single program aspect (Shah et al., 2008). However, Netland and Aspelund (2014) argued that XPS is a holistic approach that besides Lean principles can contain also the elements from Six Sigma, Total Quality Management (TQM) etc. A related point to consider is whether improvement programmes can be synergistically joined across practices to achieve a higher operational performance and on what basis company should choose the right programme and techniques to improve a particular performance dimension – these issues will be addressed in the following section.

Voss (1995) suggested that certain best practices give better performance than others do and that the best practices have to be adjusted to suit the unique company characteristics and dynamic environment. Kim and Arnold (1996) suggested that the choice of the correct programme is critical but he did not focus on synergistically effect that can be obtained through an implementation different programmes simultaneously.

Hines et al. (2004) claimed that Lean can be integrated with Agile to provide higher value to a customer without denying main objective of Lean. Agile has a different set of goals than Lean and aims to increase a flexibility and responsiveness to changes, but both approaches affects quality conformance, delivery reliability and speed (Hallgren and Olhager, 2009). Hines et al. (2004) argued that any program that gives a value to a customer could be aligned with Lean strategy, even though shop floor tools such as kanban or level scheduling have been not implemented. Programmes that aim to increase process capability and manage bottleneck such as theory of constraints (TOC) or Six Sigma are compatible with Lean. Those programmes create an effective and focused set of tools that increase the capacity if they are being applied along Lean as a core.

Andersson et al. (2006) researched similarities and differences between TQM, Lean and Six Sigma. They confirmed that those programmes are comprehensive and combining them gives a “consistent set of practices”. Bozdogan (2010) suggested that Lean, TQM and Six Sigma are interconnected and complementary approaches that together can build a “core” of an integrated management system where a Lean serves as a central point. Bringing together non-value added elimination tools from Six Sigma and techniques that increase savings creates an improvement program termed Lean sigma that has increased attention in recent years, due to its applicability to wide range of project (Shah et al., 2008). Other approaches such Theory of Constraints, Agile manufacturing can be adopted into this system to further increase the effectiveness. This approach is consistent with Rusjan (2005) findings concerning the selection of improvement programs. He provides an evidence that the choice of various techniques from different improvement programmes allows building an improvement programme that is tailored to solve particular identified problems (Rusjan, 2005).

Shah and Ward (2003) explored the relations between contextual factors and extent of implementation of key Lean practices. They have categorized 22 inter-related Lean manufacturing practices intro four bundles associated with Just-in-Time (JIT), Total Productive Maintenance (TPM), Total Quality Management (TQM) and Human resource management (HRM) there were previous treated as a separated improvement programmes (Cua et al., 2001). JIT bundle contains all practices related to the production flow, which aims to reduce all types of waste. Work-in-process (WIP) and unnecessary delays in flow time are the usually the biggest sources of wastes. The second, TQM bundle includes the practices related to the continuous improvement and sustainability of quality. The TPM bundle is created by the practices that aims to maximize the equipment effectiveness through different forms of maintenance. The fourth HRM bundle includes practices related to the employees e.g. job rotation, problem solving groups, cross training and work teams. Shah and Ward (2007) considered the TQM, JIT, HRM and TPM not as an independent or separated concepts (Shiba and Walden, 2001, Bozdogan, 2010) or programs (Cua et al., 2001), but as an inter-connected bundles that are key elements of Lean manufacturing systems. They investigate the synergistic effect of the implementation on the organization performance. They point out that the each of the bundles have a considerable impact on the operational performance and provide unambiguous evidence that the combining practices gives a synergistic effect and contribute to the operational performance.

Cua et al. (2001) investigated the relationships between TQM, JIT and TPM. They found out that specific set of human and strategic practices are common to all three programmes such as strategic planning, committed leadership, cross-functional training, employee involvement and information and feedback. However, the set of basic techniques is unique for each of the programmes. These concepts have common fundament in a continuous improvement and waste reduction and have a common goal to improve the manufacturing performance (Bozdogan, 2010, Cua et al., 2001).

As the section depicted, researchers are aligned that improvement programmes can be synergistically joined and the joint implementation of the certain best practices, tools and techniques of improvement programs can lead to increase of specific performance dimensions. Choosing the certain techniques and tools from the improvement programmes allows developing a tailored programme that will be addressed to solve the identified earlier problems and achieve the manufacturing performance objectives.

3.3.5. Brief review and comparison of common improvement programmes

Previous section confirmed that techniques and tools can be joined across different improvement programmes, hence this section aims to briefly review most known improvement programmes and compare goals and content of each programme.

Six Sigma

Receiving the National Quality Award by the Motorola Company in 1988, as a first company that launched the Six Sigma programme, triggered the interested of the concept among the other enterprises (Andersson et al., 2006). The Six Sigma is an improvement programme that reduces the variation throughout both continuous and breakthrough improvements (Andersson et al., 2006) to reduce resources, wastes, increase a quality, meet customer expectations and improve the company performance (Bozdogan, 2010). The aim of programmes is reaching the level of only 3.4 of the million unsatisfied customers (Magnusson et al., 2003) which is equal to variation Six Sigma where a Greek letter sigma measure a distribution around the mean. The key practices of the Six Sigma are management involvement, training, statistical tools infrastructure and clear roles and responsibilities (Henderson and Evans, 2000). The method used to implement a sig sigma is DMAIC (define-measure-analyze-improve-control) (Bozdogan, 2010). The key phases of improving the process are: (1) Define – improvement area, team member, customers and a map, (2) Measure – establishing the key measures, (3) Analyze – analyze key factors, (4) Improve – choosing and implementing the most effective and cost beneficial solution, (5) Control – measuring the performance of the implementation (Andersson et al., 2006). This method has its foundation in well-known Deming's' method Plan-Do-Check-Act (PDCA) which supports the data-based improvement process .Six Sigma gives a structured approach to the quality improvement. It puts a focus on employees training and the well-designed organizational structure. In addition, it has defined particular metrics to constantly monitor the improvement process (Bozdogan, 2010).

Business Process Reengineering

Business process reengineering (BPR) came into prominence in 1990s and stands for a radical improvement approach. It aims to achieve a significant performance improvement, by increasing efficiency and flexibility and meeting customer requirements by redesigning business processes as connected activities that creates a certain output by the use of particular amount of resources. It suggests that a company should not make any incremental changes but rather rethink the entire system. BPR and the system redesign is possible with the help of new information technology. The BPR is criticized for the lack of specific methods for managing complexity of such a radical changes. In addition, it does not refer to any of the methods of how the enterprise can maintain or further increase a performance after redesigning a system. It is a top-down approach that does not consider any cultural and behavioral issues, and can diminish the role of shop-floor workers (Bozdogan, 2010)

Theory of Constraints

Theory of constraints (TOC) introduced by Goldratt et al. (2004) focuses on increasing a throughput on the shop floor by identification and removing constraints that are represented by critical bottlenecks. Bottleneck can be physical, managerial, logistical or behavioral and represent the points where if change is made it affects the performance and operations of the system. TOC suggests that the scarcest resources, not the total resources available, limit the growth. Goldratt et al. (2004) claimed that every organization has at least one bottleneck that constraints the overall system and only by exploiting it, company can achieve a better performance. TOC responses to the criticism towards cost-focused JIT and TQM approaches that create constraints by e.g. implementing continuous flow. TOC proposes management and scheduling methods such as drum-buffer-rope that set a pace of production flow and coordinate constraints. However, TOC is criticized for the lack of the systematic methods for both identification and elimination of such constraints.

Total Quality Management

The 14 points on quality defined by E. Deming become a foundation for the further development of Total Quality Management that become a commonly used across the organization in 1990s (Anderson 2006). There are many definitions regarding the TQM concept e.g. corporate culture (Mi Dahlgaard-Park et al., 2006), management system of tools, values and methodologies system of practices, tools and training methods (Shiba and Walden, 2001) or distinctive perspectives reflecting evolving notions of quality (Bozdogan, 2010). All authors however agree that the TQM is an evolving and constantly developing concept. TQM is focused on better quality through and increasing customer satisfaction (Bozdogan, 2010) through a continuous improvement (Cua et al., 2001) and the management, workforce, customers and suppliers involvement (Powell, 1995). Programme contains the nine main practices; strategic planning, committed leadership, employee involvement, cross-functional training, information and feedback, customer involvement, supplier quality management, cross-functional produce design and process management (Cua et al., 2001) and techniques such as statistical process control, error-proofing as poka-yoke, quality circles, robust design. TQM aims to reduce variability as it sees the enterprise as an interconnected system that should be managed and designed together (Bozdogan, 2010). TQM utilizes a sequential procedure called PDCA (Plan-do-check-act) that aims to solve problems and continuously improve the entire organization, not only a work shop level (Motwani, 2003).

Total Productive Maintenance

Total Productive Maintenance is a programme to maximize its effectiveness to avoid breakdowns by the maintenance system through the lifecycle of the equipment. TPM sees the maintenance as a value-added activity, which is necessary part of the business. TPM schedules maintenance and tries to keep the unplanned maintenance to a minimum. Employees' involvement from the top-management to the workers is necessary for the successful implementation of TPM. TPM encompasses the entire organization and consists of both short- and long-term elements. Short-term elements includes the autonomous and planned maintenances. Long-term plan covers new equipment design that aims to maximize the equipment efficiency. TPS includes autonomous and planned maintenance, emphasis on equipment technology, committed leadership, cross-functional training, employee involvement and strategic planning as main TPM's practices.

Continuous improvement

Continuous improvement programs are mostly extensive methodologies involving the whole enterprise. They can emerge from the top management, the group or from individuals. Recently, many large organizations have started to adapt various tools and tailored them in order to suit to the company`s profile. At the top level, the significance of the continuous improvement lies in the organizations strategy. The initiatives in the groups occur through the problem-solving work, while the individuals find a small improvement in the day-to-day tasks. There is a high importance that the managers enhance the continuous improvement through all the stages and tailor the continuous improvement programs or methods according to the characteristic of the products or process (Bhuiyan and Baghel, 2005).

Agile Manufacturing

The aim of Agile manufacturing is to gain a capability to respond quickly and effectively to unpredictable changes and pressures company is imposed on in the competitive environment. By placing a focus on the quick respond to customer requirements company can achieve a competitive advantage in fact changing market. To become Agile company has to develop processes, training and tools that would allow them to meet the needs of customer while sustain the quality and control the costs. Gunasekaran and Yusuf (2002) reviewed the literature about the Agile tools and divided them into four categories; strategies, technologies, systems and people. Authors proposed seven enablers of Agile manufacturing that have to reach the whole organization, such as virtual enterprise formation tools, concurrent engineering, physically distributed manufacturing teams and architecture, rapid partnerships formation tools, integrated production systems, rapid prototyping and electronic commerce.

Table 5 Review of improvement programmes goals and techniques

	Lean	CI	TQM	TPM	Six Sigma	BPR	TOC	Agile Manufacturing
Main goals	Best quality, lowest cost, shortest lead time, best safety, high morale (Liker, 2004) Eliminate waste, continuous improvement, reduce inventory and increase productivity (Andersson et al., 2006, Powell et al., 2014)	Reduce failures and increase success by incremental, continuous improvement (Bhuiyan and Baghel, 2005)	Quality improvement, Customer focus(Andersson et al., 2006, Bozdogan, 2010))	Maximize equipment efficiency (Cua et. Al. 2010)-	No defects by reducing variation and improving processes (Roy et al., 2006)	Improve the customer satisfaction and company performance (Bozdogan, 2010)	Capacity. Maximize through put (Bozdogan, 2010)	Increase flexibility and responsiveness in the uncertain environment (Bozdogan, 2010)
Core principles and techniques	Stability and standardization, Visual management, Heijunka, Continuous improvement People Eliminating of waste Just-in-time Takt time planning Continuous flow Pull system is Quick changeover time Integrated logistics Jidoka (Liker, 2004). Supplier management (Shah and Ward,2003) Employee involvement, Strategic planning (Cua et al., 2001)	Organizational culture, Problem-solving groups, Small improvement in day-to-day tasks, Managerial encouragement (Bhuiyan and Baghel, 2005)	Customer involvement Cross-functional product design Process Management (Cua et al., 2001) Committed leadership Cross-functional training Employee involvement Information and Feedback Statistical Process control Quality circles Robust designs Error proofing (Bozdogan)	Autonomous and planned maintenance, Emphasis on equipment technology, Committed leadership, Cross-functional training, Employee involvement Strategic planning	Define, measure, Analyze, Improve and Control (Anderson) Management involvement (Henderson) Clear roles and responsibilities (Panda) Training, statistical tools (Henderson) Performance measurement Improvement experts (Bozdogan, 2010)	Focus on information technology (Bozdogan, 2010)	Focus mechanism on constraints, Drum-buffer-rope (Goldratt et al., 2004)	Virtual enterprise formation tools, Concurrent engineering, Physically distributed manufacturing teams and architecture, Rapid partnerships formation tools, Integrated production systems, Rapid prototyping and electronic commerce (Gunasekaran and Yusuf, 2002).

3.3.6. Summary of the section

The central point of the section 3.3. was XPS. It was shown that the XPS is seen from two perspectives: as a company-specific production system and a multi-plant improvement programme. Benefits achieved in the context of these two perspectives were presented in section 3.3.2. It has been concluded that XPS consists of different improvement programmes, but its foundation is built on the Lean manufacturing concept and its best practices. In the section 3.3.4. it was investigated whether Lean and other improvement programmes may by combined together. Results shown that combining the different improvements programmes is possible and can lead to performance increase of specific dimensions. Next section 3.3.5 compared different improvement programmes regarding their main goals and core practices and tools. The aims of this section were to present the XPS, consider its benefits and its content. All of the aims were therefore achieved.

3.4. Transfer of best practices from headquarter to subsidiaries

Section 3 .4. aims to
1. Analyze how the best practices are transferred from headquarter to subsidiaries. 2. Discuss whether companies should standardize best practices across subsidiaries or adapt them locally. 3. Discuss where the decisions regarding improvement programmes should be made – headquarter or subsidiaries.
Terminology
This chapter will utilized a definition of *transfer of best practice*s as follows: *“A replication of an internal practice that is performed in a superior way in some part of the organization and is deemed superior to internal alternate practices and known alternatives outside the company” (Jensen and Szulanski, 2004)*

Section 3.2. have shown that an academic literature is principally focused on the implementation of Lean manufacturing in a single plant and that there is no clarity regarding the implementation of improvement programme at the multi-plant company. Therefore this section investigates an approach on how the best practices are transferred from headquarter to subsidiaries as central aspects to the multi-plant implementation (Netland and Aspelund, 2014).

First, multi-plant companies have to decide to what degree practices will be standardized in each of the subsidiary. Secondly, to what extent companies will centrally manage implementation of these practices from headquarter (Beckman and Rosenfield, 2008). Hence, the next section, 3.4.3. discusses whether companies should standardize practices in all subsidiaries or locally adapt them. The section 3.4.5., analyzes the centralized vs decentralized approach of managing improvement programme and the decisive factors whether company should choose one over the other. Chapter is summarized in graphical form of aggregated charts that depicts the important findings.

3.4.1. Standardization vs. adaptation of practices

Transferring the best practices from headquarter to subsidiaries is challenging due to the different context of subsidiaries (Maritan et al., 2004). Company has to decide whether to standardize practices across all subsidiaries. If not, which practices adapt and apply to particular subsidiary (Beckman and Rosenfield, 2008). Therefore, company has to consider a trade-off between the global conformity and local contingencies while designing and implementing a multi-plant improvement programme (Netland and Aspelund, 2014). Multi-plant improvement programmes by definition aims to implement the standardized set of practices to all subsidiaries, but the local advantages have to be utilized. The clear distinction between the standardization and adaptation is not established in the academic literature.

The first view, adaptation of best practices means to fit better external practices into the adopter's needs and characteristics (Ansari, 2010). However, too much adaptation can lead to nullifying the advantages of the multi-plant improvement programme as a common, standardized platform. The second view, standardization (Miltenburg, 2009) view refers to the situation when subsidiaries adopt and implement all the same standard practices (Netland and Aspelund, 2014). However, if the headquarter utilizes equal management approach toward all plants without considering its unique context and characteristics, such as plant role (Taggart and Hood, 1999), capabilities and resources (Bartlett, 2002) it may provide the compromised system for all subsidiaries where some of them are not managed properly (Maritan et al., 2004).

Netland and Aspelund (2014) reviewed 30 research papers related to the corporate improvement programmes and confirmed the most of them suggest a strong adaptation to local contingencies. This is in line with Cua et al. (2001) who claimed that the improvement solution should not be copied based on the successful implementation of other plants. The decision on the configuration of practices should be based on the strategic importance of particular performance measures.

The issue of global standardization and local adaptation concerning Lean manufacturing has been considered in academic literature in regards to three perspectives: a *convergence*, a *structuralist* and a *contingency* perspective:

The *convergence* perspective sees Lean manufacturing as a universal set of management norms that can be applied anywhere (Lee and Jo, 2007, Womack and Jones, 1996). This perspective perceives TPS and later Lean as a dominant production system and emphasizes performance achieved by Japanese and Western adopters. This universal approach is termed also the best-practice paradigm (Voss, 1995) and it suggests that some of the practices are superior and therefore should be shared in the network (Netland, 2013). This perspective recommends Lean as a superior practice and assumes its universality to increase the manufacturing performance.

The *structuralist* perspective, refuses the universalism of Lean due to the specific socio-economic context under Lean have emerged in Toyota, hence it can be hardly transferred to other countries or industries (Lee and Jo, 2007).

The *contingency perspective* consider Lean as a superior approach but only if it is adopted to fit the unique context and the "organizational and the external forces as recipients site." Organizational forces refer the business strategy, labor skills, relations inside the company, mechanisms of production technology, while external forces includes market situation, local environment, structure of supply chain or social culture (Lee and Jo, 2007). Contingency perspective represent a balanced view to the Lean transferability between the companies or countries and understands the importance of certain contextual conditions that has to be meet in order be effective (Netland, 2013). However, this perspective does not clearly specify how organization should adapt the Lean to develop their own production systems hence it does not consider the "dynamic evolution of implementation". This approach is in line with the concept of dynamic capabilities (Anand and Kodali, 2008) that assumes to develop certain capabilities in order to stay competitive (Wang and Ahmed, 2007). Liker et al. 1999 views a Lean as an evolving and dynamic process itself hence this development can lead to various outcomes and various forms of Lean determined by an adopter.

Lee and Jo (2007) described how Hyundai Motor Company developed its own production system by first adopting and later adapting the TPS to fit the company unique circumstances. Author argues that the companies should not copy TPS as Toyota developed it but rather re-interpreted and modify it. The unique production systems by "selecting, interpreting, and transmuting TPS principles to meets its own business context comprised of both external and organizational forces". Hyundai Production System (HPS) tried to follow TPS but did not implement fundamental pull principles because of the mistrust with suppliers. While TPS sees involvement of all employees as a fundamental principle, HPS relies rather on engineers' knowledge and innovations emerging from their capabilities. Company had to adapt fundamental Lean principles such as human resources practices that could not be utilized in the same way as in Japanese due to the political situation, mistrust between workers and top management and labor unions policy.

HPS example is aligned with the contingency perspective. Hyundai aimed to follow the TPS first, but its productions system went through the evolutionary process to fit the local contingencies. This is in line with Jina et al. (1997) who concluded that the Lean can be applied directly only to certain manufacturers and the most organization has to carefully consider which practices can be transferred directly and which has to be adapted in order to meet particular circumstances. The adaptation of TPS to Hyundai is depicted in figure 14. Principles are emulated through emulation channels so that the recipients implemented the mutated version of TPS that emphasizes the internal contingencies and external constraints.

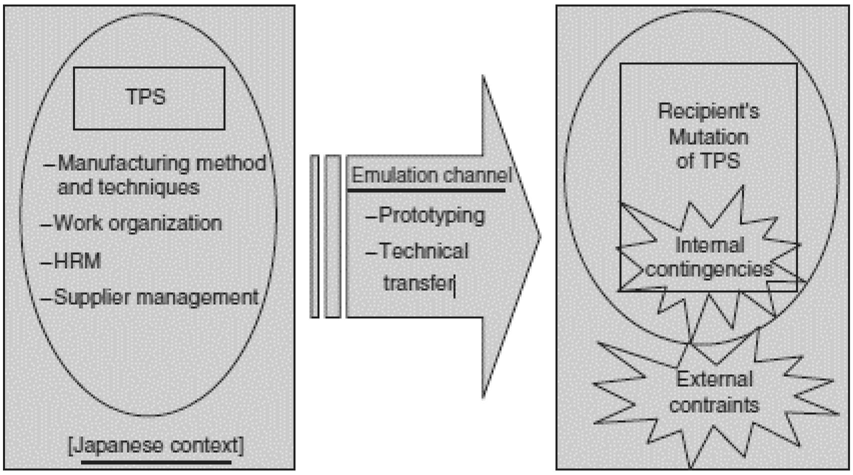


Figure 14 Diagram of TPS diffusion model (Lee and Jo, 2007)

Jensen and Szulanski (2004) however argued that the strong adaptation may increase the stickiness that refers to the difficulty of transferring a knowledge between subsidiaries. Author point out the previous researches may be still valid, but the applicability of adoption may increase in the later phases of transfer. Companies such as Xerox pressing subsidiaries to adopt the set of standardized best practices (Jensen and Szulanski, 2004) or Intel Company that also strongly argues in favor of global standardization of both technology and practices. Company has developed a system for transferring practices and technologies termed COPY EXACTLY! Intel, standardizes practices, equipment and technologies across its subsidiaries to ascertain that plants are similar as much as possible. Intel develops processes at headquarter to further replicate them in the facilities. Intel claims that this approach has a significant outcome in learning and sharing a knowledge between the facilities.

Beckman and Rosenfield (2008) discussed key considerations company has to make whether to standardize the process across their subsidiaries. Firstly, if the products that are produced in each plant are standardized, the process can be also standardized. If the products have significant variations, due to the e.g. different local market requirement, it is more difficult. Then, company can consider standardization for a part of processes with a degree of local variations or standard flexible operations adapted to the local market.

Secondly, headquarter should consider the stability of a technology at subsidiaries. When a technology changes often, it may be difficult to standardize across subsidiaries and each plant may respond to the technology changes quicker without standardization. However, standardization may to be beneficial if the technological changes are made simultaneously across the whole network.

Thirdly, the degree of standardization might depends on the size of facilities and the volume that is produced. Subsidiaries that varies significantly with the production volume may require different practices.

Fourthly, the labor factors such as labor cost and availability of skilled worker have an influence whether headquarter standardize or not. Companies that have high-automated processes will gain benefits of standardization in every locations. They would not gain any advantage of low-labor cost in adapting the low-labor content. On the other side, companies that processes are not automated necessarily might use advantage of labor-intensive processes in countries with cheap labor force. Another aspect of this is availability of skilled workers. It might be challenging to have high-tech processes in developing lands with scarce engineering resources.

When practices are standardized at all sites, any improvement developed in headquarter research and development center, can be implemented simultaneously to all plants. A related point to consider is that the individuals, which work closely to process and practices, often make the improvements. This concept can be represented by the learning curve effect. This effect occurs when the worker is learning and gaining new skills through the experience. In order to facilitate the benefits of this effect, company has to consider giving a certain degree of autonomy to each plant to allow them to adjust and improve the practices by its own. Further, headquarter might take an advantage of these improvement and implement them across the other subsidiaries (Beckman and Rosenfield, 2008). The degree of a subsidiary autonomy is elaborated in the next section.

This section emphasized the importance of the global standardization or local adoption and suggested that companies should either select practices that provide a subsidiaries' standardization or allow local plants to adapt them to respond to local contingencies.

3.4.2. Centralization vs. decentralization. Subsidiary decision-making autonomy

Next fundamental issue of practice transfer from headquarter to subsidiary is the relationship between headquarter and its subsidiaries and the way to effectively manage improvement programmes in a group of plants. Even if headquarter decides to standardize practices across its subsidiaries, practices might reshape over time due to the changes made by subsidiaries. Therefore, it should be considered whether decisions are made globally in headquarter or locally at each subsidiary. Two models can represent these relations. The first, *centralized* model describe a situation when headquarter is responsible for all the operational decisions that are further deployed to the subsidiaries as directives (Hayes, 2006). The second, *decentralized* model exists when the local managers in each subsidiary have a decisions-making autonomy, so that they are authorized to make decisions concerning the operations strategy (Hayes, 2006).

Decision-making autonomy is defined as a degree to which subsidiary can make significant decisions without the involvement from the headquarter (Roth and O'Donnell, 1996, de Jong et al., 2015). It is considered to be among the most important variables that drive the strategy, performance and behavior of subsidiary and comprises the organizational structure (de Jong et al., 2015). de Jong et al. (2015)

suggested that the autonomy is a key motivator for the subsidiaries that enables network links, enhances innovation and resource accumulation. McDonald et al. (2008) differentiated two types of decision autonomy level. Strategic decision-making autonomy refers to the major policy decisions such as productions systems, R&D or product development. Operational level decisions concern the decisions on the type and scope of operations. Expanding autonomy, according to the network theory and resource-based theory can have a positive impact on the subsidiary performance due to the local resources utilization (Bartlett, 2002, McDonald et al., 2008) and local responsiveness (de Jong et al., 2015). On the other hand, agency theory suggests that the headquarter controls subsidiaries to reduce the uncertainty (de Jong et al., 2015). Intel's COPY EXACTLY! is a good example of fully centralized approach, that all developments are supervised by the headquarter representatives. Such approach facilitates learning between the plants. However, it requires more bureaucracy and time to get an approval for any changes in the subsidiary (Beckman and Rosenfield, 2008).

Early researches perceived an autonomy as an outcome of diverse factors (Hedlund, 1979, Johnston and Menguc, 2007) rather than input to management strategy. Hedlund (1979) found out that the highest autonomy subsidiaries have in regards to the human resources, while the lowest degree of autonomy for the financial decisions. Garnier (1982) investigated network with headquarter in U.S. and pointed out that decision-making autonomy is higher in smaller networks or when headquarter acquires subsidiaries. In addition, Johnston and Menguc (2007) found that the headquarter country is also indicator for the distribution of autonomy. Garnier (1982) points out the subsidiaries that have a higher share of sales in local market has higher degree of decision-making autonomy.

The newest researches sees the autonomy as an important input of the network management strategy and consider various determinants as plant role, distance or size.

The impact of plant role for the decision autonomy

Maritan et al. (2004) claims that it should be a fit between the way a subsidiary is managed and the "what is necessary to provide the integration for its particular specialized plant role". As the manufacturing network is an aggregation of subsidiary located in different locations (Ferdows and De Meyer, 1990, Rudberg and Olhager, 2003), each subsidiary can serve different functions for the network (Olhager, 2003). It can be an important source of knowledge about technology, products, customers (Birkinshaw and Hood, 1998) and a source of advantages in cost, flexibility (Maritan et al., 2004) proximity to customer (Feldmann et al., 2013). It can enhance the local responsiveness and worldwide learning (Birkinshaw, 1997). Subsidiary role in achieving a competitive advantage is constantly increasing, since it has a specific and significant role to the network (Johnston and Menguc, 2007, Ferdows, 1997).

They investigated whether subsidiaries with different roles have a different degree of autonomy in regards to 12 decision types divided into planning, production and control decisions categories. The research utilizes a Ferdows (1989) plants role definition and distributed the responses from plants into six strategic categories: (1) Source, (2) Off-Shore, (3) Lead, (4) Outpost, (5) Contributor and (6) Server. Authors found out that plants with the higher degree of competence had a higher autonomy regarding production planning, scheduling, quality standards and maintenance with one exception in relationships between contributor and server plant where difference was not convincing. Lead type plant has less autonomy in regards to the materials, component and equipment sourcing that contributor and source plants. This finding contradicts the Ferdows (1989) approach that suggests that lead plants has a highest scope of task and therefore control over all important decisions. However, the bigger responsibility may be correlated with less autonomy over decisions. Findings are in line with de Jong et al. (2015) who claims that the strategic position of the plant is related to the higher level of autonomy regarding the production processes of particular products.

Feldmann et al. (2013) investigated the relations between the plant competence, role and operations decisions categories. They distinguished seven decision categories; (1) process, (2) capacity, (3) vertical integration, (4) organization, (5) quality system, (6) facilities and (7) planning and control system and identified two policy areas in each category. This approach allows balancing the local responsiveness and globalization pressure (Feldmann et al., 2013). Results of the analysis shown that the plants with the high level of competences are correlated with the higher level of autonomy over the operations strategy decisions. Centralized, integrated and decentralized approach follow the same structure hence and no patters for the particular decisions has been identified. Study confirms that the decision-making autonomy and the plant roles are fundamental issues of strategic management of manufacturing network (Feldmann et al., 2013). Studies are in line with the Birkinshaw and Morrison (1995) that implied that local implementers have lowest decision-making autonomy while the world mandate plants that provide a significant value to the network, has it highest. McDonald et al. (2008) investigated how changes of the distribution autonomy effect the subsidiary performance. He suggested that increasing subsidiary's operational autonomy leads to the better performance. He states that local managers are better informed on operational issues concerning production or employees. However, he could not confirmed a direct influence of increasing strategic decisions autonomy to performance

The analysis of this section depicts that the plants with the higher level of competences have higher degree of decision-making autonomy regarding the operations strategy decisions.

The impact of distance on the decision autonomy

The impact of the distance is important factor to consider because of the strategic importance of the geographic dispersion in today's competitive market (de Jong et al., 2015). Two opposite perspective can be found in the academic literature. First, agency theory suggests that the long distance to the headquarter increases the agency problems and the information asymmetry. Agency problem may arise when local managers make a conflicting with the headquarters view decisions due to the local knowledge and disparate perspective on the environment. Distance can lead to the risk of information misinterpretation and impede learning of headquarter (O'Donnell, 2000, de Jong et al., 2015). In addition, distance increases the uncertainty and the ability to obtain the correct and complete measures the current subsidiary performance, therefore the agency theory suggests the lower level of subsidiaries autonomy to avoid distance related problems (de Jong et al., 2015, Roth and O'Donnell, 1996). Distance between the subsidiary and the headquarter increases the asymmetry of the information what escalates the agency problems, hence headquarter closely monitors the behavior and inhibits the subsidiaries local incentives (de Jong et al., 2015). Secondly, the business network theory indicates that the greater distance intensifies the local autonomy due to the uniqueness of the local environment.

Subsidiary understands the local business, can obtain acquire business legitimacy (Birkinshaw and Hood, 1998) can obtain local resources what can reduce the uncertainty (de Jong et al., 2015). De Jong et al. (2015) empirically contradicted both theories and shows that the larger economic and the geographic distance gives a lower degree of autonomy to subsidiaries to reduce the information asymmetry between headquarter and subsidiary. However, this impact varies between the business functions what gives rise to single consideration.

The impact of size on decision autonomy

Size of the subsidiary is important to consider because increase of size is related with the increase of value to the network (Johnston and Menguc, 2007). The first Hedlund's (1979) exploratory research on the correlation between the subsidiary autonomy and size brought a quadrative inverted-U model as a solution. Bigger size of plants is related usually with bigger resources what leads to less headquarter dependence. However, an autonomy was concerned as an outcome of the subsidiary size, rather than an input to operations management approach towards network's subsidiaries. Johnston and Menguc (2007) refreshed a context of size and empirically validated the Hedlund's (1979) proposition. The results strongly confirmed the inverted-U shaped relationship between the decision-making autonomy and the subsidiary size. At certain point, the decision-making autonomy decrease because increasing size carries the need for expertise, experience due to the increase of coordination complexity. This brings an increasing dependence to headquarter (Johnston and Menguc, 2007).

3.4.3. Summary of the section - standardization and centralization choices

Previous sections investigated the transferring of best practices from headquarter to its subsidiaries. Firstly, the degree of best practices standardization across subsidiaries was analyzed. Secondly, the choice between centralized and decentralized approach to decision-making autonomy was discussed.

The figure 15 proposes a typology of XPS based on a degree of best practices standardization and the way in which XPS is being managed – centrally at headquarter or at each of the subsidiary. Four types of XPS has been differentiated: (1) Centralized Global XPS, (2) Centralized Local XPS, (3) Decentralized Global XPS, (4) Decentralized Local XPS.

(1) Centralized Global XPS – Headquarter designs, implements and manages a standardized, common global XPS to all subsidiaries.

(2) Centralized Local XPS - Headquarter is responsible for managing XPS. Each subsidiary develops its own local XPS to fit the local characteristics and needs. This type has some of the efficiencies of standardization.

(3) Decentralized Global XPS - One common and standardized global XPS that is managed by subsidiaries. Difficult to do due to the extra overhead cost for coordination.

(4) Decentralized Local XPS - No common XPS across subsidiaries. Each plant designs, implements and manages its own local XPS. Allows the best adaptation to respond local conditions.

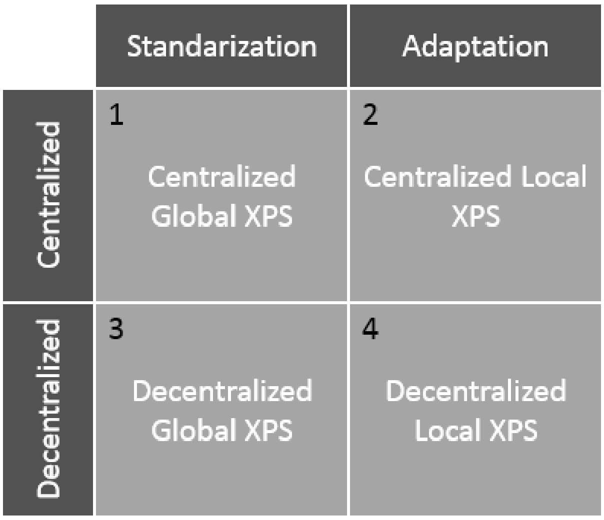


Figure 15 XPS typology

The table 6 depicts characteristics of each XPS type in regards to the *determinants* as factors that impose which type of XPS is relevant, the table 7 *benefits* company can achieve and the table 8 *difficulties* of particular XPS type.

Centralized Global XPS can be applied to companies that manufactures standardized products, with stable technology, which produce rather similar volume of products. It is recommended for companies that have high-automated processes with low labor content (Beckman). Situation when company owns big manufacturing network, with long distances between the subsidiaries that have relatively low competences requires Centralized XPS. Company can learn from previous experiences and the common

XPS that is implemented in all plants can create a common communication platform and language (Netland, 2014) that gives a foundation for better cross-plant learning (Beckman and Rosenfield, 2008, Jensen and Szulanski, 2004) through the knowledge transfer (Jensen and Szulanski, 2004). Standard best practice facilitates benchmarking between facilities. Standard practices and good communication reduces uncertainty (de Jong et al., 2015). However Centralized Global XPS is a system the might overlook the contextual factors of subsidiaries and some of them might not be managed correctly (Maritan et al., 2004). In this system decisions takes more time due to the more bureaucracy (Beckman and Rosenfield, 2008).

Centralized Local XPS is recommended rather for companies that produce non-standardized products, with different volumes where one common system would not fit to all (Beckman and Rosenfield, 2008). This type is suitable for big manufacturing networks, with big distance between subsidiaries so the headquarter. This type of XPS allows subsidiaries to adapt the system to local characteristics and needs in a controlled way, but all decisions are managed by headquarter, therefore it takes much time to implement any improvement that has been proposed locally. This XPS does not provide a good foundation for a knowledge transfer between subsidiaries, because there is no common platform and language between facilities. However, the local suggestions may be collected and filtered by headquarter and applied to other plants if suitable.

Decentralized Global XPS is very difficult to obtain and it requires high overhead cost for coordination if company aims to benefit from the standardization (Beckman and Rosenfield, 2008).Therefore, it will not be further elaborated.

Decentralized Local XPS is recommended for the companies that manufacture non-standardized products with different volumes across its plants. If processes are labor intensive, it might gain an advantage of cheap labor in particular country. Decentralized Local XPS fits best when a network is small and distances are not long between the plants that have high competences. Due to the high autonomy, subsidiary can respond to the local contextual conditions (Beckman and Rosenfield, 2008, (Netland and Aspelund, 2014), internal and external forces (Lee and Jo, 2007) and improve particular performance measures. No coordination is required, hence no extra cost has to be spend. This system benefits from the learning curve effect through the individual workers that work close to processes and suggest an improvement that is assessed and implemented quickly. However, the biggest disadvantages of this is system is lack of possibility to transfer the knowledge between subsidiaries due to the increase of stickiness (Jensen and Szulanski, 2004).

Table 6 Determinants of different XPS types

● – big impact ○ – middle impact	Centralized Global XPS	Centralized Local XPS	Decentralized Global XPS	Decentralized Local XPS
Determinants				
Standardized products (Beckman and Rosenfield, 2008)	●		○	
Non standardized products (Beckman and Rosenfield, 2008)		○		●
Stabile technology (Beckman and Rosenfield, 2008)	●		○	
Subsidiary produce similar volumes (Beckman and Rosenfield, 2008)	●		○	
Different volumes (Beckman and Rosenfield, 2008)		○		●
High automated production (Beckman and Rosenfield, 2008)	●		○	
Might use advantage of labor intensive processes in cheap labor country (Beckman and Rosenfield, 2008)		○		●
Small network (Johnston and Menguc, 2007, Garnier, 1982)	●	●		
Big network (Johnston and Menguc, 2007, Garnier, 1982)			●	●
Big distance between facilities (O'Donnell, 2000, de Jong et al., 2015)	●	●		
Small distances between facilities (O'Donnell, 2000, de Jong et al., 2015)			●	●
High competences at the factory (Feldmann et al., 2013, McDonald et al., 2008)			●	●
High R&D complexity (Garnier, 1982)			●	●
High share of local sales (Garnier, 1982)			●	●
High marketing capabilities (Garnier, 1982)			●	●

Table 7 Benefits and challenges of different XPS types

Benefits				
Learning from the previous experiences (Beckman and Rosenfield, 2008)	●		●	
Common language (Netland, 2013)	●			
Facilitates benchmarking (de Jong et al., 2015)	●			
Cross-plant learning through the gathering knowledge at the headquarter (Beckman and Rosenfield, 2008)	●			
Cross-plant knowledge transfer (Jensen and Szulanski, 2004)	●		○	
Reduce initial capital – test facility can test before the rollout (Beckman and Rosenfield, 2008)	●			
Provides common standardized platform (Beckman and Rosenfield, 2008)(Netland and Aspelund, 2014)	●		○	
Reduce the uncertainty (de Jong et al., 2015).	●		●	
Allows the local adaptation in a controlled way (Beckman and Rosenfield, 2008)		●		
Responds to the local contextual conditions (Beckman and Rosenfield, 2008) (Netland and Aspelund, 2014)		○		●
Allows to respond to importance of particular performance measures (Cua et al., 2001)		●		●
Address the organizational and external forces (Lee and Jo, 2007)		●		●
No overhead for coordination across firm (Beckman and Rosenfield, 2008)				●
Learning curve effect by individuals working close to processes (Beckman and Rosenfield, 2008)				●
Local suggestions can be filtered by headquarter and be applied/suggested to other subsidiaries (Beckman and Rosenfield, 2008)		●		○
Faster decisions regarding implementation of new improvements (Hayes, 2006)				●

Table 8 Challenges of different XPS types

Difficulties/ Disadvantages				
No common "language", standardized platform (Netland, 2013)		●		●
Difficult to do because it requires overhead on coordination and sharing (Beckman and Rosenfield, 2008)			●	
Compromised system and some of the subsidiaries may not be managed properly (Maritan et al., 2004)	●		●	
Difficulty of transferring knowledge – increasing stickiness (Jensen and Szulanski, 2004)		●		●
More bureaucracy (Beckman and Rosenfield, 2008)	●	●		
Decisions takes more time (Beckman and Rosenfield, 2008)	●	●		

4. Developing the framework for design and implementation of XPS in multi-plant company

Chapter 4 aims to:
Develop the framework for designing and implementation of XPS in multi-plant company.

This chapter aims to develop the framework for designing and implementation of XPS in multi-plant company. This framework is based on the synthesis of the literature on Lean manufacturing (section 3.2.) and company-specific production system XPS (section 3.3.) and best practice transfer from headquarter to subsidiaries (section 3.3.). The framework is divided into three main, subsequent phases; (1) conceptual, (2) design and (3) implementation and consists of two constituents – (1) technical stages and (2) organizational factors. This chapter presents subsequently each phase and its constituents.

4.1 Framework phases

Section 3.2. demonstrated that the Lean manufacturing in order to be implemented successfully should consists of technical elements such as tools and best practices and the organizational factors such as employees commitment, continuous improvement culture etc. This master thesis proposes a three-phase framework that consists of conceptual, design and implementation phases that are made up of technical stages and organizational factors

Each technical stage have corresponding organizational factors that are depicted next to the particular stage. Those factors have milestone function, meaning that unless they are not provided company should not proceed to the next phase. This section aims to describe the subsequent phases.

4.2.1. Conceptual phase

The objective of the first phase is to establish necessary structures such as XPS office, roles, provide a training to employees that are involved in the XPS design stage and develop standard KPI's.

1. *Decide to implement XPS.*

The conceptual phase starts when a company's headquarter decides to implement the mutli-plant improvement programme in the form of company-specific production. The common reasons for this decision is often a need of simultaneous performance improvement of all plants in the network (Netland and Aspelund, 2014).

Several authors emphasized the importance of organizational elements in successful implementation of Lean (Womack and Jones, 1996, Liker, 2004, Bicheno and Holweg, 2009, Åhlström, 1998). Review of frameworks in subsection 3.2.5. gives an evidence that there is a common agreement that the lack of organization factors such as top management , employees commitment, effective communication and the lack of *strategic alignment* to improvement programs are often the reasons for Lean implementation failure. Therefore, *corporate vision* and *strategic alignment* are necessary factors to consider before the improvement programmes are chosen to ascertain that the corporate, business and manufacturing strategy are in a strategic fit (Kim and Arnold, 1996).

2. *Establish XPS structures.*

Headquarter has to establish XPS structure in form of *global office* and appoint roles that will support XPS design and implementation (Netland, 2013). Global XPS office includes *XPS team* that is responsible for the XPS design and implementation (Motwani, 2003). The team is often responsible for *developing XPS intranet pages* that includes best practices and training material that play a supportive role to the XPS implementation in subsidiaries (Netland, 2013). It is important that the global XPS office employees are *dedicated* and have *strong leadership skills* so that can successfully motivate the rest employees and plants leaders during the implementation stage (Saad et al., 2006, Nordin et al., 2012).

3. *Provide training.*

Providing training and knowledge to employees that will have a key function in designing and implementation of XPS is necessary. Building the strong *team of* *expert*s that possess a necessary knowledge would enhance the XPS implementation (Anand and Kodali, 2010).

4. Define standard KPI's.

XPS office develops standardize *Key Performance Indicators* (KPI) to assess the performance of each plant**.** KPI's are a tool to monitor and assess the implementation progress that should be the same across the organization to compare effectively the subsidiaries performance. Well established KPI's clearly depicts what matter most to the company and its competitive priorities (Liker, 2004). Therefore this stage has a loop with the first stage of design stage, *determine competitive priorities,* as they have to be considered simultaneously.

4.2.2. Design phase

The objective of the XPS design phase of framework is to develop a company-specific production system that can be applied to all subsidiaries of the manufacturing network, in order to create a common, standardized platform for improvements, considering the characteristics of the each subsidiaries to fit the content to the local characteristics.

In order to simplify the design stage this thesis proposes a universal tool that can be utilized by companies that aims to design the XPS. Tool is presented in figure 17 and further explained in the section 4.3. The tool consists of several steps that company has to follow to develop the company-specific production system. The tool is constructed in a way to fit to every organization, no matter how many subsidiaries are included in manufacturing network. The focus is placed on the clear differentiation between the standard practices and tools that can be applied to all subsidiaries in form of *global XPS* and the best practices that have to be adapted to fit the subsidiary's unique characteristics and needs as a *local XPS* (Netland, 2013).

5. Determine competitive priorities

Competitive priorities are an essential input to the framework because they define the improvement goals and future performance requirements (Kim and Arnold, 1996). Choice of competitive priorities should be in line with the business and corporate strategy.

6. Analyze the current situation

It is important to consider the current situation in order to plan any improvements (Rusjan, 2005). The strategic analysis of a current situation has an essential role in the choice of the future improvement action (Mills et al., 1998). This stage has a high significance due to that identifies the problem of business unit (Rusjan, 2005). It determines the effectiveness of the decision-making about the future improvements. Without recognizing the current situation in production the appropriateness of action programmes could not be assessed (Rusjan, 2005). There is a need for a thorough problem identification and assessment before the solution is being searched. Strategic analysis should happen at the both business and the functional level and the relations between those analyses can support to establish the goal of the operations strategy. The current performances of competitive priorities decide on the classification of the strengths and weaknesses. Rusjan (2005) claimed that determining the strengths and weaknesses is the fundamental part of strategic problem identification that should happen on both strategic levels. Strategic problem at the business level "can be illustrated with a question of how to ensure competitive advantage of the enterprise" while on the functional level "can be illustrated with a question how to ensure desired results in specific competitive priorities". Getting the knowledge about the characteristics of the enterprise enhances the problem formulation that influences formulizing the strategies and strategies objectives.

7. Determine improvement goals.

This stage aims to determine the improvement goals company want to achieve through the improvement programmes. The competitive priorities should be linked with the choice of the best practices (Kim and Arnold, 1996). Improvement goals should address company's competitive priorities. It is important that improvement goals utilize strengths and opportunities, and aim to reduce threats and weaknesses prior defined.

8. Identify best practices

This phase aims to identify the best practices that supports achieving the improvement goals. Results of this stage make visible which of the best practices are correlated with the biggest number of improvement goals. The high focus, efforts and resources should be placed on these practices (Åhlström, 1998).

9. Map subsidiaries characteristics.

As the framework aims to consider the local contextual factors, the mapping of subsidiaries is proposed in order to check the applicability of best practices and tools. The mapping of environment is divided in three categories; *product, market* and *manufacturing processes* as the table 9 shows below (Johnston and Menguc, 2007).

Table 9 Categories of subsidiairy characterstics|

Product	Manufacturing process	Demand
Product complexity (BOM) Production situation	Production process Shop floor layout Batch size Throughput time	Frequency\ Volume

10. Assess the applicability of best practices and tools to each subsidiary.

Those phase aims to assess whether best practices and tools listed in the phase 6 can be applied to all subsidiaries. Applicability check is made through the comparison of mapped subsidiaries characteristics and the best practices according to the table 3 developed in subsection 3.2.6.

This phase results in a set of best practices and tools that are universal and can standardized to all subsidiaries and these that have to be adapted to fit the subsidiaries characteristics.

11. *Map the XPS type*

As it has been found out whether company can implement the same practices across the all subsidiaries, the next stage aims to determine type of XPS based on the characteristics of the manufacturing network. According to section 3.4.3. four types of XPS are here possible: Centralized Global XPS, Centralized Local XPS, Decentralized Global XPS and Decentralized Local XPS. The choice which type of XPS is suitable for certain company can be made based on determinants from table 6 such as: degree of products standardization, stability of technology, manufactured volume, degree of production automation, size of network, distance between subsidiaries, level of subsidiaries' competences, complexity of R&D, marketing capabilities and share of local sales.

Beside the choice between the Global XPS or Local XPS's, the relationships between headquarter and its subsidiaries in regards to decision-making autonomy are considered. Operational decisions can be made globally at headquarter or locally in the subsidiary, what can be represented by and *centralized* and *decentralized* model (Hayes, 2006). In centralized model global XPS office at headquarter is responsible for all the operational decisions, while the decentralized model gives a decision-making autonomy to local XPS office. Three main determinants are proposed; plants competences, size of the manufacturing network and the distance between subsidiary and headquarter. The higher competence, the higher autonomy subsidiary has. Larger distance between the subsidiary and headquarter is correlated with the lower degree of autonomy in order to reduce the information asymmetry (de Jong et al., 2015). The network size is related in a quadrative inverted model. Bigger plants has usually bigger resource, what increase their autonomy. It increases until the certain point is reached where the additional expertise and experience is needed. At this point autonomy begins to decrease (Johnston and Menguc, 2007).

12. Establish XPS Local Structures.

Each subsidiary establish its own structure to support the implementation such as *XPS local office* and *team* (Netland, 2013). Similarly, to the Global XPS structures, *XPS Local team* should be *dedicated* and possess necessary *strong leadership skills* to motivate the rest of employees and maintain the improvement.

13. Provide training locally.

Next stage aims to develop local XPS experts through the training done by the global XPS office. Local XPS experts should be able share their knowledge with other employees in each subsidiary.

4.2.3. Implementation phase

After all the XPS structures are established the implementation phase can begin.

14. Deploy XPS awareness program.

XPS awareness program as a first stage of implementation phase that aims to make all the employees familiar to the XPS concept. This stage should encompasses all subsidiaries in order to create a *common language* and establish a foundation for *an effective communication* during the XPS implementation. Common language and effective communication might facilitate the learning and experience sharing across the organization.

15. Develop an implementation plan

Each implementation should start with the clear plan developed by the XPS office. Plan should follow SMART criteria proposed by (Doran (1981)). The plan should be *specific, measurable, achievable, realistic* and *time marked.*

16. Implement a pilot programme.

Pilot project is recommended to be conducted before the XPS is applied to entire organization. Pilot project encompasses a smaller unit such as one department or one plant to try the implementation and ensure that the further implementation will be based on efficiency, effectiveness and accuracy (Anand and Kodali, 2010).

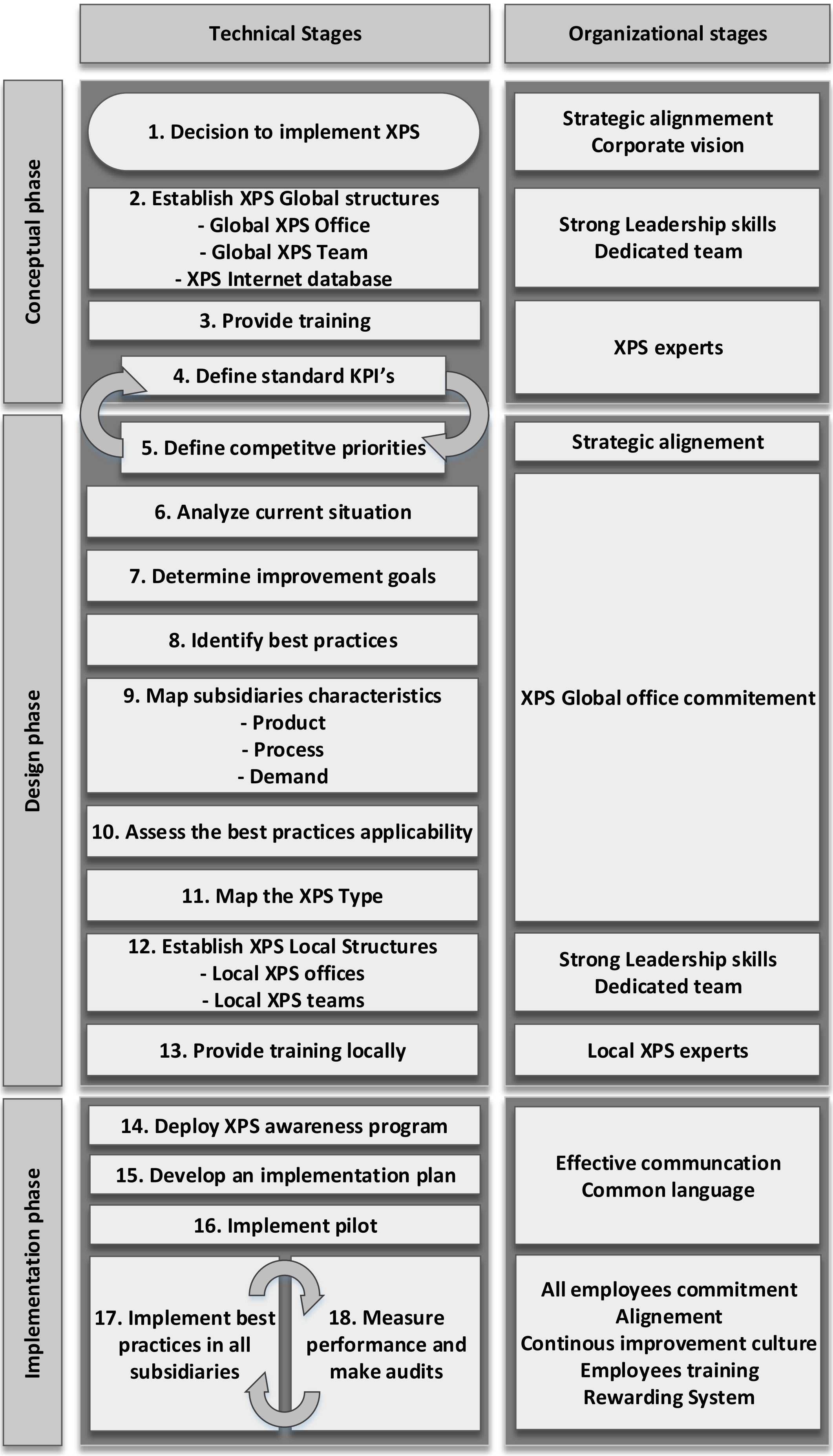
17. Implement best practices in all subsidiaries.

Åhlström (1998) emphasized that the efforts and resources in a company are limited, hence any improvement may demands implementing the particular improvements before other are adopted. Jones et al. (2003) suggested that the implementation should target the most problematic processes. As in the design stage, the commitment of top management was essential, the implementation of best practices requires also *commitment* and *alignment* of all employees in order to be successful. Organization should set a focus on constant employees' development through a series of *training.* Both training and establishing the *rewarding system* have an impact in sustaining the *continuous improvement culture.*

18. Measure performance and make audits.

This stage has an evaluative role that is performed along the entire implementation of best practices in subsidiaries. It aims to assess the changes of prior developed KPI's, to assure that the XPS is implemented according to the plan and gives expected results (Anand and Kodali, 2010). Audits performed by the XPS teams allow comparing performance between plants and find the reasons of differences (Netland, 2013). This phase has a back-loop with Implementation plan stage to imply corrective actions to the plan if needed. This loop also ascertain the continuous improvement.

Figure 16 The framework for XPS design and implementation



4.3. The tool for XPS design

This section aims to depict and explain the functionality of XPS design tool that has been developed as a supportive element of the framework. The tool has been developed based on the manufacturing strategy framework of Kim and Arnold (1996) and the contribution from Rusjan (2005) that have been depicted and discussed in the section 3.1.

The tool is universal, meaning that is applicable to all manufacturing companies regardless of its industry, number of subsidiaries or product portfolio. The ultimate goal of the XPS design tool is to create a set of best practices that consists of: (1) *standardize*, universal best practices and tools that can be standardized across all subsidiaries and (2) best practices and tools that have to be *adapted* locally to fit the unique characteristics of particular subsidiary. As the section 3.4. discussed, multi-plant company by implementing the XPS has to deal with a trade-off between the global conformity that creates a common, standardized platform and unique, local characteristics that should be taken into consideration and utilized by the programme. (Netland and Aspelund, 2014).

Tools consists of six subsequent stages that overlap with six stages from the design phases in the framework presented in section 4.2.

1) *Determine competitive priorities* – Write the company's competitive priorities.
2) *Analyze current state* - Write in the results of the current state analysis
3) *Determine improvement goals* - Write in the improvement goals
4) *Identify best practices* - Correlate improvement goals with the best practices
5) *Map subsidiaries characteristics* - Map each of the subsidiary concerning the product, manufacturing processes and demand characteristics
6) *Assess the best practices applicability* - Results of the characteristics mapping allows to assess the best practices applicability to each subsidiary.

As it has been discussed in section 3.1, due to the dynamic environment companies constantly reconfigure and adapt their core capabilities and adapt competitive requirement to sustain the competitive advantage (Wang and Ahmed, 2007, Netland and Frick, 2017). Therefore, companies should reiterate periodically the first four stages to ensure that the XPS address the dynamic priorities.

Best practices that are applicable to all subsidiaries should be standardized are marked *standardize.* Practices that has to be adapted to be applicable to particular subsidiaries are *adapt.* This is the last stage of the tool that aims to provide the set of best practices that address prior defined improvement objectives. Further, company has to follow the next stages of the framework to decide whether to manage those XPSs from headquarter or at each subsidiary.

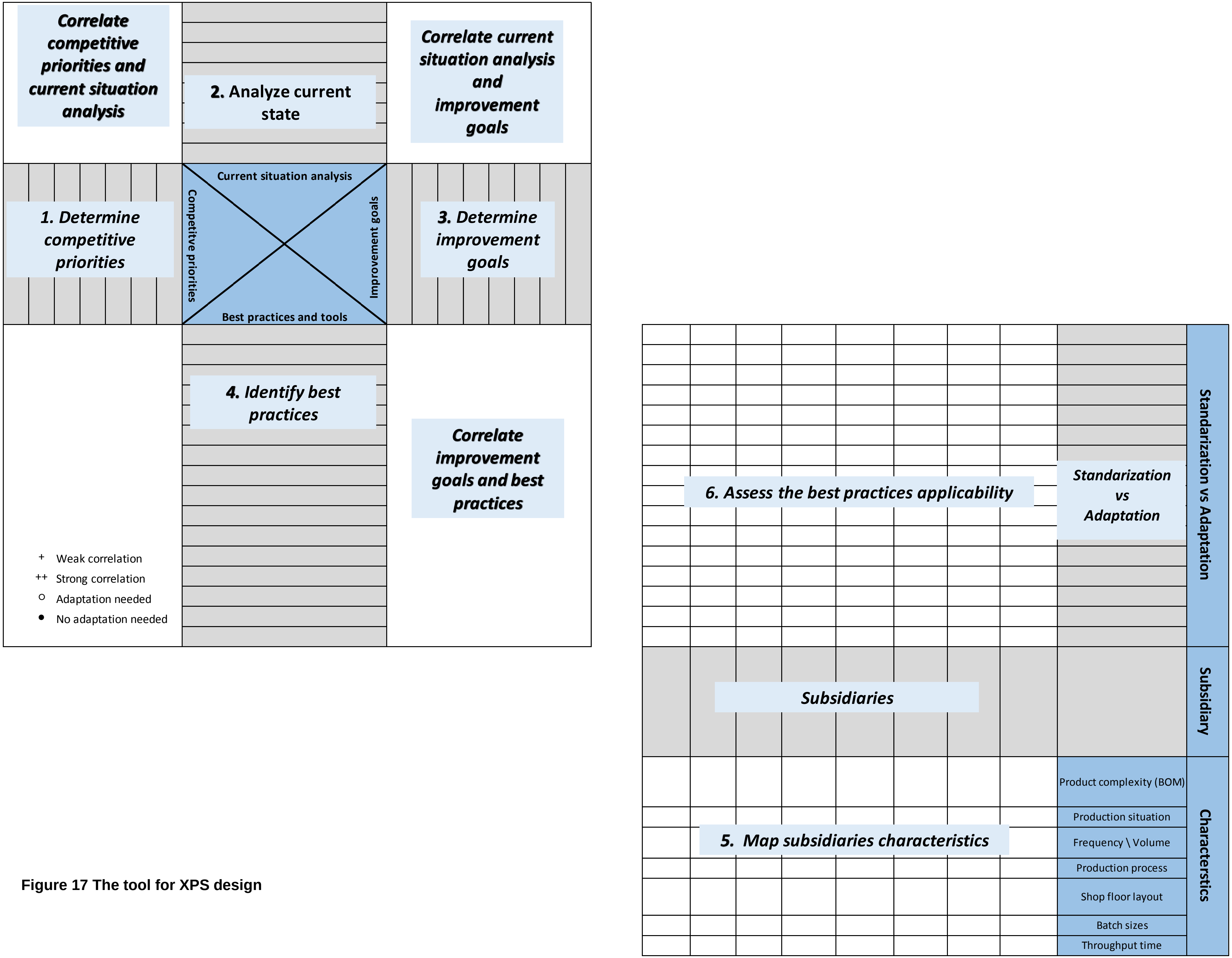


Figure 17 The tool for XPS design

5. Case study

Chapter 5 aims to:
To test and validate the framework for designing and implementing XPS in multi-plant company.

5.2. Introduction to Ekornes

This section aims to introduce the case company – Ekornes. The company background information are provided together with the business concept, vision and manufacturing strategy. Secondly, Ekornes subsidiaries are presented.

5.2.1. Company information

Ekornes is the largest furniture manufacturer in the Nordic region, which produces one of the world's most famous furniture brands and arguably the best-known brands in the Norwegian furniture market. Products are manufactured in five factories in Norway, and one factory in the USA. The products are marketed all over the world by a network of national and regional sales companies. In 2016, the Ekornes group has a turnover of 3,143 bil. NOK and around 2140 employees. The biggest market for the Ekornes products are Europe and USA (Ekornes ASA, 2017).

Ekornes gives priority to the design and development of product concepts that provide functionality, and comfort to customers. One of the Ekornes competitive advantage is its ability to combine efficiency with quality. This is being continuously improved by means of standardized components and designs, which satisfy both the requirements of the market and the need for efficient production.

Business concept and vision

Through a purposeful and consistent effort, Ekornes aims to increase continually the value of the branded products. Ekornes shall be the leading furniture manufacturer in Europe and be reputed to deliver quality at every stage. Ekornes shall take a leading position in Scandinavia as a supplier of furniture, mattresses and furnishing for ships and hotels (Ekornes ASA, 2017).

Manufacturing Strategy

Production shall be conducted in a way that attend to the brand image and secures correct quality and delivery precision. The delivery stage shall balance between consideration of the production planning and market requirements. Most of the production shall take place in Norway, where technological development and innovation shall form the basis for the competitive advantage (Ekornes ASA, 2017).

5.2.2. Factories overview

Ikornes plant – Headquarter

Figure 18 Ikornes plant (Ekornes ASA, 2017)

Factory Ikornes produces approximately 1,200 chairs per day. In addition, factory produces components for sofas (approximately 500 sofa seats per day) that are further assembled at Aure facility. Factory is focused on standardization, rationalisation and product quality.

Steel Department

Steel Department uses more than 2,500 tons of steel per year and more than 57,000 meters of steel tubing per week. Department covers 7,000 square meters and has 80 employees and sixty robots. The place has a highest density of robots in Norway. Factory produces two units a minute (1,800 seat units divided by 900 minutes on two shifts).

The components produced by this department are highly standardised. This is both efficient and cost-effective, which is vital for continued production in Norway. The back and seat frames come in three standard sizes. The only difference is in the length of the tubing used. They undergo the same operations. Rationalising the production of the different components in this way results in major cost savings. This department is equipped with a great deal of modern machinery, both off-the-shelf machines and robots that have been adapted to or specially developed for Ekornes. Each workstation undertakes a number of different operations, and the machines/robots in each cell are carefully positioned for maximum efficiency. Often one robot stands in the centre and feeds the machines around it. Around 5 per cent of the inputs ends up as scrap, which is sent for recycling in Ørsta. Departments highly invested in the new-technologies to increase efficiency of the production.

About production of back for chairs and sofas and conveyor-based internal transport system

"More accurate equipment has been developed, which has increased efficiency and produces a better quality weld. We keep up with the developments being made, and adopt new technology when this helps to rationalise our production."

"These changes mean we will no longer have to transport the parts over to the other side of the room for welding and then bring them back again for the attachment of Flexo-springs and other components. As a result we will free up the equivalent of 5 full-time employees, who can be deployed in other areas of production."

About the production of steel seat frames and epoxy coating

"In 2012 the efficiency of this cell was significantly upgraded, after the department relocated the machines and installed new welding robots. These changes almost halved the production time for the arm-bracket. This is a good example of how the plant's operators, in conjunction with mechanics and automation engineers, are constantly on the look-out for smarter ways to produce things."

About the cell production of steel chairs

"The capacity of this cell increased dramatically in the first part of 2015. A switch from stainless to carbon steel, a new bending machine, new welding equipment and a new cell layout has made it possible to triple its output. In theory, we now have the capacity to produce 25 units per hour, rather than 7 previously."

Foam Department

Foam factory covers 7,000 square meters and a separate building for storage tanks. Department produces up to 6,000 cushions a day. Department is spread over 3 floors, with different production processes in each.

Block foam are produced once or twice a week in long production runs of 300 to 400 meters with four different qualities. Then blocks are cut into 13-meter lengths. Department produces up to 1,000 cubic meters of foam per week. Around 20 % is sold to third parties. Foam blocks are send to cutting processes. Cutting processes are computer-controlled. Offcuts are reused for production mattresses or are sold to other manufacturers.

Production of cushions starts with the injection molding that uses driverless truck to transport frames into injection moldings unit. 100 molding units are produced to cover demand for all products. The molds are sprayed with a water-based slip agent that is automatically piped directly from the chemical storage facility. Each component has predefined chemical recipe. Then cushions are hung up in the curing store for at least two hours to cool down. After that, cushion are automatically transported to the gluing floor bellows, where the foam pads from the cutting department are glued on. The bulk of the output travels by conveyor directly to the upholstery department and the rest goes by truck to Aure facility.

Leather cutting and sewing

Cutting

Leather cutting production process consists of traditional cutting machines which are model-oriented, means that all the parts for one product model are cut at one machine, and computerised cutting on Lectra machines. Lectra machines are more efficient. One operator checks the hides before cutting begins, and marks the four categories with an electronic pen, which tells the machine where the parts can be used. The second operator picks out the ready-cut parts and sorts them into trolleys.

These cutting machines are *colour-oriented*, which means that parts required for several different models that have been ordered in the same quality/colour are cut from a single hide. The machine chooses the combination of parts that makes maximum use of the hide. Templates for all product models are stored in the machine, and can be called up depending on the mix of orders to be produced each week. This provides easy adjustment and great flexibility. Machines reduced the level of wastage compared with the model-oriented cutting machines. A cut in wastage of just 1 per cent, would result in significant savings, given the amount of leather Ekornes uses and the leather price.

Sewing

The cover is the part of the Stressless® production process that requires the most resources, with regard to both materials and labour. The sewing department is Ekornes' largest department by far, with around 200 employees. All transport and internal storage within the department is automated. The cut leather parts are placed in trolleys along with other essential materials. The trolleys are then moved to the various sewing machinists. Internal transport goes via an advanced system of conveyor belts. A computer system keeps track of who can do what, and in what order the operations must be carried out.. The machinists log in via a screen at their workstation, and a record is kept of the work they perform during the day. To prevent the work from involving many short, repetitive movements, each machinist completes as much of each chair cover as possible. It is also possible for them to adjust their working position to suit their particular needs.

The different models vary considerably in how labour intensive they are to produce. It is important to have a good mix of models, so that we can make the best use of the department's capacity, and avoid machinists having to wait for the next piece of work to arrive. Before being sent on for final assembly, the first upholstery operation is performed – inserting the quilting and covering armrests. Customer orders are linked to the covers, and checks are made to verify that the customer order matches the cover that has been produced. Once the cover is complete, the conveyor system transports it automatically to the upholstery section. As the trolley is lowered down, the system reads which model has arrived for upholstering and sends a message that the cushions for this model should be brought out of the cushion store.

Upholstery Department

Upholstery Department together with leather cutting and sewing department are customer-order driven. The finished covers arrive in this section from the sewing department, while the inserts (seat and back cushions) come from the foam plastic factory. A scanner records cover that has arrived, and sends a message to the cushion store stating which cushions are to be used. Then, cushions are sent automatically to the upholstery section. A vacuum is used to make it easier to get the cover onto the seat, back and footstool cushions. Most of the plastic is removed. The loops on the back cover are hooked on to the springs. On the seat and footstool cushions, the loops are attached to the underside of the plastic insert. This operation varies in difficulty and time in regards to different models. The finished components are carefully quality controlled by each upholsterer, who “signs off” that the piece has been checked.

Assembly and packing

Before being packed, the product is checked over one last time, and in the same way as the upholsterers, the assembler/packer also “signs off” on the screen after their quality assurance check. Every operation relating to a production order is logged, so it can be trace who carried out each task in the event of a complaint. Once the products have been packed, around 40 % are taken out to containers where they are collected by ship twice a week, while the rest are sent by road.

Aure plant

Figure 19 Aure plant (Ekornes ASA, 2017)

Recently merged with Ekornes Hareid. Aure is producing sofas for Ekornes and is divided in sewing department and upholstery/assembly department. Production processes include wrinkling and sewing, gluing, upholstery and assembly. Aure established recently the assembly line for sofas to improve the flow, reduce variability and improve the quality. Assembly line includes gluing, upholstery and assembly operations. Assembly line is dedicated only to one product family. The rest of products is still produced at the workstations. Production at Aure is controlled with MRP principle and daily production plans are made. Aure has a Kanban loop between the inventory of wooden components and factory in Grodås. Steel and foam is sent from Ikornes and is held in the inventory. Finished products are sent to Ikornes warehouse or directly to customer.

Grodås plant

Figure 20 Grodås plant (Ekornes ASA, 2017)

Specializes in manufacturing of internal and exposed wood components for sofas. The plant with its modern machinery, which is also designed for the surface treatment of exposed wood, is operated on an order-driven basis. Grodås subsidiary has achieve great increase of effectiveness trough the implementation of Lean tools such as 5S, kanban, and continuous flow. The very motivated and talented top-management, together with engaged and aligned employees continuously improve the cost-efficiency.

Tynes plant

Figure 21 Tynes plant (Ekornes ASA, 2017)

Tynes factory was acquainted in October 2003. The plant is specialized in the form-pressing and laminating of plywood which are the cutting-edge skills. Machine park has been constructed to process the laminates. Tynes plant has a high degree of standardization and produces components in big batches.

The laminates consist of several thin sheets of beech wood, which are stacked on top of each other with a layer of glue between each sheet. Using high pressure and high frequency heating, the wood laminate is bent into shape.

The laminated semi-circles that will become the base ring, are first split, then the ends are trimmed and cut into “fingers” to create a stronger join when the two halves are glued together to form a complete circle.

Fetsund plant

Figure 22 Fetsund plant (Ekornes ASA, 2017)

Fetsund factory produces mattress and foam. The plant is modern and well-equipped, where a large number of components are made on premises.

The factory's production of high-quality fiber-filled foamed plastic is recognized for its efficiency. Other Scandinavian manufacturers purchase the surplus volume.

Morganton plant USA

Figure 23 Morganton plant (Ekornes ASA, 2017)

Establishment of a production facility in North Carolina was initiated by the need for quicker delivery times on Stressless sofas to the expanding US market. Ekornes already ensures shorter delivery times for Stressless chairs to this market by keeping a stock of the most popular models at the US Sales and Distribution Centre in Somerset, New Jersey. Ekornes selected North Carolina because of the heritage for furniture production in that state.

5.3. Current situation regarding the improvement programmes

This section aims to analyze the current situation regarding the improvement programmes to build a foundation for the framework validation.

Ekornes is a vertical integrated company with world-class production sites. However, as a Norwegian manufacturer and high-costs, Ekornes has to improve steadily the manufacturing efficiency and implement improvement programmes in order to stay competitive. Company invested in high technologies and today possess one of the most advanced robot parks in Norway.

In 2015, the cost-cutting programme was announced. This programme aimed to strengthen the Ekornes Group’s profitability and competitiveness. In 2016 programme aimed to improve the efficiency of both organization and logistics systems. Production in Norway was adjusted and centralized. This included the decision to cut the number of sofa production units from two to one and concentrate all future sofa production at the Aure factory in Sykkylven.

Company also decide to implement the Lean manufacturing. However, not all the plants achieved the equal level of Lean implementation. Grodås factory achieved so far the highest level of Lean implementation through the engagement of all employees and the well-qualified and motivated top management. The company has not implemented a common improvement programme yet. One of the reason were different characteristics of each subsidiary. In the recent years, each factory was focused rather on its internal efficiency. Today, the company is aware that in order to gain the most from the improvements, they have to look at the value chain and subsidiaries from the whole perspective.

5.4. Validation of the framework

This section aims to test and validate the framework for XPS design and implementation in multi-plant company. Conceptual and implementation phase are discussed

5.4.1. Conceptual phase

As the section 5.2. has shown, Ekornes is aware that a holistic perspective on all subsidiaries can be bring a significant improvement of the value chain efficiency. As Netland and Aspelund (2014) claimed the need of simultaneous improvement of all subsidiaries is often the reason to consider XPS (*stage 1)*. Ekornes corporate vision to become the leading furniture manufacturer, business strategy and manufacturing strategy are in a strategic fit. This indicates that corporate vision and strategic alignment as essential organizational factors are achieved. It is recommended that Ekornes establishes the Global XPS office at Ikornes headquarter with a dedicated and trained team responsible for XPS design and implementation (*stage 2 & 3*). Further Ekornes has to determine standard KPI's (*stage 4)* that will be used to assess and benchmark performance of each subsidiary and to monitor the improvement. This stage is performed simultaneously with the first stage of the design phase

5.4.2. Design phase

First six stages of the design phase are performed with the use of the tool for XPS design developed in section 4.2.

1. Determine competitive priorities – The competitive priorities were identified based on the input from the Ekornes employees. Some of the competitive priorities were considered critical while other important.

Critical competitive priorities: new products more frequently, innovative products, better products quality, flexibility for broader product range

Important competitive priorities: flexibility for volume changes, lower selling prices, fast deliveries.

2. Analyze current state – The current situation was analyzed trough the semi-structured interviews and the SWOT analysis. After the current situations was analyzed, the results were correlated with the competitive priorities. The goal of the correlation is to see how the competitive priorities are followed in practice. It has been shown that the Ekornes put much effort to achieve a short *delivery time* and *quality*. Despite having the *innovative products* and *new products more frequently* as the competitive priorities, the *product portfolio has a low growth potential*. *The unclear strategy* might be a reason for that. Due to the recent investments in equipment, Ekornes consists of *world-class facilities*. As the correlation shows, it has a big impact on all competitive priorities what proves the reasoning behind these investments. *Flexibility for broader product range* and *volume changes* are correlated with the *vertically integrated supply chain* which allows to respond faster to market and demand changes. What is evident, Ekornes as a Norwegian manufacturer has a *high cost of work*, which makes essential to look continuously for the efficiency improvements.

3. Determine improvement goals – Based on the current situation analysis and competitive priorities the improvement goals have been determined such as; *reduce throughput time, reduce variability in throughput time, reduce WIP, improve quality, improve service level, increase innovativeness, reduce unit costs, sustain short delivery time*. Further, these improvement goals were correlated with the current situation analysis.

4. Identify best practices – Improvement goals were correlated against fifteen Lean best practices and Six Sigma. Based on the findings from section 3.3.4. and 3.3.5. it was considered that Lean manufacturing and Six Sigma are most suitable in this case and can support achieving the improvement goals.

5. Map subsidiaries characteristics – Each of the subsidiary were mapped according to their product, manufacturing process and demand characteristics as in table 10. Results has shown clearly that Ekornes subsidiaries varies significantly regarding the production situation, production process, shop floor layout and batch sizes.

6. Assess the best practices applicability - Results of the subsidiaries' characteristics mapping allow assessing the best practices applicability to each subsidiary. It has been shown that all of the best practices are equally applicable to subsidiaries Tynes, Grodås and Ikornes Steel. While to other subsidiaries, some of the best practices has to be adapted in order to be applicable or to bring expected benefits. In total, the set of nine best practices has been assessed ad universal that can be standardized, while seven practices have to be adapted to address the subsidiaries' unique characteristics.

The results of the first six stages performed with the use of XPS design tool are presented in the figure 24.

7. Map the XPS type – After the applicability of best practices has been assessed, the XPS type is going to be mapped. The section 3.4.3 presented a table 9a which will be utilized here to decide which type of XPS is most suitable for the Ekornes.

Table 10 Ekornes' determinants

● – big impact ○ – middle impact	Centralized Global XPS	Centralized Local XPS	Decentralized Global XPS	Decentralized Local XPS
Ekornes determinants				
Non standardized products		○		●
Stabile Technology	●		○	
Different volumes		○		●
High automated production	●		○	
Small network			●	●
Small distances between facilities			●	●
High competences at the factory			●	●
High R&D complexity			●	●
High share of local sales			●	●
High Marketing capabilities			●	●

As the results show most of the determinants indicated that Decentralized Global XPS and Decentralized Local XPS are most suitable for Ekornes. Findings from the Section 3.4.3. pointed out the Decentralized Global XPS is difficult to do due to the extra overhead cost for coordination. Therefore, the Decentralized Local XPS is here recommended. It means that each of the subsidiary manages its Local XPS to respond to the local, unique conditions. However, nine of the sixteen best practices were assessed as applicable to all subsidiaries, hence the local XPS's will contain the similar set of best practices. It may allow the effective benchmarking and transfer of knowledge between subsidiaries. In order to facilitate that, the Global XPS office established in headquarter Ikornes may be responsible for monitoring and measuring the improvements in each subsidiary, but without having a decision-autonomy regarding the local XPSs.

Each of the Ekornes subsidiaries should establish local structures in form of local office and team who would be responsible for managing the XPS *(stage 1*2). Experts from Global office should provide a training at each subsidiary to develop local expertize *(stage 13).*

Delivery time	New products more frequently	Innovative products	Flexibility for broader product range	Flexibility for volume changes	Better products quality	Lower selling price	Current situation analysis	Reduce throughput time	Reduce variability in throughput time	Reduce WIP	Improve quality	Improve service level	Increase innovativeness	Reduce unit costs	Sustain short delivery time
	++	++	++				Product portoflio with low growth potential						++		
	+	++					Unclear strategy	+	+	+	+	+	+		
+	+	+			+	++	High cost of work	++	+	++	++	+	+	++	++
++	++		++				Short delivery time	++	++			++			
	++	++	++		++		Product development	++			++		++		
++	++	++	++	++	++	++	World class production sites	++	++	++	++	++	++	++	++
++	++		++	++			Veritcaly integrated supply chain	++	++	++		++		++	++
		++			++		Good quality products				++		++		

Competitive priorities

Improvement goals

Best practices and tools	Reduce throughput time	Reduce variability in throughput time	Reduce WIP	Improve quality	Improve service level	Increase innovativeness	Reduce unit costs	Sustain short delivery time	Morganton (USA)	Fetsund	Tynes	Grodås	Aure	Ikornes Upholstery	Ikornes Foam	Ikornes Steel	Standarization vs Adaptation
Visual Mananagement 5S	+	+	+	+	+		+	+	●	●	●	●	●	●	●	●	Standarize
Standarized work and processes	++		++	++	+		++	++	○	●	●	●	○	○	●	●	Adapt
Stability of processes	++	++		++	+		++	++	○	●	●	●	○	○	●	●	Adapt
Level production \ Heijunka	++	++			+		++	++	○	●	●	●	○	○	○	●	Adapt
Just - in - Time	++	++	++				++	++	○	●	●	●	○	○	○	●	Adapt
Takt-time planning		++						++	○	●	●	●	○	○	○	●	Adapt
Continuous flow	++	++	++		++		++	++	○	○	●	●	○	○	○	●	Adapt
Pull system \ Kanban	++	++					++	++	○	○	●	●	○	○	○	●	Adapt
SMED	++							++	●	●	●	●	●	●	●	●	Standarize
CI\Kaizen	++	++	++	++	++	++	++	++	●	●	●	●	●	●	●	●	Standarize
Waste reduction \ Gemba	++	++	++				++	++	●	●	●	●	●	●	●	●	Standarize
People and Teamwork	++	++	++	++	++	++	++	++	●	●	●	●	●	●	●	●	Standarize
Jidoka \ Autonomation		++		++				++	●	●	●	●	●	●	●	●	Standarize
TQM				++				++	●	●	●	●	●	●	●	●	Standarize
TPM	++	++						++	●	●	●	●	●	●	●	●	Standarize
Six sigma		++		++	++			++	●	●	●	●	●	●	●	●	Standarize

Subsidiary	Morganton (USA)	Fetsund	Tynes	Grodås	Aure	Ikornes Upholstery	Ikornes Foam	Ikornes Steel
Product complexity (BOM)	3-5 levels with several items	1-2 levels and few items	1-2 levels and few items	1-2 levels and few items	1-2 levels and several items	1-2 levels and several items	1-2 levels and few items	1-2 level and few items
Production situation	MTO	MTS	MTS	MTO	ATO	MTO	MTS	MTS
Frequency \ Volume	Large\ Medium	Large\ Medium	Large\ Medium	Large\ Medium	Large\ Medium	Large\ Medium	Several\ Large	Several\ Large
Production process	One-off	Batch	Batch	Continuous	One-off	Batch	Batch	Batch
Shop floor layout	Functional	Functional	Functional	Cells	Cell	Functional	Continuous line	Functional
Batch sizes	Small	Big	Medium	Order Qty	Order Qty	Order Qty	Big	Medium
Throughput time	Short	Short	Short	Short	Short	Short	Short	Short

Characterstics

- \+ Weak correlation
- ++ Strong correlation
- ○ Adaptation needed
- ● No adaptation needed

Figure 24 Design for Ekornes XPS

5.4.3. Implementation phase

The implementation phase should begin with the XPS awareness program that deployed in each of the Ekornes subsidiaries. All employees should be aware of the XPS objectives and its purpose. When employees are aligned and understand the purpose of the XPS, they are usually more engaged in the implementation process. Achieving an effective communication in the stage 14 should become a company goal due to its importance during the implementation. Each of the local XPS offices, with the support from the global XPS office, should develop a clear plan for the implementation (stage 15) that is time constrained and can be measured. Before the XPS is deployed to the whole Ekornes organization, implementation of a pilot programme is recommended. It can encompass one production line or product family. After the pilot programme, best practices should be deployed to the rest of organization. It is necessary that all the Ekornes employees will be committed in this process. In order to sustain their commitment, local XPS offices should be provide a continuous training and establish the rewarding system. XPS implementation should be constantly monitor by the global XPS office through the number of audits. Audits should be constructed in such a way that the results would be easily translated into prior defined KPI’s. Results of audits should be discussed with local XPS offices for the learning purpose and drawing conclusions.

6. Discussion

The discussion chapter consists of two main parts. The first part presents major findings of this master thesis and discusses their importance. The second part assesses whether the objective of this research is achieved and the research questions stated in the beginning are answered.

6.2. Discussion on major findings

Findings of this master thesis:

1. The unique characteristics of each subsidiary influence the degree of best practices standardization across subsidiaries and the way XPS is implemented and managed.

XPS as the multi-plant improvement programme aims to improve the performance of all subsidiaries simultaneously. However, by applying one common improvement programme some of the subsidiaries might not be managed properly due to the different characteristics that are not utilized in the one standardized programme. Nonetheless, by having standardized practices across all subsidiaries, company can create a common platform with a common language that facilitates benchmarking between subsidiaries, cross-plant learning through the gathering knowledge at headquarter, knowledge transfer, learning from the previous experiences, reduces uncertainty and the initial capital needed. Therefore, it is essential to consider the trade-off between the global standardization and local adaptation. The issue is especially important to appraise for companies that have a diversified manufacturing network in regards to the product, manufacturing processes and demand characteristics.

The literature study has shown that the biggest number of industrial XPS's is built on the foundation of Lean manufacturing. As the Lean has developed from the repetitive manufacturing, it is not equally, easily applicable to different production environments. Chapter 3.4 has shown that the applicability of Lean manufacturing varies as it is applied to companies with different characteristics such as (*1) product complexity (2) production situation (3) frequency/volume, (4) production process, (5) shop floor, (6)* *batch size and (7) throughput time*. Therefore, subsidiaries should be mapped according to those characteristics, to assess whether the same approach to Lean practices should be utilized or whether some of the practices have to be adapted fist before are implemented.

The list of characteristics is focused around the technological aspects and might not cover the whole spectrum of characteristics that affect the applicability of Lean. As the example of Hyundai Production System shown, Lean might be not fully applicable to due to the cultural and human factors such e.g. working culture. The cultural and human aspects of best practice transfer were out of the scope of this thesis, but it is important to have in mind the those factors can impact the applicability of best practices and harm the best practice standardization across subsidiaries, especially in the manufacturing networks that are spread geographically.

2. The way in which XPS is managed from headquarter perspective depends on the XPS type.

It was found out that the XPS management model choice depends on the XPS type that can be mapped based on the determinants presented in table 6. Two main approaches have been identified: centralized and decentralized model. Each of the model, gives certain benefits and have number of drawbacks. Therefore, company has to consider scrupulously the choice of the management model based on the subsidiaries characteristics and experience. Centralized model fit better to big plants (Johnston and Menguc, 2007) and where is a longer distance between subsidiaries to provide an expertise and an experience from a headquarter and to reduce the information asymmetry. It fits better to subsidiaries that produce standardized products with similar volume with stable technology. This management model allows learning from previous experiences, facilitates benchmarking and cross-plant learning. However, the essential disadvantage of this model is that it does not allow responding to local contextual conditions. Therefore, the decentralized approach fits better to the highly competent subsidiaries that produce non-standardized products with different volume. This approach takes advantage from the learning curve of employees that work close to the process, addresses the organizational and external forces and facilitates faster decisions regarding implementation of new improvements. The biggest drawback of this approach is that it does not provide the common language and standardized platform for subsidiaries and makes it difficult to transfer knowledge across subsidiaries. Benefits and drawback of each XPS type are summarized in table 7 and 8.

3. It is possible to design and implement XPS for the multi-plant company that considers a trade-off between the global standardization of best practices and the local adaptation with the use of the framework for design and implementation of XPS in multi-plant company that includes the tool for XPS design.

The objective of that thesis was to develop a framework for XPS design and implementation in multi-plant company. The aim was to provide a sequential approach to XPS development that gives a possibility to determine a set of best practices that contains practices that can be applied and standardized in all subsidiaries and practices that have to be adapted first to address the subsidiaries' unique characteristics. There is a lack of such guidelines in the academic literature, although the industrial interest around XPS has become significant.

Based on the findings from the literature study and especially finding 1 and 2 discussed above, the framework was developed. The framework consists of three subsequent phases, conceptual, design and implementation that each phase consists of technical stages and organizational factors that company should follow to develop its XPS. Organizational factors are criteria that company should achieve before moving to the next technical stage.

It was important for the researcher that the framework will be easy to use for the end user. The goal was to develop the framework that is not rigid, hence various types of companies can utilize it. XPS is a broad concept that both content and range can vary significantly. XPS can be both developed by a medium size company that owns only few subsidiaries (There are documented examples of XPS implemented by companies that own only one plant and consider the internal departments as plant-within-plant such as Norwegian ski manufacturer Madshus) and big multinational corporations that own a big number of plants. Therefore, a tool for XPS design was developed as a part of the framework that is flexible and universal. The first part of the tool allows determining improvement goals based on the current situation analysis and competitive priorities and propose a set of best practices that address those objectives. The second part of the tool aims to map subsidiaries against characteristics that are essential to consider regarding the applicability of these best practices. This provides an important input which of the practices can be applied to all subsidiaries and which have to be adapted. This gives an important discussion point and possibility for companies to analyze whether to adapt best practices, propose different practices or adjust production system or product portfolio if possible. It provides a basis for companies to draw XPS in a graphical form. The tool can be reiterated after the XPS is implemented. It has been concluded that due to the changing environments and pressing competition, companies often reconsider and update their competitive priorities to sustain the competitive advantage. The tool gives a possibility to assess whether practices are still relevant and support the revised dynamic capabilities and make necessary changes in the XPS content.

The next stage of the framework allows determining the XPS type. The new XPS typology was proposed that consists of four types: (1) centralized global XPS, (2) decentralized global XPS, (3) centralized local XPS and (4) decentralized local XPS. Each type varies regarding the way it is managed, at headquarter or at each subsidiary and whether the practices are global or local. Mapping the XPS type is made through the number of determinants. Each of the type has certain benefits and disadvantages companies have to take into consideration.

This finding contributes to the literature gap mentioned by Netland and Aspelund (2014) that there is a need for more research regarding the adaptation vs standardization of best practices and the way in which XPS is managed from the headquarter perspective.

4. The XPS designed for case company contains of both standardized best practices that can be applied to all subsidiaries and practices that have to be adapted to address the unique characteristics of subsidiaries. The case company's XPS should be managed by the each of the subsidiaries to respond better to the local characteristics, but should be monitored and controlled by the global XPS office at headquarter.

One of the objective of this master thesis was to test and validate empirically the developed framework. The case company that was chosen is Norwegian furniture manufacturer Ekornes. Ekornes consists of five production plants in Norway and one in USA. The information regarding the Ekornes company, its subsidiaries and the current situation of the improvement programmes, together with the results of the case study are presented in the chapter 5.

Ekornes was a very interesting case company for testing and validation of the framework because of its subsidiaries that produce different products with different volumes and control principles. Due to the unique characteristics, applying one improvement programme was perceived as challenging. The process objectives of the case study was to first analyze the Ekornes' competitive priorities and the current situation, determine the improvement goals, map subsidiaries characteristics, check the applicability of best practices and define the management model based on company characteristics. The aim of the case study was to create the XPS that consists of best practices that can be applied to all subsidiaries and best practices that have to be adapted to respond to local subsidiaries'' characteristics and propose how the XPS should be managed.

The results of Ekornes' subsidiaries mapping shown that subsidiaries have a very diverge characteristics and none of the subsidiaries were similar in regards to the products, manufacturing processes and demand characteristics. This had an impact on the applicability of prior defined best practices that address the Ekornes' improvement goals. Case study identified sixteen best practices that could be applied to respond to the improvement goals. It has been evaluated that nine of the practices could be standardized and applied to all subsidiaries simultaneously, while seven of the practices have to be adapted first in order to fit the local characteristics of the subsidiaries. Further, the Ekornes was mapped against characteristics such as *product standardization, stability of technology, volume difference between subsidiaries, level of automation*, *level of competences, size of the manufacturing network and distance between subsidiaries.* The results of this analysis has shown clearly that XPS for Ekornes fits to the Decentralized Local XPS. It means that XPS should be managed locally at each of the subsidiaries. However, it was recommended to establish the global XPS office. Since the distances between subsidiaries are close, it is possible that the global XPS office consists of the top management from the local XPS offices. This might facilitate the communication and sharing of the experiences between subsidiaries. Global XPS office should also control and measure the implementation of local XPSs. Since nine of the practices can be standardized across all subsidiaries, benchmarking of subsidiaries is considered very useful. It would facilitate the problem solving, continuous improvement and the knowledge transfer between subsidiaries.

6.2. Objective and research question

Objective of the master thesis

To develop a framework for design and implementation of XPS in multi-plant that considers the unique characteristics of each subsidiary.

The framework for design and implementation of XPS in multi-plant company that consists of a tool for XPS design wad developed and presented in the chapter 4. The framework was further tested and validated through the case study of the Norwegian furniture manufacturer, Ekornes.

Research questions:

1. What is the scope of XPS?

It has been concluded in the section 3.3.3 that Lean manufacturing practices build a core of XPS. It is important to mention the findings from section 3.3.4, which has shown that Lean manufacturing can be synergistically joined with certain practices from other improvement programmes to target particular performance dimensions. Section 3.3.5 reviewed the most popular improvement programmes and compared their goals and core practices.

2. What are the benefits of XPS implementation?

The benefits of the XPS were first discussed in section 3.3.2 from the two perspectives: (1) company-specific production system and (2) multi-plant improvement programme. After the new XPS typology was proposed, benefits of each type were depicted in table 7 in the section 3.4.3. Benefits presented in the table consider the decision-autonomy and whether best practices are standardized across subsidiaries or are adapted locally.

3. What factors should be considered whether to standardize best practices across subsidiaries or adapt them at each subsidiary?

As the core of XPS is made of Lean practices, it was investigated whether the Lean practices can be applied to subsidiaries with different characteristics. Lean applicability has been analyzed in section 3.2.6. against seven characteristics linked with product, demand and manufacturing processes. It has been concluded that these characteristics may limit or make it difficult to apply certain Lean practices, hence not all Lean practices can be standardized across subsidiaries with different and unique characteristics.

Section 3.4.1. discussed the general characteristics of a company and their influence on best practices standardization. Determinants such as standardization of products, stability of technology, produced volumes, level of production automation, size of the network, distance between facilities, degree of competence, R&D complexity, share of local sales and marketing capabilities should be considered in order to decide whether to standardize on adapt best practices across subsidiaries. Determinants are presented in table 6.

4. How to manage an implementation of XPS in multi-plant company?'

To answer this research question the aspect of decision making autonomy was thoroughly analyzed in section 3.4.2. Whether company apply centralized or decentralized model of managing subsidiaries depend on the XPS type and certain determinants presented in table 6.

7. Conclusion

The objective of this master thesis was to develop a framework for design and implementation of XPS in multi-plant company that takes into consideration subsidiaries unique characteristics. The qualitative literature study discussed the content and benefits of XPS and the transfer of best practices from a subsidiary to headquarter. It identified factors that are essential whether company should standardize best practices across the subsidiaries or adapt them to each subsidiary. In addition, it mapped the determinants that influence the decision-making autonomy and the choice between the centralized and decentralized model of managing XPS.

This master thesis has shown that importance of fourteen characteristics to consider before the XPS is design. Literature review has shown that majority the XPS is built on the foundation of Lean manufacturing, therefore the applicability of Lean practices to different subsidiaries' characteristics such as *(1) product complexity, (2) production situation, (3) frequency/volume, (4) production process, (5) shop floor, (6) batch size and (7) throughput time*, has to be considered while XPS is designed to assess if Lean practices can be standardized across all subsidiaries. This thesis has shown that some of the Lean practices have to be adapted or are difficult to implement against the certain characteristics.

In addition, recognition of the factors such as (*8) product standardization, (9) stability of technology, (10) volume difference between subsidiaries, (11) level of automation*, *(12) level of competences, (13) size of the manufacturing network and (14) distance between subsidiaries* are essential to take into account to decide whether to implement standardized or adapted best practices across subsidiaries and to determine the decision-making autonomy and the model of managing XPS.

This thesis proposed a new typology of the XPS type based on the level of best practices standardization across subsidiaries and the model of XPS is managed. Four types of XPS were depicted: *(1) Centralized Global XPS, (2) Decentralized Global XPS, (3) Centralized Global XPS and (4) Decentralized Local XPS*. By mapping the XPS type, companies are able to identify the benefits and difficulties to further improve XPS and assess whether the XPS type fit to subsidiaries characteristics.

The major deliverable of this master thesis is a framework for the design and implementation of the XPS in the multi-plant company that can be used by the multi-plant companies that search for the performance improvements in all subsidiaries simultaneously. The framework consists of three major phases*: (1) conceptual, (2) design and (3) implementation*. Each of the phases contains the technical stages and the organizational factors that must be achieved in order to move to the next stage. Framework includes a tool for XPS design that consists of six stages *(1) determine competitive priorities, (2) analyze the current state, (3) determine improvement goals, (4) identify best practices, (5) map subsidiaries characteristics and (6) assess the best practices applicability*. The goal of the tool is to differentiate global, standardized practices and the local practices that have to be adapted at the subsidiary level, and ensure that the set of practices addresses the improvement goals of the XPS.

The framework was validated and tested through the case study of the Norwegian furniture manufacturer Ekornes. First the current situation was analyzed to determine the improvement goals. Next, the improvement goals were correlated with the best practices. The Ekornes' subsidiaries were mapped according to the eleven characteristics. Based on the characteristics mapping, prior depicted best practices, were checked against its applicability to each subsidiary. The results of the case study shown that XPS of Ekornes due to having different and unique subsidiaries, should consists of global, standardized practices and adapted practices to address the unique, characteristics of subsidiaries. Analysis of manufacturing network characteristics suggested the decentralized XPS that is managed at each of the subsidiary locally. However, it was recommended to establish the global XPS office to provide the necessary training to the XPS local offices and control and measure improvements.

XPS as a newly emerged concept in the academic literature needed more research regarding the standardization vs adaptation of best practices across subsidiaries and the way of managing the XPS. This thesis contributes to this theory by providing the framework for design and implementation of XPS in multi-plant company. This thesis contributes also to the improvement programme theory by providing a number of factors that should be considered before implementing one, common improvement programme for all subsidiaries. Thesis also analyzed the applicability of the Lean practices against seven different characteristics, which builds up the previous publications that were focused mostly on Lean applicability to different production situations and production types.

This thesis provide also practical contribution to the end users – practitioners such as managers of multi-plant companies. The framework and the tool may be helpful for the companies that plan to implement the XPS, while the proposed typology of XPS types may be used by companies that have already implemented the XPS, to check if there is a fit between their characteristics and XPS type.

The limitations of this study is that only one company was investigated. It would be very beneficial to validate and test the framework in the bigger number of companies from various industrial sectors. Due to the nature of the case study and the time constraint the implementation phase could not be tested. Therefore, it would be valuable to observe the implementation phase of the XPS that was designed with the help of the framework and the tool for XPS design. This might give an important feedback and results in some updated.

The future research should test and validate the framework in the more geographically spread manufacturing network. Then, it might be very interesting to consider the cultural differences and the local contingencies such as political situation that might have an impact on the applicability of certain best practices.

Appendix 1 Questionnaire

Company-specific Production System (XPS) Questionnaire

This questionnaire is a part of the Tomasz Bielec master's thesis conducted in the 2017 at the Department of Mechanical and Industrial Engineering at NTNU in Trondheim. This research investigates how the mulitplant improvement programmes should be designed and implemented to simultaneously increase the performance of all subsidiaries in the manufacturing network. Master thesis is written in the cooperation with the Ekornes ASA. This questionnaire is addressed to all subsidiaries of Ekornes consortium.

Research background.

The success story of Toyota had many followers, however not all of them succeed. The contingency theory emphasizes that there is no one way that fits to all organizations. Nor either Lean manufacturing. As an answer to that there has been observed recently a noticeable trend among the multiplants companies to deploy the company-specific improvement programmes that are customized version of Toyota Production System, where company strategically selects tools from best practices such as JIT, TQM or Six Sigma to fit the organizations unique characteristics, objectives and local contingencies. This company-specific production system is termed XPS. The "X" stands for the company name and "PS" usually for the production system. The XPS is a corporate improvement programme that is set at a corporate level and is applied further to all subsidiaries of the organization to simultaneously improve the performance of the all facilities within a manufacturing network. The objectives of the XPS is to align all plants within the network by adopting the same set of principles and best practices in multi plants to increase competitiveness and leverage knowledge. XPS creates a common platform for all plants within an organization and allows transferring the best practices within a network. Although many cases of the successful implementation of XPS have been well documented, this concept has received rather limited attention from the academic perspective. There is a lack of established methods and guidelines how to design and implement those improvement programmes considering subsidiaries unique and local capabilities, characteristics and needs and this is a motivation behind this research.

Company Information

Company Name		**Date**	
Job Title			
Department			

Competitive priorities

Assess the importance of below competitive priorities for the successful competing in the market and meeting your business goals. If you are not sure about the answer, please give your best estimate.

	1 = Not important	2 = Somewhat important	3 = Important	4 = Very important	5 = Crucial
Price					
Lower selling price					
Comments					
Quality					
Better products design and quality					
Faster deliveries					
Comments					
Flexibility					
Volume changes					
Broader product range					
Comments					
Service					

After sales service					
Comments					
Innovation					
New product more frequently					
New products more innovative					
Comments					
Sustainability					
More environmentally sound products					
More environmentally sound processes					
Comments					
Responsibility					
Committed social responsibility					
Competitive capabilities					
Comments					

What are the plants core competences? ***(Strengths)***	
What are the plant weaknesses? ***For example:*** *rigid production process, big inventory etc.*	
What are the objectives of manufacturing? **For example** Improve conformance quality, Reduce unit cost Improve safety, Increase capacity	

End of Survey

Thank you for your participation.

If you have any questions please do not hesitate to contact Tomasz Bielec at tomaszb@stud.ntnu.no questions regarding this survey.

Appendix 2. Mid-semester summary of the master project

Tomasz Bielec

Supervisor: Erlend Alfnes

Co-supervisor: Sven Vegard Bauer

Purpose and Background

Problem description and Background

Globalization, pressing economic situation and rapidly changing environment makes a market increasingly competitive. Thus manufacturing companies are forced to steadily improve their operational performance in order to sustain their market position. There has been observed a change in companies' approach from the single-plant to the manufacturing network focus (Ferdows, 1997a, Shi and Gregory 1998). That have increased the interest of the industry in the multi-plant improvement programmes. These programmes aim to aggregate plants located in different locations (Ferdows, 1898, Rudberg and Olhager, 2003) and improve their operations at the same time (Netland, 2014). Those "systematic processes of creating, formalizing and diffusing better operational practices in the intra-firm production network aim of increasing competiveness" (Netland 2013). The multi-plant production system that is tailored and is company-specific is being termed XPS. The "X" stands for the company name and "PS" for the production system. Good examples of XPSs are Volvo Production System, Madshus Business System or The Kongsberg's Way that are going to be studied and compared in my research.

Although many cases of the successful implementation of XPS have been well documented, this concept has received rather limited attention from the academic perspective. It leaves a few important aspects still to be explored and the understanding the network transformation and relations within it, has to be developed (Cheng, Farooq and Johansen, 2011).

The literature does not clearly answer to what extent the subsidiaries should adopt the XPS. This dilemma is applied mainly to the companies where plants within the network produce the different types of products for different customers and the unique productions systems are controlled by the different control principles. This problem is very relevant in the Volvo Production System's case and the problem is being solved only with the pragmatic approach (Netland, 2013). The issue of adaptation and adoption of the XPS by the single plant will be addressed in this research by investigating which decisions should made at the corporate level and included in the main XPS and which should be left to the business-unit level. By reason of coherent use, terms CXPS for the main XPS developed at the corporate level and BUXPS for the business-unit levels are proposed.

The second important aspect raised in the literature are common failures in the implementation of the new strategic initiatives. Miller (2002) has reported that more than 70 % improvement programmes fail. These ineffective corporate improvement programmes might happen due to the lack of alignment between the operational management practices and competitive strategy (Tatikonda and Tatikonda, 1996). Competitive strategy has to be supported by capabilities and resources in the organization (Pertusa-Ortega, 2010). Hence, it is important to consider the subsidiaries' local capabilities and resources before the XPS is developed and adopted. In addition, dynamic environment and increasingly competitive market require dynamic capabilities that has to be constantly developed to sustain the competitive advantage. Therefore a static XPS might hinder a continuous improvement. There is a lack of established methods in the academic researches about how to control the performance of the XPS from the corporate and business-unit level. The implementation of XPS requires a vast amount of resources, hence the managers have to be geared with a tailored performance measurement system that allows to continuously monitor the improvement and be able to react and makes decisions accordingly.

Those aspects will be addressed in this research by developing a conceptual framework / decision model that aims to support planning and control of the XPS for manufacturing network as an outcome of my thesis. The decision model will be further discussed with the Ekornes as a foundation for creating the Ekornes Production System. Ekornes is a multi-plant company that has a different production strategies for each subsidiary. In addition each subsidiary produces a different volume of distinct products. Therefore it is a very good case company for exploring the concept of divergent CXPS and BUXPS.

Research Questions:

RQ1. What strategic and operational decisions should be made at the corporate and the business-level unit?

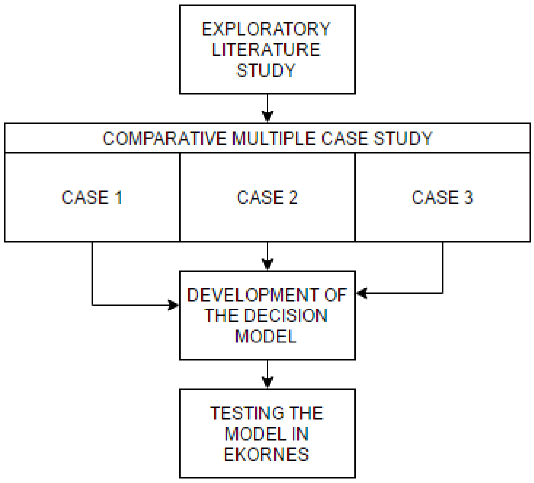
RQ2. How should XPS differ at the business-unit level from the XPS at the corporate level?

RQ2. How the XPS should be monitored from the corporate and business-unit perspective to sustain the improvement?

Limitations

The research will does not look into the cultural aspects of the manufacturing networks due to the local character of the case company

Research methodology



The research will use the qualitative methods as recommended for the newly emerged concepts (Voss,2009). First, the literature study will be performed to deepen the understanding of the XPS. Then the comparative multiple case study will be done to compare the different XPSs and investigate challenges. Consequently, the decision model will be developed and further applied to the case company – Ekornes as a foundation for building the Ekornes Production System.

Key theoretical perspectives

Literature study will first look at the available XPS's researches to explore this phenomenon in details. Afterwards, the operations strategy literature will be reviewed with the focus on the linkage between the corporate, business and operational strategies and the aspects of strategic positioning and utilizing capabilities. I will also consider the researches on strategic and operational decisions made at different levels of the company. Ultimately, the literature regarding the success factors for their implementation of best practices/ improvement programmes will be studied.

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