NTNU – Trondheim
Norwegian University of
Science and Technology

Managing Company-Specific Production Systems

The Critical Success Factors for Implementation

Thomas Laurentius
Haaskjold Eide

Industrial Economics and Technology Management
Submission date: June 2013
Supervisor: Arild Aspelund, IØT
Co-supervisor: Torbjørn Netland, IØT

Norwegian University of Science and Technology
Department of Industrial Economics and Technology Management

NTNU
Det skapende universitet

MASTERKONTRAKT
- uttak av masteroppgave

1. Studentens personalia

Etternavn, fornavn **Eide, Thomas Laurentius Haaskjold**	Fødselsdato **20. feb 1986**
E-post **thomaei@stud.ntnu.no**	Telefon **92096750**

2. Studieopplysninger

Fakultet **Fakultet for Samfunnsvitenskap og teknologiledelse**	
Institutt **Institutt for industriell økonomi og teknologiledelse**	
Studieprogram **Industriell økonomi og teknologiledelse**	Hovedprofil **Strategi og internasjonal forretningsutvikling**

3. Masteroppgave

Oppstartsdato **15. jan 2013**	Innleveringsfrist **11. jun 2013**
Oppgavens (foreløpige) tittel **Managing company-specific production systems**	
Oppgavetekst/Problembeskrivelse The aim of the study is to contribute to an increased knowledge of how to manage company-specific production systems (XPS). More specifically the study will focus on which actions facilitate the successful implementation of such a system. The study will take the form of a case study where empirical observations are evaluated in light of relevant theories within the topic. The empirical data will be gathered through access to survey data, interviews and direct observations within a case company.	
Hovedveileder ved institutt **Førsteamanuensis Arild Aspelund**	Medveileder(e) ved institutt **Torbjørn Netland**
Merknader **1 uke ekstra p.g.a påske.**	

4. Underskrift

Student: Jeg erklærer herved at jeg har satt meg inn i gjeldende bestemmelser for mastergradsstudiet og at jeg oppfyller kravene for adgang til å påbegynne oppgaven, herunder eventuelle praksiskrav.

Partene er gjort kjent med avtalens vilkår, samt kapitlene i studiehåndboken om generelle regler og aktuell studieplan for masterstudiet.

10.01.13
Sted og dato

Student

Hovedveileder

Originalen lagres i NTNUs elektroniske arkiv. Kopi av avtalen sendes til instituttet og studenten.

Preface

This paper is a diploma written as a concluding part of a master's degree in Industrial Economics and Technology Management at The Norwegian University of Science and Technology (NTNU). The study has taken place during the spring semester 2013 (January to June 2013). The author has a technical background within Product Development and Process Engineering with a specialization in Strategy and International Business Development. Prior to this thesis a pre-diploma study was conducted (fall semester 2012) where the author performed (1) a literature review summarizing the process improvement literature in a suggested framework before (2) testing this framework on a case study using survey data from a global company. Based on the model developed from theory and the findings from the case study, an updated theoretical framework for the critical success factors for implementing XPSs was proposed.

There are several people I would like to thank for their support and contributions to what has been a very interesting and rewarding semester. First, I would like thank my supervisor Torbjørn Netland for constructive, precise and inspiring feedback and discussions throughout the process of writing this diploma. Also, I would like to thank you for putting me in contact with the case company and for providing me with such an exciting and interesting real-life case to investigate. I would also like to thank the Jotun Group and especially the manager of Jotun Group Operations Improvement, Marianne Terland Nilsen, for your continuous support, cooperation and positive attitude while conducting the study. I am truly grateful for being given both the funds and the opportunity to travel to several Jotun factories around the world; the commitment and cooperation from Jotun far surpassed my expectations. In Saudi-Arabia I would like to thank the whole management teams in Jeddah and Yanbu, and especially Munir Khan for both highly valuable input and great company throughout the visit. In Vindal I would like to thank Robin Arvidsson for facilitating the visit and for putting me in contact with relevant plant personnel. In England I would like to thank Dave Cooper for all your help and support during the visit.

Summary

Multinational corporations, in their continuous pursuit to improve the productivity of their global manufacturing networks, increasingly develop and deploy lasting process improvement programmes. These improvement programmes often take the form of a company-specific production system (XPS); a variation of the Toyota Production System where also elements from other management systems are included. The Jotun Group is a multinational paint producer whom recently have developed their own XPS - Jotun Operations System (JOS) - and implemented this throughout their subsidiaries. They have however experienced varying degree of success with the implementation of JOS between plants and are curious to learn why this is the case.

While there is a vast amount of literature investigating the critical success factors for the management systems which XPSs are based on, few studies have looked at the critical success factors for an integrated system such as an XPS. This have resulted in different perceptions on how to best implement XPSs and unanswered questions related to what managers should do to enhance and facilitate the implementation of an XPS in a best possible way. The purpose of this study is to increase the knowledge of how to implement an XPS. This is achieved by applying a mixed method approach where (1) survey data is used to test several hypotheses put forward based on existing theories and where (2) a comparative case study is used to acquire additional in-depth knowledge of how to manage XPSs. In the comparative case study Jotun's subsidiaries in Saudi-Arabia, Norway and England are investigated.

My findings suggest that the implementation of an XPS is a complex task, and that its success is dependent on the application of a range of interrelated factors. Some *main determinants* for the successful XPS implementation have however been detected:

- First of all, the *role of leadership* is found to play a monumental role for the successful implementation of an XPS. *Management's prolonged commitment to the implementation* is essential for sustaining the initiatives and for achieving any change.
- Furthermore, managers need to be very conscious of the impact their involvement in *the practical management of the XPS implementation* has for its execution, and that its success is dependent on how and to what extent they are practical involved.
- *The deployment and development of process improvement experts* are found to play an essential role in organisations that are in their early stages of implementation and where the general level of knowledge and practical experience with improvements initiatives are low.
- In addition, organisations abilities to produce lasting changes when implementing an XPS are found to be highly dependent on *local manager's ability to lead the change processes*.

The application of the identified factors is also found to have a direct positive and significant impact on plant performance, and higher degrees of XPS implementation are found to be associated with higher plant performance.

Sammendrag

Multinasjonale selskaper fokuserer i økende grad på å utvikle og innføre varige prosessforbedringsprogrammer i sin kontinuerlige jakt på å forbedre produktiviteten i deres globale produksjonsnettverk. Disse forbedringsprogrammene tar ofte form av et selskapsspesifikt produksjonssystem (XPS), en variant av Toyota Production System hvor også elementer fra andre ledelsessystemer er inkludert. Jotun er en multinasjonal malingsprodusent som nylig har utviklet sin egen XPS - Jotun Operations System (JOS) - og implementert denne i sine datterselskaper. De har imidlertid opplevd varierende suksess med implementeringen av JOS i sine fabrikker og ønsker å få mer innsikt i hvorfor dette er tilfelle.

Selv om det er store mengder litteratur som undersøker de kritiske suksessfaktorene for styringssystemene som en XPS er basert på, er det få studier som har sett på de kritiske suksessfaktorene for integrerte systemer slik som en XPS. Dette har resultert i ulike oppfatninger om hvordan du best kan implementere en XPS og ubesvarte spørsmål knyttet til hva ledere bør gjøre for å forbedre og forenkle implementeringen av denne. Formålet med denne studien er å øke kunnskapen om hvordan å implementere prosessforbedringsprogrammer som en XPS. Dette oppnås ved å bruke en mixed-method tilnærming hvor (1) data fra en spørreundersøkelse brukes til å teste flere hypoteser fremsatt basert på eksisterende teorier og hvor (2) en komparativ casestudie brukes til å anskaffe ytterligere inngående kunnskap om hvordan implementere en XPS. I det komparative casestudiet undersøkes Jotuns datterselskaper i Saudi-Arabia, Norge og England.

Funnene fra studiet viser at implementeringen av en XPS er en kompleks oppgave, og at dens suksess er avhengig av anvendelsen av flere innbyrdes forbundet faktorer. Det er derimot noen faktorer som utpeker seg som særdeles viktig for en suksessfull implementasjon av en XPS:

- Først av alt så er *rollen til ledelsen* funnet å spille en monumental rolle for en vellykket implementasjon av en XPS. Ledelsens *langvarig engasjement til implementeringen* er avgjørende for å oppnå varig endring.
- Videre må ledelsen være seg veldig bevisst over påvirkningen deres *engasjement i den praktiske forvaltningen av XPS implementeringen* har for gjennomføringen, og at suksess er avhengig av hvordan og i hvilken grad de er praktisk involvert.
- *Eksperter i prosessforbedring* er funnet å spille en betydelig rolle for organisasjoner som er i sine tidlige stadier av en XPS implementasjon og hvor det generelle nivået av kunnskap og praktisk erfaring med forbedringstiltak er lav.
- I tillegg er evnen til å produsere varige endringer i organisasjonen funnet å være svært avhengig av den lokale ledelsens evne til å lede disse endringsprosessene.

Anvendelsen av de indentifiserte faktorene er også påvist å ha en direkte og positiv signifikant påvirkning på fabrikkers prestasjoner og høyere grader av implementering av en XPS er assosiert med bedre fabrikkprestasjoner.

Table of Contents

PREFACE ..... **I**

SUMMARY ..... **III**

SAMMENDRAG ..... **V**

TABLE OF CONTENTS ..... **VII**

FIGURES ..... **IX**

TABLES ..... **IX**

1 INTRODUCTION **1**

1.1 RESEARCH OBJECTIVES 2
1.2 THE STRUCTURE OF THE STUDY 2

2 LITERATURE REVIEW **4**

2.1 CSFS IN PROCESS IMPROVEMENT PROGRAMMES 4
2.2 CSFS IN TQM, SIX SIGMA AND LEAN 5
2.3 HYPOTHESES 8

3 METHODOLOGY **12**

3.1 RESEARCH DESIGN 12
3.2 RESEARCH METHODS 13
3.3 DISCUSSION OF LIMITATIONS OF THE DESIGN AND COUNTER MEASURES 16

4 TESTING OF HYPOTHESES **19**

4.1 PRINCIPAL COMPONENT ANALYSIS 19
4.2 TEST OF HYPOTHESIS 1 24
4.3 TEST OF HYPOTHESIS 2A-D 24
4.4 TEST OF HYPOTHESIS 3A-D 27
4.5 SUMMARY OF THE TESTS 30

5 CASE PRESENTATION **31**

5.1 PRESENTATION OF JOTUN GROUP 31
5.2 JOTUN OPERATIONS SYSTEM 31
5.3 JOTUN FACTORIES IN SAUDI-ARABIA 33
5.4 JOTUN FACTORY IN VINDAL, NORWAY 33
5.5 JOTUN FACTORY IN FLIXBOROUGH, ENGLAND 34

6 EMPIRICAL FINDINGS FROM CASE STUDY **35**

6.1 CASE 1: JEDDAH AND YANBU, SAUDI-ARABIA 35
6.2 CASE 2: VINDAL, NORWAY 38
6.3 CASE 3: FLIXBOROUGH, ENGLAND 40
6.4 SUMMARY OF FINDINGS FROM THE CASE STUDIES 44

7 DISCUSSION OF THE EMPIRICAL FINDINGS **45**

7.1 DISCUSSION OF THE CSFS FOR IMPLEMENTING AN XPS 45
7.2 SUMMARY OF DISCUSSION 52
8 CONCLUSIONS 53
8.1 IMPLICATIONS FOR MANAGERS 54
8.2 SUGGESTIONS FOR FUTURE RESEARCH 55
REFERENCES 57
APPENDIX A: CASE STUDY PROTOCOL 60
APPENDIX B: SURVEY 66
APPENDIX C: RELIABILITY ANALYSIS OF THE PCA 71
APPENDIX D: CORRELATION MATRIX OF THE PCA 72
APPENDIX E: PLOTS FROM HYPOTHESES TESTS 73

Figures

Figure 1 - Structure of the study....3
Figure 2 - Overview of relationships to be tested....9
Figure 3 - Overview of hypotheses....11
Figure 4 - Respondents position within the case company....14
Figure 5 - Research quality tactics....18
Figure 6 - Scatterplots from the tests of H3a and H3b....28
Figure 7 - Scatterplot from the test of H3c....28
Figure 8 - Scatterplot from the test of H3d....29
Figure 9 - Jotun Operations System....32
Figure 10 - CFSs for XPS implementation in the cases....44

Tables

Table 1 - Main streams from the literature describing process improvement....5
Table 2 - Critical Success Factors for XPS implementation (Eide, 2012)....7
Table 3 - KMO and Bartlett's Test....19
Table 4 - Rotated component matrix of the managerial control mechanisms....21
Table 5 - Components extracted from the PCA....23
Table 6 - Key data from the testing of the hypotheses....30
Table 7 - The propositions summarized....52

MANAGING COMPANY-SPECIFIC PRODUCTION SYSTEMS

The Critical Success Factors for Implementation

1 Introduction

There has been an increasing trend for companies within manufacturing industries to develop and deploy companywide improvement programmes (Netland, 2013). These improvements programmes often take the form of a company-specific production system (XPS[1]), a production system which is based on lean principles and the origins of the Toyota Production System but also consists of elements from other management systems such as total quality management (TQM) and six sigma. The main idea behind an XPS is that companies choose which elements are best for them and through this construct their very own production system. Instead of trying to fit their organisation into a generic management system, the generic *elements* from several such systems are combined, and through this a *company-specific* production system is constructed. There are several reasons why companies pursue such improvement programmes. In general, these programmes can raise the awareness and focus on performance in all levels of the firm. They also put companywide improvements into a systematic approach. Furthermore, they can serve as guidelines for managers throughout the company helping them make decisions that benefit the firm and as an effective tool for creating a sustainable competitive advantage. Some examples of XPSs are the Mercedes-Benz Production System, the Audi Production System, the Lego Production System, the Electrolux Manufacturing System and John Deere Production System.

This is also true for the Jotun Group, whom over the last years have developed and implemented their very own XPS; Jotun Operations System (JOS). This study investigates which managerial actions within the Jotun Group's subsidiaries facilitate the implementation of their XPS. The findings from this investigation are used to put forward several propositions addressing the critical success factors (CSF) for performing such an implementation

Even though there are a range of studies identifying the CSFs within each management system (lean, TQM, six sigma) which XPSs are built upon, few have looked at the CSFs of these systems simultaneously and with a holistic approach. This has resulted in different perceptions

[1] The X in this abbreviation represents the name of any given company, e.g. *Volvo* Production System.

on how to best implement XPSs and unanswered questions related to what managers should do to enhance and facilitate the implementation of an XPS in a best possible way.

1.1 Research objectives

The purpose of this study is to increase the knowledge of how to implement an XPS. More specifically it will focus on which managerial actions facilitate the successful implementation of such a system. The following research question (RQ) is proposed:

RQ: *What are the critical success factors for implementing an XPS?*

The research question will be answered by applying a mixed method approach where both quantitative and qualitative data are evaluated. First, a set of hypotheses will be tested using *survey data.* The hypotheses put forward are based on existing theories within the field and are presented in section two. Then a comparative *case study* of three subsidiaries within the case company is used to acquire additional in-depth knowledge of how to implement XPSs and to further strengthen the findings of the research. The empirical data are thus gathered through *(1) access to global survey data within the case company (quantitative)* and *(2) interviews and direct observations within three investigated subsidiaries (qualitative).*

When investigating the selected subsidiaries, the following questions have been used to facilitate the investigation:

- *To what degree has the XPS been implemented by the investigated subsidiaries?*
- *Which CSFs have influenced the investigated subsidiaries' implementation of the XPS?*
- *Has the degree of implementation of the XPS between the investigated subsidiaries varied? If so, what are the reasons for this?*

1.2 The structure of the study

This study uses a linear-analytic structure which is a standard approach for composing research reports (Yin, 2008). The first part of the study, section two, will present the relevant prior theoretical background. Based on these theories a conceptual framework is presented in order to structure the subsequent data collection and discussion. This framework is also used to put forward several hypotheses. In section three the methodology is motivated and explained. Possible limitations and weaknesses with regards to the chosen research design are also addressed. In the next part, section four, the survey data are analysed and the hypotheses tested. Section five gives an overview of the Jotun Group, Jotun Operations System and the three investigated subsidiaries. Section six presents the empirical findings from the investigated subsidiaries, before these findings are discussed and analysed together with the results from the hypotheses tests in the section seven. Finally, section eight presents a conclusion, possible

implications for managers and suggestions for future research. The structure of the study is presented in Figure 1.

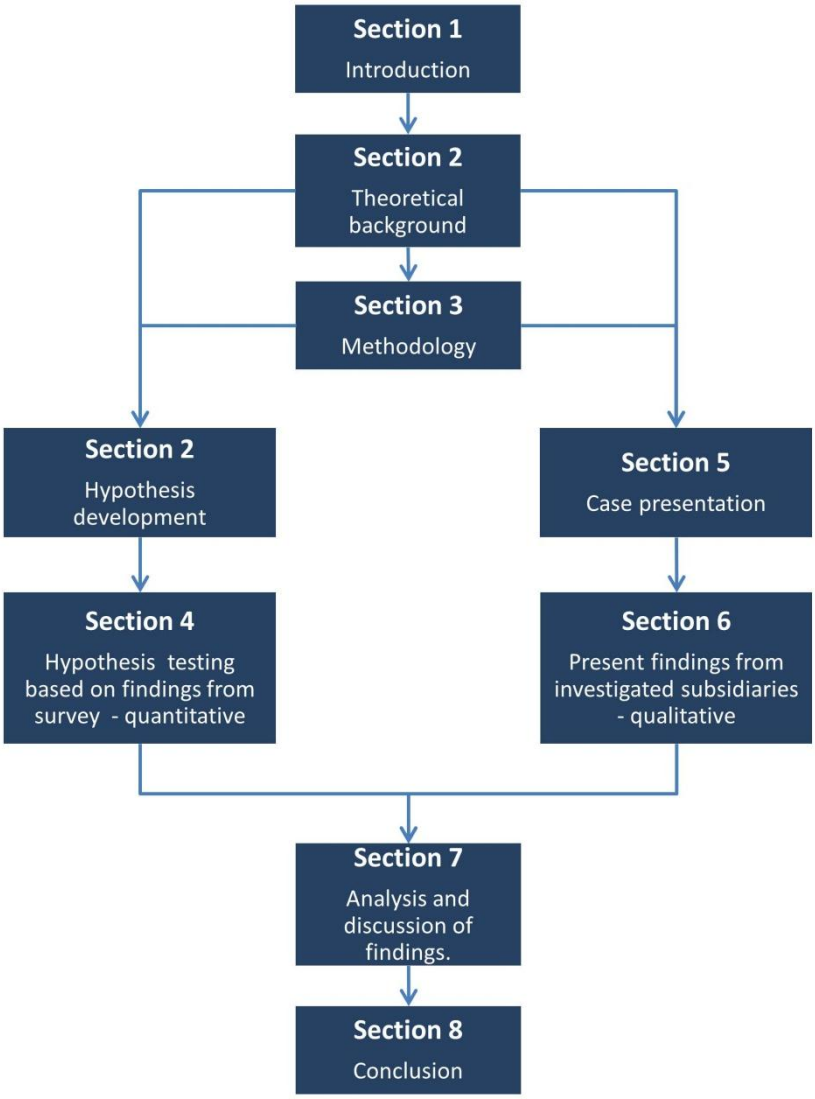


Figure 1 - Structure of the study

2 Literature review

This chapter presents literature concerning critical success factors for managing process improvements. The chapter serves several purposes. First, it places the management of XPS's in the theoretical context of that of managing process improvement. Secondly, the chapter provides an overview of three of the main streams describing CSFs for process improvement. Thirdly, a theoretical framework describing the CSF that influences the implementation of an XPS is presented. This framework is used as grounds for putting forward several hypotheses for testing. The framework is also used as a guide for the collection and analysis of data, and the following discussions of these findings.

2.1 CSFs in process improvement programmes

The topic of process improvement has its roots back to Frederick Taylors scientific management (Taylorism) and Henry Ford's concepts of mass production (Fordism) (Sprague, 2007). Through the 1940s and 1950s, scientific management evolved into operations management and operations research. In the early 1980s elements from the Japanese management systems became dominant within the field of operations management when the knowledge of their process improvement philosophies spread beyond Japan (Schonberger, 2007). The phenomena of *lean production* is commonly regarded to have gained momentum in the west with the book *The Machine That Changed the World: The story of Lean Production* (Womack et al., 1990). Schonberger (2007) does however point out that while the awareness of the expression *lean production* significantly increased with the publication of Womack et al. (1990) book, many of its elements had been present in western industries for more than a decade. Since then the process improvement system have been enhanced and modified through western contributions such as six sigma, TQM, Business Process Reengineering, direct- and activity based costing and design for manufacture and assembly (Schonberger, 2007). During this process the systems evolved through fusions and alterations where terminology has been mixed and "borders" between each system have faded. This can especially be seen among practitioners where the elements and the terminology within each system have been blended and often are used interchangeably. Today the result of the evolution of these management system are visible through companywide improvement programmes (such as XPS) consisting of integrated elements from several process improvement systems (Netland, 2013).

In this study I understand XPS as an *umbrella programme developed specifically for one company consisting of integrated elements from overlapping process improvement philosophies*. Based on the literature in general three main streams describing the CSFs of process improvement are considered; namely lean, TQM and six sigma (Eide, 2012). These streams overlap each other while at the same time having certain unique features. Together these three

streams cover all main areas discussing CSFs for the successful implementation of a process improvement system (Eide, 2012). Table 1 gives an overview over these three streams together with appurtenant acronyms and descriptions for that stream. It also presents some of the researchers investigating the topic of CSFs for *process improvement* within each stream.

Table 1 - Main streams from the literature describing process improvement

Philosophy	Abbreviations	Authors
Total Quality Management	**TQM**	(Ahire et al., 1996, Motwani, 2001, Porter and Parker, 1993, Saraph et al., 1989, Sila and Ebrahimpour, 2003, Taylor and Wright, 2003, Karuppusami and Gandhinathan, 2006, Chiarini, 2011)
Total Quality Control	TQC	
Japanese Total Quality Control	JTQC	
Six sigma	**Six sigma**	(Antony and Banuelas, 2002, Coronado and Antony, 2002, Henderson and Evans, 2000, Hilton and Sohal, 2012, Manville et al., 2012, Moosa and Sajid, 2010)
Lean six sigma	LSS	
Lean Management	**Lean**	(Achanga et al., 2006, Mehra and Inman, 1992, Nordin et al., 2012, White, 1993, Womack et al., 1990, Chiarini, 2011, Dahlgaard and Dahlgaard-Park, 2006, Scherrer-Rathje et al., 2009)
Just-In-Time	JIT	
Japanese Production Management	JPM	

The CSFs represent those areas that must be given special and continual attention by managers to bring about high performance (Boynton and Zmud, 1984). The literature treating CSFs in relation to process improvement tends to look at one improvement system at a time (Achanga et al., 2006, Nordin et al., 2012, Scherrer-Rathje et al., 2009, Karuppusami and Gandhinathan, 2006, Motwani, 2001, Sila and Ebrahimpour, 2003, Yusof and Aspinwall, 1999, Antony and Banuelas, 2002, Brun, 2011, Coronado and Antony, 2002, Manville et al., 2012). There are however examples of studies of who have compared the elements of two or more systems simultaneously (Chiarini, 2011, Cua et al., 2001, Näslund, 2008, Dahlgaard and Dahlgaard-Park, 2006, Ricondo and Viles, 2005). Johannsen (2011) find nevertheless that a set of guidelines defining the CSFs for the implementation of an integrating system consisting of elements from six sigma, TQM and lean is missing. He points out that further research within the field is necessary to define common and unique factors for the systems in question. `

2.2 CSFs in TQM, Six Sigma and Lean

TQM is an *incorporated management philosophy* aiming to achieve customer satisfaction through a continuous focus on improving quality and processes (Karuppusami and Gandhinathan, 2006). One of the more influential contributions to TQM originates from three formal evaluation models; the European Quality Award, the Malcolm Baldrige National Quality Award and the Deming Award. These formal models constitutes, together with contributions from quality gurus (Crosby, 1979, Feigenbaum, 1983, Deming, 1982, Ishikawa, 1972) and

empirical research (Black and Porter, 1996, Saraph et al., 1989, Ahire et al., 1996), the three main areas from which the definition of CSFs for TQM has emerged.

Six sigma was introduced by Motorola in 1986 as an instrument for *quality performance measurement*, but has since developed into a *statistical product and quality improvement programme* (Coronado and Antony, 2002). A range of companies such as Kodak, General Electric, Texas instruments and Hewlett Packard have applied the management system claiming significant savings as a result. Several studies have looked into which factors play a critical role when implementing the system (Coronado and Antony, 2002, Snee, 1999, Henderson and Evans, 2000).

The lean philosophy has its origins from the Japanese manufacturing culture and especially Toyota Production System (TPS), developed by Taiichi Onho in the 1960s (Chiarini, 2011). What in its "early years" was described as lean production with a focus on effectiveness in the production process, has since evolved into what today is called *lean thinking* focusing more on the *effectiveness of the company as a whole* (Chiarini, 2011). The main principle of lean is to eliminate all waste, or *muda*, through a continuous focus on the individual product and its value stream (Pepper and Spedding, 2010). Lean thinking today goes beyond the scope of the initial Japanese production philosophies providing a company-integrative system comprising of four main elements; the product development process, the supplier management process, the customer management process, and the policy focusing process for the whole enterprise (Holweg, 2007).

Ricondo and Viles (2005) compares TQM, lean and six sigma and finds that the systems applies many of the same basic tools and techniques for managing process improvement such as brainstorming, teamwork, benchmarking and statistical process control. At the same time the systems has some unique features, e.g. *statistical tools* for six sigma and TQM and *kanban* for lean. Dahlgaard and Dahlgaard-Park (2006) shows that the steps of six sigma and lean essentially can be viewed as the same and that the action plan for six sigma and lean can be regarded as new, alternative TQM action plans, thus further supporting the integrative nature of six sigma, lean and TQM.

In my pre-diploma study (Eide, 2012) I performed a literature review analysing current theories and findings within the field of process improvement and tested this on a case study. The findings from this work resulted in the proposal of an updated theoretical framework for the CSFs for process improvement programmes. The study explores the gap between the process improvement literature and its execution and the identification of critical success factors from a manager's perspective through a case study. The study revealed that when the CSF for the three different process improvement systems (TQM, Six Sigma and Lean) were evaluated

simultaneously, some factors could be considered generic, while others were specific for the system in question. The study did furthermore reveal that the current theories did not satisfactorily describe managers own perceptions of the CSFs for managing an XPS and an updated theoretical framework for the CSFs when working with XPS's was proposed. The CSFs from this framework is presented in Table 2.

Generally speaking these CSFs concerns factors that *enables* and *motivates* employees at all levels to successfully implement the process improvement initiatives in question. *Training and education* facilitates the correct understanding of the concepts and purpose of the philosophies behind the process improvement system. *Recognition and rewards* concerns *resource-based (rewards)* and *management-based (recognition)* actions that should be put into effect to motivate the workforce and promote desired behaviour and results (Antony and Banuelas, 2002). *Employee involvement and empowerment* deals with the degree to which teams are used, the extent of employee autonomy in decision making, the extent of employee interaction with customers, and the extent to which employee suggestions are taken into consideration (Motwani, 2001).

Table 2 - Critical Success Factors for XPS implementation (Eide, 2012)

#	Critical Success Factor	TQM	Lean	SixSigma	**XPS**
1	Involvement from managers	x	x	x	**x**
2	Training and education	x	x	x	**x**
3	Application of appropriate tools and techniques	x		x	**x**
4	Employee involvement and empowerment	x		x	**x**
5	Recognition and rewards	x	x	x	**x**
6	Top management support and commitment	x	x	x	**x**
7	Performance indicators	x	x	x	**x**
8	Dedicated improvement leaders, teams and projects	x	x	x	**x**
9	Allocate resources, time and technology		x	x	**x**
10	Strong focus on implementation goals				**x**
11	Strategic planning and goals for implementation	x	x	x	**x**
12	Be hands on/Gemba				**x**
13	Clear communication of improvement information	x	x	x	**x**

Furthermore the CSFs consider to which extent the improvement initiatives are aligned with the *business strategy and goals*, and the *degree of commitment* from the organisation as a whole - visible by the dedication from top management and the amount of resources allocated. *Top management support and commitment* is by all the three systems considered to be of vital importance when implementing process improvement systems (Porter and Parker, 1993, Yusof and Aspinwall, 1999, Manville et al., 2012). *Strategic planning and goal for the implementation* emphasises that the strategy and goals for process improvement should be linked to and aligned

with the overall business strategy and goals. *Allocation of sufficient resources* deals with the level of commitment from the organisation to the improvement programme, and is measured on three main parameters (time, expertise, financial) (Nordin et al., 2012).

The CSFs also address the more practical factors needing *continuous focus and monitoring,* and the *key elements, tools and techniques* that should support and facilitate the implementation and permeate the mentality of the organisation. *Involvement from managers* is considered vital when implementing strategic improvement programmes (Nordin et al., 2012, Antony and Banuelas, 2002, Karuppusami and Gandhinathan, 2006). By having a *focus on the implementation goals* when managing the improvement projects the implementation initiatives are linked to the overall strategy. This should be further supported by managers *being hands on (gemba)* and using *performance indicators* for progress tracking purposes. The *application of appropriate tools and techniques* concerns the ability to choose the right tool for the right situation; hereunder comprehending its possibilities, limitations and appurtenant manner of operation. *Clear communication of improvement information* emphasizes the importance of providing *sufficient* information, and doing so in a *clear* and *consistent* manner (Scherrer-Rathje et al., 2009). *Dedicated improvement leaders, teams and projects* refer to the importance of focusing implementation efforts and expertise.

2.3 Hypotheses

The CSFs described above will directly and indirectly affect the implementation of an XPS in some way or other. Because of the CSFs integrative nature, it has been challenging to synthesise them into reasonable and manageable *groups of factors.* As a result, the literature does not provides sufficiently clear and easy to manage guidelines for where managers should direct their available resources when implementing an integrative and complex system such as an XPS (Eide, 2012). I therefore want contribute to this field by testing if certain proposed *vital few groups of factors* (based on the CSFs from the literature) *positively and significantly* can explain changes in the degree of implementation. Furthermore I want to test if the use of the same groups of CSFs will have direct and positive impact on plant performance, and also if the degree of implementation affects plant performance. The relationships which will be tested are described in Figure 2.

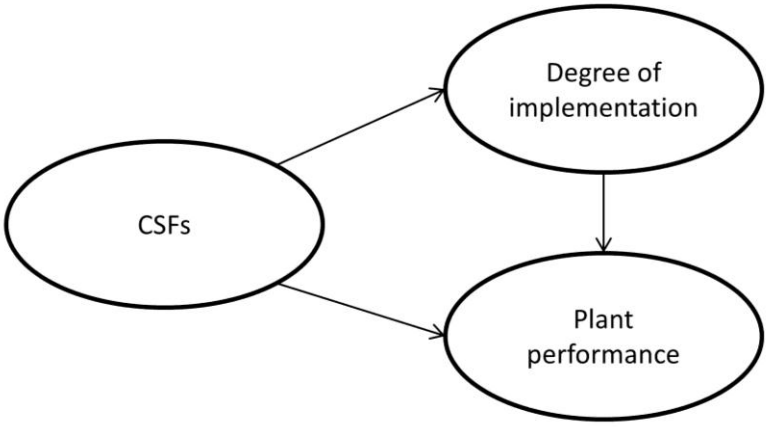


Figure 2 - Overview of relationships to be tested

DOES AN XPS IMPROVE PERFORMANCE?

The motivation for developing and implementing any process improvement programme is to eventually increase the overall performance of the company through improving the performance of its elements; in this case the different factories of Jotun. I therefore want to test whether this relationship actually is present. Thus, my first hypothesis suggests that implementing an XPS contribute positively and significantly to plant performance:

H1	→	*The degree of implementation of an XPS positively affects plant performance.*

WHICH FACTORS AFFECT THE DEGREE OF XPS IMPLEMENTATION?

The amount of factors that is directly or indirectly related to *the role of leadership* stands out in the literature. Table 2 shows that a majority of the factors is linked to leadership and that the scope of leadership covers a range of areas. The tree most obvious factors concerning the role of leadership are *top management support and commitment, the involvement from managers* and *strategic planning and goals for implementation*. The degree of involvement from managers in the implementation process is related to the extent of *top management commitment and support*, something which needs to go far beyond just deciding to develop and implement an XPS in order for it to be successful. At the company-wide level, the degree of commitment and support from top management can be viewed through the extent of which the strategy and the goals for the implementation is linked and aligned to the overall business strategy and goals. This provides basis for hypothesis 2a:

H2a	→	*More use of factor related to the commitment from management contributes positively to XPS implementation.*

In addition several off the factors concern *the practical management of the implementation.* The allocated resources must be directed to appropriate purposes; e.g. training and education and dedicated improvement leaders, teams and projects. Through this employees will obtain knowledge and gain experience. During the implementation phase, the importance of managers having a continuous and strong focus on the implementation goals is stressed. This should be complemented by managers being hands on (gemba), using performance indicators and by applying appropriate tools and techniques. In addition, they should motivate the workforce and promote desired behaviour and results actively through recognition and rewards and by involving and empowering the employees. Furthermore, providing sufficient information and doing so in a clear way should be used actively to announce, explain and prepare employees for the change and the expected effects as a result of this. Hypothesis 2b will therefore be:

H2b	→	*More use of factor related to the practical management of the implementation contributes positively to XPS implementation.*

Also, several of the factors directly or indirectly refer to the importance of *developing and using process improvement experts.* Resources (time, expertise, financial) should be allocated to *developing process improvements experts* through training and education. Furthermore, dedicated implementation experts and teams should be employed, this way focusing implementation efforts and bringing about coveted expertise. Hypothesis 2c will therefore be:

H2c	→	*More use of factor related deploying and developing process improvement experts contributes positively to XPS implementation.*

Several authors rank the CSFs by their criticality (Al-Khalifa and Aspinwall, 2008, Karuppusami and Gandhinathan, 2006, Porter and Parker, 1993). While acknowledging that the different CSFs have different criticality and that some CSFs have been shown to have higher importance than other, focusing only on the most important factors alone will not ensure successful process improvement initiatives. The CSFs are connected through their complementary qualities, only by making use of all of them will you be able to extract the full potential of an XPS (Dahlgaard and Dahlgaard-Park, 2006, Cua et al., 2001). I therefore hypothesis that:

H2d	→	*Plants that have a higher utilization of all factors are more successful in implementing the XPS than plants that have a lower utilization of all factors.*

DOES THE APPLICATION OF THE FACTORS IMPROVE PERFORMANCE?

I also want to test if the three groups of CSFs which are proposed to contribute positively and significantly to XPS implementation also have a direct positive impact on plant performance. Hypothesis 3a-c will therefore be:

H3 a-c	→	*The use of factors related to the following (a-c) will have a direct and positive impact on plant performance* *a. The commitment from management* *b. The practical management of the implementation* *c. Deploying and developing process improvement experts*

In addition I want to test if a higher utilization of all factors not only is associated with higher degrees of XPS implementation, but also if the use of all the factors is correlated with a high plant performance. This provides basis for hypothesis 3d:

H3d	→	*Plants that are identified as high performers will have a higher utilization of all factors compared to plants that are identified as low performers.*

OVERVIEW OF THE HYPOTHESES

The three hypotheses I have put forward suggest that groups of the factors impact both the degree of implementation and the plant performance, and that the plant performance is directly correlated with the degree of implementation. The proposed hypotheses and their relationship with the degree of implementation and plant performance are summarized and visualized in Figure 3. The hypotheses and the proposed relationships will be tested in section 4 based on the data from a survey within the case company.

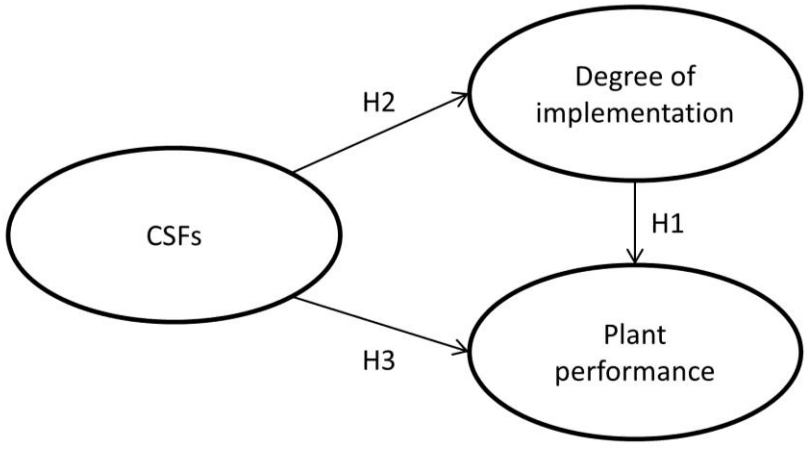


Figure 3 - Overview of hypotheses

3 Methodology

This section describes the methodology which has been used to facilitate the answering of the proposed research question. The first subsection treats the research design while the second subsection addresses the different research methods which are used. The last subsection deals with the limitations and weaknesses with the chosen methodology together with the actions taken to reduce the impact of these limitations and weaknesses.

3.1 Research design

The research design provides a set of guidelines for the collection and analysis of data and can be regarded as a framework for how the study will be conducted. It is however important to bear in mind that the research design is much more than a work plan, one of the main purposes is to help avoid the situation in which the gathered evidence does not address the initial research questions (Yin, 2008). Bryman and Bell (2011) highlight six main different research designs; experimental, cross-sectional, longitudinal, case study, comparative and mixed-method design. This study will apply a mixed method design with three case studies within a survey. Multiple sources of evidence are used to triangulate the analysis, and hence improve its validity (Yin, 2008).

3.1.1 The choice of research design and cases

The case study is preferable to use when a *how* or *why* question is being asked about a contemporary set of events over which the researcher has little or no control (Yin, 2008). This study applies a mixed method case study design (case study within a survey) where quantitative and qualitative case designs are combined. A mixed methods research permits the researcher to address more complicated research questions and collect a richer and stronger array of evidence than can be accomplished by any single method alone (Bryman and Bell, 2011). The case can for example be a single organisation, a single location or a person – in this study the cases are represented by three subsidiaries of the Jotun Group. The decision to use a mixed method design is based both on the properties of this particular research design and on the purpose of this study.

This study uses survey data to evaluate a set of hypotheses. The case study is used as a means to acquire additional in depth knowledge of the topic in question and to further strengthen the conclusions of the research. Jotun's factories in Saudi, Vindal and Flixborough were decided to be used as unit of analysis. This decision was done in collaboration with Jotun and the study supervisor and was based on Jotun's wishes, the properties of the factories and practical considerations. Each factory is the subject of an individual case study, but the whole study covers several factories. According to classification of cases by Yin (2008) this can be viewed as a multiple case study with three cases providing vital information to my research. By having

multiple cases, a replication approach can be utilized, in which triangulating evidence is sought regarding the facts and conclusions for each case (Yin, 2008).

There were several practical constraints that had to be considered when choosing the number of cases. The cost of travel, the available time for data collection and analysis and the complexity of the phenomena being researched all had to be taken into account. Given the above mentioned constraints, choosing only three cases was deemed to be a good solution allowing for more in-depth studies. These constraints does nevertheless pose a possible limitation too the study and will be addressed further in section 3.3

3.2 Research methods

A research method is a technique for collecting data (Bryman and Bell, 2011) and is in its most basic form a description for how the data are going to be collected. Yin (2008) highlights six main methods used for gathering evidence; documentation, archival records, interviews, direct observations, participant-observation and physical artefacts. A major strength of the mixed method design is the possibility to draw upon multiple sources of evidence. By utilizing data from multiple sources of evidence the investigator can address a broad range of historical and behavioural issues. More importantly, it allows the development of converging lines of inquiry by triangulating the findings from several sources of evidence and through this further strengthen the construct validity of the study (Yin, 2008). This study will primarily use four methods for collecting data; documentation, interviews, observations and a survey.

3.2.1 Survey

A survey (see Appendix B) prepared by Torbjørn Netland[2] and Kasra Ferdows for the use in Volvo AB was adapted to fit the case company and distributed throughout Jotun per e-mail. According to Voss et al. (2002) surveys or questionnaires can increase the efficiency of data collection, and makes it easier to reach a broader sample of persons to collect the data from. The survey was designed to find which set of specific managerial actions affect the successful implementation of an XPS (in this particular case the Jotun Operations System), and consisted of three main parts; 1) Performance and performance development, 2) Managerial actions and 3) Comments/viewpoints. The intention of using this survey is to gather information of how to manage an XPS.

Participating in the survey was voluntarily for all recipients. The questionnaire consisted of 50 questions, with an estimated completion time of 30 minutes and was administered to Jotun Group's factories and offices worldwide. Altogether 140 persons received the survey and within

[2] ***Torbjørn Netland,*** torbjorn.netland@iot.ntnu.no, +47 982-45-169, The Norwegian University of Science and Technology (NTNU). ***Kasra Ferdows,*** ferdowsk@georgetown.edu, +1 202-687-3814, Georgetown University – McDonough School of Business.

the two month response time limit, 120 responses were received resulting in a total response rate of 86 %. 28 plants in 16 countries participated in the survey, the respondents consisting mainly of top and middle management from the plants. Figure 4 shows the distribution of respondents.

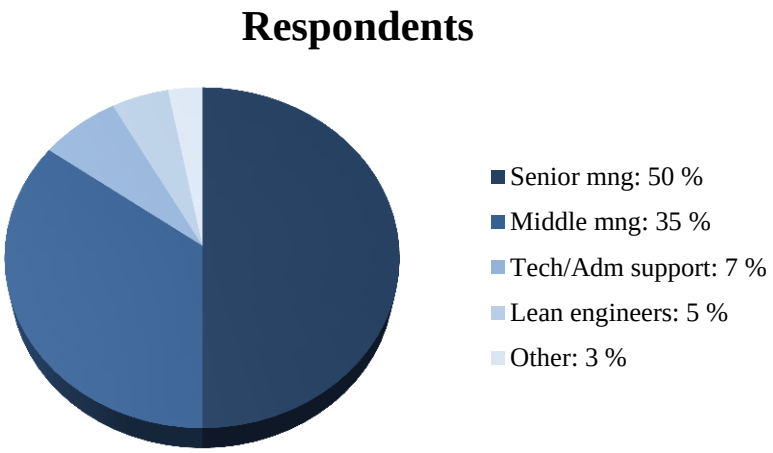


Figure 4 - Respondents position within the case company

The answers to part two of the survey have been used as data input to a principal component analysis (PCA). PCA is a mathematical variable reduction technique which maximizes the amount of variance accounted for in the observed variables by a smaller group of variables called components (Wold et al., 1987). The number of principal components is less than or equal to the number of original variables. The PCA was applied on the data in order to evaluate if it was possible to extract any statistical significant components with respect to the CSFs for managing XPS's. The findings from the PCA are, together with data from part one from the survey, used to evaluate the hypothesis and are presented in section four.

3.2.2 Interviews

Interviews are one of the most widely employed methods in qualitative research and can take many different forms such as focus groups, structured, semi-structured and in-depth interviews (Bryman and Bell, 2011). This study will make use of semi-structured and unstructured interviews. Notes will be taken during the interview, this way providing a more natural setting for the interviewee compared to using a recorder (Yin, 2008). The interviews were subsequently not transcribed but a summary were written within two days of the interview being performed.

In a *semi-structured interview* the researcher has a list of fairly specific topics to be covered, but the interviewee is allowed to answer quite freely (Bryman and Bell, 2011). The list of topics is considered a guideline for what to touch on in the interview and not as rigorous steps for how to proceed. As a part of the case study protocol (see Appendix A) an interview guide was developed before the factory visits and used to guide the interviews whilst visiting the factories.

The same guide was used for all three factory visits increasing the comparability of the findings from the three cases (Bryman and Bell, 2011). I intentionally choose to not record the interviews but rather taking notes by hand; this can allow for a more free and comfortable setting for the interviewee. Employees from different levels of the organisation were interview at all three factories, thus increasing the triangulation of data. At all the locations three semi-structured interviews were performed. The interviews lasted from 20 minutes up to 2.5 hours.

The *unstructured interview* is very similar in character to a conversion. The researcher uses at most a few keywords which prompt him to deal with a certain range of topics or a key question from which the interviewee is allowed to respond freely. The interviewer then responds to points or comments deemed worthy of following up on (Bryman and Bell, 2011). At all the locations between 3 to 8 unstructured interviews took place during the visit.

3.2.3 Direct observation

Direct observations can range from formal to casual data collection activities involving observations of meetings, side-walk activities, factory work, field visits etc. (Yin, 2008). Through this the researcher can acquire relevant behaviour or environmental conditions from the real life context of the phenomena being investigated (Bryman and Bell, 2011). In this study I primarily make use of casual observations in connections with field visits to the three investigated subsidiaries in Saudi, Vindal and Flixborough.

In Saudi I spent four days visiting both the site in Yanbu and Jeddah. In Flixborough and Vindal I spent one day at each plant. Factory tours and attendance at several morning meetings have been the main contribution to the observations at all three location. Questions were directed to the tour guide or to the responsible manager present at the relevant location during the tour. The interaction with the production can otherwise be considered marginal, meaning that the general level of involvement can be classified as low (Bryman and Bell, 2011). The intentions of the tours was to get a better picture of how the different plants were working with JOS and to get an overall impression of the improvement initiatives that had been undertaken and those currently in progress. Any other observations that possible could contribute to an improved understanding of how to manage an XPS was also noted.

3.2.4 Documentation

Documentary information is likely to be relevant to any case study topic. The most important use of documents is to corroborate and augment evidence from other sources (Yin, 2008). In this study the Annual Report for 2012 has been used to gain general knowledge about the company and its performance. Articles about the investigated subsidiaries in "The Penguin Magazine, 1 - 2013", Jotun's internal newspaper, have provided additional interesting information about Vindal and Saudi. Also pictures taken of information boards, the production and several

improvement initiatives during the factory visits have been used as a background material when presenting the empirical findings in section five and as a tool for remembering different impressions from the visits.

3.3 Discussion of limitations of the design and counter measures

The quality of any given design can be judged according to three commonly used logical tests; the construct validity, the external and internal validity and the reliability (Yin, 2008). This section discusses the limitations and weaknesses of the chosen research design and methods of the study and brings attention to which tactics have been employed to increase the quality of the research design. It also addresses weaknesses due to resource constraints and practicalities.

3.3.1 Limitations due to the chosen research design

When performing a case study with only a few cases, limits on the generalizability of conclusions drawn apply. Several potential biases are present, such as misjudging the representativeness of a single event and exaggerating easily variable data (Voss et al., 2002). On the other hand, it can be argued that the answers are obtained from several individual business units and that the study in that respect experience lower risk for generalization, and hence biases related to this. In addition, the answers are obtained from a combination of qualitative findings from the case studies and quantitative findings from the survey, thus further reducing the potential for such biases. There is however only one company being evaluated; in order to get a more differentiated and holistic picture it would be preferable to include several companies in the study. The fact that my findings are derived from data from only one company is also why I chose to present my findings as propositions and not new or updated theory.

A important issue when evaluating the quality of a research design is to what extent the study is replicable and transparent (Yin, 2008). The main concern is the question of whether the results of the study are repeatable or not. Several tactics have been employed to reduce this concern. The development of a case study protocol (see Appendix A) is the first of these tactics. The case study protocol establish procedures and general rules to be followed during data collection (Yin, 2008), this way making it clearer what the researcher did and how the data of which the conclusions are based on where gathered. In addition a research database including the empirical findings of the study has been developed; available upon request and with the permission of Jotun Group. The third tactic was establishing a chain of evidence. The purpose of the chain of evidence is to give anyone how reads the report the possibility to follow any derivation of evidence from the initial research questions to the final conclusions of the study (Yin, 2008). Measures have therefore been taken to give as clear and accurate picture as possible of the connection between the research questions, theory, empirical data and conclusions.

Another important issue when evaluating the quality of a research design is how the operational measures for the concepts being studied have been identified (Yin, 2008). The main pitfalls here are that the case study investigator fails to develop a sufficiently operational set of measures and that "subjective" judgments are used to collect the data. To avoid this subjectivity the operational measures have been based on the findings from a literature review that summarizes the process improvement literature in a suggested CSF framework developed by Eide (2012). Furthermore the use of multiple sources of evidence encourages convergent lines of enquiry. In addition a chain of evidence is established, this way enabling the reader to make their own evaluation based on the empirical findings. There will however always be some degree of interpretation involved in gathering and presenting information, this subjectivity of the researcher is therefore a potential weakness of this study.

3.3.2 Limitations due to the practicalities and resource constraints

The study has some potential weaknesses due to practicalities in the data collection phase. The survey got 120 responses from people in 16 different countries around the world. The language proficiency at the different plants in different countries varies and it is possible that some respondents failed to understand the real meaning of smaller or greater parts of the survey. English is however the business language within the case company and it should be expected that managers, which were the respondents of the survey, can display the needed language skills in order to understand the intent and content of the survey. On one of the field visits I also experienced that the term of the XPS being studied (JOS) was not very developed beyond the top management. This can also be the case in other plants which participated in the survey. The fact that people might not fully comprehend what the term JOS refers to when answering the survey constitute a potential weakness of the study.

During the field visits the interviews were conducted without the use of a recorder. This was done to provide a more natural and free setting for the interviewee, but also comes with the possibility of information having been lost or misinterpreted by the investigator. The access to interview candidates was limited subject to managers selection at the respective subsidiaries, they were in other words to some extent in control of the information made available and can be considered a potential weakness of the study. Furthermore, we were due to language barriers not able to interview personnel at the operator level in Saudi-Arabia. This could be considered a weakness of the cross-case comparability of the cases. The main area of interest is however the perceptions of personnel at management level, which is whom the majority of the interviews were conducted with, and the general cross-case comparability is therefore believed to be satisfactory.

The study also faces several potential limitations due to resource constraints. I have had limited time available to collect information through field visits. Still, the share amount of data gathered

is considered to be substantial. Also, the visits that have been performed have been subject to the availability of the investigated subsidiaries. The main constraint is however considered to be the amount of resources (time, personnel) available to process and analyse the vast amount of data gathered through the survey and field visits.

3.3.3 Summary of used quality tactics

While the two previous sub-sections have addressed potential weaknesses and limitations of the study, it should be emphasized that great efforts have been taken to reduce the impacts of these factors. The main tactics and their contribution to the three logical tests of a research's quality; the construct validity, the external and internal validity and the reliability are presented in Figure 5.

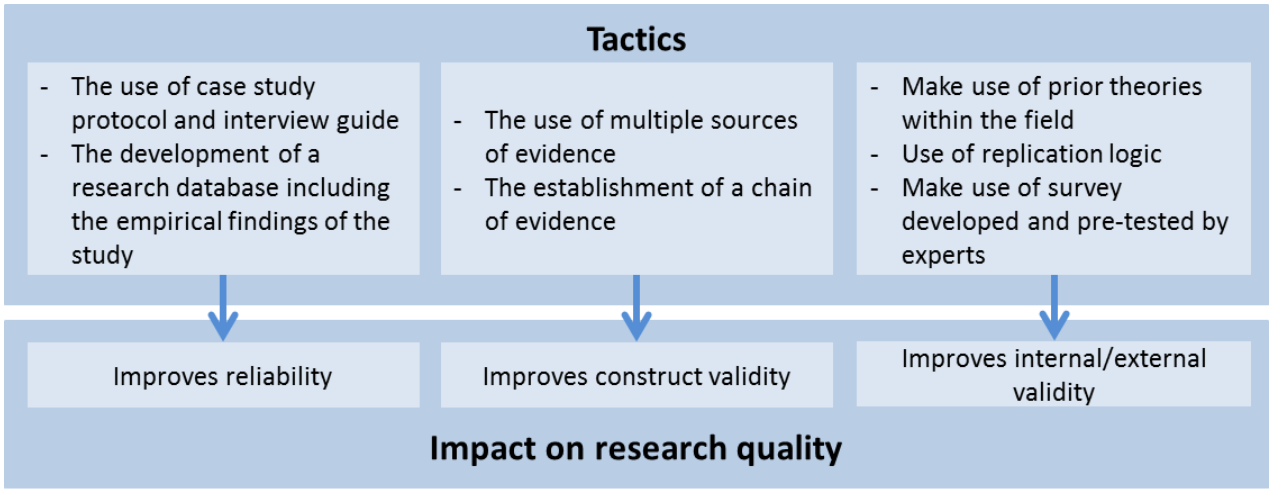


Figure 5 - Research quality tactics

4 Testing of hypotheses

This section uses data from a global survey within the case company to test the three hypotheses put forward in section 2. In the first subsection a principal component analysis (PCA) is performed in order to define possible components which coincide with the factors from the proposed hypotheses. In the subsequent parts the findings from the PCA and the data from the survey are further analysed and the hypotheses tested.

4.1 Principal component analysis

Part two of the survey considers the actions taken by managers in Jotun to implement JOS and/or continuous improvement projects in their plant, and will be the relevant part of the survey for this sub-section. The developed scale of part two of the survey is designed to evaluate the extent to which different XPS management practices are used within each plant. The participants evaluate 25 statements concerning managerial control mechanisms and how frequent each control mechanism is employed by the managers. The analytic procedures for the PCA follows the same steps as those described by (Claver et al., 2003) and are as follows: First the set of 25 managerial control mechanisms are used to develop a component analysis in order to identify the most important component. Then the reliability and validity of the identified components are tested using the recommended steps by Likert (1967) and Nunnally (1978); (1) a reliability test and (2) a detailed item analysis.

4.1.1 Identification of components

A PCA has been applied on the data gathered from the answers to the 25 variables of part two of the survey. The cut off margin for analysing component loading in empirical research is normally set to 0.4 (Huarng et al., 1999), I however chose to use a cut off margin of 0.3 because this gives me a better picture of the variables total variance between components. Component loadings are considered high if they are above 0.6 and moderately high if they are equal to or greater than 0.3. Values below this are considered meaningless (Kline, 2000). The components must be related to each other, therefore a oblimin rotation with Kaiser normalization is deemed suitable (Black and Porter, 1996, Claver et al., 2003). By evaluating Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Table 3) the analysis was verified to be adequate.

Table 3 - KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.925
Bartlett's Test of Sphericity	*Chi-Square*	1756.418
	p	0.000

Based on the eigenvalue-one criterion (also referred to as the Kaiser criterion (Kaiser, 1960)) for establishing how many components to retain in a PCA, five components accounting for 68 % of the total variance is found. The rotated component matrix converged in 22 iterations and is shown in Table 4. The first component comprises of 8 items (20-22, 28, 29, 34, 37, 40) which clearly deals with the role of leadership; how and to what degree managers are involved in the implementation process and general leadership motivation. I name this component *commitment from management.*

The second component is related to how managers benchmark and exchange to and from other plants as a means to increase knowledge of how to facilitate and execute XPS implementation. I term this component *knowledge exchange*. While this component consists primarily of four items (19, 38, 39, 41), it could be argued that also item 18 could be a part of the component. Even though it is strongest affiliated with component four some of its variability can be accounted for in component two, and when you look at its description - External consultants are hired on to help implement JOS in this plant - it does from a qualitative point of view fit well with the other items in component two.

The third component is concerned with the operational execution of the XPS implementation and how the improvements are organized. In many ways it describes the tools, techniques and instruments which can be used to manage an XPS implementation together with how to make the organisation ready for change. This factor consists of 10 items (23-27, 30-32, 35, 42) and I call this factor the *practical management of implementation*.

The fourth component consist of two items (18, 36) and addresses two very specific areas; the use of external consultants and experts to help implement the XPS and the training of top management to become experts in in XPS management. I term this component *develop and deploy process improvement experts.*

The fifth component consists only of one item (33) and will be ignored as an independent component. This is further supported by the item's description/content – Managers are regularly rewarded with financial remuneration based on operational improvement tied to JOS implementation in this plant – not being practiced within the case company.

Table 4 - Rotated component matrix of the managerial control mechanisms

	Pattern Matrix	Component				
Item	*Variable*	1	2	3	4	5
21	Top-management has explicitly mandated the implementation of JOS as a key objective in this plant's long-term strategy	*,896*				
20	Top-management in this plant is actively and hands-on involved in the JOS improvement activities at shop-floor	*,878*				
22	Sufficient investments are allocated to the JOS implementation in this plant	*,850*				
29	Top-management makes periodic visits to shop-floor to personally follow-up JOS implementation in this plant	*,804*				
28	Top-management routinely asks for performance reports of the JOS implementation progress	*,562*		*,320*		
34	Jotun HQ tends to make more investment resources available for the plant if suggested projects show explicit relationship to JOS	*,534*				
40	Managers regularly speak about JOS to employees (thus employees hear much about JOS in this plant)	*,488*		*,311*		
37	Personnel regularly meet to discuss JOS implementation in this plant	*,437*		*,394*	*-,311*	
19	Managers from other Jotun plants are employed in this plant for extended periods to help implement JOS		*,646*			
38	Personnel from this plant regularly make short-term visits to other plants for benchmarking and learning related to JOS		*,610*			
39	Personnel from other plants regularly make short-term visits to this plant to share their experience with JOS implementation		*,591*			
41	Managers regularly write about JOS in Intranet pages, magazines, flyers and similar internal marketing efforts		*,347*		*-,302*	*,282*
42	General JOS information is displayed at the shop-floor in this plant (thus logos, principles, best practices, news, etc. are clearly visible in this plant)			*,839*		
27	JOS performance charts with performance indicators are regularly posted at the shop-floor areas			*,833*		
26	Documents providing guidelines for implementation of JOS are regularly issued to shop-floor			*,738*		
24	Shop-floor JOS-teams are established to implement JOS in this plant		*-,325*	*,662*		
32	Personnel and teams are regularly rewarded with praise or non-financial benefits based on operational improvement tied to JOS implementation in this plant			*,662*	*,374*	
31	This plant's JOS performance is routinely benchmarked and compared with other plant's JOS performance			*,614*		
30	Internal JOS audits are regularly undertaken to follow up JOS implementation in this plant			*,577*		
23	The plant has an organised team of dedicated employees who lead and support the implementation of JOS	*,304*		*,526*		
25	Decisions on JOS implementation are regularly taken through an established hierarchical and linked meeting structure in the plant	*,436*		*,480*		
35	This plant holds formal training in JOS for its shop-floor personnel	*,337*		*,449*		
18	External consultants are hired on to help implement JOS in this plant		*,327*		*-,744*	
36	This plant holds formal training in JOS for its top-management				*-,493*	
33	Managers are regularly rewarded with financial remuneration based on operational improvement tied to JOS implementation in this plant					*,906*
Eigenvalue		*12,09*	*1,808*	*1,159*	*1,022*	*1,007*
Percentage variance explained by component		*48,34*	*7,23*	*4,64*	*4,09*	*4,03*
Total variance percentage explained		*48,34*	*55,57*	*60,21*	*64,30*	*68,33*

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization. Rotation converged in 22 iterations

4.1.2 Evaluation of reliability and validity of identified components

The reliability can be assessed by evaluating a reliability coefficient. I choose to use Cronbach's alpha, which measure the internal consistency of a multidimensional scales, to evaluate the reliability. In empirical research this is one of the most normal reliability measures used (Claver et al., 2003). Nunnally (1978) advises that the minimum level of the alpha should be 0.7, although Van de Ven and Ferry (1980) explains that in exploratory research in can be reduced to 0.55. Using the result from the PCA Cronbach's alpha is calculated for each of the components together with the alpha for the component after eliminating an item which belongs to the component. The output from the reliability analysis of the components can be found in Appendix C.

Within component one, *commitment from management,* Cronbach's item 34 is removed increasing Cronbach's alpha for the component to 0,930. For component two, *knowledge exchange,* I remove item 19 increasing the alpha to 0,785. The same is done with item 31 of component three, *the practical management of implementation*, increasing Cronbach's alpha for the component marginally to 0,933. Cronbach's alpha for component four, *develop and deploy process improvement experts,* is 0,370 and with only two items constituting this component it is not possible too increases the alpha for the component by removing an item. This component's alpha is consequently below 0.55 and should according to Van de Ven and Ferry (1980) therefore be ignored as a component. The PCA did however extract this as a separate component indicating that it has some relevance and might be of importance even though its alpha is low. The relevance of this component will be explored further in the case study.

The detailed item analysis evaluates how each item is assigned to the four components by looking at each items correlation with the components. This can be used validate if an item belongs to the component it is assigned to or if the initial assignment was wrong (Nunnally, 1978). The correlation matrix (see Appendix D) clearly shows that the items belonging to its respective component have the highest correlation with the same component. This indicates that the items have been correctly assigned to it scale and thus confirms the validity of the analysis.

After the analysis of the reliability and validity of the components found in the PCA I am left with four components. Item 31, 19 and 31 are removed from component one, two and three respectively. Even though Cronbach's alpha for component four is below the required level for reliability (< 0.55), I choose to explore this component further before giving a final evaluation to its relevance. The four components and their items are presented in Table 5.

Table 5 - Components extracted from the PCA

Component	No. of items		Items
Commitment from managers	7	21	Top-management has explicitly mandated the implementation of JOS as a key objective in this plant's long-term strategy
		20	Top-management in this plant is actively and hands-on involved in the JOS improvement activities at shop-floor
		22	Sufficient investments are allocated to the JOS implementation in this plant
		29	Top-management makes periodic visits to shop-floor to personally follow-up JOS implementation in this plant
		28	Top-management routinely asks for performance reports of the JOS implementation progress
		40	Managers regularly speak about JOS to employees (thus employees hear much about JOS in this plant)
		37	Personnel regularly meet to discuss JOS implementation in this plant
Knowledge exchange	3	38	Personnel from this plant regularly make short-term visits to other plants for benchmarking and learning related to JOS
		39	Personnel from other plants regularly make short-term visits to this plant to share their experience with JOS implementation
		41	Managers regularly write about JOS in Intranet pages, magazines, flyers and similar internal marketing efforts
Practical management of implementation	9	42	General JOS information is displayed at the shop-floor in this plant (thus logos, principles, best practices, news, etc. are clearly visible in this plant)
		27	JOS performance charts with performance indicators are regularly posted at the shop-floor areas
		26	Documents providing guidelines for implementation of JOS are regularly issued to shop-floor
		24	Shop-floor JOS-teams are established to implement JOS in this plant
		32	Personnel and teams are regularly rewarded with praise or non-financial benefits based on operational improvement tied to JOS implementation in this plant
		30	Internal JOS audits are regularly undertaken to follow up JOS implementation in this plant
		23	The plant has an organised team of dedicated employees who lead and support the implementation of JOS
		25	Decisions on JOS implementation are regularly taken through an established hierarchical and linked meeting structure in the plant
		35	This plant holds formal training in JOS for its shop-floor personnel
Develop & deploy process improvement experts	*2*	*18*	*External consultants are hired on to help implement JOS in this plant*
		36	*This plant holds formal training in JOS for its top-management*

4.2 Test of hypothesis 1

I have proposed that the degree of implementation of an XPS positively and significantly affect plant performance. For this hypothesis (H1) to be supported, the *degree of implementation* must explain significant variance in plant performance. The degree of implementation is extracted from question 14 from part one of the survey and is measured using an scale from 1-5 where 1 represents *not implemented at all/just started* and 5 represent *fully implemented in all areas* (see Appendix B). Plant performance is evaluated based on an index created by averaging the scores measured from 11 single-item scales representing different dimensions of performance (see Appendix B).

H1 is tested through evaluating Pearson's product-moment correlation, where a coefficient, r, is calculated measuring the strength and direction of a linear relationship between two continuous variables. The general guidelines for the strength of the association of the coefficient value, presented by Cohen (1988), are used to evaluate the strength of r. The linear relationship between the degree of implementation and plant performance has been verified through a visual inspection of the scatter plot of the variables (see Appendix E). The normal distribution has been verified by visual inspection of the Normal Q-Q Plots (see Appendix E). There was found to be a moderate positive correlation between the degree of implementation and the plant performance, $r(113) = .377$, with the relationship being significant at the $p < .0005$. The degree of implementation can statistically explain 14% ($R^2 = 0.142$) of the variation in plant performance. Higher values of plant performance are found to be associated with higher degree of XPS implementation and H1 is thus supported.

			Supported
H1	*The degree of implementation of an XPS positively affects plant performance*	→	✓

4.3 Test of hypothesis 2a-d

I have proposed that more use of factors related to the commitment of management (component one), the practical management of implementation (component three) and the deployment and development of process improvement experts (component four) positively and significantly affect the implementation of an XPS (H2a-c). For this hypotheses to be supported there must be a positive correlation between more use of the three components and the degree of implementation of an XPS.

This relationship is evaluated by using simple linear regression to predict the value of the dependent variable (degree of implementation) based on the value of an independent variable (component one/three/four). An *independence of residuals* is found, as assessed by a Durbin-Watson statistic of 2,014 for component one, 1.882 for component three and 1.574 for

component four. By visually inspecting the scatter plot of the studentized residuals against the unstandardized predicted values the dependent variable are found to be *linearly related* to the independent variable. The latter scatter plot also provides evidence that *the assumption of homoscedasticity* (that the residuals are equal for all values of the predicted dependent variable) has not been violated. Furthermore, no *outliers* are detected; determined by evaluating the standardized residuals with a cut-off criterion of ±3. In order to be able to run inferential statistics (i.e., determine statistical significance), the errors in prediction - the residuals - need to be normally distributed. This condition is verified through visual inspection of a *normal P-P Plot of the standardized residuals* (see Appendix E).

The linear regression established that *management commitment* could statistically significantly predict the degree of XPS implementation, $F(1, 113) = 70.157$, with the relationship being significant at $p < .0005$. The commitment from management accounted for 38% ($R^2 = 0.383$) of the explained variability in XPS implementation. Hypothesis H2a is thus supported.

			Supported
H2a	*More use of factors related to the commitment of management contributes positively to XPS implementation*	→	✓

Linear regression also established that the *practical management of implementation* could statistically significantly predict the degree of XPS implementation, $F(1, 113) = 98,049$, with the relationship being significant at $p < .0005$. The practical management of implementation accounted for 47% ($R^2 = 0.465$) of the explained variability in XPS implementation. Hypothesis H2b is thus supported.

			Supported
H2b	*More use of factors related to the practical management of implementation contributes positively to XPS implementation*	→	✓

The linear regression did in addition establish that *deploying and developing process improvement experts* could statistically significantly predict the degree of XPS implementation, $F(1, 113) = 11.215$, with the relationship being significant at $p < .05$. Deploying and developing process improvement experts accounted for 9% ($R^2 = 0.091$) of the explained variability in XPS implementation. Hypothesis H2c is thus supported.

			Supported
H2c	*More use of factors related to deploying and developing process improvement experts contributes positively to XPS implementation*	→	✓

I have also proposed that plants with a higher degree if XPS implementation also has a higher utilization of all factors compared to plants with a lesser degree of XPS implementation (H2d). To test H2d I want to determine whether there are any statistically significant differences of utilization of all factors between the factories with high to low degree of implementation. For this purpose a one-way analysis of variance (ANOVA) is used. There were four outliers in the analysed data, as assessed by inspection of a boxplot for values greater than 1.5 box-lengths from the edge of the box (see Appendix E). Three of the outliers are only marginally greater than 1.5 box-lengths and is not believed to materially affect the result. Outlier 15 is removed from the further analysis due to the fact that it is more than 3 box-lengths away from the edge of the box (extreme points). The utilization of factors was normally distributed for the "basic", "somewhat", "much" and "fully" degree of implementation groups of plants, as assessed by Shapiro-Wilk's test ($p > .05$). The "not implemented at all" group only had two responses, and will be ignored in the further analysis. The assumption of homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance ($p = 0.002$). Therefore, a robust tests of equality of means was used showing that the utilization of factors was significantly different between different degrees of XPS implementation, $p < .0005$ (Welch's $F(3, 27.976) = 52.958$). The utilization of factors increased with the level of implementation; from "basic" ($M = 2.3$, $SD = 0.7$), to "somewhat" ($M = 2.8$, $SD = 0.5$), to "much" ($M = 3.3$, $SD = 0.5$) to "fully" ($M = 4.2$, $SD = 0.2$), in that order.

To compare all possible combinations of group differences, under the assumption of homogeneity of variances being violated, the Games-Howell *post-hoc* test is used. This *post-hoc* test provides both confidence intervals for the differences between group means and whether the differences are statistically significant. Games-Howell *post-hoc* test (see Appendix E) revealed that the mean increase from "basic" to "much" of 1.07 (95%CI [0.60 to 1.53]) and from "somewhat" to "much" of 0.54 (95%CI [0.25, 0.84]) was statistically significant at $p < .0005$. The mean increase from "basic" to "fully" of 1.88 (95%CI [1.39, 2.37]), "somewhat" to "fully" of 1.36 (95%CI [1.00, 1.72]) and "much" to "fully" of 0.82 (95%CI [0.45, 1.19]) was also found to be statistically significant at $p <.0005$. This gives evidence to H2d being supported.

			Supported
H2d	*Plants that have a higher utilization of all factors are more successful in implementing the XPS than plants that have a lower utilization of all factors*	→	✓

4.4 Test of hypothesis 3a-d

I have proposed that the use of factors related to the commitment of management (component one), the practical management of implementation (component three) and the deployment and development of process improvement experts (component four) have a direct and positive impact on plant performance (H3a-c). For this hypotheses to be supported the three components must explain significant variance in plant performance

This relationship is evaluated using Pearson's product-moment correlation where the guidelines for the strength of the association of the coefficient value, presented by Cohen (1988), are used to evaluate the strength of r. The linear relationship between the three factors and plant performance has been verified through a visual inspection of the scatter plot of the variables (Figure 6 and Figure 7). The normal distribution is evaluated based on the z scores of the variables skewness and are accepted at a statistical significance level of .01, which equates to a z-score of ±2.58. The factor for H3a is found to be normally distributed with a skewness of -.524 and kurtosis of -.224, the factor for H3b normally distributed with a skewness of -.142 and kurtosis of -.282 and the factor for H3c normally distributed with a skewness of .570 and kurtosis of .072. The plant performance is normal distributed with a skewness of -.569 and kurtosis of .949. The standard error for the skewness and kurtosis for all four distributions are .223 and .442 respectively.

There was found to be a strong positive correlation between the commitment from management and the plant performance, $r(117) = .563$, with the relationship being significant at $p < .0005$. The commitment from management can statistically explain 32% ($R^2 = 0.317$) of the variation in plant performance. H3a is thus supported.

			Supported
H3a	*The commitment from management to XPS implementation have a direct and positive impact on plant performance*	→	✓

There was found to be a moderate positive correlation between the practical management of the implementation and the plant performance, $r(117) = .495$, significant at $p < .0005$. The practical management of the implementation can statistically explain 25% ($R^2 = 0.246$) of the variation in plant performance. H3b is thus supported.

			Supported
H3b	*The use of factors related to the practical management of the implementation of an XPS have a direct and positive impact on plant performance*	→	✓

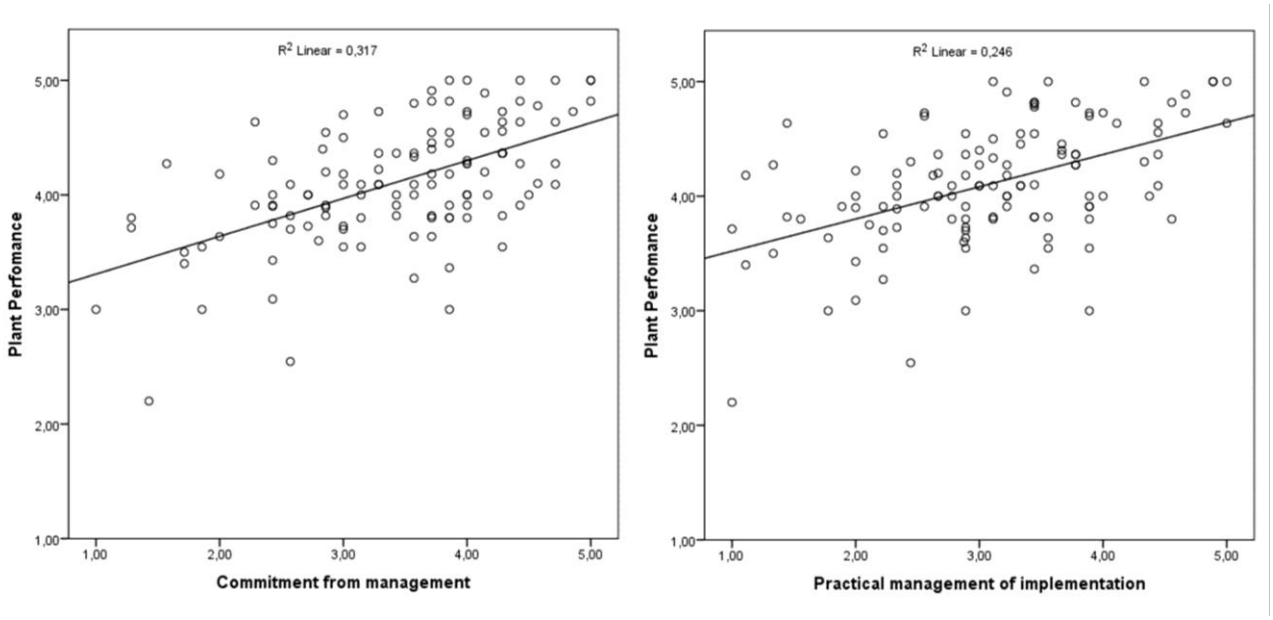


Figure 6 - Scatterplots from the tests of H3a and H3b

There was found to be a moderate positive correlation between deploying and developing process improvement experts and the plant performance, *r(117)* = .0390, with the relationship being significant at $p < .0005$. The degree of implementation can statistically explain 15% (r^2 = 0.152) of the variation in plant performance. H3c is thus supported.

			Supported
H3c	*The use of factors related to developing and deploying process improvement experts to XPS implementation have a direct and positive impact on plant performance*	→	✓

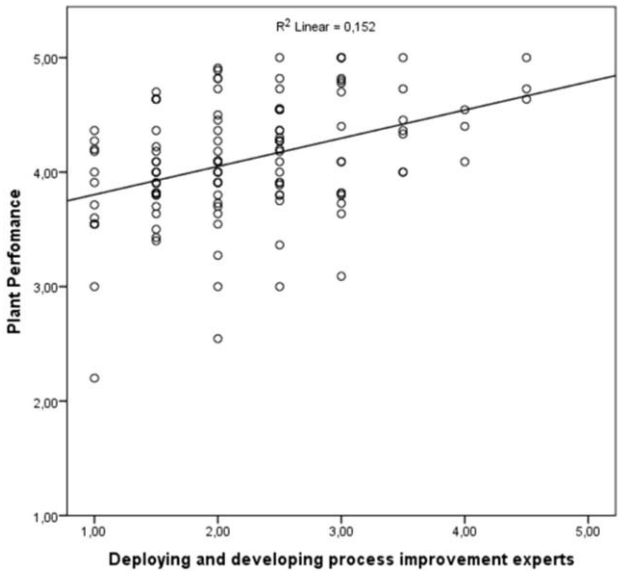


Figure 7 - Scatterplot from the test of H3c

I have also proposed that plants with a high performance have a higher utilization of all factors compared to plants with a lower performance (H2d). To test H3d an independent-samples t-test was run to determine if there were differences in the utilization of the factors between low and high performers. High performers are recognized by having a value ≥ 4 on the plant performance index (runs from 1-5) while low performers have values <4. No outliers were detected in the data, as assessed by inspection of a boxplot. The utilization of factors for each level of performance were normally distributed, as assessed by Shapiro-Wilks test ($p > .05$), and there was homogeneity of variances, as assessed by Levene's Test for Equality of Variances ($p = .254$). The utilization of factors was higher for high performers ($M = 3.14$, $SD = 0.65$) than low performers ($M = 2.50$, $SD = 0.70$). High performers mean utilization was 0.64 (95% CI [0.39 to 0.89]) higher than low performers mean utilization of factors. There was a strong statistically significant difference in mean utilization of factors between high and low performers, $t(117) = 5.015$, significant with $p < .0005$. This means that hypothesis H3d is supported.

			Supported
H3d	*Plants that are identified as high performers will have a higher utilization of all factors compared to plants that are identified as low performers*	→	✓

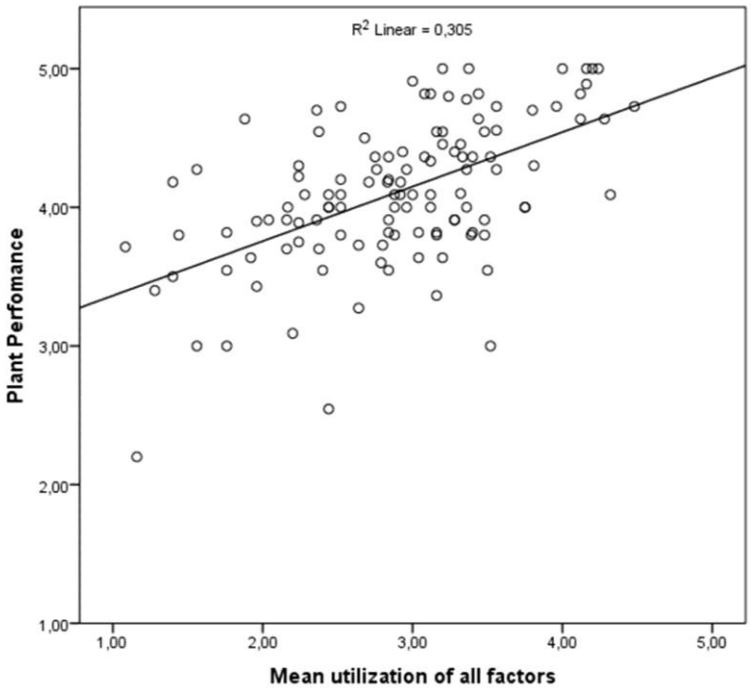


Figure 8 - Scatterplot from the test of H3d

4.5 Summary of the tests

Based on analysis of the data from the survey the three proposed hypothesis have been found to be supported. The groups of CSFs have a positively and significant impact on both the degree of implementation and the plant performance. In addition, plant performance is also found to be positively and significantly associated with the degree of implementation. The key data from the testing of the hypotheses are presented in Table 6.

Table 6 - Key data from the testing of the hypotheses

	Hypothesis	r	R^2	**Significance (p <)**	**Support**
H1	The degree of implementation of an XPS positively affects plant performance	0,377	0,142	***.0005***	***Moderate***
H2a	More use of factor related to the commitment from management contributes positively to XPS implementation	0,619	0,383	***.0005***	***Strong***
H2b	More use of factor related to the practical management of the implementation contributes positively to XPS implementation	0,682	0,465	***.0005***	***Strong***
H2c	More use of factor related deploying and developing process improvement experts contributes positively to XPS implementation	0,302	0,091	***.05***	***Moderate***
H2d	Plants that have a higher utilization of all factors are more successful in implementing the XPS than plants that have a lower utilization of all factors	0,667	0,445	***.0005***	***Strong***
H3a	The use of factors related to the commitment from management have a direct and positive impact on plant performance	0,563	0,317	***.0005***	***Strong***
H3b	The use of factors related to the practical management of the implementation have a direct and positive impact on plant performance	0,495	0,245	***.0005***	***Moderate***
H3c	The use of factors related to deploying and developing process improvement experts have a direct and positive impact on plant performance	0,390	0,152	***.0005***	***Moderate***
H3d	Plants that are identified as high performers will have a higher utilization of all factors compared to plants that are identified as low performers.	0,552	0,305	***.0005***	***Strong***

5 Case presentation

This section provides relevant background information of the chosen case. The first chapter gives a presentation of the case company while the second chapter gives specific information of the XPS being studied, namely Jotun Operations System. The last three chapters present the investigated subsidiaries.

5.1 Presentation of Jotun Group

Jotun Group is a family owned company originating from Sandefjord, Norway and is headquartered at the same location. Since the beginning in 1920 the company has through expansions and mergers evolved into the Jotun Group as can be seen today. The group, including Joint Ventures and associates, has 36 production facilities and 71 companies on all continents and is represented in more than 45 countries worldwide (Jotun, 2012).

Jotun's 36 plants operate principally independent from each other. The size of each plant is determined by the "local" demand and optimal size in regards to economies of scale. The location is decided upon at Jotun's corporate headquarters in an "optimal" way relative to the rest of the network. When deciding on location Jotun regards proximity to attractive markets to be the most important factor concerning a site's location, but factors such as access to low cost production, access to skills and knowledge and socio-political factors are also taken into consideration (Jotun, 2012).

The average number of employees (including shares in joint ventures) are approximately 8 700. The employees are organized in four divisions with specific product, segment and geographical responsibilities. *Jotun Dekorativ* covers the Scandinavian markets, while *Jotun Paints* has segment responsibility for decorative paints outside Scandinavia and protective coatings in selected markets in the Middle East and South East Asia. *Jotun Coatings* has global segment responsibility for marine and protective coatings while *Jotun Powder Coatings* has global responsibility for powder coatings, ea. architectural, functional and industrial market segments. The Groups total operating revenue was NOKM 11 351 in 2012, up from NOKM 10 659 in 2011. Their consolidated profit for 2012 ended on NOKM 795 compared to NOK 654 million in 2011 (Jotun, 2012).

5.2 Jotun Operations System

As a result of Jotun Group's growth over the past years, the company has realized an increasing need to standardize their production systems and the need for a method for continuously optimizing and evaluating their production facilities. As an answer to these emerging needs, Jotun Operation System (JOS) has been developed and started implemented throughout the organisation. JOS is to a large extent based on the underlying principles of the Toyota

Productions System and lean philosophy, and is designed in accordance with Jotun Group's values; loyalty, care, respect, and boldness. These values permeate the organisation and form the core of their company identity, the "Penguin Spirit". The same way JOS standardizes and defines how production should be conducted, the "Penguin Spirit" defines how Jotun's values should be interpreted correctly to communicate company strategy. Such a *Management by Value* approach is important as large differences in national markets complicate creation of aligned objectives throughout the company, hence making management by objectives challenging (Barkema and Vermeulen, 1997).

JOS is visualized through an *operation house* consisting of four layers; namely fundamental operation principles, best practice process and product management, continuous improvement and competence development and results obtained by improving the contents of the house. JOS helps Jotun make sure that their factories are run in an efficient way, and that the production at the facilities is aligned with current standards and values. This system constitutes the backbone of the firms audit and survey tools, and is among other things used when benchmarking between factories through Jotun Operation Survey. However, the company is careful when comparing facilities in different countries because of cultural differences etc. Rather, the company prefers benchmarking facilities against themselves, focusing on improvement from year to year. The deployment of JOS combined with "the Penguin Spirit" is central in their commitment to their continuous improvement strategy. The design of JOS is presented in Figure 9.

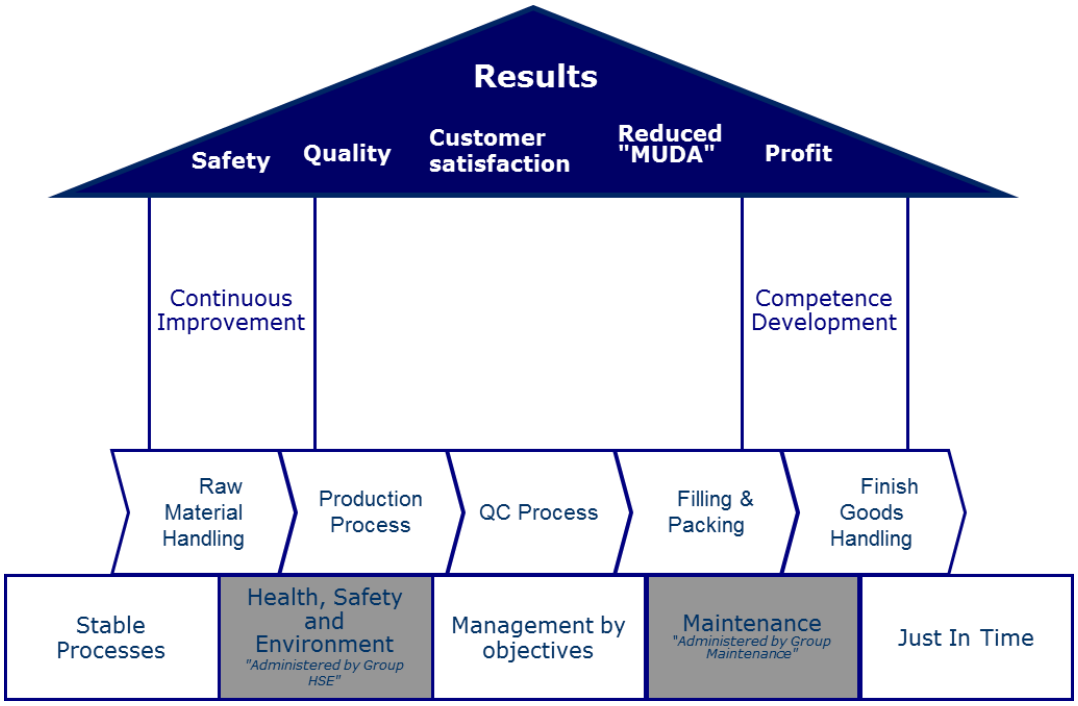


Figure 9 - Jotun Operations System

The Group Operations Improvement (GOI) department has had a central role in developing JOS. GOI can be considered as an internal Jotun consultant department whom visit factories helping them improve. They also conduct audits of the factories evaluating how they perform with respect to JOS and have the responsibility for continuous improvement of production and deliverance worldwide in the Jotun Group. Jotun Operations Academy (JOA) is a competence development academy run by GOI and the Group Competence Department in Jotun.

5.3 Jotun factories in Saudi-Arabia

The Jotun activities in Saudi-Arabia have its origins back to the foundation of Red Sea Paint in 1976. This company merged with Jotun in 1996. At that time Jotun was already established in Saudi-Arabia in Yanbu where solvent based production started in 1983. By 2005 Red Sea as a label was completely phased out.

The factories in Jeddah and Yanbu produce mainly decorative paints. The products are to a large degree (80%) fast moving water based decorative paint that is transported out to retailers and sales offices where the multicolour system is applied. The remaining 20% of their production volumes consist of different solvent based decorative articles. The sites are certified according to the standards of ISO9001 (quality management), ISO14001 (environmental management) and OHSAS 18001 (occupational health and safety). In Yanbu 100 people are employed in the production and 40 in the warehouse while in Jeddah 96 works in the production and 56 in the warehouse. Both plants operate with one shift. In 2009 a SAR 100 million expansion of a highly- automated factory in Yanbu were finished. The new factory boasts a high degree of automation and will exclusively produce water based paints. With the inauguration of the new factory Jotun's installed production capacity of paints and coatings in the Kingdom reaches 110 million litres of paint (Jotun, 2009). This investment makes an important contribution to Jotun Saudi-Arabia's ambitious growth plans; they aim to double their turnover of SAR 500 million in 2012 to SAR 1000 million within the end of 2014. The implementation of JOS is however also planned to contribute significantly to reaching this goal (Munir Kahn, 15.04.13).

5.4 Jotun factory in Vindal, Norway

To meet future demands and to increase their competitiveness the board of director of the Jotun Group in 2009 decided to invest NOKM 500 in an expansion of Jotun's production facilities in Vindal, the largest single investment in the history of Jotun. The investment meant a co-location all of Jotun's production facilities in Norway to Vindal and as a result of this the production facilities in Fredrikstad, Manger and Gimle were closed down. The production of industrial and marine coating in Fredrikstad was moved to Flixborough, all other production was moved to Vindal. The new 13 000 m2 factory in Vindal opened in March 2012 and serves now the entire Scandinavian market with decorative products with a total capacity of 80 million litres per year.

The site is certified according to the standards of ISO9001 (quality management), ISO14001 (environmental management) and OHSAS 18001 (occupational health and safety).

The factory employs 240 persons and operates currently with two shifts, but can increase this to three shifts if need be. They try however to avoid this and instead work on increasing efficiency through improvement initiatives rather than increasing the number of shifts. Since production started last year they have had several start-up problems which have resulting in a rather large rest order list[3] (Øyvind Askeland, 24.04.2013). This has however been significantly reduced over the last months due to both overtime and several improvements projects lead by GOI. GOI have had a team deployed in Vindal for three months solely working on initiating and introducing improvement projects and supporting the managements continuous improvement work.

5.5 Jotun factory in Flixborough, England

The Jotun operations in the UK were initiated through the purchase of Henry Clarke & Sons Ltd in 1970, representing an exception from their general business strategy of organic growth. The current plant in Flixborough was operational in 1989 and has grown substantial since that. The factory belongs to Jotun Paints Europe Ltd; this company has approximately 380 employees, 190 of which are based in the UK. The main function of Jotun Paints Europe Ltd is to supply goods in Europe, but it also exports to Central and South America, The Caribbean, West Africa and for the time being Russia.

The factory in Flixborough produces heavy duty marine and protective coatings. The products are mainly solvent based, but they also have some production of water based paints. In 2012 the factory had a manufactured volume of 26.0 million litres. The site is certified according to the standards of ISO9001 (quality management), ISO14001 (environmental management) and OHSAS 18001 (occupational health and safety). The factory went through a major transformation during in the period between 2006 and 2011 (Aa and Anthonsen, 2011). In 2005, the plant was performing poorly. The inventories were large, but one was still unable to satisfy customer demands. The results were so poor that the factory was under threat of being closed (Aa and Anthonsen, 2011). Today, the situation has improved but the factory has had problems sustaining several of the improvement projects which were initiated in order to secure the future survival of the company. They have however ambitious plans for increasing their overall efficiency and has a long term goal of become the “plant of choice” within Jotun (Dave Cooper, 02.05.2013).

[3] Back log of orders not met due to lower production volumes than expected.

6 Empirical findings from the case study

This section presents the main findings from the field visits to Jotun's plants in Yanbu and Jeddah, Vindal and Flixborough. The empirical findings are presented with respect to the CFSs for XPS implementation from theory (described in section two). The last sub-section provides a short summary of the main findings from the three investigated subsidiaries.

6.1 Case 1: Jeddah and Yanbu, Saudi-Arabia

The first steps of Saudis "process improvement journey" were initiated with the participation of a few selected managers in Jotun Operations Academy (JOA) in 2007. Prior to this, the knowledge of process improvement was low at the factory. Since 2007, a majority of the production management from the plants in Saudi have attended JOA; this being their main introduction to the concepts of which JOS is built upon. This *training and education* of personnel is viewed as a critical factor for the initiation of continuous improvement efforts in Saudi, supported by the following statements:

> *"Without JOA - no lean. It has been extremely important for starting the lean journey." (Manager #2, Saudi)*

> *"We immediately saw the potential and could identify a lot of muda in our plants already during the course" (Munir Kahn, Continuous Improvement Manager)*

Today the attendance in JOA is closer connected with Saudis continuous improvement efforts than in the beginning, increasing the value of *allocating resources and time* to send personnel to training. The people who are attending JOA have to perform work related to what they have been thought when they get back; typically in the form of a smaller improvement project which they have to identify and carry out before the course is passed. In addition, the shop floor personnel are educated through a course called Jotun Operator Training (JOT) held in the three main languages operators use; Urdu, Arabic and English. Through this course the operators are, among other things, introduced to the most basic JOS elements and tools.

While the *training and education* provided knowledge of process improvement, they did in the beginning face difficulties when trying to put the newly acquired knowledge into use in the factories. First of all they lacked experience and were uncertain of how to implement and what to do. Secondly, process improvements had little or no focus among top management. This changed with Kjell Gundersen becoming the new Managing Director (MD) in early 2010. He had both the *experience* and *commitment* to start working with implementing improvement initiatives and *supported* the projects in their initial phases by providing *expert knowledge.* The following two statements shed further light on the importance of the commitment from management and expert knowledge:

> *"After the courses we didn't now properly how to implement. When Kjell arrived this changed. He knew what to do and wanted us to do it" (Munir Kahn, Continuous Improvement Manager)*

> *"Sustainability of improvements is very hard in the beginning. The support and continuous focus from top management is vital for sustainability." (Manager #3, Saudi)*

The *top management support and commitment* have been continued by the current MD Dave Wright. Their ambitious goal of doubling the turnover from 500 million Riyals in 2012 to 1 billion in 2014 is to be achieved partly through the effects of process improvement projects. They have acknowledged that they cannot meet this goal without improving their operations in several areas and have thus had a strong focus on this, especially for the last two years. By strategically linking this overall goal to the *plans and goals for implementation*, the overall target has been spilt in smaller targets for what must be done in terms of increasing production efficiency and total volume. Previously the focus was directed at handling one problem at a time without a holistic approach for how to detect and select the improvement initiatives. Now they use the two year goal as a starting point for identifying possible challenges and improvement areas; where are we now, and where do we need to be in order to reach the goal? Rather than focusing on the more intangible overall goal, the have a *strong focus on the smaller implementation goals* of the improvement projects which in turn will contribute to reaching the overall goal. This strong focus is manifested through two main instruments; *performance indicators* and *by managers being hands on.* The performance indicators, such as OTIF, RFT, litres per man hour, total production in volume per day/week/month, gives insight into how they are performing with respect to the set targets.

By managers *being hands* on a continuous focus on the implementation goals have become visible and rooted in the organisation. The close *involvement from management* has served as an important means for detecting and treating possible challenges and improvement possibilities within the factory, supported by this statement:

> *"You can't solve production problems in your office. If there is a bottleneck on the factory floor, you have to go to the source, observe how things are done and talk to the people at the scene to learn first-hand what's going on. Only then can you begin doing the work to develop a solution". (Dave Wright, Managing Director, Penguin Magazine 1 - 2013)*

Furthermore they have found that by breaking down the overall goals into smaller targets, they can more easily *communicate clearly* to the operators why change must occur and what is expected of them; the connection between the smaller target and the "big picture" becomes somewhat more comprehendible. This improvement information is communicated, besides from

in production meetings, through several boards around in the factory displaying performance indicators, goals, team qualifications, achievements and other information deemed important. In addition they have identified the current best practice of any given operation and made signs describing the baselines of these practices; signs which are in the process of being fitted at relevant locations around the factory. Their focus now is to first ensure that the operating best practices are fully incorporated as the operating standard at the different work areas, and then focus on continuously improving this standard.

The increased understanding of the reasons behind the improvements initiatives and its importance has influenced the motivation to carry out the improvement initiatives. They do however not incentivise such behaviour further by awarding financial remuneration or other tangible rewards to employees who suggest or carry out improvement initiatives. What they rather try to show is that an improvement initiative means an easier and more pleasant work life, and not increased work which is what many operators associate with change - this way overcoming any possible resistance to the improvement initiatives.

> *"We want them to understand that this makes their life easier. While we at the same time improve the operations." (Munir Kahn, Continuous Improvement Manager)*

In Saudi they have a continuous improvement team consisting of one manager and five team members, with one more person to be hired. This group work continuously with improving the operations at the sites in Jeddah and Yanbu. The personnel help identify areas for improvement and either run or support improvement projects. This use of *dedicated improvement leaders, teams and projects* has played an important role as an initiator and facilitator for Saudis process improvement journey. Most people in the plants, especially above operator level, are familiar with a number of the tools and techniques related to JOS. These include Kanban, Kaizen, Muda, the 5S methodology to help organize the workplaces more efficiently, process mapping and fishbone diagrams – structured processes to identify cause and effect. Gemba is also, as previously mentioned, being used actively by management. The line personnel give the impression of having enough knowledge of how to *use and apply the appropriate tools and techniques* to the right situation, either by themselves or by the assistance of the continuous improvement personnel.

The employees at the shop floor are only to a limited degree involved in the improvement processes; e.g. they do the improvements they are told to do. This can partly be explained by the nature of the Saudi society being quite hierarchical. The operators have a quite passive approach to the process improvements, and it has proven challenging to make them contribute with their own ideas and suggestions. The low degree of operator autonomy can however also partly be

explained by the low degree of empowerment and involvement of operators in the implementation initiatives within the plants.

The long term commitment to process improvement has laid a foundation for an improvement culture being built up, while at the same time experience with running improvement projects has been acquired. Wright says that while these steps have made significant impact on Jotun Saudi's bottom line, the real value of the philosophy behind JOS is its effect on Jotun personnel:

> *"Everywhere I look, I see people working hard, working together and having fun." (Dave Wright, Managing Director, Penguin Magazine 1 - 2013)*

6.2 Case 2: Vindal, Norway

The "process improvement journey" in Vindal was initiated about 7 years ago by representatives from the Orkla Group (GOI have now taken over this role). Previous to this the organisation at Vindal (and at Gimle and Fredrikstad) had no or little knowledge about continuous improvement philosophies. While the old organisations at these three locations acquired both knowledge and experience of process improvement during the period up to the opening of the new factory in Vindal, it seems as the application of this knowledge and experience has been given a lower priority after the opening of the new factory in March 2012. After the completion the focus has been (naturally) directed at getting the production running properly, resulting in less *commitment from the management* to continuous improvement initiatives in the factory.

> *"Lean initiatives have not been the main focus in this organisation after the completion date of the new factory. We've had to direct a lot of attention to getting the production up and running." (Øyvind Askeland, Production Manager)*

Getting the production up and running have however proven challenging, something which have resulted in troubles meeting the demand and a relatively large back log of orders being built up. The management team has however taken actions to reduce the back log and improve the operations, among them the deployment of a team from GOI early 2013 to assist with the implementation of JOS elements. The project team from GOI arrived with a clear mandate to start improving the production processes, and with it brought process improvement back on the agenda. This *dedicated team* introduced two vital factors for continuous improvement that were wanting in Vindal; *expert knowledge* and a *constant and continued focus on process improvements*.

> *"For us we need people with experience with these matters in order to carry out such improvements projects. It was necessary with lean initiators who put continuous improvement on the agenda and kept the focus there." (Øyvind Askeland, Production Manager)*

With the management team struggling to balance their efforts between getting the new factory up and running while at the same time working on implementing JOS elements, the GOI team represented highly coveted *resources* which could relieve this struggle. The GOI team are however about to finish up their projects and when they leave it will be up to the plant manager and production manager, together with the rest of the management team, to follow up the improvement initiatives and projects. It is important that the ownership for continuous improvement now is *transferred and anchored* within the organisation and that *sufficient resources and time* are allocated to this purpose going forward. It seems however that this might prove a challenging task and that it is believed that it is easier when GOI does "these things" rather than personnel from the Vindal organisation performing it by themselves (Manager #1, Vindal). They do however now experience *a stronger support from the top management* to perform continuous improvement projects. Yet, the organisation is struggling to recognize the value of working with continuous improvement, and there seems to be a lack of sufficient skills, experience and knowledge within the organisation to lead such projects by themselves. It indicates that a *dedicated improvement leader and team* within the Vindal organisation are essential for driving the process improvement forward.

The arrival of the GOI team and the projects they have run together with the organisation in Vindal have brought about several changes to the production. Whether these changes are solely due to GOIs initiatives is hard to tell, but it is most likely a result of the combined efforts of getting the operations up and running while also performing process improvement activities. They now experience a more stable production with less stop and less ad hoc "fire extinguishing" of problems. The increased control of the production has resulted in a smoother and more continuous flow in the production, which again has allowed them to start with production levelling. This again is connected with the shift towards the *performance indicators* now being closer related to the production planning and the use of additional indicators than that of total volume produced. In march 2013 the operating goals where changed from focusing primarily on total production volume to also focus on other performance indicators such as OTIF, production levelling, RFT etc. This allows for a closer monitoring of the production, and makes it easier to detect and react to any deviations from the set targets.

They also experience a positive change in the operator's attitude after the recent improvements, with an increase in the general atmosphere and team spirit, supported by this statement:

> *"The workers are happier. They experience less chaos and we have seen a decrease in sick leaves." (Øyvind Askeland, Production Manager)*

The GOI team has worked closely with a few teams at the production level and has, together with the operators in these teams, been able to carry out several successful improvement

projects. The implementation of kanban and a supermarket in the raw material warehouse is one example of such a successful project. While the team members here are happy with the changes that now has occurred, they point out that several of the improvements have been suggested to the management prior to GOIs arrival without the management taking any notice or action. This indicates that the *involvement and empowerment* of the employees could be better managed, and that *the involvement from managers* could be higher. This indication is further strengthened through operator's impression of the organisation lacking both the interest and the abilities to perform such improvements before GOIs arrival (Operator #1, Vindal).

Resources have been allocated to *training and education* of both management and operators. While there exists a relatively fair understanding of the basic tools within JOS, few of them are actively being used. During the factory tour one does not get the impression of an organisation where continuous improvement is alive, on the agenda and guiding the way the operations are conducted. This perception is shared by management personnel, whom find the mind-set of the employees a challenge when working with continuous improvement:

> *"Continuous improvement is for them unknown territory and are by most operators viewed as extra work. They do not see the benefits for them yet. And that they have a lot to contribute." (Manager #1, Vindal).*

The management does however not seem to exercise any strong commitment to continuous improvement, this way encouraging and motivating the shop floor level to take part of this work. There does also not seem to be any system for *recognizing or rewarding* improvement initiatives or suggestion from operators. It is however clear that the management is trying and that effort is being made. They have applied several JOS *tools and techniques* to different areas; though still fail to properly implement it, exemplified by team boards not being in use and 5S areas not being kept at the level set initially. This again indicates that both *the commitment to* and *knowledge of* continuous improvement is not adequate for the initiatives to work as intended. They have also started to strategically *plan the implementation.* The *goals for the implementation* have been linked to the *performance indicators*, which again are used as a means for *communicating improvement information* throughout the organisation. During GOIs stay there has been a *strong focus on the implementation goals*, this need to be continued when they leave through managers being hands on (walking the gemba) and being directly involved and engaged in the initiatives.

6.3 Case 3: Flixborough, England

In Flixborough there have been attempts to implement process improvement practices as far back as early 2000 (Aa and Anthonsen, 2011). However, these early attempts did not lead to any lasting changes in the organisation. It was not until a new management team was in place in

2007 that process improvement really was put on the agenda. While Aa and Anthonsen (2011) in their case study of Flixborough showed that substantial improvements in the period up to 2011 were achieved, the findings from this investigation indicate that these efforts have stagnated somewhat since that. This can be attributed to two main events over the last two years. First of all, they have had an increase in volume produced from 22 million in 2010 to 27 million in 2013 (expected). Secondly, one year ago they had a major spill accident in the factory which caught the attention of the legislative authorities. They have had several inspections in the aftermath of the spill and have had to make several investments in upgrades and new equipment to meet the new requirements enforced by the regulatory authorities. These two events have tied up a lot of the resources which previously were aimed at process improvement efforts. The effect of the decrease in *attention to and resources available for performing process improvements* is manifested in two areas. While they from 2007 to 2011 managed to reduce the number of shifts from three to two by increasing the efficiency of the production through improvement efforts, this is increased to three again in order to meet the increase in demand. Also, several of the improvement initiatives implemented prior to these two events suffers under the lack of *support and involvement from management,* something which has led to challenges with sustaining several of the implemented initiatives such as the mini business areas (MBA).

> *"The pressure to meet increasing demands makes us fall back to old and know methods." (Manager #3, Flixborough)*

The consequences of the spill are however now dealt with, and attentions again directed towards process improvements. One year ago a new continuous improvement manager with 12 years of experience with process improvement in the automobile industry was hired. He has, together with the rest of the management team, ambitious goals for the factory; among them reducing the shifts from three to two again and Flixborough becoming the "plant of choice" within Jotun. With "plant of choice" they aim at becoming the preferred plant in Jotun from which other subsidiaries visit for learning purposes and to get inspiration of how the operations in a Jotun factory could be conducted. They are however aware that they have a long way to go before they will reach this goal, and are humble about the task in front of them. In order to achieve this goal they are working on several improvements. First of all they are working on linking *the performance indicators* to the *goals for the implementation* initiatives, and to *strategically plan* which implementation projects to run. This again makes it easier to *communicate the improvement information* to the personnel. It also makes it easier for personnel to relate to why an improvement is being performed, and its connection to "the bigger picture". The management are however conscious of the fact that change is a process which takes time and that if they jump into it to quick people might back away and resists.

> *"We are trying to hurry slowly to become better." (Dave Cooper, Continuous Improvement Manager)*

Flixborough has also made changes to their operational goals. The current targets have been adapted to better fit the current performance level of the production. Rather than having goals which no one pays attention to or believes possible to reach, they instead focus on continuously improving within realistic boundaries. They stress the importance of the success criterion being easy to manage and easy for the operator to see and understand.

> *Before we had a RTF goal of 80%, but we never reached that goal. Now we are working with more realistic goals, and have initiatives going in order to meet this goal." (Dave Cooper, Continuous Improvement Manager)*

While it is clear that the continuous manager have a *strong focus on the implementation goals*, it is however not clear if this focus to the same extent is shared by the whole management team. They are on board, but there is still a way to go. At the moment it seems that the main focus still is directed to total volume and at meeting increasing demands, resulting in less *involvement from the management* in the improvement work. This is again reflected in lower awareness of and contributions to process improvement from operators. They are working on getting the shop floor personnel to understand that continuous improvement is essential for Flixborough improving their operations and for securing the plants future; this way creating a need for change. This work also includes changing the mentality towards process improvement and getting them to understand that it does not necessarily mean working harder, but smarter and more efficient. This is however a long and time consuming process, something which this statement reinforces:

> *"To change the mentality is like turning a ship. It is very slow in the beginning until you get the momentum going." (Mark Grainger, Shift Manager)*

The work of changing the mentality includes highlighting previous achievements and their impact on both the operators work life and on the overall performance of the plant, this way *communicating clearly* the benefits of performing process improvements. They do however not systematically use *recognition and rewards* as a tool for further encouraging participation in continuous improvement work. The general level of *involvement and empowerment*, which can be an effective tool for getting the operators "on board", can also be considered quite low.

When looking at how *training and education* is managed in Flixborough, there does not seem to be a systematic approach for educating and training management personnel in JOS philosophies and tools. There are options for training and education through JOA, but the execution of this is not systematically connected to the implementation of JOS. The operators have no formal

education in *continuous improvement tools*, but are trained by managers *being hands on* and working alongside them. This is the main method for how *tools and techniques* are applied in the factory and educated to the operators:

> *"They have the answers; we need to give them the tools." (Mark Grainger, Flixborough)*

As I have mentioned, several of the previous implemented initiatives in Flixborough were reduced from having a dynamic impact on how operations were conducted to a more insignificant role when the attention and commitment from management faded due to above mentioned reasons. Measures have however been taken to reverse this "set-back" and to improve further. Firstly, work has commenced to standardize operations; e.g. identifying the current best practices. When these standards have been incorporated at the work places, they aim to start to improve these standards. Ideally, employees will end up with two jobs; doing the job according to the standard and improving the standard:

> *"Standardised Work is the foundations to any manufacturing facility. Without it, you cannot improve on anything. We need to standardize the operations, and then we can start to improve that standard. Therefore we are currently working on identifying and clarifying the current best practices." (Dave Cooper, Continuous Improvement Manager)*

Secondly, they have identified a *pilot line* at which they will allocate substantial resources aiming to improve this production line significantly. The pilot line project serves three main purposes; (1) to see how well they can get one line up and running, (2) visually display how things can be done when the mind is set to it and (3) transfer the lessons from this project to other lines. These two initiatives are how Flixborough have chosen to prioritize and focus their available resources in order to maximize the impact of their continuous improvement work. The amount of *available resources* dedicated to continuous improvement could still favourably be higher; they have for example currently no dedicated continuous *improvement team*, only one manager. The continuous improvement manager does however work closely with the production manager and the four shift managers in his improvement work and progress is being made.

6.4 Summary of findings from the case studies

The degree of implementation varies between the three investigated subsidiaries of Jotun. So does the managers application of the most important CSFs defined from theory. Figure 10 summarizes the extent of which the different factors are present in the three cases, subject to the researcher's evaluation. The variations in the degree of JOS implementation and of the CSFs being used in the investigated subsidiaries and what they represent will be discussed in the next section.

Critical Success Factors for XPS implementation in the cases				
#	Critical Success Factor	Saudi	Vindal	Flixborough
1	Involvement from managers	3	1	2
2	Training and education	3	1	1
3	Application of appropriate tools and techniques	2	1	1
4	Employee involvement and empowerment	1	1	1
5	Recognition and rewards	1	1	1
6	Top management support and commitment	3	1	1
7	Performance indicators	3	2	2
8	Dedicated improvement leaders, teams and projects	3	1/3*	2
9	Allocate resources, time and technology	2	1	2
10	Strong focus on implementation goals	2	2	2
11	Strategic planning and goals for implementation	3	1	2
12	Be hands on/Genba	3	1	1
13	Clear communication of improvement information	3	1	2
	Total score	**32**	**15/18***	**20**

1 – low degree, 2 – average degree, 3 – high degree

*Without or with GOI

Figure 10 - CFSs for XPS implementation in the cases

7 Discussion of the empirical findings

In this section the empirical findings from both the survey and the case studies are discussed with respect to the research question and in light of the theory presented in chapter 2. Based on the discussion, several propositions are put forward. At the end, the discussion and the propositions put forward are shortly summarized.

7.1 Discussion of the CSFs for implementing an XPS

Based on a theoretical framework consisting of 13 CSFs, a set of three more comprehensive groups of factors for the implementation of an XPS was defined. Even though these factors are "bigger" than the CSFs from theory, the content of the three groups of factors reflects the CSFs described in theory, and are believed to better present the CSFs for the challenging task of managing a highly complex and integrative system such as an XPS. By putting forward several hypotheses these groups of CFS were suggested to have a positive and significant impact on both the degree of XPS implementation and plant performance. By evaluating the data from the survey through a PCA I found four components, from which three of them coincide quite well with the factors put forward for hypothesis testing.

7.1.1 Degree of XPS implementation

To facilitate the investigation of the three subsidiaries a set of questions, presented in section 1.1, was used. The first question dealt with *to what degree the XPS had been implemented by the investigated subsidiaries.* Before addressing this question, it should be made clear that the Jotun Group is relatively inexperienced with implementing and managing their XPS and that the degree of implementation of most of their subsidiaries can be placed in phase one (establishment) and phase two (reengineering) of Netland (2012) four phased lifecycle of an XPS. JOS as a term is subsequently not very well developed beyond the top management in Jotun's subsidiaries. The elements and philosophies of JOS have however been applied and integrated with the operations to a varying degree within the three cases, affecting both the degree of JOS implementation and the plant performance.

Of the three investigated subsidiaries Saudi is found to have the highest degree of XPS implementation. In general, the implementation of JOS elements is more deeply rooted in the Saudi organisation compared to Vindal and Flixborough. In Saudi continuous improvement initiatives are widespread and valued within the organisation. The employees are committed to the implementation of process improvement initiatives and the sustainment of initiatives is good. In Vindal and Flixborough, the implementations are not yet very widespread and the sustainment of the initiatives have been challenging. This is recognized by few adopters and limited knowledge of process improvement in the organisation resulting in a situation where sustaining the improvement initiatives is difficult.

7.1.2 Factors influencing the degree of XPS implementation

In order to understand why the degree of XPS implementation has varied between the investigated subsidiaries, it is necessary to address the two other questions used to facilitate the investigation of the three cases. These two questions concern w*hich CSFs has been present in the investigated subsidiaries* and *why the application of the CSFs has varied?*

The decision to develop and implement an XPS normally involves allocating substantial time and resources from within the company and is general a decision taken at the executive level. The extent of *top management commitment and support* needs however to go far beyond just deciding to develop and implement an XPS. This is emphasized as the most crucial factor when implementing process improvement systems by several authors in the literature (Porter and Parker, 1993, Yusof and Aspinwall, 1999, Manville et al., 2012) and is further strengthen by the verification of hypothesis H2a - More use of factors related to the commitment of management contribute positively to XPS implementation – and the findings from the investigated subsidiaries.

At the company-wide level, the degree of *commitment from management* can be viewed through the extent of which the *strategy and the goals for the implementation* is *linked and aligned to the overall business strategy and goals*. In Saudi, they are using process improvement as a means to reach their performance goals and experience a strong link between the overall goals and the goals for the implementation efforts. Linking these to each other have set a clear direction for the organisation, put process improvement on the agenda and have committed the organisation to the implementation initiatives. Failure to do so properly can lead to unfocused improvement efforts (Coronado and Antony, 2002), something which is visible in Vindal with improvement initiatives being treated as stand-alone activities or limited to the introduction of only certain tools or techniques. Changes have however recently been made to connect and align the performance goals with the goals for improvement efforts. In Flixborough there seems to have been a strong link between the overall goals and the goals for process improvement (Aa and Anthonsen, 2011), but this link have faded slowly as the commitment and focus from management has been drawn more and more towards handling increases in demand and the consequences of the spill accident. However, now that the spill has been "taken care of" and the demand has levelled out somewhat, several measures are being taken to again bring focus back to process improvement.

The commitment from management is also reflected in the amount of *resources allocated* to support and facilitate the implementation of an XPS. When implementing an XPS it is to be expected that most employees do not have the wanted level of knowledge and experience with the how's and what's of conducting process improvements. By allocating *resources and time* to *training and education* the general level of knowledge and experience with regards to

conducting process improvement will increase. The findings from the investigated subsidiaries do however suggest that this takes time and it therefore, especially in the initial stages of the implementation, can be beneficial to bring in e*xternal expertise* to select, execute and sustain the initiatives. In Saudi *the training and education* in continuous improvement through JOA initiated their process improvement "journey". They were however uncertain of how to put the newly acquired knowledge into use. This changed with the arrival of a new general manager whom both had the necessary knowledge of how to conduct process improvements and the commitment to carry them out. It seems that it was crucial that the *training and education was accompanied* by the arrival of a *process improvement expert* with a strong mandate to carry out process improvements. The presence of an expert, together with the prolonged commitment from management, has enabled Saudi to sustain the process improvement initiatives. They have also succeeded in *transferring knowledge* from this process improvement expert to the organisation. This has, combined with a continued and systematic training of the management and employees, resulted in process improvement being incorporated into the company culture and the organisation now having their own in-house continuous improvement expertise.

While the management in Vindal also have received much of the same training as the management in Saudi, much of their time and resources has been tied up with getting the operations processes of the new factory up and running. As a result, *process improvement has suffered under the lack of attention*, recognized by piecemeal adoption of tools and techniques and a lack of culture that supports improvement initiatives. This has changed somewhat since the arrival of a dedicated process improvement ex*pert and team* from GOI. Still, there seems to be little focus on *transferring* the knowledge and experience from the experts from GOI to personnel within the organisation. As a result they risk that no fundamental change in mind-set and commitment to the implementation is transferred to the company. This is supported by Mehra and Inman (1992) who found that when implementation consultants leave a company, the implementation initiatives tend to slowly die out.

In Flixborough, though not having a systematic approach to it, training and education are available for the management. They have also over an extended period of time had a dedicated continuous improvement manager whom can be regarded as a process improvement expert. It is apparent that resources have been allocated to facilitate continuous improvement, but is seems that the deviation of management's attention to other areas has left the process improvement initiatives to suffer. This suggests that while the allocation of resources may increase the ability of an organisation to carry out process improvement initiatives, it does not alone ensure a successful implementation. It will be vital that Flixborough experience a continued support and commitment from top management to continue to go through with the plans they have for the factory.

Variation in the *commitment from managers* seems to a great extent able to explain variations in the degree of implementation within the three cases. All three subsidiaries have initiated several improvement initiatives, but the impression is that only in Saudi has this been done wholeheartedly and with a long term commitment to improve performance. Here the *top management has acted as a driving force* for the change initiatives, and sustained them by managers *exercising a strong focus on the initiatives over time*. A similar strong commitment from management have not been correspondingly present in Flixborough and Vindal, and can be considered the main determinant for why Saudis degree of implementation is higher compared that of to Vindal and Flixborough. My first proposition goes thus as follows:

> **P1: A *prolonged commitment from management* is crucial for initiating and sustaining improvement efforts and ensuring the successful implementation of an XPS.**

The above discussion also suggests that *process improvement experts* play a vital role for the successful implementation of an XPS. In the PCA it was decided that even though Cronbach's alpha for component four, *deploying and developing process improvement experts*, was below the required level for reliability (< 0.55), the relevance of this component would be explored further in the case study. From the hypothesis test (H2c) it was found that more use of factors related to deploying and developing process improvement could significantly predict the degree of XPS implementation. The case study revealed that the introduction of a process improvement expert played a crucial role in Saudis JOS implementation. This was also the case for Vindal, where the arrival of improvement experts (GOI) has been vital for carrying out and sustaining larger improvement projects. My second proposition is therefore:

> **P2: *Developing and deploying process improvement experts*, especially in the initial phases of the implementation, are crucial for the successful XPS implementation.**

When working with implementing an XPS a lot of the CSFs relate to creating a culture where continuous improvement is incorporated in how the operations are conducted; it becomes the natural way to do things. Only when the mentality of the organisation is right will the employees actually start to identify and perform smaller or greater improvement suggestions and initiatives by themselves (Schneider et al., 1996). This process of changing the mentality can however be very challenging to both achieve and sustain. Of the investigated cases, it seems that Saudi is the one who have had the greatest success in doing so. This is one of the many reasons why Saudi seems to have the highest degree of XPS implementation of the investigated subsidiaries. Managers and employees resist change initiatives due to the lack of skills and knowledge about process improvement (Barker, 1998) and may arise as a result of *low commitment from management* and *insufficient allocation of resources to training and education*. Adequate

training of the philosophies of which the XPS is based upon, hereunder their appurtenant tools and reasons, can help overcome this resistance by increasing knowledge and enhancing motivation. Saudi has enabled to incorporate such an improvement culture over time based on management's abilities and through their prolonged commitment. This again makes it less challenging to continue their process improvement work, and has made them less dependent on outside expertise – something which is the basis for my third proposition:

> **P3: The ability to produce lasting changes in the organisation is highly dependent on *local manager's ability to lead the change processes*.**

When undertaking the task of implementing an XPS, the *practical management of the implementation* can have a significant effect on the success of such an implementation. This is supported by the findings from the survey data. The investigation of the three subsidiaries gives additional evidence to this and provides insight to why it is important.

As I have discussed above, the allocated resources should be directed to appropriate purposes; e.g. training and education and dedicated improvement leaders, teams and projects. The experts ensure that the implementation efforts are put to efficient use. The training and education provides *knowledge of the appropriate tools and techniques,* which again provides a foundation from which to base the selection of what tool to use for a given situation; hereunder comprehending its possibilities, limitations and appurtenant manner of operation.

During the implementation phase, the *practical management of the implementation* addresses the importance of *the involvement of managers* and having a *continuous and strong focus on the implementation goals.* As I have touched upon, the link between the overall performance goals and the goals for the implementation as well as the commitment from management varies between the investigated subsidiaries. This is also the case for the degree of involvement from managers. In Saudi the managers follow up the improvement initiatives closely and are hands on implementation efforts; e.g. walking the shop floor (gemba). This enables them to follow up the performance indicators closely, and ensure that a strong focus on the implementation goals is kept and that appropriate tools and techniques are applied. The use of performance indicators combined with a strong focus on performance goals also serve as an early warning system capable of signalling whether progress is being made or if there are problems that needs to be solved. In Flixborough management is also involved, but here that task is somewhat limited to the one continuous improvement manager. With his resources being spread this thin, it is challenging to ensure a strong focus and awareness throughout the organisation. But again, there appears to have been a shift back towards a stronger awareness of the importance of continuous improvements recently with more managers "getting on board". In Vindal there is evidence of implementation efforts having been made, but which now either is not functional or only partly

in use, e.g. 5S areas not at the initial level set. This indicates that although work on the initiatives has commenced, they have not been satisfactorily monitored; e.g. the required level of focus for sustaining the initiatives is not present. On the other hand, they have recently made several successful implementations which have been sustained for now, among other things, by the presence of GOI.

In general it appears that in systems with a high complexity such as an XPS the involvement from mangers and the strong focus on implementation goals plays a vital role for the outcome of the implementation of such a system. The *management of the improvement processes* should be exercised through continuously evaluating the improvement projects by managers who have the necessary competences within the field. Eckes (2000) showed that initiated improvement projects fail mainly due to poorly developed management skills, or the lack of these. The importance of managers being involved in the initiatives, having the necessary skill set needed to set and keep ground rules, apply appropriate evaluation indicators, determining roles and responsibilities and meeting the defined goals for the project is further supported by both the hypothesis test (H2b) and the findings from the case study and provides a basis for the fourth proposition:

> **P4: The continuous involvement from managers in *the practical management of the XPS implementation* is crucial for deploying an XPS and for incorporating a continuous improvement culture in the company**

While *knowledge exchange* is found as a factor in the PCA and deemed important in the literature, its importance is not reflected to the same extent in the investigated subsidiaries. Whether this is due to the fact that this is an area where the three plants could benefit from focusing more on, or if the factor rather is given a too high importance I cannot conclude. It is however clear that Saudi, which is the investigated subsidiary whom has the highest degree of implementation, could positively benefit from external input and benchmarking. While being among the frontier of the subsidiaries within Jotun when it comes to their degree of JOS implementation, they still have a lot of potential when compared to other industries such as the automobile industry. In order to identify the gap to other industries and realize their potential, exchange of knowledge with entities outside of Jotun could prove to be beneficial. It is therefore possible that this factor has higher relevance and becomes more important as factories become more mature and have a higher degree of implementation. My fifth proposition will thus be:

> **P5: Whatever the effects of *knowledge exchange* on XPS implementation are, there are in the initial phases of the implementation others factors that by far triumph this factor.**

While theory states that managers should actively use *recognition and rewards* to motivate the workforce and promote desired behaviour and results, this CSF is not found to be actively in use in neither of the investigated subsidiaries. It appears that the managers in all three cases could be better at giving recognition and "social reward" when suggestions and initiatives are put forward from operators, this way stimulating such conduct further and providing incentives for employees to carry out improvement initiatives. Rewards and recognitions could in addition be linked to the improvement *strategy and goals*, using this as means for focusing the improvement commitments in the desired direction. There seems also to be a low degree of *empowering and involving the employees* in the implementation in the three cases. Even though managers actively work towards a supportive change culture and encourage team work, there is little employee autonomy in decision making and no systematic approach for capturing improvement suggestions from employees. That is a task left solely for managers. While good results can be achieved without involving all employees in early phases of the implementation, the participant of all employees is crucial for the continued development of the XPS (Netland, 2012). Even though the three cases are found to have variations in the degree if XPS implementation, no corresponding variations is found in the degree of application for the two above factors; (1) recognitions and rewards and (2) the empowering and involvement of employees. All three subsidiaries have a low utilization of the two, and it seems as if they have a rather insignificant role in the in the initial stages of the XPS implementation.

7.1.3 Impact on plant performance

Even though the incentives for developing and deploying an XPS are to eventually increase the overall performance of the firm, it can during the implementation phase be hard to tell if the actual performance increase (if any) outweighs the resources invested in the implementation. In section four two hypotheses was tested, addressing whether the impact of the degree of XPS implementation (H1) and the use of CSFs (H3a-d) have any impact on plant performance. From the test of H1 the degree of implementation was found to contribute positively and significantly to plant performance. From the test of H3a-c the use of certain groups of CFSs was found to have a direct positive and significant contribution to plant performance. H3d also showed that there was a strong statistically significant difference in mean utilization of all factors between high and low performers. This confirms that the implementation of an XPS and the application of the CSFs have a direct positive impact on plant performance, and that even though it can be hard to detect at times the implementation does indeed statistically significant improve plant performance. The support of hypotheses H1 and H3a-d gives evidence to my sixth proposition:

> **P6: The implementation of an XPS has a direct and positive impact on plant performance, and utilization of the CSFs is directly associated with higher plant performance.**

7.2 Summary of discussion

Based on the discussion of the findings from the hypotheses test and the findings from the investigated subsidiaries, I have put forward six propositions. These are summarized in Table 7. Three of the components identified in the PCA are supported by both the hypotheses test and the findings from the investigated case study, providing a basis for P1, P2 and P4. The findings from the case study do also strongly suggest that organisations ability to create lasing change is dependent on *local management's ability to lead the change processes* (P3). This factor concerns, even though not explicitly mentioned as a CSF in the literature, the importance *management's abilities* and *the role of leadership* has when implementing XPSs. The importance of *knowledge exchange* was on the other hand not supported by the findings from the case study, even though it was found as a component in the PCA. This inconsistency can be explained by the fact that Jotun currently is at the starting line of their XPS implementation, and that it in the initial stages of XPS implementation are other factors that are far more important (P5). The implementation of an XPS and the utilization of the factors is also found to be associated with higher plant performance, confirming that implementing an XPS indeed have a direct positive impact on plant performance (P6).

Table 7 - The propositions summarized

		Supported by the findings from:	
	Propositions	Investigated subsidiaries	Analysis of survey data
P1	A *prolonged commitment from management* is crucial for initiating and sustaining improvement efforts and ensuring the successful implementation of an XPS.	✓	✓
P2	*Developing and deploying process improvement experts*, especially in the initial phases of the implementation, are crucial for the successful XPS implementation.	✓	✓
P3	The ability to produce lasting changes in the organisation is highly dependent on *local manager's ability to lead the change processes*.	✓	NA
P4	The continuous involvement from managers in *the practical management of the XPS implementation* is crucial for deploying an XPS and incorporating a continuous improvement culture in the company	✓	✓
P5	Whatever the effects *knowledge exchange* has on XPS implementation, there are in the initial phases of the implementation others factors that by far triumph this factor.	✓	NA
P6	The implementation of an XPS has a direct and positive impact on plant performance and the utilization of the CSFs is directly associated with higher plant performance.	NA	✓

8 Conclusions

This last section aims to answer the research question based on the empirical findings and the discussion of these.

RQ: What are the critical success factors for implementing an XPS?

As the study has illustrated, the implementation of an XPS is a complex task and its success is dependent on the application of several interrelated factors. This study identifies several critical success factors which significantly affect the implementation of an XPS. ***The role of leadership***, which concerns various areas, stands out as the most prominent determinant for the successful XPS implementation. The findings from the principal component analysis, the hypotheses tests and the investigated cases all strongly suggest that ***a prolonged commitment of management*** is critical for XPS success. Without a sufficient and prolonged commitment from the management, organisations fail to (1) sustain initiatives, (2) mandate the implementation as a key-objective in the long-term strategy, (3) incorporate an improvement culture and (4) allocate sufficient resources to the implementation.

The role of leadership also concerns managing the more practical how's and what's of carrying out an XPS implementation. Both the findings from the hypotheses test, the principal component analysis and the case studies give strong support to ***the practical management of the implementation*** being critical for a successful implementation of an XPS. This includes, but is not limited to, (1) directing the improvement efforts to appropriate purposes, (2) applying the appurtenant tools and techniques, (3) keeping a strong focus on the implementation goals and (4) monitoring the progress of the improvement initiatives closely through the use of performance indicators and the direct involvement from managers.

The discussion also shows that the ability to produce lasting changes in organisations is highly dependent on ***local manager's ability to lead the change processes***. In the early stages of implementation where organisations general level of knowledge and practical experience with running change processes are low, ***the deployment of process improvement experts*** is found to play an essential role for the successful implementation. The experts provides the organisation with highly coveted knowledge and experience and are in the initial phases vital for detecting, selecting and carrying out improvement initiatives. In addition, plants that manage to ***transfer the knowledge*** and experience of such an expert to the organisation and ***develop*** permanent in-house expertise are more successful in implementing the XPS, and more successful at building a firm foundation to base further continuous improvement work from.

While the application of these factors to some extent can predict the degree of XPS implementation singlehandedly, the benefits from the factors increase when more of the factors

are utilized simultaneously. The implementation of a process improvement system such as an XPS requires the adherence of all the critical factors in order to realize the full potential of the system. Based on the discussion of the findings from the principal component analysis, the hypotheses test and the investigation of the three subsidiaries six propositions have been put forward, these are reproduced in the table below:

P1	A *prolonged commitment from management* is crucial for initiating and sustaining improvement efforts and ensuring the successful implementation of an XPS.
P2	*Developing and deploying process improvement experts*, especially in the initial phases of the implementation, are crucial for the successful XPS implementation.
P3	The ability to produce lasting changes in the organisation is highly dependent on *local manager's ability to lead the change processes*.
P4	The continuous involvement from managers in *the practical management of the XPS implementation* is crucial for deploying an XPS and for incorporating a continuous improvement culture in the company
P5	Whatever the effects of *knowledge exchange* on XPS implementation are, there are in the initial phases of the implementation others factors that by far triumph this factor.
P6	The implementation of an XPS has a direct and positive impact on plant performance, and the utilization of the CSFs is directly associated with higher plant performance.

8.1 Implications for managers

Based on a principal component analysis and the investigation of three cases the range of critical success factors that currently exists within the literature have been synthesised into fewer, but more extensive groups of main factors providing managers with clear guidelines for where to focus their efforts and how to more economically employ their available resources. First of all, managers should recognize the monumental role they play for the successful implementation of an XPS and that their prolonged commitment to the implementation is necessary to sustain the initiatives and to achieve any change. The task of implementing an XPS is a complex execution which requires managers to ***exercise a strong commitment to the implementation*** and doing so ***over an extended period of time.*** Knowledge and practical experience must be acquired, and an improvement culture built before the long term benefits of implementing an XPS can be truly harvested. Managers must be able to align the implementation goals with the long term business strategy and goals and provide visible and clear incentives for performing such initiatives.

The findings also suggest that it is vital that managers actively engage in the work of implementing the XPS. The initiatives need to be detected and selected by managers with the adequate skills to do so. Furthermore, the progression of the initiatives needs to be closely monitored and corrective actions taken when deviations and challenges arise. The constant focus from managers, and the way this focus is exercised, is also vital for building an ***improvement culture*** and getting the organisation "on board" with the changes that are being performed. Managers should in other words be very conscious of the impact their ***involvement in the practical management of the XPS implementation*** has for its execution, and that its success is dependent on how and to what extent they are involved.

Managers should also be aware that while the allocation of resources may increase the ability of an organisation to carry out process improvement initiatives, it does not alone ensure a successful implementation. Managers need to be the *driving force behind the change initiatives* and *apply a strong focus over time* for lasting changes in the organisation to occur. The ability to produce lasting changes is dependent on management's capabilities to lead the change processes. Their theoretical understanding of how to implement an XPS needs to be accompanied by practical experience. This is something the ***deployment of process improvement experts*** can provide, especially in the initial stages of an implementation where managements own experience and knowledge of how to implement an XPS are low. The experts can then act as a "trigger" for commencing improvement initiatives, and guide the organisation through the XPS implementation. With the introduction of experts, managers should also focus on ***transferring*** this knowledge to the organisation and through this ***develop*** process improvement experts within the plant.

The study also confirms that *the application of the critical success factors* not only affects the degree of XPS implementation, but also has a *direct impact on plant performance*. Managers should realize that it is in their best interest to continuously work with implementing the XPS, and through this directly improve plant performance by applying the critical success factors. The *degree of XPS implementation* is also found to be directly positively correlated with *plant performance*, suggesting that plant performance increases as the degree of XPS implementation increases.

8.2 Suggestions for future research

I have put forward several propositions addressing factors that significantly affect the implementation of an XPS. The data from which these propositions are derived from are however limited to survey data from only one company, and from a limited number of cases. Future research is therefore encouraged to conduct similar research where survey data and cases from several companies are evaluated, this way testing the robustness and generalizability of the identified factors and the propositions put forward. This includes evaluating the propositions

with data from companies with higher level of XPS implementation, and this way investigate if there are differences in the utilization of the critical success factors in different stages of an XPS implementation. More efforts should also be directed at testing the propositions which addresses the impact on plant performance, preferably with real plant performance data and not perceptual answers from a few respondents in each plant which has been the case for this study.

References

AA, O. A. & ANTHONSEN, H. S. 2011. *Management of best practices in mutinational companies - A comparative case study concerning implementation of operations best practices in two subsidiaries of the Jotun Group.* MSc Diploma, Norwegian University of Science and Technology.

ACHANGA, P., SHEHAB, E., ROY, R. & NELDER, G. 2006. Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management,* 17**,** 460-471.

AHIRE, S. L., GOLHAR, D. Y. & WALLER, M. A. 1996. Development and validation of TQM implementation constructs. *Decision Sciences,* 27**,** 23-23.

AL-KHALIFA, K. & ASPINWALL, E. 2008. Critical success factors of TQM: a UK study. *International Journal of Productivity and Quality Management,* 3**,** 430-443.

ANTONY, J. & BANUELAS, R. 2002. Key ingredients for the effective implementation of Six Sigma program. *Measuring Business Excellence,* 6**,** 20-27.

BARKEMA, H. G. & VERMEULEN, F. 1997. What differences in the cultural backgrounds of partners are detrimental for international joint ventures? *Journal of international business studies***,** 845-864.

BARKER, B. 1998. The identification of factors affecting change towards best practice in manufacturing organisations. *Management Decision,* 36**,** 549-556.

BLACK, S. A. & PORTER, L. J. 1996. Identification of the critical factors of TQM. *Decision Sciences,* 27**,** 1-17.

BOYNTON, A. & ZMUD, R. 1984. An assessment of critical success factors. *Sloan Management Review (pre-1986),* 25**,** 17-27.

BRUN, A. 2011. Critical success factors of Six Sigma implementations in Italian companies. *International Journal of Production Economics,* 131**,** 158-164.

BRYMAN, A. & BELL, E. 2011. *Business research methods*, Oxford University Press, USA.

CHIARINI, A. 2011. Japanese total quality control, TQM, Deming's system of profound knowledge, BPR, Lean and Six Sigma. *International Journal of Lean Six Sigma,* 2**,** 332-355.

CLAVER, E., TARÍ, J. J. & MOLINA, J. F. 2003. Critical factors and results of quality management: An empirical study. *Total Quality Management & Business Excellence,* 14**,** 91-118.

COHEN, J. 1988. *Statistical power analysis for the behavioral sciences*, Routledge Academic.

CORONADO, R. & ANTONY, J. 2002. Critical success factors for the successful implementation of six sigma projects in organisations. *The TQM Journal,* 14**,** 92 - 99.

CROSBY, P. B. 1979. *Quality is Free,* New York, NY, McGraw-Hill.

CUA, K. O., MCKONE, K. E. & SCHROEDER, R. G. 2001. Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of Operations Management,* 19**,** 675-694.

DAHLGAARD, J. J. & DAHLGAARD-PARK, S. M. 2006. Lean production, six sigma quality, TQM and company culture. *The TQM Magazine,* 18**,** 263-281.

DEMING, W. E. (ed.) 1982. *Quality, Productivity and Competitive Position,* Cambridge, MA: MIT Centre for Advanced Engineering Study.

ECKES, G. 2000. General Electric‘s Six Sigma Revolution. Wiley and Sons, NY.

EIDE, T. L. H. 2012. *Critical success factors for managing company-specific production systems.* MSc Pre-diploma study, Norwegian University of Science and Technology.

FEIGENBAUM, A. V. 1983. *Total Quality Control,* New York, NY, McGraw-Hill.

HENDERSON, K. M. & EVANS, J. R. 2000. Successful implementation of six sigma: benchmarking General Electric Company. *Benchmarking: An International Journal,* 7**,** 260-282.

HOLWEG, M. 2007. The genealogy of lean production. *Journal of Operations Management,* 25**,** 420-437.

HUARNG, F., HORNG, C. & CHEN, C. 1999. A study of ISO 9000 process, motivation and performance. *Total Quality Management,* 10**,** 1009-1025.

ISHIKAWA, K. 1972. *Guide to Quality Control,* Tokyo, Asian Productivity Organisation.

JOHANNSEN, F. State of the art concerning the integration of methods and techniques in quality management - literature review and an agenda for research. European Conference on Information Systems (ECIS) 2011 Proceedings, 2011 University of Regensburg, Regensburg.

JOTUN. 2009. Jotun inaugurates new state-of-the-art paint factory in Yanbu, Saudi Arabia.

JOTUN. 2012. *Annual Report 2011* [Online]. www.jotun.no: Jotun Group.

KAISER, H. F. 1960. The application of electronic computers to factor analysis. *Educational and psychological measurement*.

KARUPPUSAMI, G. & GANDHINATHAN, R. 2006. Pareto analysis of critical success factors of total quality management: A literature review and analysis. *TQM Magazine,* 18**,** 372-385.

KLINE, J. 2000. An Easy Guide to Factor Analysis. Routledge, London.

LIKERT, R. 1967. THE HUMAN ORGANIZATION; ITS MANAGEMENT AND VALUE.

MANVILLE, G., GREATBANKS, R., KRISHNASAMY, R. & PARKER, D. W. 2012. Critical success factors for Lean Six Sigma programmes: a view from middle management. *International Journal of Quality & Reliability Management,* 29**,** 7-20.

MEHRA, S. & INMAN, R. A. 1992. Determining the Critical Elements of Just-in-Time Implementation. *Decision Sciences,* 23**,** 160-160.

MOTWANI, J. 2001. Critical factors and performance measures of TQM. *TQM Magazine,* 13**,** 292-300.

NETLAND, T. 2013. Exploring the phenomenon of company-specific production systems: one-best-way or own-best-way? *International Journal of Production Research***,** 1-14.

NETLAND, T. H. 2012. Managing strategic improvement programs: the XPS program management framework. *Journal of Project, Program and Portfolio Management***,** 31-44.

NORDIN, N., DEROS, B. M., WAHAB, D. A. & RAHMAN, M. N. A. 2012. A framework for organisational change management in lean manufacturing implementation. *International Journal of Services and Operations Management,* 12**,** 101-117.

NUNNALLY, J. 1978. C.(1978). Psychometric theory. New York: McGraw-Hill.

NÄSLUND, D. 2008. Lean, six sigma and lean sigma: Fads or real process improvement methods? *Business Process Management Journal,* 14**,** 269-287.

PEPPER, M. P. J. & SPEDDING, T. A. 2010. The evolution of lean Six Sigma. *The International Journal of Quality & Reliability Management,* 27**,** 138-155.

PORTER, L. J. & PARKER, A. J. 1993. Total quality management—the critical success factors. *Total Quality Management,* 4**,** 13-22.

RICONDO, I. & VILES, E. 2005. Six Sigma and its link to TQM, BPR, lean and the learning organisation. *International Journal of Six Sigma and Competitive Advantage,* 1**,** 323-354.

SARAPH, J. V., BENSON, P. G. & SCHROEDER, R. G. 1989. An Instrument For Measuring The Critical Factors Of Quality Management. *Decision Sciences,* 20**,** 810-810.

SCHERRER-RATHJE, M., BOYLE, T. A. & DEFLORIN, P. 2009. Lean, take two! Reflections from the second attempt at lean implementation. *Business Horizons,* 52**,** 79-88.

SCHNEIDER, B., BRIEF, A. P. & GUZZO, R. A. 1996. Creating a climate and culture for sustainable organizational change. *Organizational Dynamics,* 24**,** 7-19.

SCHONBERGER, R. J. 2007. Japanese production management: An evolution—With mixed success. *Journal of Operations Management,* 25**,** 403-419.

SILA, I. & EBRAHIMPOUR, M. 2003. Examination and comparison of the critical factors of total quality management (TQM) across countries. *International Journal of Production Research,* 41**,** 235-268.

SNEE, R. D. 1999. Impact of Six Sigma: today and in the future. *1999 ASA Quality and Productivity Research Conference.* Schenectady, NY.

SPRAGUE, L. G. 2007. Evolution of the field of operations management. *Journal of Operations Management,* 25**,** 219-238.

VAN DE VEN, A. H. & FERRY, D. L. 1980. *Measuring and assessing organizations*, Wiley New York.

VOSS, C., TSIKRIKTSIS, N. & FROHLICH, M. 2002. Case research in operations management. *International journal of operations & production management,* 22**,** 195-219.

WOLD, S., ESBENSEN, K. & GELADI, P. 1987. Principal component analysis. *Chemometrics and Intelligent Laboratory Systems,* 2**,** 37-52.

WOMACK, J., JONES, D. T. & ROOS, D. 1990. *The Machine that Changed the World,* New York, NY, Rawson Associates.

YIN, R. K. 2008. *Case study research: Design and methods*, Sage Publications, Incorporated.

YUSOF, S. R. M. & ASPINWALL, E. 1999. Critical success factors for total quality management implementation in small and medium enterprises. *Total Quality Management,* 10**,** 803-809.

APPENDIX A: Case study protocol

The purpose of this protocol is to guide the inquiries of the researchers during field investigations. First, a short introduction of the study is given, followed by the theoretical framework that is developed for the study. Then a general overview of the data collection procedures is provided before an outline of the case study report is given. Finally, an interview guide is described, including questions for structuring the conducted interviews.

1. Introduction to the case study

This study is conducted as the concluding part of a master degree in Industrial Economics and Technology Management. The work is conducted over the course of one semester, and the findings will be presented in a diploma paper. The study is performed on the behalf of, and in collaboration with, Jotun. The aim of this study is to contribute/increase knowledge of how to manage company-specific production systems (XPS). More specifically the study will focus on which managerial actions facilitate the successful implementation of such a system. There has been an increasing trend for companies within manufacturing industries to develop and deploy companywide improvement programmes such as XPS's. Even though there are a range of studies identifying the critical success factors (CSF) within each management system (lean, TQM, six sigma) which XPS's are built upon, few have looked at the CSFs of these systems simultaneously and with a holistic approach. This have resulted in different perceptions on how to best implement XPS's and unanswered questions related to what managers should do to enhance and facilitate the implementation of an XPS in a best possible way. The empirical data will be gathered through access to survey data within the case company and interviews and direct observations within 3 investigated subsidiaries. Based on existing theories within the field a set of hypothesis are proposed, and evaluated based on the findings from the survey. To further strengthen the results, a case study is performed on four subsidiaries within Jotun Group. The findings from the survey and the investigation of the subsidiaries are used to test the hypothesis and identify critical success factors for managing XPS's. Suggestions for how Jotun Group should efficiently manage the implementation of Jotun Production System will be developed. The following research question is proposed:

RQ: What are the critical success factors for implementing an XPS?

2. Theoretical framework for the case study

The CSFs explained

Generally speaking these CSFs concerns factors that *enables* and *motivates* employees at all levels to successfully implement the process improvement initiatives in question. *Training and education* facilitates the correct understanding of the concepts and purpose of the philosophies behind the process improvement system. *Recognition and rewards* concerns *resource-based (rewards)* and *management-based (recognition)* actions that should be put into effect to motivate the workforce and promote desired behaviour and results. *Employee involvement and empowerment* deals with the degree to which teams are used, the extent of employee autonomy in decision making, the extent of employee interaction with customers, and the extent to which employee suggestions are taken into consideration.

Furthermore the CSFs consider to which extent the improvement initiatives are aligned with the *business strategy and goals*, and the *degree of commitment* from the organisation as a whole - visible by the dedication from top management and the amount of resources allocated. *Top management support and commitment* is by all the three systems considered to be of vital importance when implementing process improvement systems. *Strategic planning and goal for the implementation* emphasises that the strategy and goals for process improvement should be linked to and aligned with the overall business strategy and goals. *Allocation of sufficient resources* deals with the level of commitment from the organisation to the improvement programme, and is measured on three main parameters (time, expertise, financial).

The CSFs also address the more practical factors needing *continuous focus and monitoring*, and the *key elements, tools and techniques* that should support and facilitate the implementation and permeate the mentality of the organisation. *Involvement from managers* is considered vital when implementing strategic improvement programmes. By having a *focus on the implementation goals* when managing the improvement projects the implementation initiatives are linked to the overall strategy. This should be further supported by managers *being hands on (gemba)* and using *performance indicators* for progress tracking purposes. The *application of appropriate tools and techniques* concerns the ability to choose the right tool for the right situation; hereunder comprehending its possibilities, limitations and appurtenant manner of operation. *Clear communication of improvement information* emphasizes the importance of providing *sufficient* information, and doing so in a *clear* and *consistent* manner. *Dedicated improvement leaders, teams and projects* refer to the importance of focusing implementation efforts and expertise.

3. Data collection procedures

The following section describes the sites to be visited, including contact persons, the types of data to be collected, and the expected prior preparations.

Names of sites to be visited, including contact persons		
Jeddah & Yanbu, Saudi-Arabia	**Flixborough, United Kingdom**	**Vindal, Norway**
Jotun Saudia Co Ltd Visiting date: 13-18.04.2013 Munir Khan CI Manager munir.khan@jotun.com Mobile: +966 569552719 Dave Wright Managing Director Mobile: +966 500 104987 dave.wright@jotun.com	Jotun Paints (Europe) Ltd Visiting date: 02.05.2013 Ben Parsley Head of Operations ben.parsley@jotun.co.uk Mobile: +44 7917 007 685	Jotun A/S Visiting date: 24.04.2013 Robin Arvidsson GOI Project Manager robin.arvidsson@jotun.no

Data collection plan and expected prior preparations

During the visit at the site, the following types of data are expected to be collected:

a. Minimum 3-5 interviews with people with different roles in the factory: one with a change agent, one with a production manager, one with a line manager, one with a cell/team leader.
b. Observation of the paint production. These observations should be supported by unstructured interviews/conversations with operators in the production.
c. Other documentation that will increase our understanding of the conditions at, or history of, the visited factory.

Prior to the field investigations, the researcher is expected to:

a. Establish contact with the contact person at the site to be visited.
b. Send interview questions to the designated contact person so that interview objects can make necessary preparations.
c. Become familiar with the purpose of the study, the proposed research questions, the established theoretical foundation, and the described interview questions.

4. General outline of case study report

1. Introduction
2. Theoretical background
3. Methodology
4. Testing of hypotheses
5. Description of Jotun and Jotun Operations System and the investigated subsidiaries
6. Empirical findings from the investigated subsidiaries
7. Discussion of empirical findings
8. Conclusion

5. Interview guide

The interview should take a semi-structured form encouraging the interviewee to speak freely. However, the discussion should at least touch upon the topics proposed below. A summary of the interview will be written.

1. Introduction

The first 5-10 minutes will be used for a brief introduction to the study, and to make sure key data on the interviewee are collected

2. Structure of the interview

a. Introduction of the study
b. Collection of interviewee data
c. Topics for discussion
    i. The impact of Jotun Operations System
    ii. Actions taken by management to implement JOS
    iii. Perceptions about Jotun Operations System
d. Further progression
e. Contact information

3. Interviewee data

a. Name
b. E-mail address
c. Position
d. Education
e. Years in Jotun
f. Any other important information

4. The impact of Jotun Operations System

The following questions are concerned with the impact of Jotun Operations System. All interviewees will be asked to elaborate on them, but we do not expect all to be able to answer all of the questions in detail.

Effects of Jotun Operations System

a. Can you give a general description of your factory's participation in Jotun Operations System (JOS)?
b. Which impact has JOS had on the factory? Has JOS led to changes in practices? Any improvements in performance outcomes?
c. If you have experienced any results after participation in JOS, how long did it take before you saw the first results?
d. To what degree would you say that the operations of the factory are in line with JOS today?

The implementation process

e. Can you describe, in as much detail as possible, how the implementation of JOS has been conducted? What was done to implement the teachings of JOS? What were the results?
f. What have, in your opinion, been the major managerial factors in this process?
g. How did the workers respond to the new initiatives? Why do you think they reacted in this way?
h. How is the implementation supported by managers/management?
i. In your experience, has it been communicated clearly *why* the new practices/JOS should be implemented, and *how* this will impact performance outcomes?

5. Actions taken by management to implement JOS in the plant

The following questions are concerned with the actions taken by management to implement JOS in the plant.

a. Education and training

i. How and to what extent (if any) have the workforce been educated and trained in JOS and its elements? How would you describe the educational level of the workforce in this unit?
ii. Have all positions in operations a clear competence profile?
iii. To what degree were the workers and managers familiar with (heard of, knowledge about) the practices that were communicated through JOS?

b. Recognition and rewards

i. What are your incentives to comply with/implement JOS?
ii. Are workers on different levels rewarded for taking the new practices into use?
iii. Has headquarters controlled or measured the degree of implementation of practices/compliance with JOS?

c. Employee involvement and empowerment?

i. How are the employees involved in the improvement initiatives?

d. Plan and goals for implementation

i. Is there a structured way to prioritize and secure that improvements are aligned with business objectives?

e. Top management support and commitment

ii. Do the GM and/or Operation Manager take an active role in initiating and supporting improvement work?
iii. Is there a visible management support for systematic and continuous improvement efforts?

f. Allocation of resources

iv. Are resources (time, people and funds) allocated for doing competence development? For performing improvement initiatives?

g. Involvement from management/being hands on/gemba

i. Is there a visible management support for systematic and continuous improvement efforts?
ii. Is management allocating it's time for doing improvement work?
iii. Are improvements on the agenda of regular meetings in operations?

h. Focus on implementation goals

i. Is the implementation of JOS linked to overall goals for the plant? Management-by-objectives?

i. Application of appropriate tools and techniques

iv. Is there a procedure for carrying out daily "small types of improvement" (Speedy Kaizen)?

j. Performance indicators

v. Is the effect of improvements carried out, measured and registered? Is so, how?
vi. How is the success of the improvement projects/initiatives evaluated??

k. Communication of improvement information

vii. Is continuous improvement work visible and alive in the organisation (on boards, walls, in offices, meeting rooms etc.)?

l. Dedicated improvement personnel (leaders, teams or projects)

viii. Is improvement work and methodology depended on specific persons, or is it anchored in the culture?
ix. Are personnel from cross functional departments (also outside operations) involved in the improvement work?
x. Is it defined which person(s) is responsible for initiating improvement work?

6. Perceptions about Jotun Operations System

a. What are your opinions about the usefulness of JOS?
b. What are your opinions about the way that JOS is or was implemented?
c. Do you have any suggestions for improvement?

Thomas Laurentius Haaskjold Eide
The Norwegian University of Science and Technology
Mail: Thomas@eide.biz
Phone: +47 920 96 750

APPENDIX B: Survey

Washington DC, March 2012

The JOS and Managerial Actions Survey

Introduction

This survey is designed to find which set of specific managerial actions affect the successful implementation of the Jotun Operations System (JOS). The survey is administered in all Jotun Group's factories worldwide, as well as in other multinational corporations (MNCs). ***It will take you about 30 minutes to fill out the survey***.

We encourage you to fill out the survey online at [link soon available].

All responses will be treated as strictly confidential and made anonymous in all reports. We ask for your name and e-mail only to verify validity of responses and to send you a summary report. No one inside or outside the Jotun Group will be able to see individual responses. This research has been registered at the Data Protection Official at the Norwegian Social Science Data Services (NSD). Participation is voluntary.

Background

This research has spun out of Torbjørn Netland's long-lasting cooperation with the Volvo Group. We want to add more MNCs to the study, and the Jotun Group is one of the first companies to be added. The results will constitute a major part of Netland's PhD dissertation at the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. The survey has been developed in cooperation with Professor Kasra Ferdows at Georgetown University, Washington D.C, USA, and pre-tested in several Volvo plants worldwide.

It is a research project supported, but *not funded*, by Jotun's Group Operations Improvement. In addition to receiving interesting research-based knowledge about its own operations, Jotun will receive benchmarking results with other leading MNCs as a result of this research. We gratefully acknowledge financial support from NTNU and the SFI Norman research project at SINTEF (Trondheim, Norway).

Contact information

Torbjørn H. Netland
Fulbright Visiting Research Fellow, Georgetown University, McDonough School of Business
37 and O Street NW, Washington DC 20057, USA
[PhD Candidate, NTNU, Trondheim, Norway]
Telephone: +47 982 45 169
E-mail: torbjorn.netland@sintef.no

NTNU – Trondheim Norwegian University of Science and Technology
Georgetown University McDonough School of Business
JOTUN

The Jotun Operations System and Managerial Actions Survey

NTNU Georgetown University McDonough School of Business JOTUN

Part I) Respondent and plant data

1	Your name			Date			
2	E-mail address						
3;4	Your position			Total years in Jotun or plant			
5	Business area						
		Fully owned	Majority owner	Minority owner			*Don't know*
6	Jotun ownership of your plant	○	○	○			○
		City				Country	
7;8	Plant location						
		Today				Two years ago	
9;10	Number of employees (approx.) (leave blank if you don't know)						
		Yes in majority	Yes in minority	No			*Don't know*
11	Operators are represented by a union	○	○	○			○
		<1950	50-70s	80-90s	2000s		*Don't know*
12	Plant age (start-up year)	○	○	○	○		○

13 Over the last two years, how has the performance of this plant changed along the following measures?
(Note that we only want to know the *degree of change* - not how well the plant performs in these measures)

		Significantly declined	Somewhat declined	No change	Somewhat improved	Significantly improved	*Don't know*
.1	On-time delivery to customers	○	○	○	○	○	○
.2	Throughput time (production lead-time)	○	○	○	○	○	○
.3	Inventory turns in factory	○	○	○	○	○	○
.4	Productivity of machines and labour	○	○	○	○	○	○
.5	Percentage of first-time-through good quality products	○	○	○	○	○	○
.6	Customer satisfaction	○	○	○	○	○	○
.7	Employee satisfaction	○	○	○	○	○	○
.8	Safety records	○	○	○	○	○	○
.9	Environmental performance	○	○	○	○	○	○
.10	Plant's overall financial performance	○	○	○	○	○	○
.11	General market climate evolvement for this plant	○	○	○	○	○	○

		Not implemented at all / just started	Basics implemented in some areas	Somewhat implemented in several areas	Much implemented in all areas	Fully implemented in all areas	*Don't know*
14;15	To what extent is the JOS implemented in your plant?						
	Today	○	○	○	○	○	○
	Two years ago	○	○	○	○	○	○

					Don't know
16;17	Other program name used for JOS implementation in this plant (if any)*		Start year		○
Info	*Note: In the remainder of this survey the term "JOS" also refers to this program.				

The Jotun Operations System and Managerial Actions Survey

NTNU Georgetown University McDonough School of Business JOTUN

Part II) Actions taken by management to implement JOS in the plant

Please rate the degree that each of these actions takes place today and took place two years ago in your plant.
We ask you to rate the existence of actions at two points of time because we are interested in change over time.
If you are not sure about the answer, please give your best estimate.

	Use of action control mechanisms		Never	Rarely	Occasionally	Frequently	Very frequently
18	External consultants are hired on to help implement JOS in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
19	Managers from other Jotun plants are employed in this plant for extended periods to help implement JOS	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
20	Top-management in this plant is actively and hands-on involved in the JOS improvement activities at shop-floor	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
21	Top-management has explicitly mandated the implementation of JOS as a key objective in this plant's long-term strategy	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
22	Sufficient investments are allocated to the JOS implementation in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
23	The plant has an organised team of dedicated employees who lead and support the implementation of JOS	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
24	Shop-floor JOS-teams are established to implement JOS in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
25	Decisions on JOS implementation are regularly taken through an established hierarchical and linked meeting structure in the plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
26	Documents providing guidelines for implementation of JOS are regularly issued to shop-floor	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○

	Use of result control mechanisms		Never	Rarely	Occasionally	Frequently	Very frequently
27	JOS performance charts with performance indicators are regularly posted at the shop-floor areas	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
28	Top-management routinely asks for performance reports of the JOS implementation progress	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
29	Top-management makes periodic visits to shop-floor to personally follow-up JOS implementation in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
30	Internal JOS audits are regularly undertaken to follow up JOS implementation in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
31	This plant's JOS performance is routinely benchmarked and compared with other plant's JOS performance	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
32	Personnel and teams are regularly rewarded with praise or non-financial benefits based on operational improvement tied to JOS implementation in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
33	Managers are regularly rewarded with financial remuneration based on operational improvement tied to JOS implementation in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
34	Jotun HQ tends to make more investment resources available for the plant if suggested projects show explicit relationship to JOS	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○

The Jotun Operations System and Managerial Actions Survey

	Use of social control mechanisms		Never	Rarely	Occasionally	Frequently	Very frequently
35	This plant holds formal training in JOS for its shop-floor personnel	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
36	This plant holds formal training in JOS for its top-management	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
37	Personnel regularly meet to discuss JOS implementation in this plant	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
38	Personnel from this plant regularly make short-term visits to other plants for benchmarking and learning related to JOS	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
39	Personnel from other plants regularly make short-term visits to this plant to share their experience with JOS implementation	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
40	Managers regularly speak about JOS to employees (thus employees hear much about JOS in this plant)	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
41	Managers regularly write about JOS in Intranet pages, magazines, flyers and similar internal marketing efforts	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○
42	General JOS information is displayed at the shop-floor in this plant (thus logos, principles, best practices, news, etc. are clearly visible in this plant)	Today	○	○	○	○	○
		Two years ago	○	○	○	○	○

Part III) Effect of JOS on plant performance

43 **In your opinion, how has JOS affected the following measures in the last two years?**

		JOS has had a...					
		significantly negative impact	somewhat negative impact	neither negative nor positive impact	somewhat positive impact	significantly positive impact	*Don't know*
.1	On-time delivery to customers	○	○	○	○	○	○
.2	Throughput time (production lead-time)	○	○	○	○	○	○
.3	Inventory turns in factory	○	○	○	○	○	○
.4	Productivity of machines and labour	○	○	○	○	○	○
.5	Percentage of first-time-through good quality products	○	○	○	○	○	○
.6	Customer satisfaction	○	○	○	○	○	○
.7	Employee satisfaction	○	○	○	○	○	○
.8	Safety records	○	○	○	○	○	○
.9	Environmental performance	○	○	○	○	○	○

The Jotun Operations System and Managerial Actions Survey

NTNU Georgetown University McDonough School of Business JOTUN

Part IV) Optional closing remarks

In your opinion and experience, what are the three most important direct actions managers can take to improve JOS implementation?

44	1)
45	2)
46	3)

		Yes	No	
47	If you could go back in time, would you recommend implementing JOS in this plant?	○	○	Please briefly explain the main reason(s) behind your answer:
48				

49 **In your opinion and experience, in which areas has the JOS been most effective and least effective?**

50 **Do you have any other comments or suggestions abouth the JOS in general?**

END OF SURVEY

Thank you for your participation!

You are welcome to contact Torbjørn Netland at torbjorn.netland@sintef.no for any questions regarding the survey.

APPENDIX C: Reliability analysis of the PCA

Reliability analysis

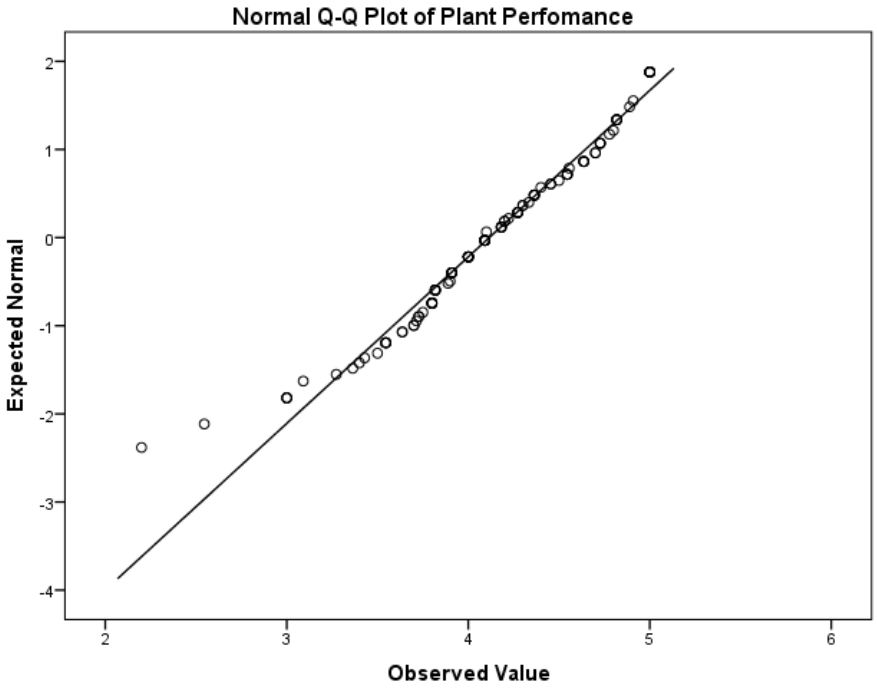
Component	No. of items		Items	Alpha after eliminating item
1	7	21	Top-management has explicitly mandated the implementation of JOS as a key objective in this plant's long-term strategy	0,912
Alpha = 0,925		20	Top-management in this plant is actively and hands-on involved in the JOS improvement activities at shop-floor	0,921
		22	Sufficient investments are allocated to the JOS implementation in this plant	0,913
		29	Top-management makes periodic visits to shop-floor to personally follow-up JOS implementation in this plant	0,906
		28	Top-management routinely asks for performance reports of the JOS implementation progress	0,911
		40	Managers regularly speak about JOS to employees (thus employees hear much about JOS in this plant)	0,915
		37	Personnel regularly meet to discuss JOS implementation in this plant	0,915
2	3	38	Personnel from this plant regularly make short-term visits to other plants for benchmarking and learning related to JOS	0,636
Alpha = 0,738		39	Personnel from other plants regularly make short-term visits to this plant to share their experience with JOS implementation	0,600
		41	Managers regularly write about JOS in Intranet pages, magazines, flyers and similar internal marketing efforts	0,677
3	9	42	General JOS information is displayed at the shop-floor in this plant (thus logos, principles, best practices, news, etc. are clearly visible in this plant)	0,927
Alpha = 0,932		27	JOS performance charts with performance indicators are regularly posted at the shop-floor areas	0,924
		26	Documents providing guidelines for implementation of JOS are regularly issued to shop-floor	0,923
		24	Shop-floor JOS-teams are established to implement JOS in this plant	0,924
		32	Personnel and teams are regularly rewarded with praise or non-financial benefits based on operational improvement tied to JOS implementation in this plant	0,928
		30	Internal JOS audits are regularly undertaken to follow up JOS implementation in this plant	0,921
		23	The plant has an organised team of dedicated employees who lead and support the implementation of JOS	0,926
		25	Decisions on JOS implementation are regularly taken through an established hierarchical and linked meeting structure in the plant	0,921
		35	This plant holds formal training in JOS for its shop-floor personnel	0,926

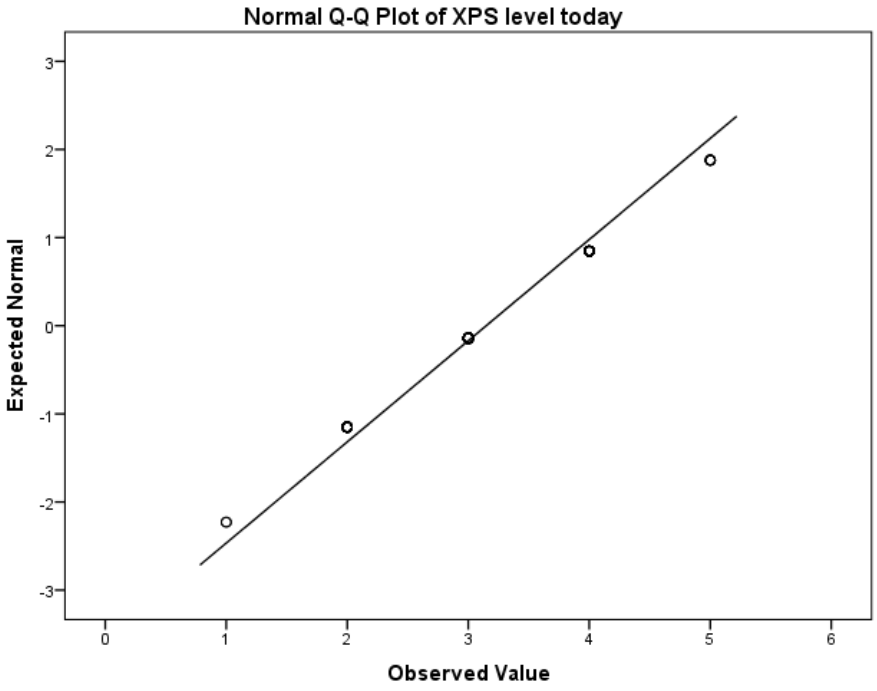
APPENDIX D: Correlation matrix of the PCA

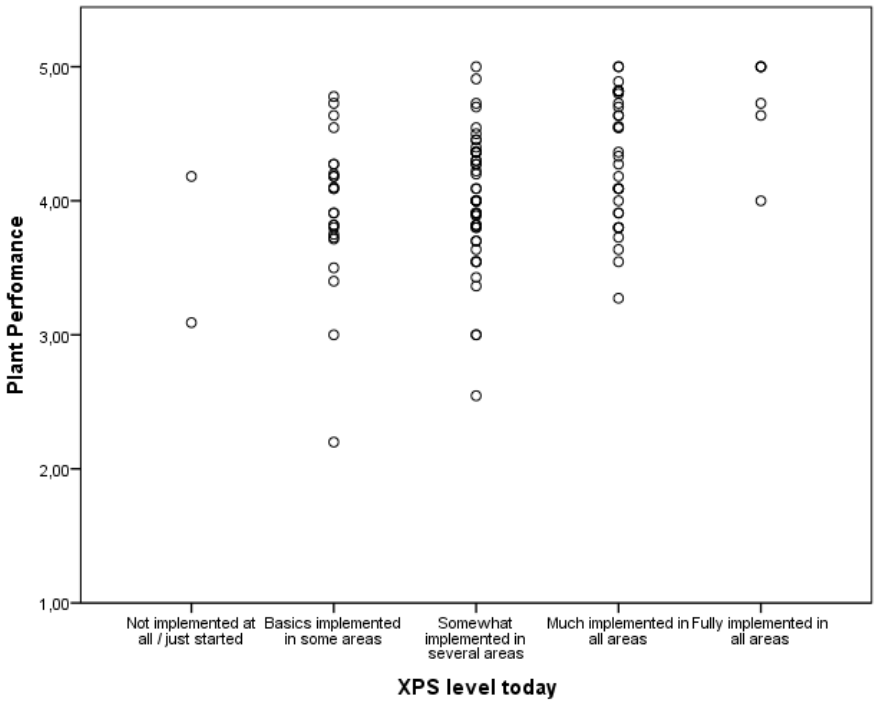
Correlation Matrix		Component			
	Item	1	2	3	4
Component 1	20	,808	,209	,495	-,029
	21	,874	,093	,564	-,222
	22	,854	,173	,550	-,310
	28	,796	,328	,709	-,258
	29	,883	,324	,641	-,227
	37	,751	,094	,734	-,505
	40	,746	,125	,685	-,414
Component 2	38	,499	,700	,515	-,311
	39	,557	,695	,541	-,376
	41	,456	,504	,383	-,484
Component 3	27	,558	,291	,831	-,134
	30	,712	,341	,813	-,348
	26	,555	,150	,801	-,411
	25	,773	,081	,787	-,390
	42	,458	,163	,781	-,126
	24	,585	-,123	,764	-,361
	32	,588	,338	,750	,095
	35	,678	,222	,715	-,310
	23	,639	,012	,714	-,333
	31	,475	,285	,693	-,328
Component 4	18	,111	,424	,131	-,753
	36	,540	,182	,486	-,626

APPENDIX E: Plots from hypotheses tests

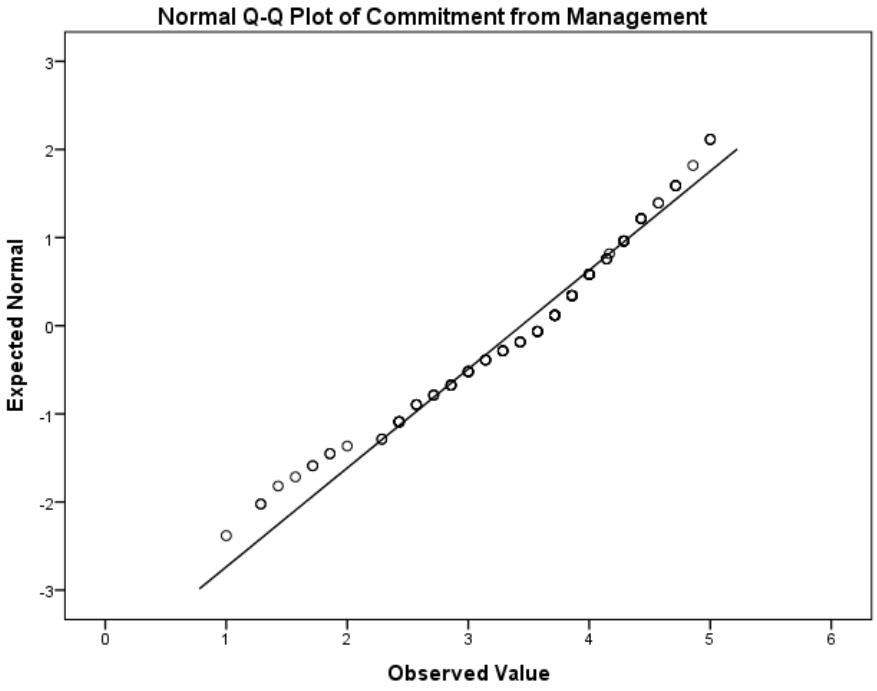
Plots related to the testing of H1:

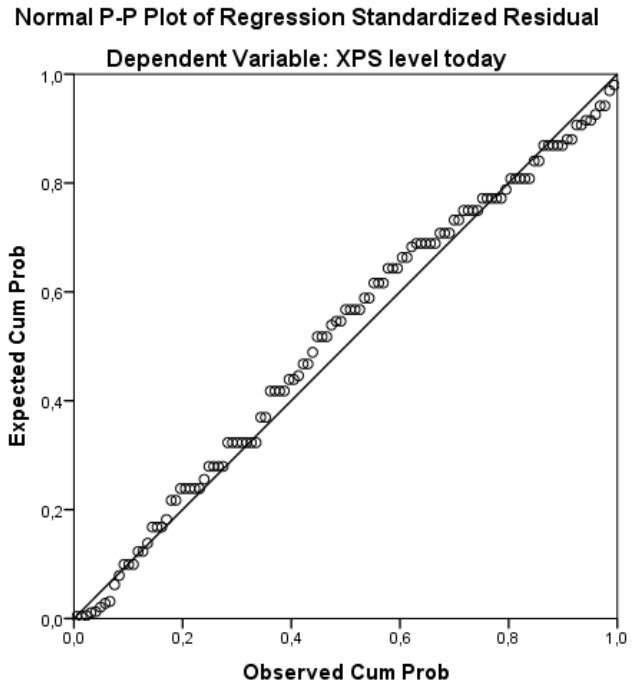




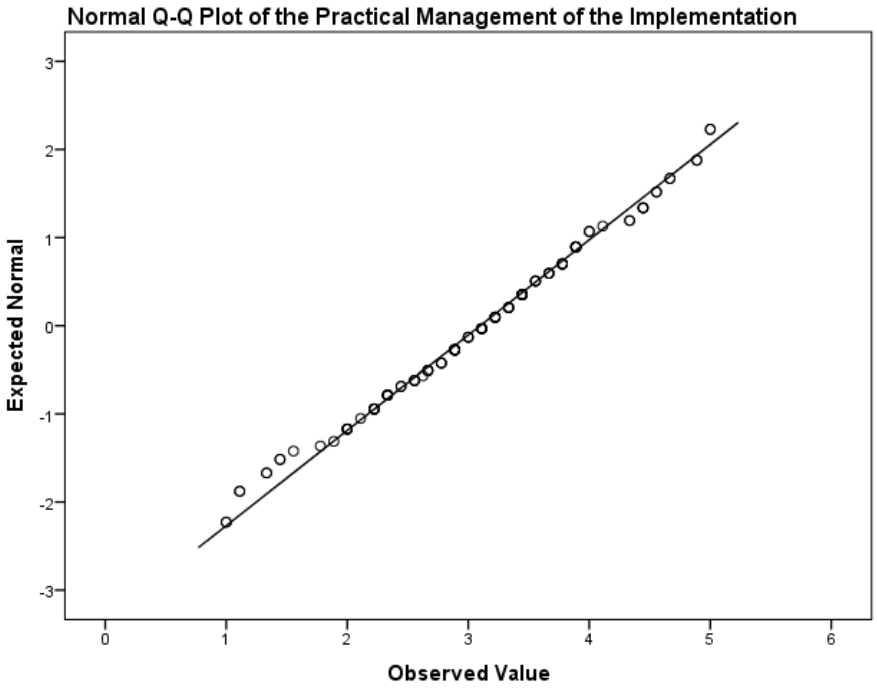

Plant Perfomance
5,00
4,00
3,00
2,00
1,00
Not implemented at all / just started
Basics implemented in some areas
Somewhat implemented in several areas
Much implemented in all areas
Fully implemented in all areas
XPS level today

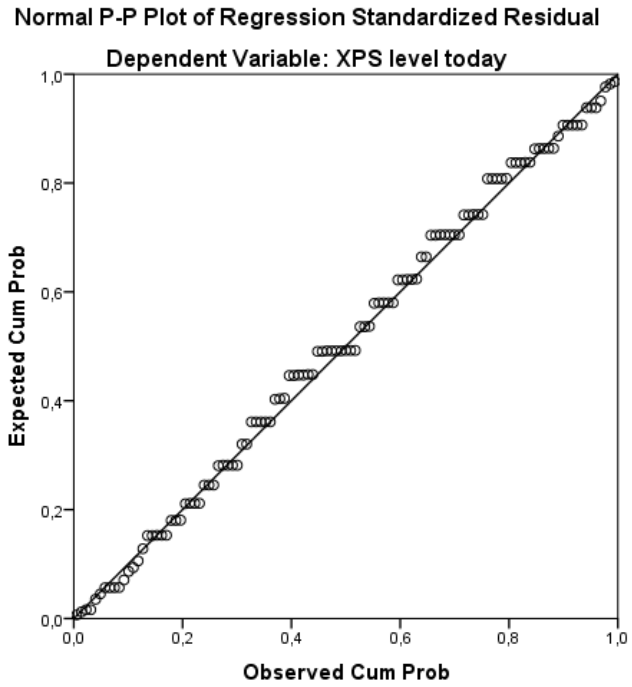
Plots related to the testing of H2a:



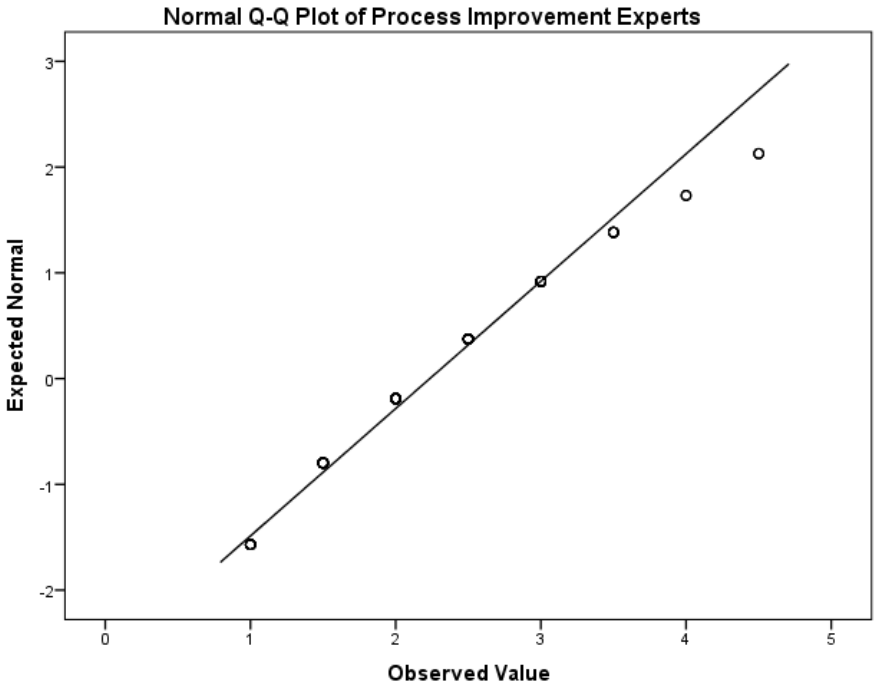


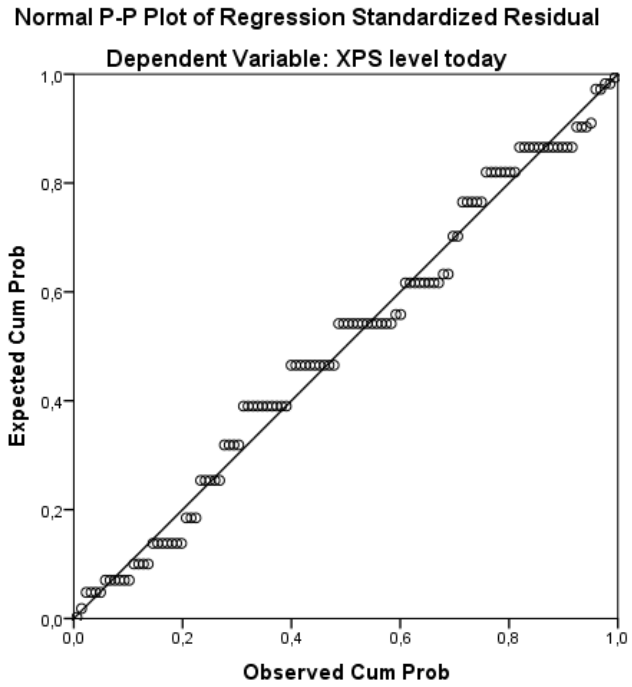
Plots related to the testing of H2b:





Plots related to the testing of H2c:





Plots related to the testing of H2d: