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Contents

1. Introduction

1.1. Introduction to the topic of this thesis

Due to a variety of reasons such as increased competition, resource scarcity and transparency in price and quality for buyers, organizations are increasingly focused on efficiently delivering high quality services and products. Due to the high pace and complexity of business environments, organizations not only compete on the current quality of their services and products, but on their ability to continually improve these services and products (Teece, 2007). Consequently, in recent years we see an increase in the popularity of operational excellence methods that are being applied in a variety of businesses and industries. These operational excellence methods include amongst others Total Quality Management, Business Process Reengineering, Lean Manufacturing, Business Process Management, Six Sigma, Theory of Constraints and Lean Six Sigma. This thesis focuses on operational excellence following the Lean Six Sigma (LSS) method.

1.1.1. Practical example to introduce implementing operational excellence in organizations

Imagine you are working in an organization and are awarded with the responsibility for the efficiency and effectiveness of the daily operations. You are responsible for delivering high quality products and services, at a competitive price and in a timely fashion. Because you want to know the operational performance, you install a performance monitoring system. Such systems will most likely signal area's for improvement in your business operations in one or more of the following performance dimensions: Quality, dependability, speed, flexibility or costs (Ferdows and De Meyer, 1990; Schroeder et al., 2011; Bortolotti et al., 2015). But how will you achieve demonstrable improvements in one or more of these performance dimensions?

A commonly applied operational excellence method to improve performance is LSS (Shah et al., 2008). The LSS method is designed to define, measure, analyze, improve and control (DMAIC) areas for improvement that arise in the business operations of an organization (De Mast and Lokkerbol, 2012). The LSS method is typically applied in a phased project structure, aiming to establish the improvement objectives. Each of the phases of a LSS project contributes to clarifying, sizing and solving the business problem at hand. In addition, a monitoring mechanism is installed after the LSS project is finalized to demonstrate the effect of the solution and signal recurrence of the problem at hand.

An example of such a LSS approach is a project we have studied, designed to increase the service quality in the customer contact center of a bank (Zwetsloot et al., 2015a). This project was implemented according to the five DMAIC stages which we will briefly discuss to introduce our topic of study.

Define: In the define phase, the project leader described the process for clients that call the bank's contact center (Figure 1.1). The project objective was to increase the first-time fix rate (FTFR) of incoming client calls. The FTFR equals the percentage of calls the contact center employees can answer directly without consulting a second tier colleague.

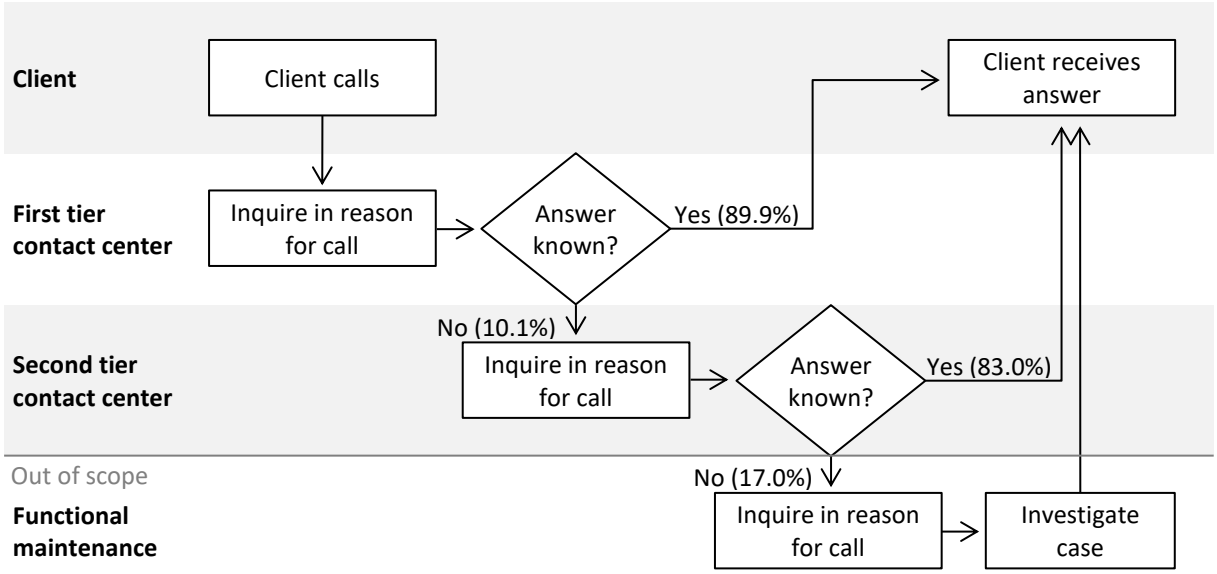

Figure 1.1: Process description in a LSS project

Measure: The first step in the measure phase is setting project objectives, which were a reduction in personnel headcount in the first tier and second tier group. The corresponding improvement indicators (Critical To Quality indicators or CTQ's) were to increase the FTFR and reduce the total handling time for first tier employees. For second tier employees, a reduction in consults and handling time was targeted. The relationship between project objectives and strategic focal points can be schematically illustrated by means of a CTQ flow down (Figure 1.2) (De Koning and De Mast, 2007).

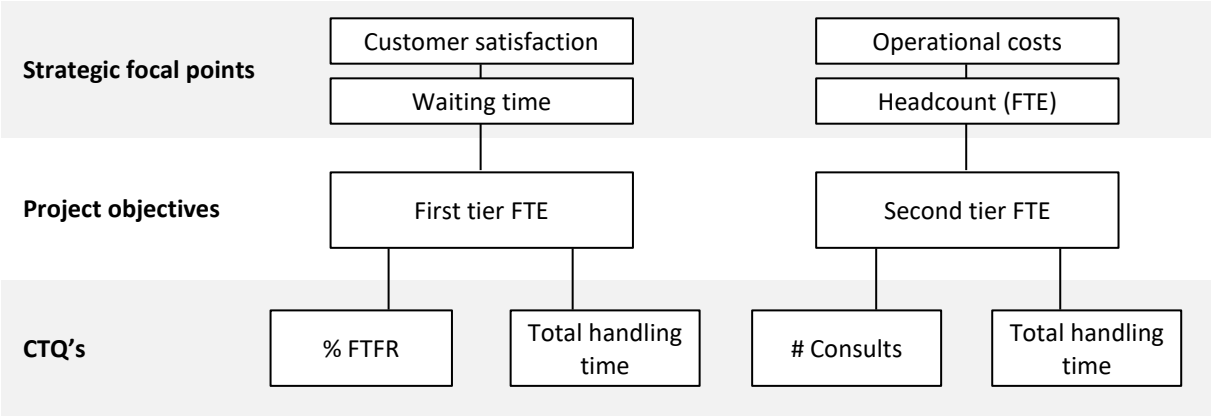

Figure 1.2: CTQ flow down of the project

Analyze: The analysis of the FTFR and consults showed that on average 89.9 percent of calls are handled by the first tier (Figure 1.1). Hence, the target FTFR of 95 percent is not met. A thorough analysis of the problem, using Ishikawa diagrams, brainstorming sessions, autopsies, and a value stream map analysis, resulted in a list of potential influencing factors. Important ones are (1) variation in the total handling time between employees with and without training, (2) the use of aimed enquiry to quickly understand client demands and (3) the private use of mobile banking by employees (Table 1.1).

Influence factor		No.	Handling time		P-value	No. of consults		P-value
		employees	Average	SD		Average	SD	
Level of training	High	3	172	34	0.025	0.67	0.58	0.655
	Low	5	345	136		1.40	1.30	
Aimed enquiry	Yes	6	211	53	0.046	0.83	0.75	0.739
	No	2	488	60		2.00	2.12	
Use mobile banking	Yes	5	257	157	0.297	1.20	1.23	0.881
	No	3	319	115		1.00	1.00	

Table 1.1: Effects of potential influence factors on First-Tier total handling time in seconds

Improve: In the improve phase, the project leader selected the most important and changeable influence factors and provided evidence for their effects on the CTQ's. It was concluded that the most important factors were (1) level of training and (2) inability to access databases with specific instructions. The project leader designed improvements, together with the teams. With these improvement actions, all reasons to call the second tier were eliminated. In the redesigned process, the second tier is omitted (Figure 1.3).

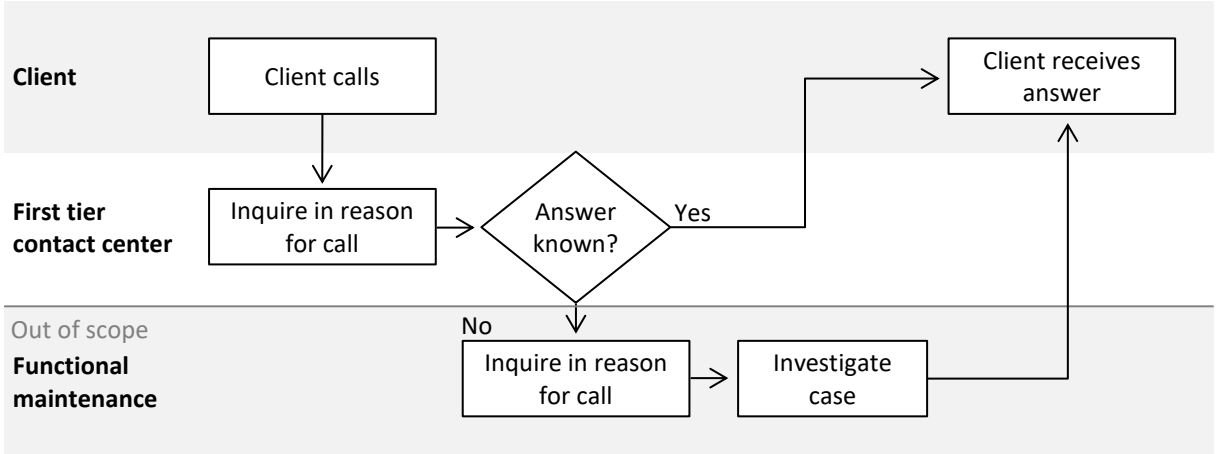

Figure 1.3: Micro process description of the redesigned process

Control: The improve phase resulted in improvement actions that increased the FTFR and reduced the total handling time of the first tier team. In the control phase the project leader created a control plan to deal with possibly arising irregularities in the new process and assigned roles and responsibilities. The benefits of the projects are calculated and finally, the project is closed.

The study of this LSS project illustrates how the DMAIC project structure provides focus. Core principles of LSS, such as a data-based diagnosis and evidence-based improvement actions eventually helped to solve the service quality problem. Another example is a LSS project we have studied by Kuiper et al. (2016). In this case study, we have improved a customer value stream at a financial service provider. Also here the problems are translated into measurable performance indicators. Subsequent root cause analysis led to elimination of inefficiencies in the value stream of study.

1.1.2. Necessity of studying the implementation of LSS in organizations

The results of these and other LSS projects are, amongst other success factors, determined by the quality of the applied tools and techniques. For instance, measuring the problem at hand and discovering root causes demands robust and proven statistical methods. Here we see that academic efforts into the quantitative tools (e.g. statistical process control or the process flow chart as in figure 1.1) and project management techniques (e.g. the DMAIC structure for LSS projects) have established the LSS method as a sound operations improvement method (De Koning and De Mast, 2006; Schroeder et al., 2008).

Now assume you have successfully executed the first LSS project and you have achieved demonstrable improvement in one or more business areas. As the most pressing area of improvement has been addressed, the next problems come to your attention. Instead of executing just one more LSS project, you decide to deploy a collection of LSS projects. You are not executing an isolated LSS project; you decide to implement LSS as a strategic organizational change initiative. As more LSS projects are executed and the LSS method is applied more broadly throughout the organization, you are confronted with more success factors than the quality of the LSS tools and techniques. Questions about implementing LSS in organizations arise. These questions are transcending the area of LSS's quantitative tools and project management techniques.

1.1.3. Objective of this thesis

The objective of this thesis is to investigate and contribute to the understanding of implementing LSS in organizations. This first chapter introduces the topic of study and discusses the contributions of this thesis to the broader literature on implementing LSS in organizations. The broader operational excellence discipline is introduced in section 1.2 and section 1.3 further introduces the specific area of interest, namely the LSS method. In section 1.4 we specifically discuss the current knowledge on implementing LSS in organizations, and in sections 1.5 and 1.6 we discuss the unaddressed problems in implementing LSS in organizations at the LSS project level and the organizational level. Finally, in section 1.7, the contribution of me and others to the research and the structure of this thesis are discussed.

1.2. Introduction to operational excellence

Operational excellence is a broad term that captures multiple methods. First we will briefly explore the history of operational excellence as an introduction to the LSS method.

1.2.1. The origination of operational excellence early 1900

We begin early 1900, when Frederick Taylor (1914) introduced the concept of measurement and observation with the objective to continuously improve operations. Simultaneously, industrial statistics as a discipline to improve operations was constructed by early statisticians such as William Gosset (known as 'Student') and Walter Shewhart. Statistical instruments still in use today stem from these early statisticians, such as the two sample t-test (Student, 1908) and the control chart (Shewhart, 1931).

1.2.2. The origination of Lean production around 1950

Around 1950, a difference in production philosophies between the East (Japan) and West (America) spurred an era of innovation in industrial statistics. Western academics introduced the "plan-do-check-act" cycle for continuous improvement (Deming, 1986), the role of leadership in quality improvement and control (Juran, 1989) and the concept of "zero-defects" (Crosby, 1980). These methods were initially adopted by Japanese organizations such as Toyota and eastern scientists such as Kaoru Ishikawa (1986) learned these methods and developed applicable quality improvement tools and techniques, such as the fishbone (or Ishikawa) diagram and the process flowchart. At the same time at Toyota Company, one lead engineer named Taiichi Ohno introduced the concept of achieving improvements by the elimination of waste in processes (Ohno, 1988). Techniques for housekeeping in industry environments (5S) and visual just-in-time workflows (Kanban) were introduced. This soon became a unique human based continuous improvement production system, driven by leadership and empowerment through education and training. The collective of Japanese production system philosophies, tools and techniques that originated was later introduced as Lean production (Lean) (Womack et al., 1990). For a more detailed description of the history of Lean see Shah and Ward (2007).

1.2.3. The origination of Six Sigma around 1980

In response to increased global competition and poor quality standards, engineers at the American Motorola Corporation developed the Six Sigma method around 1980. The statistical fundaments for quality and the objective of Six Sigma quality standards were developed by Motorola engineers, such as Bill Smith (1993) and later popularized by Mikel Harry (1988) and Michael George (2003). Also the popularized DMAIC (define, measure, analyze, improve and control) project structure and Green- and Black Belt consultant structure were develop at Motorola. In later years, the method was increasingly applied and further developed in companies such as General Electric and Honeywell. For a more detailed description of the history of Six Sigma see (Shah et al., 2008) and for biographies of the key practitioners see Breyfogle III (2001).

1.3. Introduction to Lean Six Sigma

In the previous section we introduced the roots of the LSS method in Lean production principles and statistical quality control methods. This section further substantiates both the Lean and Six Sigma methods. Also, we acknowledge the debate on whether LSS is unambiguously different from other operational excellence methods, specifically Total Quality Management (TQM) (see Dahlgaard et al., 1998 for a definition of TQM). There is a chasm between those who argue LSS is different from TQM because LSS is solely an operations improvement method that fits within the larger context of TQM (Dahlgaard and Dahlgaard-Park, 2006). The other end of the spectrum advocates that LSS is a modified form of TQM because of the additional practices such as project organizations and structures for operations improvement (Linderman et al., 2003; Schroeder et al., 2008). Regardless the debate, the definitions of Lean and Six Sigma need further substantiation here.

1.3.1. Substantiation of the Lean concept

Lean emerged in practice, and started being codified when authors such as Womack et al. (1990) and Spear and Bowen (1999) tried to articulate its principles (Bhasin and Burcher, 2006; Holweg, 2007; Bicheno and Holweg, 2009; Slack et al., 2010; De Mast et al., 2016). In the recent literature, Lean is usually understood as a coherent system of practices focused on the elimination of waste by concurrently reducing supplier, customer and internal variability (Shah and Ward, 2007). The practices of Lean pertain to just-in-time production,

quality management, preventive maintenance and human resources management (Shah and Ward, 2003). Pettersen (2009) subsequently studied the terms that apply to Lean and distilled a list of eight attributes that define Lean:

- Just in Time (JIT): Producing when and which is needed by customer pull
- Resource reduction: Non-value adding process steps, often cited as the 7 forms of waste
- Improvement strategies: Participation in improvement circles and problem solving
- Defects control: A strong focus on quality and eliminating root causes of defects
- Standardization: Standardization and '5S' practices, resulting in continuous improvement
- Scientific management: Rational allocation (or reduction) of resources in a process
- Human resource management: Bottom-up participation and basic understanding of Lean
- Supply chain management: Active supplier involvement and management

1.3.2. Substantiation of the Six Sigma concept

The Six Sigma method has been widely embraced since its origination mid-1980. Many companies have adopted the method and dozens of books have been devoted to the method, such as Pande et al. (2000). Six Sigma methods are strongly focused on defects- and variability reduction in business processes and we adopt the definition of Linderman et al. (2003): *"*Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates*"*. The systematic method is the project by project structure (Juran, 1989). These projects are managed according to the five phase define, measure, analyze, improve, and control (DMAIC) cycle (De Mast and Lokkerbol, 2012), something which was left much vaguer in prior quality management methods (Zu et al., 2008). Although the use of metrics to reduce variation is far from unique to Six Sigma, Schroeder et al. (2008) assert that specific metrics such as defects per million defect opportunities (DPMO), critical-to-quality (CTQ) and process sigma measurements are innovations introduced by Six Sigma. Kwak and Anbari (2006) list six attributes that collectively define Six Sigma as a unique method:

- TQM culture principles: Corporate culture in which all employees actively participate in continuous improvement (Dahlgaard et al., 1998)
- Customer focus: Definition and measurement of customer requirements and expectations

- Additional metrics: Advanced statistical data analysis tools to measure performance
- Financial results: Measured and reported financial results
- Structure improvement method: The DMAIC procedure for improvement projects
- Project management structure: Organized according to project management methodology and tools

In recent years, the Lean and Six Sigma methodologies are applied and studied as one (Shah et al., 2008) and although the LSS method has its origins in manufacturing, it is increasingly used in service organizations. As such, LSS has evolved into a widely studied and applied robust business improvement initiative (De Koning and De Mast, 2007). As a result several streams of LSS research have emerged. We will focus on *implementing* LSS in organizations, as this is where we aim to contribute.

1.4. Implementing LSS in organizations

This section will explore the research on implementing LSS in organizations. From 2000 onwards we see that research into the implementation of LSS in organizations started to emerge. A comprehensive meta-study by Arumugam et al. (2014) summarizes the research on LSS implementation and serves as an inspiration for this section.

1.4.1. The effects of implementing LSS on firm performance

The first researches that we discuss are those studies about the rationale for implementing LSS; namely research into the effect of implementing LSS on firm performance.

First there are studies where firm performance is operationalized through perceptual data. These studies found positive effects by LSS project savings, process improvements, improvement of on-time delivery, reduction of inventory and setup time reduction (Braunscheidel et al., 2011). Others find that implementing LSS improves the delivery of products and cycle time (Shah and Ward, 2003; Shah et al., 2008), improves profitability of the firm (Van Iwaarden et al., 2008), improves customer satisfaction (Kumar et al., 2007), increases employee satisfaction (Schon et al., 2010) and creates competitive advantage (Lewis, 2000; Choi et al., 2012).

Secondly, research that uses secondary financial data to establish the effect of implementing LSS on firm performance compares the financial performance of companies

that implement LSS before and after the deployment (Foster, 2007; Fullerton and Wempe, 2009; Pulakanam, 2012; Shaffer and Moeller, 2012; Swink and Jacobs, 2012). These studies report enhanced firm performance by implementing LSS.

In this thesis, we are interested in *how* the implementation of LSS leads to these performance effects. We therefore explore (1) the research on critical success factors for implementation of LSS and (2) case study research on LSS implementations (Nonthaleerak and Hendry, 2006). The unit of analysis in these studies varies between (1) the LSS project level and (2) the organizational level (McAdam and Lafferty, 2004; Choo et al., 2007; Schroeder et al., 2008; Zu et al., 2008; Anand et al., 2009; Nair et al., 2011). This thesis on implementing LSS in organizations is structured according to these two levels of analysis.

1.5. Implementing LSS at the project level

The first level of analysis is about the implementation of LSS projects, which we will name LSS project implementation. Previous research found critical success factors for implementing LSS projects and are defined as organizational ingredients that influence the outcome of LSS projects *within* projects, and factors *in the context* of the projects. Factors *within* LSS projects are for instance (1) the application of structured methods, (2) perceived psychological safety by project members (Choo et al., 2007), (3) challenging objectives to drive knowledge creation and innovation (Linderman et al., 2006; Choo, 2011) and (4) Black Belt coaching (Hagen, 2010). Factors *in the context* of LSS projects have converged into nine critical success factors (Coronado and Antony, 2002; Brun, 2011):

- Management commitment and support for projects, training, and prioritization
- Involvement of improvement specialists in projects
- Structured approaches to project execution
- Customer focus in project objectives
- Usage of tools and techniques
- The link of LSS to business strategy
- A focus on metrics
- The link of LSS to Human Resource Management
- Data based decision making

These critical success factors are also fundamental conditions for implementing LSS as a strategic change initiative at the organizational level and subsequently researchers started to investigate how these critical success factors lead to effective deployment roadmaps for implementation of LSS in the organization (Nonthaleerak and Hendry, 2008; Chakravorty, 2009a; Chakravorty, 2009b). This is the subject of section 1.6.

1.5.1. Contributions to implementing LSS at the project level

Research into critical success factors for LSS project implementation recognized the importance of commitment and support from people (such as management, employees and improvement specialists). Later studies confirmed that success of LSS projects and adoption of LSS attributes is indeed determined by employee attitudes and perceptions (Antony et al., 2007) and organizational culture (Detert et al., 2000; Ansari et al., 2010). We identified two areas in need of further research that addresses *the attitude of people towards* LSS projects and LSS attributes that are implemented by these LSS projects (LSS attributes were introduced in section 1.3.1 and 1.3.2).

The first research is the perception of LSS projects and the attitude towards LSS attributes. Although the Lean concept holds "*bottom-up participation*" and Six Sigma advocates a "corporate culture in which *all employees actively participate* in continuous improvement", the effect of implementing LSS projects on employee perception and attitude remained scarcely addressed (Dahlgaard and Dahlgaard-Park, 2006). The number of publications that study employees' feelings and perceptions during and after LSS implementations (the human element as Antony et al. (2007) specifically notes for service organizations) are few (Skorstad, 1994; Shafer et al., 1995; De Treville and Antonakis, 2006; Losonci et al., 2011). Early research on Lean implementations in manufacturing dictates that in the majority of cases, the main barriers to achieving successful Lean change are related to the human element; insufficient communication and employee opposition are amongst other important reasons (Bhasin, 2012). We therefore investigate how the perception of LSS projects is determined in chapter 2.

The second research concerns the clarity of LSS project definitions. Early research identified the clarity of the project goals as an important reason for LSS project failure (Lynch et al., 2003; Linderman et al., 2003). The determinants of negative LSS project outcomes converge to (1) the correct definition of LSS projects (Chakravorty, 2009b) and (2) vague

definitions of LSS project goals (Szeto and Tsang, 2012). Unclear project objectives results in diverging views of the same project by project leaders, managers and employees and this leads to different views of what entails a relevant and successful project. We argue that the resulting ambiguity does not contribute to acceptance of LSS projects or adoption of LSS attributes, and therefore we investigate what LSS project definitions are most common and present a set of generically applicable project definitions for multiple industries in chapter 3.

1.6. Implementing LSS at the organizational level

The second level of analysis is about the implementation of LSS as a strategic organizational change initiative, which we will name implementing LSS at the organizational level. At the organizational level, success factors for implementing LSS such as (1) empowerment of- and communication with the workforce, (2) the management of LSS consultants and projects in a program structure (McAdam and Lafferty, 2004; Schroeder et al., 2008; Zu et al., 2008; Anand et al., 2009), (3) direct reporting to business executives (Nonthaleerak and Hendry, 2008), and an environment of psychological safety (Nair et al., 2011) were amongst others recognized. Besides these factors, instruction, guidance or specific models for the implementation of LSS are scarce (see Hilton and Sohal, 2012, and Kumar et al., 2011, for discussions on LSS deployment). Naslund (2008) observes that the academic literature does not offer a systematic approach to the implementation of LSS and Chakravorty (2009b) even argues that many LSS implementations fail to produce the results it can bring, because an adequate LSS deployment model “to guide the implementation” does not exist.

1.6.1. Contributions to implementing LSS at the organizational level

For the implementation of LSS at the organizational level we identified two areas for further research. We thereby contribute to research that recognizes LSS as a strategic organizational change initiative (McAdam and Lafferty, 2004; Schroeder et al., 2008; Antony et al., 2008) instead of a mechanical improvement method. Although we are interested in *if* LSS is a strategic change initiative; we focus on the scientific grounding of *how* strategic organizational change is achieved by implementing LSS. Therefore we have identified and reviewed the current knowledge on LSS implementation; we have collected the publications on LSS implementation and compare these to organizational change theories (Beer and Nohria, 2000; Poole and Van de Ven, 2004). Our findings in chapter 5 suggest that the

current knowledge on implementing LSS (1) seems decoupled from established organizational change theory, (2) is generic and (3) does not address organizational learning patterns in LSS implementation processes.

Therefore, we have studied organizational learning patterns in implementing LSS in chapter 6. We thereby contribute to LSS research on knowledge creation and learning in LSS project teams. It is argued that the structured LSS problem solving approach (such as the DMAIC structure) facilitates rational decision making and thereby affects the result of projects (Anand et al., 2009). As more LSS projects are applied, organizational members gain better understanding of how to solve problems. Better knowledge on problem solving enables more intentional LSS improvement projects and thereby creates a better understanding about the organization and how to further improve the organization. It is argued that implementing LSS projects thereby drives individual and organizational learning (Wiklund and Wiklund, 2002; Savolainen and Haikonen, 2007). Our findings in chapter 6 take the organizational level as unit of analysis and we present insights in how a LSS implementation process unfolds and what organizational learning patterns underlay the implementation process.

1.7. Contribution and outline of this thesis

This thesis investigates and contributes to the understanding of implementing LSS in organizations at the project level and the organizational level. This section describes the contributions of me and all others who have helped me perform the research and write the resulting publications.

In chapter 2 we study how LSS attributes affect attitude towards LSS projects, in terms of acceptance, contribution or rejection, of managers and employees. We find that cost-saving is the likely candidate to receive long-lasting attention in LSS project implementations. We find a tendency to simplify the accounts of LSS, which forms a fertile basis for misconceptions and extreme interpretations about LSS. We conclude that the drive required keeping the LSS implementation going comes from an incremental and bottom-up implementation. This chapter is published as ‘Perceptions of Lean Six Sigma: A multiple case study in the financial services industry’ in the Quality Management Journal (Lameijer et al., 2016a). This publication is based on the master thesis of David Veen, which was supervised

by Ronald Does. From this thesis I have adopted the research idea, the raw interview data of four cases, the initial research framework and a substantial part of the referred academic literature. I have supplemented the interview data with one more case and, due to a modification of the research framework, performed coding of all the raw interview data. In writing the publication together with Ronald Does and Jeroen de Mast, I took the lead and used the master thesis as an inspiration (Veen, 2013).

Chapter 3 contributes to the quality of the LSS project definition phase by establishing well defined and useable generic LSS project definitions including generic CTQ measures, applicable in multiple industries. The study sample consists of 312 LSS improvement projects that are executed in a broad variety of industries. This chapter is published as 'Inter-industry generic Lean Six Sigma project definitions' in the International Journal of Lean Six Sigma (Lameijer et al., 2016b) and has been selected by the journal's editorial team as Outstanding Paper in the 2017 Emerald Literati Network Awards for Excellence. This chapter is based on previous generic LSS project definitions research within four separate industries, namely healthcare (Does et al., 2006; Niemeijer et al., 2011), finance (De Koning et al., 2008; Lokkerbol et al., 2012), publishing (De Koning et al., 2010) and construction (Van den Bos et al., 2014). The contribution of this paper lays in the sample of LSS projects that stem from eight different industries and thereby increase the applicability for LSS practitioners. This paper has been a combined effort of Ronald Does, Jeroen de Mast and me, whereby I had the lead in the data collection, coding, analysis and interpretation followed by writing the paper as first author.

Chapter 4 is a result of the research in chapter 3 and is about the implementation of LSS projects in a separate industry (public administration) which was discussed by Ronald Does at the Fifth Stu Hunter Research Conference in Copenhagen. In response to a conference contribution by Saraiva (2018) where the positive effects of statistical thinking (Snee and Hoerl, 2003) on political processes in Portugal are demonstrated, Ronald Does invited me to write together a discussion on the suitability of LSS projects in the public sector based on chapter 3. This will appear in Quality Engineering (Lameijer et al., 2018).

In chapter 5 we perform an analysis of LSS deployment and maturity models for implementing LSS at the organizational level. We find that the analyzed models are poorly grounded in theory, appear disconnected from established organizational development theory, and the given advice lacks in specificity and operationality. We conclude that the

underlying notion of deployment processes seems a programmatic view, leaving little room for idiosyncrasy and learning elements. This chapter is currently in the process of being reviewed for publication. For this research, I took the lead in performing the research and writing the paper together and with the help of Jeroen de Mast.

Chapter 6 has the objective to study how the process of implementing LSS at the organizational level unfolds. We are interested into what extent it is a programmatic- or a learning process. Therefore we have studied the pattern of learning dynamics over the course of the LSS implementation process. We find that the process is driven, for one, by adopting practices from outside sources, but at least as important are lessons that the organization needs to discover itself through organizational learning patterns. Finally, we argue that the process of implementing LSS is not an incremental process, but characterized by periods of inertia followed by radical and wide-reaching changes. We end this chapter by concluding that the implementation of LSS largely depends on the resourcefulness and learning efforts of the company's own management and professionals and cannot be copied from the existing LSS implementation models. This chapter is currently in the process of being reviewed for publication. This paper was a combined effort of Jeroen de Mast, me and Kevin Linderman and Andrew van de Ven. The research project was led by Jeroen de Mast. My efforts were preparing and structuring the raw data for analysis, performing the first round of coding the data, identification of the relevant literature and reviewing intermediate versions of the paper.

Finally, chapter 7 provides a summary of the contributions that this thesis makes on implementing LSS in organizations.

Part 1: Implementing Lean Six Sigma at the project level

2. Perceptions of LSS project implementations

When implementing LSS projects, the attitude of employees and managers towards the introduced LSS projects affects the result of these LSS projects. The objective of this chapter is to find which LSS attributes have an effect on employee and management attitude and how contextual framing affects this relation. We study how attitude towards LSS projects is determined, in terms of acceptance versus rejection (positive responses versus negative responses) and active versus passive (attitudes of being empowered versus attitudes of powerlessness). This chapter is based on Lameijer et al. (2016a).

2.1. Introduction

From 2001 onwards, books and papers have been written on LSS and some of them describe typical LSS project implementation issues for service organizations such as a lack of tangible output, a lack of a process view of work, the scarcer availability of useful measurements, and a greater human element (Antony et al., 2007). The literature on Lean change success in manufacturing dictates that in the majority of cases, the main barriers to achieving successful Lean change are related to the human element; insufficient communication and employee opposition are amongst other important reasons (Bhasin, 2012). Nevertheless, the number of publications that study employees' feelings and perceptions during and after LSS implementation (the human element as Antony et al. (2007) specifically notes for service organizations) are few (Skorstad, 1994; Shafer et al., 1995; De Treville and Antonakis, 2006; Losonci et al., 2011). In addition, the results from studies on LSS perception by employees are scarce, contradictory and inconsistent, though very relevant for LSS implementation success (Vidal, 2007).

The objective of this research is to study how manager and employee attitudes, in terms of acceptance of-, contribution to- or rejection of LSS projects in a LSS implementation are determined. The focus is on two possible explaining variables. The first is which LSS attributes are experienced and how these have an effect on employee and management attitude. The second is how contextual framing affects the relation between LSS attributes and attitude. This study focuses on the financial service industry, with a control case from healthcare, as efficiency gains are large and many financial institutions have implemented LSS projects (De Koning et al., 2008; Delgado et al., 2010).

We will introduce the concepts of attitude and the resulting behavior, LSS attributes, and framing of the LSS implementation in the section 2.2. Section 2.3 presents the research methodology and the research strategy. Section 2.4 presents the results and discussion and section 2.5 the conclusions. Section 2.6 discusses limitations and suggestions for further research.

2.2. Literature review on perceptions of LSS

There are various challenges when implementing LSS projects in the service sector as described by Antony et al. (2007) and the human element in service organizations is thereby of pivotal importance: (1) Human behavioral characteristics such as courteousness, eagerness to help, honesty, etc., have a major influence on service processes that determine the quality of services provided to customers. (2) The resistance to change in a service-focused environment is comparatively higher than in a manufacturing setting due to the high involvement of soft issues (human behavior, friendliness, honesty, courtesy, etc.). (3) Service processes in general are much more dependent on human and organizational change than the changes to manufacturing processes. Changing the machine parameter settings on a particular machine is quite a different matter than training staff or adjusting work procedures or tasks. When we look at previous research on attitudes towards LSS, Hasle et al. (2012) found that both positive and negative effects of LSS on amongst other commitment levels have been reported, whereby much seemingly depends on employee framing of the context. Therefore we have included a construct for context in our study. In addition, we acknowledge that LSS builds on earlier manifestation of operational excellence, where research into employee and manager attitudes has been performed (see Boiral (2003) for ISO 9000 and Zbaracki (1998) for TQM).

2.2.1. Attitude and behavior

In research done on employee responses to a merger, Howard and Geist (1995) have captured the concept of ideological positioning (attitude). Ideological positioning "reveals individual beliefs, values, and perceptions about cultural norms that define and/or clarify their position on an issue". Ideological positioning occurs "as organizational members attempt to rationalize and explain the choices they make in response" to a change initiative. The ideological positioning concept moves on two axes; acceptance versus rejection

(positive responses versus negative responses) and active versus passive (attitudes of being empowered versus attitudes of powerlessness). Differences in attitudes between hierarchical layers in organizations are held as important drivers for unintended consequences of implementations (Harris and Ogbonna, 2002; Jian, 2007). These differences are holding true for cultural changes or restructuring efforts especially (McKinley and Scherer, 2000) and the attitudes of top management may have a more immediate effect on the change initiative compared to individual employees (Choi and Ruona, 2011). Next we will discuss how attitude will most likely result in corresponding behavior.

The Theory of Reasoned Action (TRA) focuses on theoretical constructs concerned with individual motivational factors for the likelihood of performing a specific behavior (Ajzen and Fishbein, 1980). TRA states that the most important determinant of behavior is behavioral intention. A direct determinant of individuals' behavioral intention is their attitude toward performing the behavior. Thus, a person who perceives that positively valued outcomes will result from LSS projects (e.g. better working conditions or less rework without loss of paid work) from performing contributing behavior (e.g. engage in process optimizations and standardize daily work) will have a positive attitude toward that behavior (contributing) and vice versa. Hence, TRA holds that employee perception explains for actual behavior, which will have a significant impact on the successful implementation of LSS (Antony et al., 2007). Following the existing literature on employee attitude and behavior, we propose two research questions:

- Research question 1A: How do attitudes towards Lean Six Sigma projects differ per case?
- Research question 1B: How do attitudes differ between managers and employees?

2.2.2. LSS attributes

LSS attributes are LSS methods or LSS tools that are implemented or applied in LSS projects and are introduced to distinguish which LSS attributes carry the most weight in management and employee perception of LSS projects. For an introduction to LSS, we refer to section 1.3. We present the LSS attributes of study in table 2.1 and propose the following research question:

- Research question 2: How do the perceived Lean Six Sigma attributes differ per case?

Definition of LSS attributes	Description
Definition of Lean	
Just in Time (JIT)	Producing when and which is needed by customer pull
Resource reduction	Non-value adding steps of a process, often cited as the 7 forms of waste
Improvement strategies	Participation in improvement circles and find root causes of problems
Defects control	A strong focus on quality and eliminating root causes of defects
Standardization	Standardization and '5S' practices, resulting in continuous improvement
Scientific management	Rational allocation (or reduction) of resources in a process
Human relations management	Bottom-up participation and a basic understanding of Lean principles
Supply chain management	Active supplier involvement and management
Definition of Six Sigma	
TQM	Corporate culture in which all employees actively participate in continuous improvement (Dahlgaard et al., 1998)
Customer focus	Definition and measurement of customer requirements and
Additional metrics	Advanced statistical data analysis tools to measure performance
Financial results	Measured and reported financial results
Structure improvement method	Following the DMAIC procedure for improvement projects
Project management structure	Organized according to project management methodology and tools

Table 2.1: Lean (Pettersen, 2009) and Six Sigma (Kwak and Anbari, 2006) attributes

2.2.3. Framing

In order to study and explain why perceptions differ per manager or employee it is crucial to capture how LSS project implementations are framed. The concept of framing the context and content captures the differences in meaning between groups or individuals and therefore allows for situational comparisons (Dewulf et al., 2009). Context frames relate to the way that actors view reasons behind the LSS implementation. Content frames regard the main goals of the LSS projects. Content frames help us understand why which LSS attributes are dominant in the perception of employees and management. We propose the following research question based upon the literature on the concept of framing:

- Research question 3: How does the framing of Lean Six Sigma implementation differ per case?

2.3. Research methodology

The objective of this chapter is to explain employee and manager attitudes toward the implementation of LSS projects by studying which LSS attributes are perceived. Manager and employee framing of the LSS implementation's context and content are believed to moderate the perception of the LSS attributes and thereby the attitude towards the LSS project implementation (see Figure 2.1).

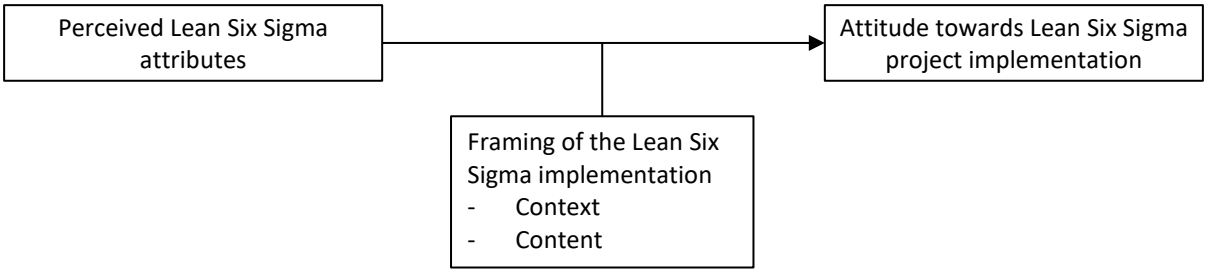

Figure 2.1: Conceptual model of the research

2.3.1. Research strategy

The research is set up as a qualitative multiple-case study. As this study is attempting to explain for phenomena under different conditions, the multiple-case setup is particularly suitable (Miles and Huberman, 1994). The qualitative nature of the research is reflected in the research questions, where there are—in potential—many more variables of interest than data points available (Yin, 2003). In methodological terms, the study uses 'locally grounded', or 'thick descriptions' suited for finding meaning rather than (statistical) relations (Miles and Huberman, 1994) and is therefore considered ‘theory generating’ after Ketokivi and Choi (2014). The study follows the structure as proposed by Eisenhardt (1989). Within case analysis provides detailed write-ups for each case to get intimately familiar with the cases and discover patterns. Then, searching for cross-case patterns by selection of categories and look for within-case similarities- and differences is performed. Finally, we compared the findings with external theory as conflicting theories invoke an opportunity for creative thinking (Eisenhardt, 1989).

We have researched four firms within the financial service industry and one hospital.

- Company 1 is a medium sized Dutch retail- and wholesale bank. Initial LSS projects were carried out successfully in the operations unit after which the entire company engaged in a full-scale LSS implementation executed by Black Belts (LSS specialists). For this case study at the operations department, the implementation started in 2010.
- Company 2 is a large Dutch pension funds administrator. The organization is part of a much larger corporation, with activities across Europe. LSS projects were carried out successfully by Black Belts in another corporate business unit prior to implementation within this unit in 2008.

- Company 3 is a Dutch subsidiary of a European life insurance company, and is a relatively small player on the Dutch market. The organization employs about 450 people. Implementation of LSS projects by Black Belts started in 2009.
- Company 4 is a Dutch general hospital. It is one of the larger general hospitals in the Netherlands, employing almost 3,000 people (including about 200 medical specialists) at several hospital locations and laboratories. Implementation of LSS projects started in 2009 by training management into Green Belts.
- Company 5 is a medium-sized pension and life insurance company. The firm employs about 700 people, and is a subsidiary company of a larger corporation. The organization started the implementation of LSS project, which were executed by Black Belts, in 2007.

All five companies in this research are characterized by implementing LSS through LSS projects. The start-up phase, in which pilot projects are started with the expectation of significant impact with effort only from project leaders, is present in all five companies. Then all five companies started LSS projects in core processes or service segment teams. More Black Belts are then trained for these projects. Senior management monitors results and presents a clear vision on the deployment of the LSS projects. Despite the similarities, these companies do hold meaningful contrasts for theoretical reasoning (Yin, 2003). Differences between the cases exists in terms of industry contingencies (e.g. power of employees over managers, familiarity with organizational change), LSS implementation (e.g. bottom-up vs. top down, use of external consultants) and intensity of LSS implementation.

For every participating company, five interviews were arranged with people at different organizational levels who had recently been involved with a LSS project implementation. Three types of respondents have been incorporated, being managers, employees and Black Belts. The interview setup intended to invoke a narrative account of the LSS project by the semi-structured nature (the interview questions are available as supplementary material). The transcripts amounted to 265 pages of plain text. Each transcription was placed as a separate source in qualitative research software QSR NVivo 10 (see www.qsrinternational.com). The transcripts were coded in two iterations (the transcripts are available as supplementary material). In the first coding phase, all transcripts were coded for attitudes, frames and LSS attributes. To check and improve accuracy, a second coding round was done by a second researcher.

A 'discourse' label was added, signaling frames of how 'others' viewed the LSS implementation in general terms from the point of view of the interviewee. The discourse label was assigned to any passage where the interviewee made statements about the views of colleagues, superiors or subordinates regarding the projects.

2.4. Results and discussion

The analysis is structured by (1) attitude towards LSS projects, (2) perceived LSS attributes and (3) framing of the LSS implementation. The resulting references made per category of study are displayed per company and are divided into management, Black Belt and employee results (see Table 2.2). The displayed references can be direct or indirect (discourse) references. For example, managers in company 2 (C2) have 8 rejecting references. The content of these references does not only apply to their own attitude, though also on what they believe the attitude of others is (the discourse).

The case segments were combined into 'within-case displays' as a short descriptive basis for each case; highlighting the main findings per case in table 2.3 (the extensive within-case analysis was part of the publication and is available upon request). In the within case display, the narratives of managers and Black Belts are combined for two reasons. The first is that some cases managers took up the role of Black Belt. The other reason is that the differences between manager and Black Belt attitudes appeared to be limited (cf. Table 2.2). The subsequent cross case analysis highlights the most interesting findings and answers the research questions.

		Company 1			Company 2			Company 3			Company 4			Company 5		
	Roles	Managers	Black Belts	Employees	Managers	Black Belts	Employees	Managers	Black Belts	Employees	Managers	Black Belts	Employees	Managers	Black Belts	Employees
Amount of respondents (N=25)		2	1	2	2	0	2	2	2	2	3	0	2	1	1	3
Attitude toward LSS projects (# coded observation)																
Active		2	3	3	4			5	3	3	5			2	1	3
Acceptance		4	5	6	3		2	1	1	1	3		1		1	3
Passive			2	1	3		4	1	1	2	1			1	1	2
Rejecting		1	1	1	8	1	6	1					3			2
Perceived LSS Attributes (# coded observations)																
Lean	Just in time practices															
	Resource reduction	3	4	1				1	2	3	3		1		1	2
	Improvement strategies	5	2	4	1		1	2	5	5	7		2	2	3	7
	Defects control										3					
	Standardization	3	1	2	2		2	1	1		4		1		1	7
	Scientific management	3	1	2	1		2	1	1	5	9		2	1	1	2
	Human relations management	6	3	6	5		3	3	4	3	8		5	3	2	1
	Supply chain management	8		1	1					4	5		1		1	2
Six Sigma	Total Quality Management	14	2	1	3		2	6	12	8	17		5	1	6	2
	Customer focus	2	1	1	1		2	3	3	7	5		3	2	2	2
	Additional metrics	10	1	3	7		4	3	6	1	3			1	2	
	Financial results				2		2			1	3			2	2	2
	Structured improvement method	3		2	2		1	1	1	1	5			1	4	3
	Project management structure	7	1	2	5		4	1	2	2	5				2	1
Framing of LSS implementation (# coded observations)																
Context	Pressures to reduce costs			2	1		1	2	2	2	3					
	Low customer satisfaction	2	1		2		2							1	1	2
	Organizational improvement	2							1				2			
Content	Improving service and quality	7	5	8	2		8	8	9	8	13		7	5	4	14
	Reducing the cost-base	9	4	8	9		9	8	8	5	11		9	5	4	11
	Improving employee well-being	7	4	6	3		6	8	7	8	7		7	3	3	13
	Improving employee efficiency	4	4	9	8		9	9	8	5	14		9	5	4	15
	Increase process reliability				7		6	6	8	8	8		4	5	3	14
	Increase process flexibility				5		3	9	8	4	9		8	4	5	10
	Increase speed of delivery				6		8	9	7	8	12		9	5	5	14

Table 2.2: Quantitative within case results

	Attitudes (towards LSS projects)	**Perceived LSS Attributes** (in LSS project implementations)	**Framing LSS implementation** (context and content)
Company 1 Managers and Black Belts	• Accepting and active • Management doubts the moment of deployment and fear loss of leadership control	• Telling the story and leading the implementation by exemplary behavior • Focus on additional metrics	• Low customer satisfaction and consequently cost reduction • Employee satisfaction
Employees	• More accepting than active • Transparency increased work stress	• Bottom up approach in structured improvement • Opportunity to learn and contribute	• Cost reduction by means of process optimization • Improving employee efficiency
Company 2 Managers and Black Belts	• Accepting though critical on the LSS methodology • Strong focus on realizing company objectives with LSS	• Insight in performance metrics perceived as blessing • Clear project management structure	• Initiated to improve customer satisfaction • Strong focus on cost reduction “always FTE’s”
Employees	• Rejecting the LSS projects, introduced attributes perceived as waste of time	• LSS expert support perceived as absent • LSS in house training perceived as insufficient	• Low customer satisfaction • Improved efficiency should lead to cost reductions (a means to reduce cost).
Company 3 Managers and Black Belts	• Accepting and active • Lack of vision caused chaotic implementation • Fun to solve the problems	• Searching for root causes of problems with employees • Voice of the customer research put forward	• Trend to restructure and optimize in financial industry • Focused on realizing efficiency gains
Employees	• Accepting • Desire to see LSS further implemented in the organization	• Knowing what customer value is remains vague • measurements are rough estimates due to lack of data	• Assignment from local management to start • Focused on process improvements
Company 4 Managers and Black Belts	• Accepting • LSS only one of many management instruments	• Difficulty in adopting each other’s best-practices • Management received LSS training to execute projects	• Increased competitive pressure on market • improved service, quality and employee efficiency
Employees	• Passive • Initiative primarily focused on middle and higher management	• Measurement of process data is perceived more important than what their opinion • No training, less involved	• Reputational reasons as main driver • Focus on cost reduction and employee efficiency
Company 5 Managers and Black Belts	• Active • Customer focus achieved through application of LSS projects	• Management involvement is important though doesn’t participate in LSS projects • Received LSS training	• Management decision • To enhance reputation • reducing a certain amount of man-hours per year
Employees	• Accepting and active • "Inspiring" to improve processes together	• Team worked step by step towards a solution • Unify service by standard operating procedures.	• Management decision • Reducing a certain amount of man-hours per year • Personal savings targets

Table 2.3: Qualitative within case descriptions of the research results

2.4.1. Attitude towards LSS project implementations

Based upon the narratives from management, this group is mostly accepting towards LSS projects (despite C2). Management mentions how LSS projects can help them in meeting their objectives by the tools LSS provides, such as problem solving and integration of voice of the customer in the organization. Doubts that all these managers have concern factors that are not controllable -though must be managed- by them. This comprises (1) little control over the implementation, (2) the focus on data interpretation and financial focus instead of trust in management experience, (3) pace and structure of the LSS projects and (4) skill level of the Black Belts. Black Belts attitudes are mostly accepting and active.

The larger group of employees has a passive acceptance attitude towards LSS projects. Rejection of LSS projects is passive and not active, while acceptance is active. Company 5 (C5) employees are actively accepting, stating the "inspiring" aspect of improving processes together with colleagues. C1 employees have an accepting, though not actively, attitude towards LSS projects. They perceive the LSS projects as a possibility to improve one's work, despite how LSS projects have increased work stress for the employees due to improved performance transparency. C3 and C4 employees have an accepting though passive attitude towards the LSS projects. C3 employees agreed that it would be good to implement LSS further and more formally in the organization, feeling that management support for the initiative is lacking and the LSS way of working is fading away. C4 employees cited LSS projects as an ability to discover and develop skills, though are only aware of what the projects are supposed to achieve in the most general terms. C2 employees have a passive rejection attitude and mention that carrying out the required daily activities are a waste of time. The C2 employee indicated that if the LSS projects would stop today, everyone would be relieved.

- Research question 1A: How do attitudes towards Lean Six Sigma projects differ per case?

Almost all managers are accepting toward LSS projects. Narratives that support an active or a passive stance have been registered. More in depth analysis has revealed that in all cases, when managers talk about each other's attitude, references of passive attitudes are being made. This is a signal of 'professional acceptance' in which no personal motivation is felt, though from a functional perspective one cannot be against. In the discourse this observation is supported, as managers indicate that other managers have less acceptance

and employees indicate that managers probably must be accepting. This phenomenon has been described in previous literature; it is theorized that, as management is simultaneously subject to as well as carrying a responsibility to co-implement the quality improvement discipline, a passive or rejecting attitude would hinder the success of the implementation (Boiral, 2003).

- Research question 1B: How do attitudes differ between managers and employees?

Employee attitudes vary more than manager attitudes. Nevertheless, people who are against LSS projects rather lay low than protest. In the discourse this observation is supported, as employees and managers indicate that most employees fear the loss of jobs (rejection) and do not want to be part of and/or understand LSS projects (passive).

2.4.2. Perceived LSS attributes

Four attributes were mentioned most often, being the management involvement aspect of Total Quality Management (C1, C3, C4 and C5), human relations management (C1, C2 and C4), improvement strategies (C1, C3 and C5) and additional metrics (C1, C2). Scientific management (C4), standardization (C5), project management structure (C2) and customer focus (C3) are more fragmentally mentioned. Here, just in time (C1, C2, C3, C4 and C5) and defects control (C1, C2, C3 and C5) were not mentioned (Table 2.2).

Management involvement: Management involvement resulted in clear differences in perception by management and employees. For C1, setting direction and pace and making an example of continuous improvement are all perceived by management as one of their core activities in LSS projects. However, the Black Belt perceived a focus of LSS projects on the workshop floor and employees perceived that lower management was only involved in executing the LSS tooling. C3 management perceives the organization as too undetermined to make the LSS implementation into a lasting success. However, the Black Belts do perceive a culture of continuous improvement among the employees though not enough management involvement in terms of leadership and LSS knowledge. Employees perceive management involvement as too little and are not really sure whether they are expected to continue LSS projects. C4 references are mainly about the perceived determination of top management and the lack of determination and involvement by the middle management. Employees perceive that there is a need for wider commitment towards LSS projects and

that management should enforce this. Today there is too much of a not-invented-here mentality and this hinders the success of LSS projects. For C5, the manager, the Black Belt and the employee indicate that management involvement is important though management doesn't participate in LSS projects (although they do 'allow' it).

Human relations management (HRM): For C1, management and the Black Belt have perceived the bottom up approach of the LSS projects and employees describe how the bottom up character created the possibility to be involved and share ideas. Employees perceived involvement by starting with small scale project and increase effort, while in the meantime receive training in LSS tooling. For C2, the in-house training program, and the level of the in-house Black Belts were mentioned in negative fashion. Still, the continuing effort to train employees at various levels, and ingrain certain daily habits and activities was considered an important aspect of the LSS projects. C4 management has received training (Green Belt) in order to be able to execute LSS projects. Employees perceived that projects are executed by management and are favoring more employee participation.

Improvement strategies: For C1, improvement ideas are generated by employees, in small steps in learning-by-doing fashion. Management perceives this as something which needs constant attention. Employees describe that new ideas for improvement are less easily generated. For C3, management and Black Belts perceive the search for problem root causes, together with all the employees, as a continuous process. Employees perceive improvement strategies as defining the standard and look for ways to improve this standard with a pragmatic approach, without any structure. C5 respondents mention the pleasure in getting together in a multi-disciplined team (improvement strategy). By starting with a joint problem indication, the team worked step by step towards a solution (structured improvement method). The problems were manageable, and because of representation of all departments concerned, decision making was fast and results became quickly visible.

Additional metrics: For C1, additional metrics is mentioned as the discussion about the data in the daily huddle, the so called performance dialogues. One could learn from each other. But even more so data is a burden as one must explain worse or better performance, is the perception. For C2, looking at individual and team performance was described as a blessing for management, but was described as extra work, to be done for management, by the employees at team level.

- Research question 2: How do the perceived Lean Six Sigma attributes differ per case?

Four attributes were mentioned most often, being the management involvement aspect of Total Quality Management, human relations management, improvement strategies and additional metrics. These findings align with previous research. These studies had the objective to find critical success factors for LSS improvement projects (Coronado and Antony, 2002; Brun, 2011) and addressed: (1) Management commitment and support for projects, training, selection and prioritization of projects, (2) the link of LSS to Human Resource Management (HRM), (3) structured approaches to project execution and (4) a focus on metrics. In this study, scientific management, the use of standards, project management structures and customer focus are less frequently perceived and mentioned. Just-in-time and defects control were not mentioned at all.

2.4.3. Framing of the LSS implementation

Context: Management perceive contextual factors to commence LSS implementations mainly as low customer satisfaction due to/or bad reputation amongst customers, the need to reduce the company's cost base by efficiency optimization or to improve the competitive position of the company. Interestingly to note here is that when top management priority is perceived as primary contextual driver, the underlying reason varies between cost reduction, competitive pressure and reputation enhancement. This indicates that not one clear strategic reason resonates as main contextual driver to commence LSS implementation. When top management priority is not perceived, contextual factors such as customer- satisfactory and reputational reasons apply with a direct reference to cost optimizing benefits. Employees perceive contextual factors to commence LSS implementation as the need for cost reduction by means of optimization or a bad reputation amongst customers. Here we see that perception of contextual factors is similar between management and employees. Management does incidentally perceive more- contextual factors than employees or different contextual factors.

Content: The perceived content, or objectives, of the LSS implementation is divided for two groups of managers. One group of management perceives LSS project objectives to be primarily customer oriented with a focus on service and quality improvements in which cost reduction is a means to an end. By improving processes, quality and reducing errors in the service delivery process, higher customer satisfaction will follow. Higher employee efficiency

is one of the means to achieve this; as a result, lower costs will be a significant benefit. The other group of managers perceives LSS project objectives primarily as a focus on cost reduction. Statements such as “people never asked for how many improvements, but do asked about the FTE reduction” are exemplary for this group. Cost base reductions by improving reliability and flexibility of processes are of primary focus.

Employees perceive LSS project objectives to be cost-driven, in which cost reduction is the ultimate objective. Employees have seen FTE numbers decrease ever since the LSS implementation started or feel that the focus on employee efficiency has intensified. By improving service quality and employee efficiency more work can be handled, if necessary with fewer people. Employees do perceive LSS project objectives to be about employee well-being as a means to improve efficiency and reduce the cost base. Employees incidentally perceive employee well-being as a LSS project objective by means of process improvement. Management incidentally believes that employee well-being is an important objective, as a means to better performance, of LSS projects.

All management characterizes the LSS implementation as successful. The projected cost/income advantages have been accomplished, customer satisfaction has increased, better lead times and less rework have been accomplished and directly reporting managers are actively using LSS attributes to continuously improve the service quality of their teams. Reasons for doubt by managers are about the continuity in the way of working and the usage of LSS attributes. Management perceives a growing employee perception of seeing a LSS project as a one-off result and not a way of working in which LSS attributes are continuously applied.

For employees, there is group that is clearly happy about the results of the LSS projects. Colleagues are happier and there are clear examples of reduced waste and better customer service. Also the possibility to learn, participate and make mistakes is mentioned. Despite the perception of success, there is a fear that not everybody is willing to keep on using LSS attributes in their way of working. Another group of employees is not so clear about the results and perceives the LSS projects as unsuccessful. The one-off result is not clear. Though, there has been a change in the way of working which is more focused on continuous improvement. However, the decrease in management attention on LSS projects affects the adoption of LSS attributes throughout the organization.

Hence, we see a difference in the employee and manager perception of the results. Previous research has addressed the gap between management and employee perception of results, whereby management is known to be consuming rhetoric of success to further drive and develop their change initiative (Zbaracki, 1998).

- Research question 3: How does the framing of Lean Six Sigma implementation differ per case?

What stands out is that contextual reasons for LSS implementation are perceived similar amongst managers and employees. This indicates that there is alignment of management and employee framing about why LSS implementation has commenced. Top management reasons to start LSS implementation varies for three cases, but in these three cases employee perception is aligned with management perception of top management reasons. This finding is in line with existing LSS implementation literature that found that a strong and wide recognition of the need for change is an important element (Kumar et al., 2007).

Content perception differs between management and employees. Employees perceive the cost reduction objective the most. Management perceives customer and customer related objectives, such as service and quality improvements which will lead to a better cost base. This indicates that employee perception about LSS project objectives is not fully aligned with management. Contrary to management, employees perceive employee well-being objectives as a means to meet cost reduction, while management generally does not perceive employee well-being as a means to meet LSS project objectives. Employee narratives about well-being highlighted the positive influence of LSS project involvement. This indicates that the importance of employee's in contributing to LSS project objectives is not always addressed by management (this group does not perceive employee well-being).

In two cases, employees indicate that the one-off results of the LSS projects were not clear. In all other cases, management and employees undoubtedly perceived the one-off results as successful. The main reasons for doubt about the success by management and employees lay in the perceived acceptance and adoption of the LSS attributes in the way of working. This indicates the importance of employee involvement and ownership of LSS project implementations. Again, employee narratives about well-being mainly highlighted the positive influence of LSS project involvement. However, only being involved does not ensure on-going LSS attributes adoption by employees.

2.5. Conclusions

Three factors that have stood out in this study are considered.

2.5.1. Employee and manager attitudes; balancing cost-saving and improvement focus

In a negative organizational context with unfavorable market conditions (the 'bad' context), LSS perceptions relate to fear and resistance. In the positive organizational context with more favorable market conditions (the 'good' context), the improvement aspect of LSS projects will naturally receive most attention. Then, both employees and managers seem willing enough to engage in the projects. As was explicitly remarked in C4 (i.e. the hospital), in a context where competition is increasing the quest for efficiency will result in more work that is handled by fewer people. The 'bad' context effect certainly seemed the case in C2. However, market conditions were also unfavorable for C1, C3 and C5, without triggering a negative response to LSS implementation. Even though employees in C5 were faced with a major reorganization, including a significant cost-saving operation, employees did not blame LSS projects as a cause for the loss of jobs. This suggests that market conditions alone are insufficient to predict attitudes towards LSS projects. Managers overall seemed less averse to the cost-saving focus, which consequently weighed less heavily on their overall attitude. It is theorized that managers are less afraid of cost saving initiatives. Managers have a more active attitude, and when faced with adversarial change simply decide to leave the organization (it was stated in C2 that several managers chose to leave the organization when the implementation was started). In most cases (C1, C3, C4 and C5) perceptions of too little management involvement are reported. The result is a lack in LSS- leadership and knowledge as observed by employees and Black Belts. As management expectations are not clear, employee interpretations about the rationale of LSS projects are not managed and can unintentionally induce a 'cost saving' perception of the LSS implementation.

Theoretical propositions: From a theoretical perspective the relation between market conditions, cost-saving versus improvement strategy and employee attitudes towards change projects forms an interesting triangle which allows modeling (and testing) in multiple ways. It can be hypothesized that a relation between market conditions and attitudes to LSS projects exists which is modified by the perceived balance of cost saving versus improvement. This mediating effect is expected to be stronger for employees than for managers.

Recommendations for practitioners: We believe that companies implementing LSS can face a 'cost bias problem'. This means that of all aspects of LSS projects, cost saving is most likely receiving long-lasting and negative attention. In general, best practices in this regard seem to entail at least (1) being clear up-front about the aims of the implementation and (2) decoupling cost saving expectations from LSS implementation in communication and in practice at least below management level. This research shows that management needs to deal consciously and continuously with the cost bias problem.

2.5.2. Perceived LSS attributes; narrow employee and manager perception

For each interviewee a few LSS attributes stood out. Just-in-time production methods as well as supply chain management were not mentioned at all. Standardization, for example, looks to be an important attribute of all LSS projects, but—except for C1— remained implicit. Much the same goes for the element of defects control. Perceived as the most well-known, important and enjoyable way to be involved as employees and management is in solving problems and looking for root causes (C1, C3 and C5). Four LSS attributes are perceived repeatedly (TQM, HRM, improvement strategies, metrics), whereas others such as just in time or defect control are not mentioned at all (C1-C5). One explanation is that service industries do not produce services in advance and are therefore less subject to the concept of pull. Hence, there is a tendency for managers and employees to base their attitude towards LSS projects on just a few attributes.

Theoretical proposition: In this study, the framing of the LSS project implementations is quite narrow compared to the broad scope of the LSS attributes that are applied in the LSS projects. In conjunction with the aforementioned cost bias problem, a particularly narrow framing seems to further encourage strong responses. We can hypothesis that the more narrowly LSS project implementation is portrayed, the stronger either a negative or positive response will be. This can be an avenue for further research.

Recommendations for practitioners: The discussion suggests that conscious effort seems required to keep emphasizing a broad range of LSS attributes, both communicatively and in practice. As the content frames of LSS project implementation are generally quite narrow, attempts to broaden the perception of the projects to include much more than, say, improvement strategies and standardization has a positive effect on the perception LSS projects.

2.5.3. Employee and manager framing; differences in LSS approaches

C1 and C5 was framed as the most involving LSS implementation, actively engaging employees in the entire implementation, with both employees and management framing the implementation as bringing lasting change, and creating bottom-up demand for further projects. C2 was characterized by a strong top-down implementation. C4 was characterized by a similar approach, with LSS explicitly framed as a tool which could be used to achieve certain goals in specific situations and was targeted to a large extent at the managerial level. For C2 and C4 specifically, managers were wondering how to implement a 'next step', noting that despite significant investments the implementation would not carry on without continued management pressure and support. Managers were wondering when the LSS projects would realize bottom-up participation and noticeable cultural change. The implementation in C3 could best be described as 'unobtrusive', with no significant pressure towards either employees or management to implement LSS projects. There was no sense of bottom-up initiative carrying the projects further, with implementation being portrayed as 'instrumental' in nature. The purported idea behind it was that the organization could have achieved more over the past years when the implementation was carried bottom-up. No firm viewed implementation of LSS projects as a way to distinguish it from others or to obtain sustainable competitive advantage.

Recommendations for practitioners: Based upon our findings, there is a distinction between quick wins (gained from discrete LSS project implementation) and long-term goals (targeted by a more involved approach). A tension between long-term incremental improvement supported by Lean theory, and a more radical directed approach purported by Six Sigma methods seems at play. Our research suggests that while the Six Sigma project approach can have a larger and more immediate effect, the drive required to keep the initiative going after initial management-initiated projects are exhausted comes from a much more gradual and bottom-up implementation of LSS at the shop floor level.

2.6. Limitations and further research

We acknowledge that our methodological approach has some drawbacks.

2.6.1. Limitations

The first thing to note may be that interview selection was biased up front towards employees (and managers) actively involved in LSS projects. It would take some courage to come forward for people who actively resist the projects. Of all the people invited, those with the most positive attitude towards LSS would be more likely to accept the invitation. Secondly, we run the risk of falling for the narrative fallacy. The narrative fallacy entails the fact that we humans tend to make sense of events after they have occurred, constructing and simplifying meaning, breaking down complex stories to manageable accounts (Kahneman, 2011). This plays a role, for example, in the question which attributes of LSS received most attention. Thirdly, one of the drawbacks of open-ended interviews and qualitative case studies in general is the low generalizability of research findings. The small sample size and uniqueness of each data point forces us to carefully limit the scope and ambition of our research conclusions. Another inherent drawback of the research setup is the fact that the evidence gathered is mostly anecdotal in nature. The danger lies in taking one account of a certain phenomenon and turning it into a generalized statement. Aware of this problem we have attempted faithfully to re-construct the accounts for each case using all the available data.

2.6.2. Further research

Interesting questions for further research are the particular change characteristics associated with LSS project implementations. LSS requires change to be both incremental and radical (Womack and Jones, 2003), technical and cultural, organizational and behavioral (Bhasin and Burcher, 2006), top-down and bottom-up, and systemic and local (Bicheno and Holweg, 2009). These requirements seem to be contradictory. The concept of dualities places central emphasis on this idea (Seo et al., 2004). Seo et al. (2004) have listed 8 different dualities, together forming the 16 change characteristics. It would seem worthwhile to further research how one should manage such dualities in LSS implementations, an endeavor which we further investigate in chapters 5 and 6.

3. Inter-industry generic LSS project definitions

When implementing LSS projects in organizations, the success of such LSS projects is largely determined by the clarity of the project definitions and objectives. Unclear LSS project objectives results in diverging views of the same project by project leaders, managers and employees and this leads to different views of what entails relevant and successful project. We therefore investigate what LSS project definitions are most common and present a set of generically applicable project definitions. This chapter is based on Lameijer et al. (2016b).

3.1. Introduction

The LSS project methodology follows a project-by-project structure, aiming to solve organizational problems. These projects are managed according to the five-phased define, measure, analyze, improve, and control (DMAIC) cycle (De Mast and Lokkerbol, 2012). Despite this clear structure, not all LSS projects meet their prior set objectives for various reasons (Arumugam et al., 2014). Scholars have started investigating key determining factors that are impeding successful LSS project execution and adoption, in which the clarity of the project definition is highlighted as one of the most important factors for project failure (Lynch et al., 2003; Linderman et al., 2003). In practice, a broad variety of LSS project definitions are distinguished. Unclear project definitions can result in diverging views of the same project by the project leaders (Green Belts or Black Belts) and project sponsors (champions), which will lead to different views of what entails a relevant and successful project. Missed deadlines or even project termination may be the outcome. The objective of this research is to enhance the quality of the LSS project definition phase by establishing well defined and useable generic LSS project definitions including generic Critical To Quality (CTQ) (De Koning and De Mast, 2007) measures, for multiple industries.

Section 3.2 provides a discussion on the literature concerning generic project definitions. In section 3.3 the research methodology is elaborated, after which we present the results and discuss the generic LSS project definitions in section 3.4. Section 3.5 presents the conclusions and section 3.6 ends with the limitations and avenues for further research.

3.2. Literature review on LSS project definitions

Juran's (1986) early notion that operational excellence initiatives such as Total Quality Management (TQM) are universally applicable has not been agreed upon. As a result, a contingency perspective started to emerge; industry or organizational conditions, under which the uses of different aspects of operational excellence implementations (such as TQM) are effective, were studied (Sitkin et al., 1994). Addressing the culture (Detert et al., 2000) and interacting aspects of systems such as processes, people and machines became acknowledged as important determinants of the effect of operational excellence implementations (Foster, 2008). Consequently, empirical as well as case studies have been conducted in the field to identify unique critical success factors for LSS projects (and are introduced in section 1.5) (Coronado and Antony, 2002; Brun, 2011).

Subsequently, scholars have started investigating factors that are impeding successful LSS project execution and adoption. Amongst others (1) a lack of management commitment (McAdam and Evans, 2004), and (2) more precisely the inadequate involvement of management in project selection and involvement during the project life cycle (Nonthaleerak and Hendry, 2008) and (3) poor resource allocation are factors that adversely affect LSS project success.

3.2.1. LSS project definitions

A substantial part of the key determinants that have a negative effect on LSS project success are most likely to emerge in the project definition phase. The correct definition or sequencing of LSS projects (Chakravorty, 2009a), vague definitions of LSS project expectations (Szeto and Tsang, 2012) and finally LSS coach availability for LSS projects (Nonthaleerak and Hendry, 2008) are known determinants that impede LSS project success. This is corroborated by findings that highlight the clarity of the project definition as most important factors for project failure (Lynch et al., 2003; Linderman et al., 2003).

Project definitions, whereby strategic objectives are related to operational project goals, can be operationalized with a balanced scorecard (Kaplan and Norton, 1992) or a CTQ flow down (De Koning and De Mast, 2007). The CTQ flow down relates high level strategic focal points to project objectives and in their turn, project objectives are related to and decomposed into CTQ's. The CTQ's are operationalized in the form of measurements, as displayed in figure 3.1.

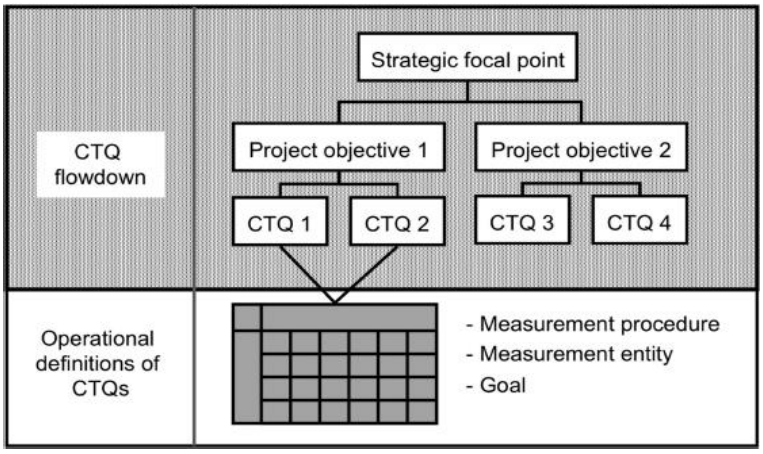

Figure 3.1: LSS project definitions comprising CTQ flow down and operational definitions

The CTQ flow down has several objectives. Besides providing clear project definitions, it clarifies the business rational of an improvement project (e.g. 'what needs to be improved'). CTQ flow down's help to focus on the vital few real business drivers and thereby facilitate problem solving. For LSS, the CTQ flow down has emerged as a more widely applied LSS project definition method, being project specific and less holistic than the balanced scorecard. With a CTQ flow down, strategic project objectives are related to project goals and further decomposed into CTQ's. CTQ's are then made operational in terms of measurement procedures (De Koning and De Mast, 2007; Zu et al., 2008).

3.2.2. LSS performance dimensions

Since the use of CTQ flow downs by practitioners has evolved, researchers have tried to define generic LSS project definitions. Scholars have compared CTQ flow downs from separate industries. In each of these industries, the generic CTQ templates emphasize several performance dimensions. To distinguish the different performance dimensions we specifically draw upon the cumulative capability model by Ferdows and De Meyer (1990). The cumulative capability or the 'sand cone' model has been central in the academic debate on the effect of performance dimensions on business results. For a comprehensive review on the 'sand cone' model, see Schroeder et al. (2011) or Bortolotti et al. (2015) and for previous performance dimensions categories, see Smith (2000). The central thesis of the sand cone model is that business results follow an accumulation of performance dimensions, of which quality is the foundation. In general, the cumulative capability model distinguishes five performance dimensions:

- Quality: Meeting the needs and wishes of customer, effectiveness and suitability of the services, courtesy, expertise and skills of the supplier, quality of the service, et cetera.
- Dependability and safety: Failures, mistakes, rework, punctuality, keeping promises.
- Speed: Throughput time, waiting time, time of service, admission times.
- Flexibility: Ability to adapt the process to changes in demand (fluctuations in workload, specific needs of customers, range and customizability of services offered).
- Cost efficiency: Efficient use of man-hours, facilities, material.

These five performance dimensions serve as a framework for further exploration on the existent generic CTQ flow downs. We examine per industry which performance dimensions are addressed by generic CTQ flow downs.

3.2.3. Generic LSS project definitions

Scholars have generated generic classifications of LSS projects that serve a common performance dimension. The first research stems from the healthcare industry by Does at al. (2006), where nine categories have been identified (Does et al., 2006; Niemeijer et al., 2011). The identified project definitions correspond to four out of the five performance dimensions and the primary focus in healthcare seems to be on the cost efficiency performance dimension. This initial research by Does et al. (2006) turned out to be a landmark paper for future retrospective analyses of LSS projects on other sectors. Consequently, in the finance industry, research has found eight generic categories of project definitions, which correspond to three of the five performance dimensions of the cumulative capability model (De Koning et al., 2008; Lokkerbol et al., 2012). The publishing industry has been subject to similar research into generic project definitions as in finance and healthcare. Seven generic project definitions are identified and three out of the five performance dimensions are addressed by this research (De Koning et al., 2010). Studies in the construction industry have generated seven project definitions; thereby addressing four out of the five performance dimensions (Van den Bos et al., 2014). Comparing these four industries shows that the focus of generic project definitions is mainly on the performance dimensions quality and cost efficiency (see Table 3.1). Differences in project definitions and underlying CTQ's appear to be more semantic than substantial. For instance: 'Improving process efficiency' by optimizing man-hour utilization and 'improving productivity of personnel'.

	Generic category of project definitions	Quality	Dependability	Speed	Flexibility	Cost Efficiency
Finance industry						
1	Decreasing operational cost by improving processing efficiency					X
2	Decreasing operational cost by using cheaper channels (automation)					X
3	Improving revenue by increasing customer satisfaction	X				
4	Improving revenue by servicing more customers	X				
5	Decreasing operational losses		X			
6	Improving business decision making	X				
7	Increasing customer satisfaction and improving processing efficiency	X				X
8	Increasing revenue by increasing timeliness of received payments			X		
Healthcare industry						
1	Reduce costs by improving productivity of personnel					X
2	Reduce costs by improving utilization of equipment / facilities					X
3	Reduce costs by improving purchasing processes					X
4	Reduce costs by reducing unnecessary use of resources					X
5	Reduce costs by reducing inventory					X
6	Improve safety by reducing complications and incidents		X			
7	Increase revenue by improving registration		X			
8	Increase revenue by increasing the number of admissions			X		
9	Increase revenue by increasing capacity					X
Publishing industry						
1	Revenue improvement by servicing more customers	X				
2	Cost reduction by improving efficiency of processes					X
3	Improvement of customer satisfaction and processing efficiency	X				X
4	EBIT improvement by reducing discounts and cost of sales channel					X
5	Cost reduction by improving efficiency of internal processes and sourcing effective suppliers	X				X
6	Cost reduction by improving forecasting					X
7	Working capital reduction by improving cash management and fast delivery			X		X
Construction industry						
1	Increase profitability of sales by reducing cost of sales					X
2	Reduce operational cost by reducing realized costs					X
3	Increase customer satisfaction (and reduce cost) by reducing the number of defects	X				X
4	Reduce costs by optimizing cost of warranty claims and inspection		X			
5	Reduce costs by reducing purchases and time to handle purchases					X
6	Increase profitability by reducing lost income					X
7	Increase customer satisfaction (and reduce costs) by improving the throughput time of delivery and the quality of complaints handled		X	X		X

Table 3.1: Generic LSS project definitions that are addressed in previous research

An academic attempt to integrate the intra-generic project definitions of these four industries into inter-generic project definitions has not been performed to date. In addition, outside of these four industries, no generic project definitions have been researched. The objective of this research is to establish inter-industry generic project definitions applicable for LSS practitioners in multiple industries.

3.3. Research methodology

The objective of this research is to provide practitioners with rules and guidelines for the LSS project definition phase. These rules and guidelines can be discovered through analysis of previous project definitions (Niemeijer et al., 2011). However, project definition is generally an ill-structured task and is hard to capture with rules and guidelines (Lokkerbol et al., 2012). For such ill-structured tasks, an alternative method is provided, by initially artificial intelligence researchers, in the form of Case Based Reasoning (CBR) (Aamodt and Plaza, 1994). CBR is a paradigm that allows for problem solving and decision making that is not based on knowledge framed in rules, guidelines and principles. CBR is a problem solving paradigm that uses specific knowledge of previously experienced and detailed problem situations. A problem is solved by finding similar past cases to reuse in the new problem situation. Further benefits of the CBR methodology comprise the element of sustained learning. New experiences are retained each time a problem has been solved (e.g. a project definition has been successfully applied) and are thereby made available for future problems (e.g. future project definition phases). CBR originates out of the cognitive sciences and its classical definition is that a case based researcher solves problems by using or adapting solutions from old problems (Watson, 1999). CBR is characterized by the CBR-cycle, comprising four main activities.

- Retrieve cases that share a similarity to the problem at hand (e.g. past project definitions)
- Reuse a solution that is suggested by a similar case
- Revise or alter the solution to better fit the problem when necessary
- Retain the newly found solution once its effectiveness is confirmed and validated

The research applies a case based reasoning approach to a substantial collection of past LSS project definitions (cases). This research thereby provides accessible experience and sustained learning that is structured into inter-industry generic LSS project definition templates by application of the CBR-cycle (see Figure 3.2).

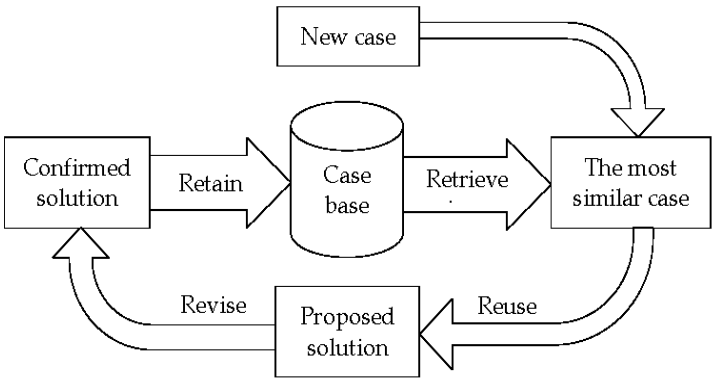

Figure 3.2: CBR method

3.3.1. Research strategy

The sample consists of 312 LSS improvement projects that are executed in a broad variety of industries. All these projects have followed the LSS methodology and are characterized by the use of CTQ's and the structured DMAIC improvement method (De Mast and Lokkerbol, 2012). The LSS projects in the sample have been performed by LSS practitioners (Black Belt and Master Black Belt), all trained by the University of Amsterdam. From 2005 onwards, the university has certified 312 Black Belts and Master Black Belts. From each student, the last LSS project that was executed for certification served as input for the sample of this study. By doing so, struggles in finding the right CTQ flow down in the first projects are filtered out. Table 3.2 provides an overview of the amount of projects per industry, their total benefit and the time range in which these projects have been executed.

Industry (SIC)	Amount of projects	Total benefits (EUR)	Time range of projects
Agriculture, Forestry, Fishing	2	€ 670.000	2007 – 2007
Construction	36	€ 10.778.888	2003 – 2015
Finance, Insurance, Real Estate	63	€ 10.219.144	2006 – 2015
Manufacturing	105	€ 36.267.774	2005 – 2015
Public Administration	22	€ 6.003.891	2008 – 2015
Retail Trade	3	€ 524.000	2014 – 2014
Services (including Healthcare)	52	€ 4.020.377	2006 – 2015
Transportation and Public Utilities	29	€ 6.911.770	2009 – 2014
Total	**312**	**€ 75.395.844**	**2003 - 2015**

Table 3.2: LSS projects of study sorted by Standard Industrial Classification code (SIC)

The projects vary on multiple dimensions, such as industry, the objective of the project and size of the projected benefits. Each of the studied project definitions included at least:

- A business case
- A (macro level) process map
- Key performance indicators that are to be improved, CTQ´s in LSS terminology
- CTQ flow down (indicating the relation between CTQ's and the strategic company goals)
- An operational definition for each CTQ
- A description of the measurement procedure for each CTQ

For an overview of acceptance criteria for LSS projects per DMAIC phase, see table 3.3.

Define	Measure	Analyze	Improve	Control
Project charter	CTQ flowdown	Process behavior in time	Select important influence factors	Process documentation
SIPOC	Operational definitions	Process capability analysis	Determine effects of influence factors	Control plan
Flowchart	Measurement plan	Value stream map	Summarize your evidence	Roles and responsibilities
Benefit analysis	Validity of the measurements	Updated project objectives	Design improvement actions	SPC and other process controls
Organization (time, review board)	Precision: Gauge R&R or kappa	Brainstorm session / group meetings	Should-be process map	Logs, dashboards, Q-reports
Stakeholder analysis	Measurements started	Expert interviews		Mistake proofing
		BOB vs WOW / autopsies		Benefit realization of improvements
		FMEA analysis		Implementation plan and benefit tracking
		Process inefficiencies identified		Project documentation
		Process matrix completed		Follow-ups are scheduled

Table 3.3: University of Amsterdam acceptance criteria for LSS projects

This research aims for analysis at the intermediate level of detail. Project specifics are removed; project objectives are unit of analysis. This organizing principle establishes reusable elements from each project definition. Nevertheless, lessons learned from the corresponding strategic objectives in each of the individual project definitions are discussed in section 3.5.

3.4. Results and discussion

The research and analysis resulted in generic LSS project definitions in four performance dimensions. For flexibility no individual projects have been identified and therefore no generic project definitions are presented. For each of the performance dimensions, individual LSS project definitions have been distilled into 'general areas of improvement'. The areas of improvement are then generalized into distinct generic LSS project definitions (see Table 3.4).

Performance dimension ⇒	**General areas of improvement ⇒**	**Generic project definitions**
Quality	Improvement of quality Improvement of customer satisfaction	Improving perceived quality
	Reduction of customer complaints	Improving customer satisfaction
Dependability and Safety	Improving first time right	First time right improvement
	Reducing the amount of rework	Rework reduction
	Reducing operational losses	Operational loss reduction
	Reducing the amount of disturbances	Process reliability improvement
Speed	Reduction of cycle time	Cycle time reduction
	Reduction of idle time (waiting) Improving timeliness of the process	Idle time reduction
Cost efficiency	Improving human capital efficiency Reducing FTE Reducing the illness absence rate Improve employee satisfaction Reduce processing times	Human resource efficiency
	Increase the process output Reduction of required resources Improving productivity	Overall operating efficiency
	Reduction of inventory levels	Inventory optimization
	Reduction of selection costs Reduction of general costs	General cost reduction
	Improving the margin Improving business operations results	Margin optimization

Table 3.4: General areas of improvement per performance dimension, generalized into generic LSS project definitions

In the next section, each generic LSS project definition and the underlying specifics will be presented and elaborated. Detailed operational definitions will be given, stating the unit whereby the CTQ is measured. Then, a measurement procedure for the CTQ's is proposed and finally a goal for the CTQ's is defined. LSS practitioners looking for further guidance on the operationalization of measurement plans are referred to Kemper and De Mast (2013).

These results are considered helpful for practitioners setting up their project definition and subsequent research strategy. Additionally, combinations of generic performance dimensions can be applied by practitioners. For instance, improving the reliability of the process while simultaneously improving the speed of the process can go hand in hand. The practitioner can select the applicable generic project definitions based upon the project scope and objectives and combine these where necessary.

3.4.1. Generic LSS project definitions for performance dimension quality

Two generic LSS project definitions for performance dimension quality are proposed (see Table 3.5). Example projects from the quality dimension may be found in Van den Bos et al. (2014).

Generic LSS project definitions for performance dimension quality				
Project objective	**Generic CTQ's**	**Measurement unit**	**Measure procedure**	**Goal**
Improving perceived quality	Amount or percentage of warranty cases or claims	Per day / per week	Job tracking system	As little / low as possible
	Amount or percentage of customer enquiries	Per day / per week	Job tracking system	As little as possible
	Cycle time of product or service delivery	Per job (purchase)	Time stamps /Job tracking system	As short as possible
	Amount or percentage satisfied customers	Per customer	Interviews / Surveys	As much / high as possible
Improving customer satisfaction	Amount or percentage complaints or disruptions	Per day / per week	Job tracking system	As little / low as possible
	Timeliness of response	Per product or service	Time stamps / Surveys / Interviews	As short as possible
	Cycle time of product or service delivery	Per product or service	Time stamps / Job tracking system	As short as possible
	Cost of ownership	Per customer	Interviews / Surveys	As low as possible
	Amount or percentage of satisfied customers	Per customer	Interviews / Surveys	As much / high as possible

Table 3.5: Generic LSS project definitions for performance dimension quality

Improving perceived quality: We find that the actual quality is not of primary interest here. CTQ's of individual project definitions were defined as amount of customer complaints or enquires (as a result of lower than expected quality). These CTQ's refer to the perceived quality and subsequent action by the customer (sending in a complaint or enquiry).

Improving customer satisfaction: CTQ's for this generic project definition comprise those elements that are considered valuable for customers. CTQ's of the general area 'reduction of complaints' have been included in this generic project definition, as logic dictates that a reduction of complaints is followed by improved customer satisfaction.

A remarkable finding is that both generic project definitions only have internal CTQ's for customer satisfaction (complaints or enquiries as a result of non-satisfaction). Hence, when customers do not actively provide their feedback in terms of enquiries or complaints, the level of customer satisfaction would remain unknown. Therefore we propose an additional CTQ in both generic project definitions, being the actual level of customer satisfaction about the product or service.

3.4.2. Generic LSS project definitions for performance dimension dependability

Four generic LSS project definitions for the performance dimension dependability and safety are proposed (see Table 3.6). Exemplary projects from the dependability dimension may be found in Kemper et al. (2011) and Mooren, De Mast and Does (2012).

First time right improvement: First time right improvement is an integration of first time right improvement and reducing the amount of errors in product- or service delivery. The CTQ´s concern the amount of products or services that are rejected or repaired and subsequently what the costs per repair are. In addition, the amounts of products or services that have not been signaled are of interest, as this indicates the ability to detect poor quality before the final user does.

Rework reduction: Rework reduction is about the consequence of not achieving first time right objectives and having rework. Nevertheless, first time right improvement and rework reduction are not the same. When products or services are not first time right, it is still a managerial decision to rework the product or service. The CTQ´s for rework reduction specify the amount of rework, the time allocated on rework and the cost per rework.

Operational loss reduction: Operational loss reduction is concerned with two types of loss. The first entails the waste that is incurred in the production process of the product or service. The other is when a product or service is ready for delivery and the full margin on the product or service is not collected due to various reasons, such as claims due to malfunctioning, overdue or non-payment by clients and impaired products or services.

Generic LSS project definitions for performance dimension dependability and safety				
Project objective	**Generic CTQ's**	**Measurement unit**	**Measure procedure**	**Goal**
First time right improvement	Amount or percentage of products or services that are rejected or repaired	Per day / per week	Job tracking system	As little / low as possible
	Amount or percentage of products or services that should be rejected or repaired, but are unnoticed	Per day / per week	Job tracking system	As little / low as possible
	Cost per product or service that is rejected or repaired	Per product or service	From ERP or other logging system	As little as possible
Rework reduction	Amount or percentage of products or services that are reworked on	Per day / per week	Job tracking system	As little /low as possible
	Time spent per product or service that is reworked on	Per day / per week	From ERP or other logging system	As little as possible
	Costs per product or service that is reworked on	Per product or service	From ERP or other logging system	As little as possible
Operational loss reduction	Amount of products or services	Per day / per week	Job tracking system	As little as possible
	Amount or percentage of waste or loss per product or service	Per day / per week	Job tracking system	As little / low as possible
	Costs of waste or loss per product or service	Per product or service	From ERP or other logging system	As little as possible
Process reliability improvement	Percentage deviation to product or service norm	Per production cycle	Job tracking system	As low as possible
	Percentage deviation to product or service cycle time norm	Per production cycle	Job tracking system	As low as possible
	Percentage of test accuracy norm or test duration norm	Per production cycle	By means of experiments with a sample	As high as possible
	Amount of process disruptions (blockages) or accidents	Per production cycle	From ERP or other logging system	As little as possible

Table 3.6: Generic LSS project definitions for performance dimension dependability and safety

Process reliability improvement: Process reliability improvement is concerned with process deviations from the norms. The previous three generic project definitions are focusing on the variability of the product or the service. Whether it is cycle time or product specific norms, this generic project definition allows for exact measurements of other than expected process metrics. The CTQ's percentage deviations to part or case norm and cycle time are focused on operating the process according to the designed standards and thereby measure operational effectives of the process. Test accuracy holds the ability to truly detect deviations. Blockages and accidents cover disruptions in the process, making the process non-operational.

3.4.3. Generic LSS project definitions for performance dimension speed

Two generic LSS project definitions for the performance dimension speed are proposed (see Table 3.7). Delivering a product or service faster to the final user is achieved by improving cycle time. Idle time reduction makes a process more efficient and/or enjoyable by specifically targeting waiting in the process. By reducing the capacity mismatch, and thereby improving the speed and decrease the waiting (when the client is part of the process), a reduction in idle time is achieved. Example projects in this dimension are published in Schoonhoven, Lubbers and Does (2013) and Erdmann, Janssen and Does (2013b).

Cycle time reduction: The generic project definition of cycle time reduction focuses on the end to end process, meaning from customer demand to customer delivery. The deviation from required cycle time is the first CTQ, stating the actual cycle time performance of the process compared to the desired cycle time. Then, non-value added and value added processing time, idle time, amount of errors in the process and time to repair an error are the CTQ's. These CTQ's are to be improved in order to reduce the cycle time and achieve an acceptable cycle time.

Idle time reduction: Idle time reduction is primarily concerned with time waiting (idle time) in the product or service delivery process, because of suboptimal process capacity planning. The CTQ's focus on required capacity to deliver the product or service and compare this to the available capacity. Here, capacity is not just human capital, non-human capital such as production line availability, computer processor availability, etcetera is relevant. The last CTQ is concerned with the time spent per unit of production or service.

Thereby, it is possible to calculate what the over- or under capacity in the process is and what the result for idle time in the process is.

Generic LSS project definitions for performance dimension speed				
Project objective	**Generic CTQ's**	**Measurement unit**	**Measure procedure**	**Goal**
Cycle time reduction	Amount or percentage overdue cycle time norm	Per day / per week	Time stamps / Job tracking system	As little / low as possible
	(Non) value added processing time in the process	Per product or service	Time stamps / Job tracking system	As low as possible
	Idle time in the process	Per product or service	Time stamps / Job tracking system	As low as possible
	Amount or percentage of products or services that are rejected or repaired	Per day / per week	Job tracking system	As little / low as possible
	Time spent per product or service that is reworked on	Per day / per week	From ERP or other logging system	As little as possible
Idle time reduction	Amount of capacity demand (in unit of production or service)	Per day / per week	From ERP or other logging system	As close to capacity available as possible
	Amount of capacity available (in unit of production or service)	Per day / per week	From ERP or other logging system	As close to capacity demand as possible
	Time spent per unit	Per product or service	Time stamps / Job tracking system	As close to norm as possible

Table 3.7: Generic LSS project definitions for performance dimension speed

3.4.4. Generic LSS project definitions for performance dimension cost efficiency

Five generic LSS project definitions are proposed (see Table 3.8) and address the efficient use of human capital and non-human capital. Many example projects are available; see Erdmann et al. (2013a), Kuiper et al. (2014), Lokkerbol et al. (2012), Zwetsloot et al. (2015a) and Zwetsloot and Does (2015b).

Human resource efficiency: The generic project definition of human resource efficiency is frequently observed. Here, the aim is to utilize human capital as efficient as possible. Total cycle time serves as the denominator in the calculation of process efficiency. The sums of non-value added / value added processing time and idle time serves as the numerator resulting in process efficiency. Capacity mismatch serves to catch the effect of human resource inefficiency on product or service delivery backlog (as explanation for cycle time overrun, when applicable). If the capacity according to existing efficiency standards is not sufficient to keep up product or service demand, backlogs will be the result. When human resource efficiency improves, the capacity mismatch should balance out to zero.

Generic LSS project definitions for performance dimension cost efficiency				
Project objective	**Generic CTQ's**	**Measurement unit**	**Measure procedure**	**Goal**
Human resource efficiency	Cycle time	Per day / per week	Time stamps / Job tracking system	As low as possible
	Amount or percentage of capacity mismatch	Per day / per week	From ERP or other logging system	As little / low as possible
	(Non) value added processing time in the process	Per day / per week	Time stamps / Job tracking system	As low as possible
	Amount or percentage idle time	Per day / per week	Time stamps / Job tracking system	As little / low as possible
	Amount or percentage satisfied employees	Per employee	Interviews / Surveys	As much / high as possible
Overall operating efficiency	Cycle time	Per day / per week	Time stamps / Job tracking system	As low / timely as possible
	Amount or percentage of capacity usage	Per day / per week	From ERP or other logging system	As much / high as possible
	Amount or percentage of productivity (units in time)	Per day / per week	From ERP or other logging system	As high / much as possible
	Amount or percentage of products or services that are rejected or repaired	Per day / per week	Job tracking system	As little / low as possible
	Amount or percentage idle time	Per day / per week	Time stamps / Job tracking system	As little / low as possible
Inventory optimization	Turnover time of inventory	Per product / batch	Time stamps / Job tracking system	As low / optimal as possible
	Amount or percentage of inventory surplus	Per day / per week	From ERP or other logging system	As little / low as possible
	Amount or percentage of inventory loss	Per day / per week	From ERP or other logging system	As little / low as possible
	Cost per inventory unit	Per product / batch	From ERP or other logging system	As low as possible
General cost reduction	Overall costs	Per day / per week	From ERP or other logging system	As little / low as possible
	Amount or percentage of units in use	Per day / per week	From ERP or other logging system	As little / low as possible
	Amount or percentage of cost surplus per unit	Per day / per week	From ERP or other logging system	As little / low as possible
	Amount or percentage of products or services that are rejected or repaired	Per day / per week	Job tracking system	As little / low as possible
Margin optimization	Amount or percentage of margin on units	Per product / service	From financial systems	As much / high as possible
	Amount or percentage of conversion (per channel)	Per day / per week	From sales database	As much / high as possible

Table 3.8: Generic LSS project definitions for performance dimension cost efficiency

Overall operating efficiency: Overall operating efficiency is the most similar to the human resource efficiency and is the non-human resource equivalent. Objective of this generic project definition is to optimize the efficiency of operations. The CTQ cycle time serves as the denominator in the calculation of process efficiency. Productivity, amounts rejected or repaired, and idle time is serving as the numerator in the calculation. The CTQ capacity usage serves to catch the effect of operating inefficiency on product or service delivery backlog (as explanation for cycle time overrun, when applicable). If the capacity is not sufficient to keep up product or service demand, backlogs will be the result. When operating efficiency improves, the capacity mismatch should balance out to zero.

Inventory optimization: Inventory optimization has the objective to organize inventory as efficient as possible. Turnover time of inventory as CTQ in combination with cost per inventory unit measures the inventory costs per product group per timeframe. The inventory surplus (in raw, work-in-progress and finished state) should be reduced, just as losses in inventory. Optimally, turnover time of inventory is as short as possible and inventory surplus should not ascend below zero, meaning not being able to deliver.

General cost reduction: General cost reduction is defined by those project definitions with no specific cost reducing objective. Overall cost as CTQ is about reducing the cost level, by investigating the current cost base. Units in use help specify the search for cost reduction improvements by the amount of costs per unit X or Y and subsequently being able to specify what the surplus in costs per unit X or Y is. This allows for comparison of the cost base (surplus) per unit making it possible to identify root causes for higher costs. Finally, rejects or repairs incur unnecessary costs, making it an opportunity to reduce costs.

Margin optimization: Margin optimization is the first generic project definition that solely focuses on improving income generation instead of reducing the cost base / delivering the sales more efficiently. Margin optimization consists of the margin on a product or service (unit) and the conversion ratio.

3.5. Conclusions

This research resulted in thirteen inter industry generic project definitions that are divided by the four performance dimensions quality, dependability, speed and cost efficiency. In the process of analyzing the data and presenting the generic project definitions, three factors that have stood out in this research are discussed. The factors are (1) the difficulty to capture the performance dimension flexibility in LSS project definitions, (2) the strong focus on organizational benefits in defining CTQ's and (3) the unclear alignment of LSS project definitions to existing strategic objectives of the organization.

3.5.1. Performance dimension flexibility in LSS project definitions

The analyzed project definitions have corresponded to all performance dimensions but flexibility. We believe this is because the variety in meaning for the definition of flexibility is broad (see Neely et al. (2005) for a review). Flexibility can be about varying production volumes (Weelwright, 1984) or a company's ability to achieve a short time to market in new product development (Tunälv, 1992). In essence, the distinction lies in product flexibility (customization), volume flexibility (adjusting capacity), launch and time to market flexibility, access flexibility (distribution coverage) and responsiveness to target market flexibility (Vickery et al., 1999; Koste and Malhotra, 1999).

Therefore we believe that in this study the flexibility dimension is not separately addressed due to the ambiguousness and interrelatedness with other performance dimensions. For example, adjusting human or non-human resource capacity to a change in demand can be categorized as performance dimension flexibility (volume flexibility) though also as cost efficiency (an unwanted progressive increase in cost base by up- or down scaling capacity to be flexible). This would depend on the transcending strategic objective providing the rationale for the project. For performance dimensions dependability, speed and quality; maintaining or improving process and product or service reliability, speed or quality over time, while demands are changing and flexibility is needed, can be categorized as flexibility or as dependability, speed or quality. This, in our view, depends on the perspective of the project objective, being internally or externally focused. When reasoned from the customer (externally), flexibility means receiving a new product or service without mistakes, fast and adhering to quality standards. When reasoned from the company, flexibility means delivering a product or service without mistakes (dependability), fast (speed) and with

adherence to quality standards (quality). Hence, flexibility is a broad definition and should be made specific in LSS project definitions to capture the actual project objective and provide focus for the LSS practitioner and project stakeholders.

3.5.2. Strong focus on organizational benefits in LSS project definitions

The generic project definitions in all four performance dimensions are failing to address CTQ's that measure the performance beyond the borders of the organization. For instance, generic project definitions try to capture external (customer) opinions my measuring internal signals of unsatisfied customers (complaints); perceived quality is measured by amount of warranty claims and enquiries. Another example is the performance dimension dependability that primarily consists of internally measured CTQ's, such as rejects, repairs and deviations to internal norms. This does not address the reliability as experienced by customers or end-users (which would then be labeled as performance dimension quality). For the performance dimension speed, focus is on the internal elements that make up cycle time. Cycle time consists of several parts, such as processing time, idle time, and time taken to repair rejects. Elements such as time for distribution and transportation to the client are not addressed. Finally, the performance dimension cost efficiency consists mainly of generic project definitions aiming to improve efficiency that are internally measured.

The essence lies in the failure to address CTQ's for the end-user in LSS project definitions, and instead focus on internal processes and not on external results, which is a known phenomenon for TQM (Harari, 1993). For the performance dimension quality we have proposed the CTQ "amount or percentage of satisfied customers" for the project objectives "improving perceived quality" and "improving customer satisfaction". Hence, we urge LSS practitioners to consider the end-users while setting the project objective and choosing the CTQ's to ensure actual improvement instead of problem signal reduction.

3.5.3. Alignment of LSS project definitions to strategic objectives

Each of the LSS project definitions contained transcending strategic focal points, thereby aligning the LSS project objectives to the strategic objectives of the company. Previous literature on TQM addresses the importance of aligning project objectives to existing company strategy. Strategic alignment is considered key to acceptance and even adoption of TQM as a way of working in companies (Lau and Anderson, 1998). Further research suggests

that management accounting systems should satisfies the need for information that supports a continuous improvement oriented culture, such as information on quality delivery (Wruck and Jensen, 1994) (Hoque and Alam, 1999). In other words, the improvement objectives must be integrated in the objective function of the firm in order to facilitate; (1) mutual understanding and discussions about areas of improvement, (2) establishment of improvement goals, feedback on improvement progress and specific improvement results to be forecasted and (3) employee reward and motivational programs for encouragement of improvement potential realization (Lau and Anderson, 1998). In the sample of LSS project definitions, a wide variety of strategic focal points were identified. The strategic focal points could mostly not be related to general accounting measures from for instance the popularized DuPont scheme (Kaplan, 1984).

The first category of non-relatedness is due to unspecific strategic focal points. For instance: A reduction in costs, improving quality, improving turnover and profit and improving efficiency. It is unclear how these focal points contribute to accounting measures; reduction in costs can be contributing to total expenses, variable expenses or fixed expenses.

The other category of non-relatedness is due to a lack of quantification of the strategic focal point. For instance: Improving customer satisfaction, improving employee satisfaction and reducing cycle time. For these strategic focal points, it is unclear to which accounting measures they contribute; improving customer satisfaction can contribute to accounting measures for sales, variable expenses (less warranty claims) and profit margin.

3.6. Limitations and further research

The sample size consists of 312 projects, thereby limiting the generalizability of the results. When the accumulated learning from previous LSS project definitions in the form of best practice generic LSS project definitions is applied, LSS practitioners should carefully validate and tailor the templates to their unique LSS project at hand.

Further research should work towards building a stronger empirical foundation of the generic LSS project definitions in multiple industries. Currently we mainly see research on LSS project implementations in service organizations that stem from sectors such as manufacturing, finance (Delgado et al., 2010; Lameijer et al., 2016a) and healthcare (Does et al., 2006; Niemeijer et al., 2011). Our research shows that LSS project implementations also

happen in less investigated sectors such as public administration and public utilities (Table 3.2). This observation is corroborated by Antony et al. (2016) who states that, although scarce, LSS project implementations are happening in public sector organizations. We encourage LSS academics and practitioners to further apply and study the implementation of LSS projects in other sectors in order to test and optimize the presented generic LSS project definitions where possible. In the next chapter we will discuss the implementation of LSS projects in public sector organizations.

4. Implementing LSS projects in the public sector

This chapter resulted from a response to a Stu Hunter Research Conference paper by Saraiva (2018) that demonstrated the positive effects of statistical thinking (Snee and Hoerl, 2003) on political processes in Portugal. In response to the findings and conclusions of Saraiva (2018) about the added value of statistical thinking and the application of quality management tools, we discuss the suitability of LSS project implementations for public (administration) sector organizations and share our experience on implementing LSS projects in the public sector (Lameijer et al., 2018). Our conference contribution is based upon the research and findings in chapter 3. In this chapter 4 we discuss the suitability of LSS project implementations for the public sector and is based upon the publication by Lameijer et al. (2018).

4.1. Introduction

Since 1996 the Institute for Business and Industrial Statistics (IBIS UvA), which is an independent consulting bureau within the University of Amsterdam, has been involved in the implementation of many LSS projects in organizations in the public sector. This ranges from organizations where unemployment benefits are processed, to agencies responsible for managing the temporarily unfit for work, to local municipality administrations. In all of these organizations we have observed a potential for efficiency and effectiveness improvement and we believe that there is a growing need for organizations in the public sector to further improve their operations. Exemplary for this growing need are recent processing problems with personal care budgets by local municipalities in the Netherlands (NRC, 2015) or the increased disturbances in tax handling processes in the Netherlands (Tax Authority Commission, 2017). In addition, we see an international trend of introducing performance measurement and private sector management techniques that is driving the need for operational excellence in public sector organizations (Speklé and Verbeeten, 2014).

We discuss the suitability of LSS project implementations for the public sector in section 4.2. In section 4.3 we discuss the differentiator for implementing LSS projects instead of statistical quality- or Lean tools. Then we introduce our experience on implementing LSS projects in organizations in the public sector in sector 4.4, and we discuss three exemplary LSS projects in this sector. Our contribution is based upon a research on LSS project implementations we have discussed in chapter 3 by Lameijer et al. (2016b).

4.2. Are LSS project implementations suitable for public sector organizations?

To determine the suitability of LSS in the public sector, we explore similarities and differences in public sector- and other sector organizations where LSS projects are successfully implemented.

Studies on LSS project implementations in service organizations stem from several sectors, such as finance (Delgado et al., 2010; Lameijer et al., 2016a) and healthcare (Does et al., 2006; Niemeijer et al., 2011). In a research by Lameijer et al. (2016b) we have studied 312 LSS projects that have been implemented in organizations under the supervision of IBIS UvA in the period 2003-2015. The results show that although manufacturing is an important sector for LSS project implementations, sectors such as finance and insurance, healthcare services, construction and indeed public administration and public utilities are well represented (Table 4.1).

Industry (SIC)	Amount of projects	Total benefits (EUR)	Time range of projects
Agriculture, Forestry, Fishing	2	€ 670.000	2007 – 2007
Construction	36	€ 10.778.888	2003 – 2015
Finance, Insurance, Real Estate	63	€ 10.219.144	2006 – 2015
Manufacturing	105	€ 36.267.774	2005 – 2015
Public Administration	**22**	**€ 6.003.891**	**2008 – 2015**
Retail Trade	3	€ 524.000	2014 – 2014
Services (including Healthcare)	52	€ 4.020.377	2006 – 2015
Transportation and Public Utilities	29	€ 6.911.770	2009 – 2014
Total	**312**	**€ 75.395.844**	**2003 - 2015**

Table 4.1: LSS projects under University of Amsterdam supervision sorted by Standard Industrial Classification code (SIC)

Although scarce, as confirmed by Antony et al. (2016), LSS project implementations are happening and we are interested in how suitable LSS project implementations are for public sector organizations. Public sector organizations exist in great variety such as legislative governments, justice departments and public finance and tax authorities. Despite the broad range of organizations that classify as public administration under the Standard Industry Classification (SIC) system (US Department of Labor, 2017), all these organizations share the same objective: To serve society at best on a non-profit basis. To do so, public sector organizations share organizing principles with commercial organizations, such as long term strategy planning, professional management and the need for efficient operations. From a

technical organizational perspective we believe public sector organizations are just as eligible for LSS project implementations as for-profit commercial organizations; these organizations are all characterized by processes, executed to deliver value to customers, and can be optimized by the LSS method.

For another perspective on determining if LSS is suitable for public sector organizations, we look at critical success factors for LSS project implementations. In a study by Coronado and Antony (2002) and Brun (2011) nine essential organizational ingredients for LSS project success are identified. Out of these nine we believe there are three relevant factors for public sector organizations, which are (1) a customer focus in LSS project objectives, (2) clear links of LSS projects to business strategy and (3) management commitment and support for LSS projects. For these three factors, an underlying characteristic is indisputably different between commercial and public sector organizations when it comes to the implementation of change by LSS projects. That is sense of urgency; a prerequisite for any change according to organizational change literature (Tushman et al., 1986) and more popular change literature (Kotter, 1995). We believe that sense of urgency drives the need for focus on customer requirements, a corresponding ambitious business strategy and subsequent management commitment to convincingly deploy a method such as LSS. We acknowledge that sense of urgency can also be driven by non-commercial incidental motives such as public scrutiny, though believe lower sense of urgency is an inherent non-profit characteristic. This is corroborated by the finding that public sector efficiency indicators have historically been scarce (Afonso et al., 2005). Hence, we believe LSS project implementation is technically suitable for public sector organizations, when attention is paid to the momentum and governance of LSS project implementations.

4.3. When is it feasible to implement LSS projects?

Before we move into discussion on how LSS projects can be implemented in the public sector, we need to define the differentiators for LSS project implementation and the application of statistical quality- or Lean tools. We therefore turn to Hoerl and Snee (2013) who distinguish two important differentiators for LSS project implementation, namely whether the *solution* for the inefficiency or problem is known or not and whether the *complexity* of the problem at hand is high or low (see Figure 4.1).

		Solution	
		Known	Unknown
Complexity	Low	Just do it *(divide tasks and execute)*	Six Sigma problem solving *(find an statistical explanation for certain phenomena)*
	High	Lean event *(find an efficient and effective way to implement solution)*	Lean Six Sigma project *(find root causes of the problem and develop and implement evidence based solutions)*

Figure 4.1: Problem solving method selection matrix

Saraiva (2018) described how the application of statistical quality tools in political processes can lead to a better understanding of the problem at hand, prior to moving into the definition and approval of solutions. Examples of such applications are for instance the measurement of 'left' or 'right' oriented parliaments and the effects on the public debt deficit. This is categorized as 'Six Sigma problem solving: Finding a statistical explanation for certain phenomena. The examples described by Saraiva (2018) also showed how with Lean tools complex issues can be tackled, such as the application of the Ishikawa diagram to find root causes for societal problems. Based on the descriptions in Saraiva (2018) we believe that most of these examples fit into the quadrant 'Lean events'. Both 'Six Sigma problem solving' and 'Lean events' are technically different from 'Lean Six Sigma project' in the bottom right quadrant. LSS projects additionally seek evidence-based solutions that solve a problem with a high degree of certainty and prevent recurring manifestations of the problem, of which we will present three examples.

4.4. How can LSS projects contribute to organizational performance?

The LSS project implementations we have supervised are categorized by five strategic collectively exhaustive and mutually exclusive performance dimensions and are grouped by the cumulative capability model (Ferdows and De Meyer, 1990; Schroeder et al., 2011; Bortolotti et al., 2015):

- Quality: Effectiveness and suitability of the services, quality of the service
- Dependability and safety: Failures, mistakes, rework, punctuality
- Speed: Throughput time, waiting time, time of service
- Flexibility: Ability to adapt the process to changes in demand
- Cost efficiency: Efficient use of man-hours, facilities, material

That means, the objectives of LSS projects are linked to strategic focal points in one of these five performance dimensions in which an organization wants to improve or excel and thereby, clear links of LSS project objectives to business strategy are secured.

Subsequently, LSS project objectives are operationalized in measurable Critical To Quality (CTQ) indicators that represent measurable properties of a product or service that are relevant for the customer and need to be improved. These CTQs are then operationalized by measurement plans, which specify the measurements that should be done. These consecutive steps collectively make up the *LSS project definition*; a project initiation documentation with the strategic focal point, the project objectives and the CTQs which are then operationalized in a measurement plan (see Figure 4.2).

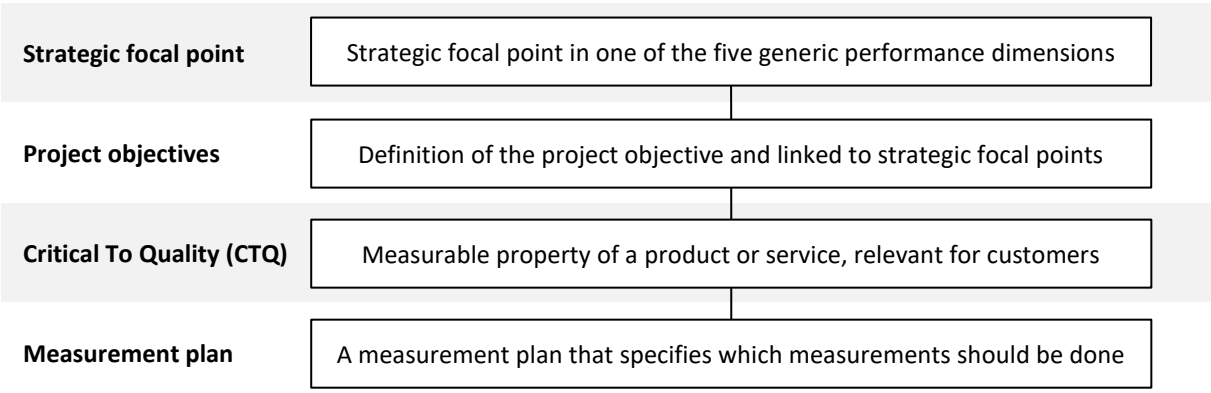

Figure 4.2: Generic LSS project definition

The LSS project definition template above structures our further discussion on exemplary LSS projects that have been implemented in public sector organizations. We provide concrete examples of how LSS projects can contribute to operations improvement and is based on a previously discussed research by Lameijer et al. (2016b), whereby a sample of 312 LSS projects in a variety of industries are analyzed. In the public sector, we see that LSS projects generally focus on the performance dimensions cost efficiency, dependability and speed. In the next section we discuss three concrete examples of LSS projects in the public sector that each contributed to one of these three performance dimensions.

4.4.1. LSS project that contributes to cost efficiency of public sector processes

LSS projects that contribute to strategic cost efficiency focal points can have a variety of project objectives. We have analyzed that LSS projects that contribute to cost efficiency can be categorized in five different generic LSS project objectives (Lameijer et al., 2016b), being (1) human resource efficiency, (2) overall operating efficiency, (3) inventory optimization, (4) general cost reduction and (5) margin optimization. Here we will discuss a LSS project with the objective to improve human resource efficiency. This LSS project was executed to optimize an administrative process at a social security authority in the Netherlands with special focus on reducing the processing- and idle time in the process (see Figure 4.3).

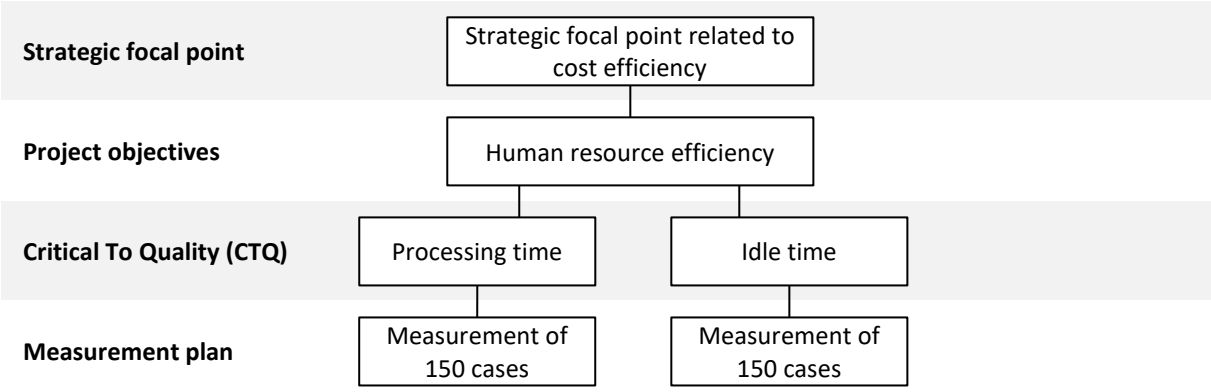

Figure 4.3: LSS project definition to improve cost efficiency

The project leader collected a sample of 150 requests and measured the current performance of the CTQs. Statistical analysis of the processing time in a Shewhart control chart signaled too high processing times (on average 3 minutes) and idle times (on average 5 days) in the process. Diagnosis of the process by means of value stream mapping led to a series of root causes, structured by an Ishikawa diagram. After statistical analysis, the significant root causes were (1) non-uniformity in the execution of requests, (2) a low degree of request completeness and (3) waiting for third party suppliers. The design of improvement actions resulted in an improved process whereby instead of 4.5 only 2.5 FTE was necessary.

4.4.2. LSS project that contributes to dependability of public sector processes

Another example is a LSS project that contributed to the dependability of the unemployment benefits process at the department of health and social security in the Netherlands. We have found that LSS projects that contribute to dependability can be categorized in four generic LSS project objectives (Lameijer et al., 2016b), being (1) first time right improvement, (2) rework reduction, (3) operational loss reduction and (4) process reliability improvement. Here we discuss a LSS project for reducing rework in the process (See Figure 4.4).

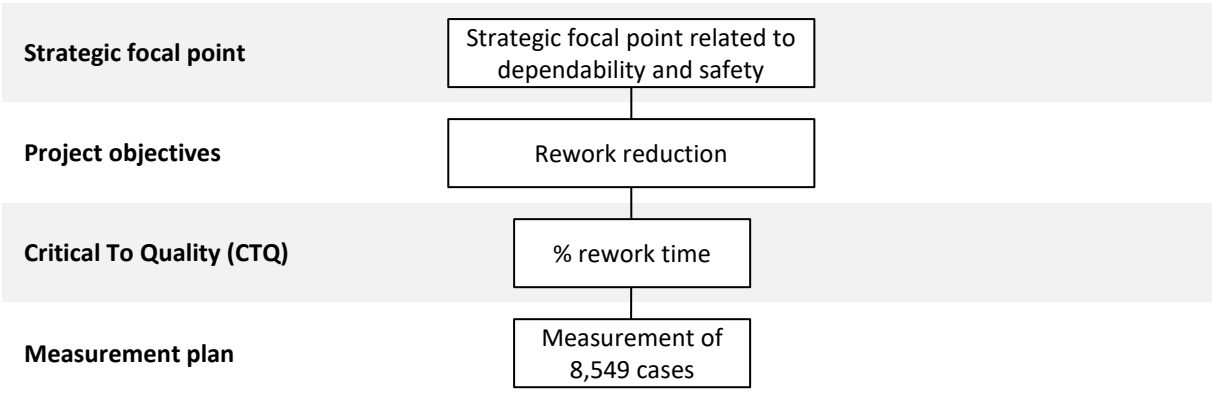

Figure 4.4: LSS project definition to improve dependability

This LSS project was designed to reduce the rework in the unemployment benefits application process that originates from unrightfully granted unemployment benefits. Consequences are, besides rework, time consuming communication efforts, complaints and formal objections. A sample of 8,549 cases was analyzed of which 25% needed rework. Subsequent process analysis resulted in a set of root causes that explained 60% of the rework and were (1) unrightfully applied for benefits, (2) missing client information in the application and (3) applications that are filed too early to process. The project leader designed improvement actions with the involved department, such as process standardization and improvement of training and instructions for employees in the process. The result is a reduction of rework from 25% to 17% with calculated benefits that exceed half a million euro p.a.

4.4.3. LSS project that contributes to speed of public sector processes

The last example we present is a LSS project designed to increase the throughput speed of a social welfare process, which was executed at a local municipality office in the east of the Netherlands. We have found that LSS projects that contribute to speed can be categorized in two generic LSS project objectives (Lameijer et al., 2016b), being (1) cycle time reduction and (2) idle time reduction. This particular project had the objective to reduce the cycle time of the process (see Figure 4.5).

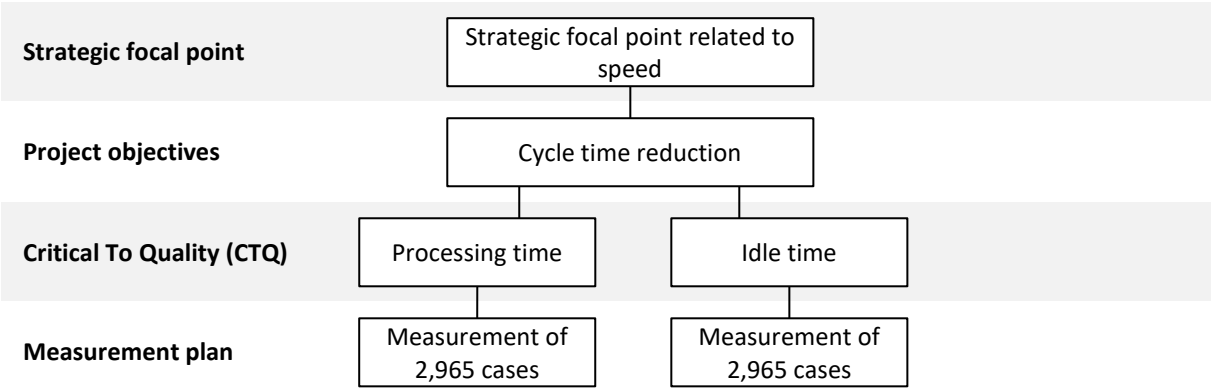

Figure 4.5: LSS project definition to improve speed

The project leader analyzed 2,965 cases and determined that only 31% of the applications was actually processed within the desired 14 days, and the process had an average cycle time of 28 days. Subsequent value stream mapping revealed a chaotic current process design, and root cause analysis led to 90 areas for improvement. The most important improvement efforts comprised (1) the design and operationalization of a new customer service desk, (2) the installation of go or no-go judgements earlier in the process and (3) the deployment of a shorter and simpler application handling process. The result was an improved average process cycle time of 12 days and a reduction in resources needed.

4.5. Concluding remarks on implementing LSS in the public sector

In conclusion we can say that although the public sector is not an early adopter of the LSS method, it is possible to implement LSS projects in this sector. Publications on implementing LSS in the public sector are scarce and start to emerge, such as for instance (Antony et al., 2016), and we encourage LSS academics and practitioners to further apply and study the implementation of LSS projects in public sector organizations.

Part 2: Implementing Lean Six Sigma at the organizational level

5. A review of LSS deployment models

Implementing LSS as a strategic change initiative at the organizational level, and the translation to organizational structures, policy and action plans creates a task for an organization's leadership, namely, that of managing the LSS implementation process. The academic and practitioners' literatures on LSS offer a multitude of deployment and maturity models for structuring this implementation task. In this chapter a critical appraisal of the quality and usefulness of these LSS implementation models is made. We find that the analyzed models are poorly grounded in theory, appear disconnected from established theory in organizational development, and the given advice lacks in specificity and operationality. The underlying notion of implementation processes seems an exclusively programmatic view, leaving little room for idiosyncrasy and learning elements. This chapter is based on Lameijer et al. (2017).

5.1. Introduction

Implementing LSS involves amongst others the design of the initiative, its day-to-day control and when needed the adjustment of the initiative. This chapter focuses on this task of implementing LSS at the organizational level, and we refer to this task as LSS deployment. The academic and practitioners' literature on LSS offers a multitude of models for structuring the deployment task, and we will name them deployment models. In addition, this literature offers models for assessing how far an organization has progressed in deploying LSS; we refer to these models as maturity models.

Academic literature offers a vast and mature theory on organizational change and development, but specific models for the deployment of LSS are scarce (see Hilton and Sohal (2012) and Kumar et al. (2011) for discussions on maturity in LSS deployment). Naslund (2008) observes that the academic literature does not offer a systematic approach to the deployment of LSS. Chakravorty (2009b) even argues that many LSS deployments fail to produce the results LSS can bring, because an adequate LSS deployment model "to guide the implementation" does not exist.

This study makes a critical appraisal of the quality and usefulness of the LSS deployment and maturity models offered in the practitioners' and the academic literature. Such models are widely used, and they appear in management course books and LSS practitioner publications. Therefore, these models can have a great impact on the deployment of LSS in

organizations. This makes a critical assessment important for the field. For the academic community, a review of applied manifestations of organizational change and development theory reveals how the academic body-of-knowledge is transferred to the field. Questions that we are interested in include: How useful and understandable are the prescriptions for managers and practitioners? How complete are these models? To what extent are these models in line with theory in the field of organizational change and development? What is the level of agreement between these models? How well is the advice embodied in LSS deployment and maturity models based on a solid evidence-base or theory? And finally, how can these models be improved? To answer these questions, we have designed a review protocol where deployment and maturity models in the literature are assessed on the basis of criteria in four categories: operational requirements, the comprehensiveness of the organizational scope, presence and detail of an underlying organizational development paradigm, and finally the strength of the theoretical grounding.

In the next section, we define the theoretical framework of our study and present the review protocol. Our research sample consists of 20 deployment and maturity models, which were reviewed following our protocol. Section 5.3 presents the within- and cross-case findings and results. In section 5.4, we discuss the implications of the results, draw conclusions and define implications for future research.

5.2. Literature review on LSS deployment

Academic research on LSS deployment focuses on (1) deployment of LSS as a program (a collection of LSS projects) and (2) the implementation of LSS projects (Arumugam et al., 2014). We are interested in the first phenomenon, deploying LSS as a program at the organizational level that drives organizational change. In LSS literature, little is published on LSS deployment other than success factors for implementing LSS at the organizational level such as (1) empowerment of- and communication with the workforce and (2) the management of LSS consultants and projects in a program structure (McAdam and Lafferty, 2004; Schroeder et al., 2008; Zu et al., 2008; Nonthaleerak and Hendry, 2008; Anand et al., 2009; Nair et al., 2011). However, LSS builds on a tradition of operational excellence manifestations, such as Continuous Improvement and Total Quality Management (Zu et al., 2008) (Schroeder et al., 2008). Deployment was also studied in these earlier frameworks, as in Wu and Chen (2006), Kanji (1996) and Leonard et al. (2002).

We look to the organizational development theory to review the knowledge on LSS deployment processes.

5.2.1. Organizational development theory

Since the implementation of LSS is a transformation or development of the organization, our framework for reviewing deployment and maturity models is based on the theory of organizational development (OD). Poole and Van de Ven (2004) defined OD as "a difference in form, quality or state over time in an organizational entity". Studies on the OD process find their roots in the early work of Lewin (1947) and developed through three phases (Seo et al., 2004). In the third and latest generation of research, the notions of organizational learning and perceiving change as a process gained wide attention (Senge et al., 1994; Pettigrew et al., 2001). We focus on this process research approach.

Van de Ven and Poole (1995) propose that OD processes are driven by four essentially different mechanisms (or combinations thereof). The mechanisms differ in whether they assume a prescriptive or a constructive change process, and in whether they assume a single or multiple actors in the change process.

- The first mechanism is the life-cycle model, which sees change as driven by a given agenda, program or principles (prescriptive).
- The teleological model, to the contrary, sees change as driven by a learning process in which agents discover themselves by trial-and-error what works and what does not (constructive).
- Dialectical change, sees change as constructed, but here the learning process involves multiple actors, each with their own perceptions, logic and interpretations, and learning occurs when multiple views are synthesized or reconciled.
- The evolutionary model, finally, also involves multiple actors. These actors have a variety of plans, but they do not engage in a process of dialectical learning by synthesis and reconciliation. Rather, they compete for scarce resources such as time and budget, where some plans prevail and other are abandoned.

During these OD processes, change leaders have to make decisions that involve trade-offs. Such decisions are named dualities. They result in tensions and have played an important role in OD process research (Cameron and Quinn, 1999; Seo et al., 2004). The theory on these trade-off situations is also included in our review protocol. In their summarizing work on change processes, Beer and Nohria (2000) identify six dualities:

- The purpose duality is about whether OD should aim at economic value maximization, or rather at the development of competences of the organization and its employees.
- The leadership duality distinguishes between top-down leadership versus bottom-up participation in OD processes.
- The focus duality entails whether the subject of change are mostly formal structures and systems such as procedures, hierarchy and governance structures, or rather, whether OD focuses on changing the culture.
- The planning duality distinguishes OD initiatives that proceed in a planned and programmatic fashion from initiatives that are left to emerge and evolve.
- The motivation duality is about the importance of financial incentives, early or later in the change cycle, to reinforce the goals of the change initiative.
- The consultants' duality is the trade-off between the involvements of many or few consultants.

5.3. Research methodology

The research questions concern the quality and usefulness of deployment and maturity models offered to practitioners. To answer these questions, we review a selection of models on a number of criteria explained below. The review assesses how well the offered models are grounded in and reflect LSS deployment and OD theory. These OD and LSS deployment theories in their turn are grounded in empirical evidence by the normal process of scientific research, but this linkage is beyond the scope of our study (see Figure 5.1).

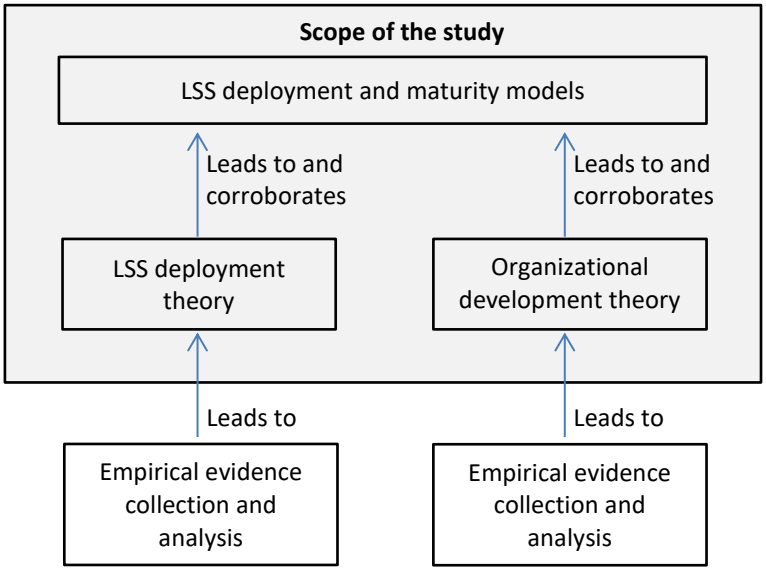

Figure 5.1: Conceptual model and scope of the research

We have searched various sources to identify LSS deployment and maturity models for inclusion in our review protocol.

- Academic publications: We have systematically searched for LSS deployment and maturity models in 150 journals that the Scimago Journal and Country Ranking categorizes as management science- and operations research journals (Scimago Lab, 2015). We have searched for "Lean" and or "Six Sigma" in combination with "deployment" or "roadmap" or "maturity" in each of the 150 journal databases. This resulted in LSS deployment and maturity models from the following journals: International Journal of Quality and Reliability Management, International Journal of Production Research, Journal of Manufacturing Technology Management and Total Quality Management & Business Excellence.
- Practitioner publications: A similar search in publications and online platforms aimed at practitioners, using the same keywords, resulted in LSS maturity and deployment models that were included in our sample from the following sources: The Quality Management Forum (ASQ), Quality Progress (ASQ) and iSixSigma.com
- Textbooks and course materials: Many books have been written on Lean, Six Sigma, and Lean Six Sigma. We have performed desk research for books and publicly available course materials in LSS deployment and maturity. The search protocol consisted of searches for "Lean" and or "Six Sigma" in combination with "deployment" or "roadmap" or "maturity" through internet search engines and online book libraries.

The search resulted in deployment and maturity models varying in form from research papers to slide-show presentations and teaching materials. After a first round of reviewing, we have dropped 7 models that obtained a 0% score for three or four (out of four) review categories (categories are elaborated in table 5.1), as we consider such models not sufficiently developed to allow a meaningful review. Table 5.2 presents the resulting sample of 20 deployment and maturity models, which we take to be a fair representation of the available guidance for LSS practitioners.

5.3.1. Review protocol

Subsequently, we present our review methodology for deployment and maturity models. The review protocol is based on design principles for deployment and maturity models; see Becker et al. (2009) and Röglinger et al. (2012). Our review model comprises four categories:

- The operational requirements that must be met for a model to be useful
- The organizational scope of the model
- The OD paradigm underlying the model
- The strength of the model's theoretical grounding

These categories are refined in 11 review criteria (Table 5.1). The objective of our review protocol is twofold.

First, we aim to assess the usefulness of deployment and maturity models. We do this by a quantitative review of the comprehensiveness of the reviewed deployment and maturity models (that is, what proportion of the issues defined by our review criteria are addressed by each of the reviewed models?). For each of the 11 detailed criteria in table 5.1, each model's coverage was scored as 0 (not addressed) or 1 (addressed), and these scores were aggregated into a coverage percentage for each of the four review categories in table 5.1. For example, the coverage of model no. 4 of the criteria in category 1 are scored as 1, 0, 1, 1, 0, resulting in a coverage percentage for category 1 ("operational requirements") of 60%.

Second, we aim to assess the quality of deployment and maturity models. We do this by qualitatively reviewing the agreement of interpretations with other deployment and maturity models and the agreement with existing LSS and OD theory. For each of the 11 review criteria, we established each model's interpretation or substantiation (that is, how the topics defined by our review criteria are addressed in a model). For example, the

interpretation of model no. 4 for criterion 1A (”What is the function of the model?”) was substantiated as “The assessment enables detailed, step-by-step, quantitative scoring to diagnose the current state,” which indeed defines the function of model no. 4. Below, we explain the details of this rating for criteria where the rating is not straightforward.

Category Review criteria
1. Operational requirements
Research Question (RQ) 1: “How useable is the deployment and maturity model for the target group?”
A. The function of the deployment or maturity model.
B. The stated goal or claimed effect of applying Lean Six Sigma according to the model.
C. The intended target group or target user of the model.
D. The level of the operationalization of the model.
E. The limitations for applying the model.
2. Organizational scope
RQ2: “How comprehensive is the deployment and maturity model in covering organizational development?”
A. The width of organizational scope: Organizational dimensions that the model addresses.
B. The depth of organizational scope: The start and end point of deployment process coverage by the model.
3. Organizational development paradigm
RQ3: “How are concepts and theory in the OD literature reflected in the deployment and maturity models?”
A. The four process theories of OD by Van de Ven and Poole (1995) addressed by the model.
B. The six dualities in OD processes by Beer and Nohria (2000) addressed by the model.
4. Strength of theoretical grounding
RQ4: “How strong is the scientific support for the deployment and maturity model offered by its authors?”
A. The other deployment or maturity models or theories that are integrated into the model.
B. The LSS deployment theory or organizational development theory that is integrated into the model.

Table 5.1: LSS deployment and maturity model review criteria

Operational requirements: By rating on a 2-point scale (0 or 1) whether the criteria 1A through 1C are covered, we evaluate whether a model is precise and specific enough to be used easily without substantial resourcefulness of the user herself. That is, is the function, the stated goal or claimed effect and the intended target group clearly given (score 1) or not (score 0) by the deployment and maturity models? For deployment as well as maturity models, the operationalization criterion 1D rate models as 1 if at least two out of the following three are met satisfactorily. First, are steps and levels in the deployment or maturity tangibly delineated? An example of a tangible demarcation between two successive levels is: “10% of the employees are LSS Green Belt trained”. Second, do models go beyond stating what to achieve, and tangibly specify how to achieve it? Third, do the models provide specific indicators for establishing the effect of deployment actions? For the limitations criterion 1E, we review whether a model specifies contingency factors for applying the

model, especially in the categories environmental uncertainty, organizational size, and industry sector (Damanpour, 1996).

The organizational scope: The organizational scope category reviews how comprehensive the deployment and maturity model covers organizational dimensions. The width of the organizational scope (criterion 2A) expresses how many organizational dimensions are integrated or covered in a model. We rate the models on the basis of the 7S model by Waterman et al. (1980). The seven dimensions are strategy, systems, style, staff, skill, structure and shared values. For each of these dimensions models obtain a score of 1 (covered) or 0. The depth of the organizational scope (criterion 2B) addresses whether models define the point of departure for deployment (what prerequisites should be met?) and the end point of deployment (when is the deployment roadmap completed and LSS implementation achieved?). The model is rated 1 if both points are defined and 0 otherwise. The seven binary ratings of 2A and the binary rating of 2B are added up and divided by 8 to arrive at the category coverage percentage.

The organizational development paradigm: The organizational development paradigm category reviews to what extent the deployment and maturity models are grounded in OD theory. We review which of the four process theories (Van de Ven and Poole, 1995) a deployment or maturity model implicitly follows in review criterion 3A. When a process theory is implicitly followed, the corresponding process theory is scored 1, otherwise 0. The six dualities of OD processes by Beer and Nohria (2000) are reviewed in criterion 3B. When the existence of the duality is explicitly recognized or implicitly recognized by promoting one of the two sides of the duality, a 1 score is given. When both sides of the duality are discussed and the existence of the duality is not recognized, a 0 score is given. The scores for 3A and 3B are summed up and divided by 10. This results in the total review category coverage percentages.

The strength of theoretical grounding: The final review category is the reflection of concepts and theory from the OD literature in the deployment and maturity models. Criterion 4A scores whether a reviewed model refers to other deployment or maturity models in the practitioners' or academic literature (score of 1) or not (score of 0). Criterion 4B scores whether a reviewed model is grounded explicitly by its authors in the academic OD or LSS literature (peer-reviewed literature) (score of 1) or not (score of 0). The results of the

two review criteria are added up and divided by 2 to generate the review category coverage percentages as presented in table 5.2.

5.4. Results and discussion

The presentation of the results and findings is structured according to the four review categories: operational requirements, organizational scope, organizational paradigm and theoretical grounding. We first present the summary of the within-case analysis results in table 5.2 (the extensive within-case analyses are available upon request). Then we will present the results of the cross-case analysis, which highlights the most interesting findings on similarities and differences between deployment and maturity models. Subsequent sections will discuss the descriptive statistics, findings, and results.

Deployment or maturity model title	Category	Operational requirements	Organizational scope	OD paradigm	Theoretical grounding	**Average coverage**
A conceptual model for the successful deployment of LSS (Hilton and Sohal, 2012)	Academic publications	40%	63%	60%	100%	**66%**
Six Sigma implementation for SMEs - A roadmap to manage and sustain the change (Kumar et al., 2011)	Academic publications	60%	88%	40%	100%	**72%**
Applying LSS in a small engineering company, a model for change (Thomas et al., 2008)	Academic publications	80%	50%	40%	50%	**55%**
A framework for effective Six Sigma Implementation (Jones et al., 2010)	Academic publications	60%	50%	30%	100%	**60%**
Combining Lean and Six Sigma for optimal results (Cudney et al., 2006)	Academic publications	60%	50%	40%	50%	**50%**
Does your deployment measure up? Presenting a maturity model for LSS (Watson-Hemphill and Bradley, 2012)	Practitioner publications	60%	100%	60%	0%	**55%**
Progress Report: Learn something about your Six Sigma program's maturity (He, 2009)	Practitioner publications	60%	100%	60%	50%	**68%**
Are you ready? How to conduct a LSS maturity assessment (Choudhury, 2016)	Practitioner publications	60%	75%	20%	0%	**39%**
Maturity model describes stages of Six Sigma evolution (Raje, 2009)	Practitioner publications	80%	75%	30%	0%	**46%**
Successful Six Sigma deployment (Phadnis, 2016)	Practitioner publications	20%	38%	30%	0%	**22%**
Eight steps to a successful LSS implementation (Lokesh, 2016)	Practitioner publications	20%	25%	20%	0%	**16%**
Assessing process maturity to make LSS more effective; the CMMI[1] capability maturity model (Hung, 2005)	Practitioner publications	20%	38%	50%	50%	**39%**
Basic LSS maturity model (Lean Management Institute, 2016)	Practitioner publications	0%	38%	30%	0%	**17%**
Fail to consider these areas in a LSS project and risk failure (Toppazzini, 2013)	Books and course materials	20%	63%	40%	50%	**43%**
Successfully Implementing LSS: The LSS deployment roadmap (Gardner, 2013)	Books and course materials	40%	63%	40%	0%	**36%**
LSS deployment timeline (Pyzdek, 2003)	Books and course materials	80%	63%	50%	0%	**48%**
Deploying LSS in service organizations (George, 2003)	Books and course materials	40%	63%	40%	0%	**36%**
LSS audit worksheets (Cole, 2011)	Books and course materials	0%	63%	40%	0%	**26%**
LESAT[2]: The Lean enterprise self-assessment tool (Nightingale, 2005)	Books and course materials	80%	100%	60%	0%	**60%**
LSS deployment alternatives (Breyfogle III et al., 2001)	Books and course materials	60%	88%	70%	0%	**54%**
Average coverage		**47%**	**64%**	**42%**	**28%**	**45%**

Table 5.2: Within-case results of the 20 reviewed deployment and maturity models, and per-category coverage percentages ([1]Capability Maturity Model Integration, [2]Lean Enterprise Self-Assessment Tool)

The average coverage percentages (based on identical weights for each category) express the comprehensiveness of each of the deployment and maturity models. None of the 20 reviewed models has an average score higher than 72%. The models offered in the academic literature have a substantially better average coverage than models in practitioners' publications and in books and course materials (61% academic- versus 38% practitioner publications and 43% books and course materials), and this is almost entirely due to the better scores of academic publications on the fourth category (theoretical grounding). Note that these scores give a favorable view of the comprehensiveness of deployment and maturity models in practitioners' publications and course materials, since the 7 models excluded in the first review round for scoring 0% on three or four categories were all from these domains. We turn now to the cross-case analysis, structured by the four review categories.

5.4.1. Operational requirements of LSS deployment models

This analysis answers the first research question: "How usable is the deployment and maturity model for the target group?" We assess usability by the comprehensiveness of the addressed operational requirements. Table 5.3 shows that the overall comprehensiveness is low because most models only state their function (1A: 75%) and the goal or claimed effect of the implementation of LSS (1B: 60%) but fail to identify their target group (1C) and limitations to their applicability (1E), and the level of operationality (1D) is relatively low.

Operational requirements:	1A: Function	1B: Goal or effect	1C: Target group	1D: Operationalization	1E: Limitations	**Average coverage**
Academic publications	100%	60%	40%	80%	20%	**60%**
Practitioner publications	63%	63%	38%	38%	0%	**40%**
Books and course materials	71%	57%	43%	57%	0%	**46%**
Average coverage	**75%**	**60%**	**40%**	**55%**	**5%**	

Table 5.3: Results of the 6 operational requirement criteria review

We qualitatively discuss how the reviewed models substantiate operational requirements. The functions of deployment models (criterion 1A) are typically described as: to benchmark a deployment initiative, identify performance gaps, pinpoint the next steps and communicate progress. The functions of maturity models are typically described as: to provide a "detailed, step-by-step, quantitative scoring to diagnose the current state [of the

deployment] (Choudhury, 2016). The stated goals or claimed effects of LSS deployment (1B) are mostly linked to monetary benefits, improved customer satisfaction, improved process performance and motivated employees.

The criteria 1C through 1E are under-addressed in most models (see Table 5.3). Where covered, the operationalization of the deployment and maturity models (criterion 1D) is done by sequences of steps that prescribe what should be accomplished. Examples of such steps are: “create top management commitment” (Nightingale, 2005), "LSS project metrics should be linked to strategic metrics" (Raje, 2009), and "continuous improvement should be fully integrated into the culture" (Watson-Hemphill and Bradley, 2012). Many models are limited to stating what results should be achieved, but omit to offer guidance on how the user should go about pursuing these results. The target group for applying the deployment and maturity models (1C) includes business leaders, actors taking part in the LSS initiative (Green Belts, Black Belts, champions, deployment leaders) and scholars. Almost none of the models discuss limitations and contingency factors for their applicability (1E). For example, the models do not discuss to what extent the application should be adjusted to the size of the organization or in what circumstances the models should not be applied.

We observe that deployment and maturity models generally fall short in basic operational requirements such as defining their target group, pointing out limitations to their applicability and offering guidance to users in a form that is specific enough to be operational. This finding suggests that such models, although perhaps useful for a novice user looking to obtain an overview of themes in deploying LSS, are likely to fall short in guiding users through the process.

5.4.2. Organizational scope of LSS deployment models

This analysis answers the question: “How comprehensive is the deployment and maturity model in covering organizational development?” Horizontal width, criterion 2A, addresses comprehensiveness in terms of organizational domains that a model covers, and vertical depth addresses the range of a model in terms of its stated begin and end point. Table 5.4 shows that deployment and maturity models mostly cover Strategy, Systems, Style, Staff and Skills; Structure and Shared values are covered to a lesser degree. Most practical models

delineate the part of the implementation process that they cover (2B) by defining begin- and end points of implementation.

Organizational scope:	2A[1]: Strategy	2A[2]: Systems	2A[3]: Style	2A[4]: Staff	2A[5]: Skills	2A[6]: Structure	2A[7]: Shared values	2B: Vertical depth	**Average coverage**
Academic publications	40%	100%	80%	80%	100%	0%	60%	20%	**60%**
Practitioner publications	63%	88%	63%	75%	63%	25%	38%	75%	**61%**
Books and course materials	86%	86%	71%	86%	86%	57%	29%	71%	**71%**
Average coverage	**65%**	**90%**	**70%**	**80%**	**80%**	**30%**	**40%**	**60%**	

Table 5.4: Results of the 8 organizational scope criteria review

Strategy: Although the Strategy dimension (2A[1]) is covered by most deployment and maturity models, a qualitative evaluation of the offered guidance reveals that only scant strategic direction is offered for the users. One strategic idea, generally promoted, is that of cost reduction through LSS projects, and revenue improvement by satisfying customers. Some models give ambitious but unsubstantiated targets such as “eventually LSS projects will yield 20 times return on investment ratio” (Watson-Hemphill and Bradley, 2012). Besides achieving monetary goals, models typically state that LSS deployment should contribute to realizing the business strategy already adopted by an organization by (1) deployment alignment with such business strategy and (2) project alignment with the business strategy. To achieve this, traceability from project metrics to key strategic metrics in corporate dashboards is prescribed. Also this line of strategic advice is limited to sketching the general idea, but few of the models give operational guidance or a substantiation of the made claims.

Systems: The Systems dimension (2A[2]) is best covered by deployment and maturity models. Prescriptions for altering five organizational systems and procedures are found. (1) The organization’s training system should develop the capability to deliver LSS courses internally. (2) LSS activity planning should be integrated into the corporate resource planning processes. (3) Financial accounting reporting systems should integrate reports on the impact of LSS deployment. (4) Existing decision procedures should be improved by adding data about for instance the root causes of problems, the progress of LSS projects and key performance metrics. (5) Product and process design should evolve into processes that better include customers and stakeholders. In line with our earlier findings, also here most

models are limited to describing what should be achieved but fail to offer guidance for how to effectuate that.

Style: Deployment and maturity models typically interpret Leadership Style ($2A^3$) as top management commitment and line management drive towards LSS deployment. This is generally operationalized in five pieces of advice: (1) management is educated in the principles of LSS, for example: "leaders invest two days of their own time in learning more about Lean Six Sigma and their role" (Kumar et al., 2011). (2) Management approves the LSS initiative, sets goals and scope and links it to the mission and vision of the organization. (3) Management monitors aggregated LSS deployment results versus plan and takes corrective action. (4) Management undertakes follow-up communication and action on LSS issues with both direct reports and other organizational members. Exemplary statements about leadership style include; "CEO and senior management team own it [LSS deployment], support it and drive it" (Kumar et al., 2011). Here we also find a limited operationalization of the organizational dimension of leadership style.

Staff: As for the Staff domain ($2A^4$), most deployment and maturity models emphasize the empowerment and motivation of employees to participate in the deployment of LSS; for example Lokesh (2016) advises to "train team members to be powerful change agents that share the organization's vision". Three elements are generally described. (1) Information processes must enable empowerment of employees by frequent communication about the improvement initiatives. (2) Policies for the development of current and future business leaders in Black Belt, Master Black Belt, and champion roles. (3) Contributions to improvement initiatives should be recognized in the reward system for employees.

Skills: Skills ($2A^5$) refer to the mastery of LSS tools and principles. Three commonly addressed skills are: (1) to understand and respond to customer requirements at every level in the company. (2) The ability to manage value streams by establishing appropriate process ownership. (3) LSS project management (such as skills in coaching, project selection, and planning), fact-based problem solving and the DMAIC structure and tools.

Structure: The Structure ($2A^6$) dimension has an overlap with the second point of the Skills dimension above. Structure is interpreted as a reorganization of functional hierarchy into product or process based value streams. An important step is to implement value stream metrics. How-to instructions for realizing value stream management are absent.

Shared Values: Finally, Shared Values (2A[7]) are generally interpreted in terms of "LSS should be in the DNA of the organization and is a way of life" (Lean Management Institute, 2016). More detailed prescriptions contain (1) attention to the involvement and empowerment of employees, based on "relationships based on mutual trust" and "open and timely communications" (Nightingale, 2005). (2) The result should be a mindset for continuous improvement and a mentality of zero defects. (3) The result should also be an organization-wide focus on customers' demand and attention to customer satisfaction. Finally, (4) the use of data should lead to more fact-based decision making.

Vertical depth: The vertical depth (2B) refers to the extensiveness of the models' scope of the implementation process. The covered part starts with a begin-point, defined by prerequisites that should be in place before implementation can start. We did not find notable differences among the reviewed models regarding the begin-point. The end-point defines the terms that are fulfilled when the implementation is considered completed. These last phase presents generic actions or results, such as "continuous improvement is fully integrated in the culture and linking continuous improvement to performance planning for employees is no longer needed" or "there is a broad understanding of customer requirements at every level in the company and key decisions are made with the perspective of how it will help the customer" (Watson-Hemphill and Bradley, 2012). Deviations from this norm, because of organizational idiosyncrasies, are ignored.

We conclude that deployment and maturity models offer a comprehensive but generic interpretation of organizational dimensions.

5.4.3. Organizational development paradigm of LSS deployment models

The review answers the research question: "How are concepts and theory in the OD literature reflected in the deployment and maturity models?" Review criterion 3A analyzes whether deployment and maturity models embody some or all of the four change mechanisms of Van de Ven and Poole (1995). Table 5.5 shows that the life-cycle mechanism is dominant, which sees change as driven by a prescribed program of actions. None of the reviewed models refers to the process theory of Van de Ven and Poole (1995) explicitly, and although a few models contain traces of a teleological or evolutionary view on change, in general there appears no awareness of the alternative mechanisms by which change is

driven. Neither is there awareness of trade-offs that the management of change involves, as characterized by the six dualities of Beer and Nohria (2000). Deployment and maturity models mostly and implicitly address one side of the duality. We further discuss how the process theories and change process dualities are interpreted by deployment and maturity models.

Organizational development paradigm:	3A[1]: Life cycle theory	3A[2]: Teleological theory	3A[3]: Dialectical theory	3A[4]: Evolutionary theory	3B[1]: Purpose duality	3B[2]: Leadership duality	3B[3]: Focus duality	3B[4]: Planning duality	3B[5]: Motivation duality	3B[6]: Consultants duality	**Average coverage**
Academic publications	60%	20%	0%	40%	20%	60%	60%	20%	100%	40%	**42%**
Practitioner publications	100%	0%	0%	0%	38%	13%	38%	88%	50%	50%	**38%**
Books and course materials	86%	43%	0%	0%	57%	71%	43%	43%	71%	71%	**49%**
Average coverage	**85%**	**20%**	**0%**	**10%**	**40%**	**45%**	**45%**	**55%**	**70%**	**55%**	

Table 5.5: Results of the 10 OD paradigm criteria review

Process theories: The deployment and maturity models predominantly view the implementation process as programmatic change, driven by step-by-step models and plans, which is the life-cycle model of change (3A[1]). Consequently, other modes of change are ignored or underrepresented. In particular, deployment and maturity models offer almost no awareness that adaptive learning (Argote and Miron-Spektor, 2011; Levinthal and March, 1981) could play an important role in the deployment of LSS. This is the teleological mechanism (3A[2]) in the theory of Van de Ven and Poole (1995), also named trial-and-error learning or plan-do-check-act, where organizations learn by trying out ideas, evaluating their outcomes, and modifying their actions accordingly. Exceptions are a few general and isolated pieces of advice such as: "Deployment progress and areas for improvement should be part of each steering committee meeting" (Cole, 2011). Also dialectical change mechanisms (3A[3]), also known as conflictive change (Van de Ven and Sun, 2011), and evolutionary change mechanisms (3A[4]) are ignored.

Dualities: Some choices and modes in deploying change imply incompatibilities and strains with other choices and modes, and the most common of these are summarized in the six dualities by Beer and Nohria (2000). Leaders of change have to deal with these inherent strains, for example, by making a clear choice for one or the other extreme of the duality, by focusing on one pole of the duality first and on the second later, or by finding a way to

reconcile seemingly incompatible modes. In the deployment and maturity models that we reviewed, there is an unawareness of such inherent strains. Options on both ends of the dualities are sometimes explained, but in a fragmentary and rather gratuitous manner, that does not acknowledge the underlying trade-offs and incompatibilities. There is no guidance for making trade-offs, or for dealing with the inherent strains in other ways.

- For the purpose duality (3B[1]), the dual goals of economic value (monetary benefits) and organizational learning are generally acknowledged, but without awareness that these ambitions imply incompatibilities to some extent.
- Also for the leadership duality (3B[2]) both poles of the duality, top-down and bottom-up leadership, are generally described and elaborated. Top-down leadership is elaborated into elements such as: (1) creation of a leadership vision for the deployment, (2) executive steering committees to lead the deployment, (3) LSS education and training for top management. Also the other pole, bottom-up participation, is explained: (1) bottom-up selection of LSS projects, (2) empowerment of employees and alignment of incentives by participation in LSS projects and (3) training and development of employees in LSS positions. There is, however, no recognition of the inherent tensions between these modes, and that choices are to be made.
- The reviewed deployment and maturity models are equally ambiguous and gratuitous about the focus of change (3B[3]; should change efforts concentrate on organizational structures or culture?), the planning duality (3B[4]; planned change versus emergent initiatives), the motivation duality (3B[5]; what and when extrinsic incentives should be used) and the consultants' duality (3B[6]; many expert consultants who perform the change versus few consultants who facilitate the organizational learning and change process).

Our review of deployment and maturity models for the deployment of LSS makes it clear that such models do not incorporate core concepts from the OD literature. In particular, there is no awareness that change processes are driven by different sorts of mechanisms, and instead, all reviewed models appear to adopt a life-cycle notion inadvertently. Also, there seems no awareness of tensions and incompatibilities implied by choices that deployment leaders could make, and instead, options are presented and explained without any recognition of their consequences or guidance in dealing with the strains that they are likely to bring about.

5.4.4. Theoretical grounding of LSS deployment models

The theoretical grounding review answers: “How strong is the scientific support for the deployment and maturity models offered by its authors?” The review assesses the integration with other deployment and maturity models and OD and LSS literature on change processes. Table 5.6 shows that deployment and maturity models predominantly refer to other deployment and maturity models as evidence for their model.

Theoretical grounding	4A: Reference to other models	4B: Reference to OD/LSS theory	**Average coverage**
Academic publications	100%	60%	**80%**
Practitioner publications	25%	0%	**13%**
Books and course materials	14%	0%	**7%**
Average coverage	**40%**	**15%**	

Table 5.6: Results of the 3 theoretical grounding criteria review

References to other models (4A) are for example (1) Baldrige criteria, (2) Motorola corporate quality system guidelines or (3) previous quality improvement initiatives such as TQM. Few deployment and maturity models discuss known LSS or OD theory (4B). When discussed, these were (1) critical success factors for LSS deployment, (2) literature on maturity- and self-assessment models for TQM and (3) literature on LSS methodology. The offered evidence predominantly consists of experiences of consultants. Statements that illustrate this observation are: "having been a part of hundreds of deployments, we have seen some common themes emerge" (Watson-Hemphill and Bradley, 2012) or “this model has been built out of the experience of working with dozens of leading Six Sigma companies, executive advisory boards and luminaries in the field” (Raje, 2009).

Based on our findings we conclude that deployment and maturity models present little evidence. We argue that this is problematic because claims about effects of the prescriptions remain thereby invalidated.

5.5. Conclusions

This chapter studies the quality and usefulness of deployment and maturity models for LSS. The study finds that established principles in the literature on OD are not properly reflected in them, and that their theoretical grounding is rather unsatisfactory. Finally, the advice offered through almost all models is rather sketchy, hinting at what should be achieved but failing to offer specific, operational advice on how to get there. Our assessment of the quality and usefulness of advice for implementing LSS at the organizational level is therefore not positive, and the study marks a clear need for deployment support of a more useful and better grounded nature.

5.5.1. Generic prescription of LSS implementation

A salient characteristic of all studied models is that they describe implementation processes as generic. The desired end-state of implementation is not described as something that is open to adjustment, but rather, it is fixed and given, copied from best-practices such as Toyota and General Electric. This is in sharp contrast to the literature on the diffusion of practices where a recurring theme is that practices need adjustment when they are adopted. When practices such as LSS are adopted by an organization, they are bound to hit on misfits, such as technical, cultural or political misfits (Ansari et al., 2010). Consequently, organizations need to adjust practices such that these misfits are overcome (Bresman, 2013). Therefore, implementations differ in the degree of fidelity to the original practice and the extensiveness of the deployment in the organization (Ansari et al., 2010).

Also the implementation process itself is treated as generic by the 20 models that we reviewed. This contrasts with the academic literature on organizational transformation, which acknowledges that such processes are idiosyncratic and difficult to chart from the start. Tushman and Romanelli (1985; 1986), for example, emphasize the idiosyncratic and unpredictable nature of such processes, and observed that "… organizations do not evolve through a standard set of stages."

5.5.2. Learning mechanisms in LSS implementation

The 20 models in our sample describe the deployment process as a program, that is, as a linear and generic sequence of steps. Consistent with this notion, all models are built on the prescriptive life-cycle mechanism of change, as we discussed in the previous section, and

ignore constructive learning mechanisms such as the teleological and dialectical mechanisms. This one-sided view on change processes is also apparent in the lack of appreciation for typical choices that implementation leaders can make one way or another. The six dualities of Beer and Nohria (2000) show that implementation processes come in many varieties, but this variety is not reflected in the studied models.

Rather than acknowledging and allowing the variety and idiosyncrasy in implementation processes, the view on deployment reflected in the reviewed models is, therefore, rather one-sided and undifferentiated. This view sees implementation as, what we call, a copy-paste exercise, where the desired end-state of implementation is given by a generic blueprint, which is deployed in programmatic fashion. We acknowledge that substantial parts of implementing LSS consist of copying practices and principles from elsewhere. But in view of the criticisms voiced above, we believe that the exclusiveness of this view is too limited. Implementation support for practitioners would be more useful if it acknowledged that deployment processes are partly idiosyncratic and difficult to plan, and if it offered more support for constructive learning efforts needed to adjust LSS to one's organization.

5.6. Limitations and further research

Based upon the collection of deployment and maturity models, we have been able to distil a foundation for more comprehensive and realistic LSS deployment guidance. We believe that a valuable step would be to define deployment and maturity guidelines that integrate all the good practices and makes up for the shortcomings that are addressed. Therefore, we urge researchers to study how and when the characteristics of learning processes and trade-offs are most relevant in LSS deployment processes.

The main limitation of our research lies in the sample, as we have been limited to integrating the publicly available deployment and maturity models. The final sample was filtered down from 27 to 20 deployment and maturity models and thereby the generalizability of the results is limited.

6. Implementing LSS: Programmatic change or transformational learning process?

LSS implementation models for the implementation of LSS at the organizational level are introduced in chapter 5. These models present LSS as a strategic organizational change initiative and we concluded that these prescriptive LSS implementation models do not acknowledge organizational learning patterns in the implementation process. We are interested in if, and what, learning processes occur in the implementation of LSS. Therefore we conducted an in-depth nine year longitudinal case analysis of a LSS implementation in an organization. We find that learning patterns exists, and that implementing LSS is not a copy-paste exercise. This chapter is based on De Mast et al., (2017).

6.1. Introduction

LSS teams learn to create knowledge about products or processes by applying statistical techniques and problem-solving methods, and also by following a systematic approach to inquiry named DMAIC (Define, Measure, Analyze, Improve and Control) (De Mast and Lokkerbol, 2012). This systematic attitude towards inquiry is often equated to learning by scientific method or a simplified version of it (Wruck and Jensen, 1994; Linderman et al., 2003). LSS's organizational models for project management, its focus on metrics, and its other structures for control and exploration facilitate that created knowledge is put to effective use and results in process and product improvements (Zu et al., 2008; Schroeder et al., 2008). Wruck and Jensen (1994), Choo et al. (2007) and Anand et al. (2010) identify this as the crux of LSS's potential for creating value; the efficient and decentralized creation of specific and tacit knowledge.

By implementing LSS at the organizational level, therefore, organizations start a process of operations improvement driven by decentralized, project-wise learning (Linderman et al., 2010) which may constitute a dynamic capability and result in knowledge as a strategic resource (Choo et al., 2007) (Anand et al., 2009). Implementing LSS in organization entails that the organization goes through a process of implementing the way of working. Besides training employees in LSS's methods and techniques, the organization needs to make many other adjustments in order to establish an organizational infrastructure that supports project-wise improvement (Anand et al., 2009). The practitioners' literature offers a large volume of implementation models; see Lameijer et al., (2017) for an overview and critical

appraisal. With almost no exception, these models describe the implementation process as programmatic (as opposed to emergent), where the LSS method is rolled out over the organization. These models generally characterize the implementation of LSS as follows:

- The desired end-state of implementation is not something that the organization needs to discover. Rather, it is given and fixed, and generic (copied from best practices such as Baldrige Award winners or blueprint examples such as Toyota and General Electric). The practitioners' literature offers an abundance of maturity models, which de facto define the generic end-state.
- There is no notion that implementation processes may be idiosyncratic and difficult to chart from the beginning. Instead, implementation models offer generic step-by-step programs in which implementation tasks are organized in a linear sequence. Some of these tasks imply that the organization needs to figure out things by itself, for example: "Align the initiative with the company's strategy". Such learning tasks are however presented as well-structured: the desired end-term is clear, and tools and methods are offered as recipes for executing them, such as the business balanced scorecard to achieve strategic alignment.
- Implementation models generally suggest that organizations manage the implementation process in programmatic fashion. After a pilot phase in which input is gathered, organizations are advised to establish a deployment roadmap or plan that maps out the rest of the implementation process.
- Some implementation models portray the implementation as a cultural transformation. On closer examination, however, this appears to boil down to an indoctrination model of change (Ouchi, 1979), where implementing LSS is a matter of convincing people to adopt its principles. The stages in such implementation models are defined by successive degrees of penetration, from small pilot initiatives in the beginning driven by "early believers" and "initial visionaries", to organization-wide acceptance and institutionalization ("buy-in") in the end. Actors who have reservations or different views are framed as "resistors to change".

Chakravorty (2009b) goes so far as to attribute a substantial part of implementation failures to the unavailability of a satisfactory "implementation model detailing the sequence of LSS elements and activities." If this portrayal is realistic, the implementation of LSS is or should largely be driven by a program, and the organization merely has to execute it without much resourcefulness and innovation: implementation becomes a copy-paste exercise. On the

other hand, it is plausible that a true internalization of LSS is a much more involved process than the implementation of a preconceived model and plan. Where the crux of LSS at the level of projects is that improvement is driven by efficient learning following the DMAIC procedure, it is likely that at the organizational level, the implementation process itself also has characteristics of a learning process. For one, it is plausible that the methodology needs adjustment to the specifics of an organization adopting it to overcome technical, cultural or political misfit (Ansari et al., 2010). Second, it is likely that reshaping an organization along the lines suggested by LSS models requires that the organization as a whole and individuals in it go through stages such as becoming aware of core obstacles in the organization, developing and testing potential remedies, and reconciling conflicting perceptions and interpretations. In that case, the implementation requires much more from the inventiveness and resourcefulness of the organization, and it should be managed differently, not as a program but as a learning process.

6.2. Literature review on learning processes in implementing LSS

The central question in this study is how the process of implementing LSS at the organizational level unfolds. To what extent is it programmatic, driven by generic knowledge and a roadmap originating from outside of the organization? And to what extent is it a learning process, driven by an organization's own resourcefulness and inventiveness? The question has implications for how implementations of LSS should be managed; it is relevant for assessing how much time and effort an implementation cost, and for predicting what the critical points for success are. The question is a manifestation of one of the central dualities in managing change: whether such initiatives should be managed as programmatic or emergent processes (Beer and Nohria, 2000). It is unlikely that the implementation of LSS is strictly one or the other. Real change processes are highly complex and can be understood from a multitude of models of change dynamics. It is important to recognize this diversity and to have a repertoire of conceptualizations of change processes from which events in a particular implementation initiative can be interpreted. If management reasons from only a single mental model, such as a programmatic view, it becomes difficult to diagnose and understand aspects of the implementation that do not go well. It is likely that management, in that case, will resort to blaming setbacks on individuals and framing reservations as resistance to change or disobedience (Ford et al., 2008). If management, however, has a

repertoire of models, it can revise its model to one that better fits the implementation process that unfolds (Van de Ven and Sun, 2011). This attitude towards managing implementation processes, where an implementation strategy is tested and replaced for an alternative if observations do not support it, would also better reflect the scientific spirit of LSS's own DMAIC method.

To address the question, we conducted a detailed and extensive study of the implementation process of LSS in the product development department of a high-tech company in The Netherlands. The implementation commenced in 2007 and reached a mature stage in 2010–11. We reconstructed the process up until the end of 2014. This longitudinal study based on archival documents and supported by interviews, aimed to understand the implementation process as a sequence of events and follows the rationale of process studies rather than variance studies (Poole, 2004; Langley et al., 2013). The study involved a single case study, and the attractiveness is in the richness of details that it offers. We study the types of learning that occurred, and the pattern of learning dynamics over the course of the implementation process.

In the next section, we formulate the theoretical framework from which we designed our study, and we present the sources that we used and the coding scheme that we executed. Next, before we make an attempt at explanation and generalization, we first build a thorough understanding of the particular case that we aim to explain, and this is presented as a narrative in section 6.4. We proceed in section 6.5 to explain what has happened in the particular case from relevant theories in management ("What is this a case of?" (Tsoukas, 2009), and the explanations that emerge guide an assessment of the generalizability of our conclusions. Section 6.6 concludes the chapter by summarizing and discussing the implications of the study. The central question is whether LSS implementation is a mainly programmatic process or rather a learning process driven by internal innovation. We approach the question by investigating what sort of mechanisms drive the implementation process.

6.3. Research methodology

6.3.1. Programmatic and learning mechanisms in implementing LSS

Van de Ven and Poole (1995) and Poole (2004) propose a typology of patterns of change based on the sort of basic motors that drive them. One differentiator is whether change is brought about by a prescriptive or a constructive mechanism. Approached from this typology, the research question can be addressed by investigating what motor drives critical events in the implementation of LSS:

- Programmatic (prescriptive) mechanisms, such as compulsory behavior ("accept others' vision on authority", "follow instructions") and persistent behavior in case of adverseness ("denial"). The pattern is comparable to the life cycle model in Poole (2004) and regulated change in Van de Ven and Sun (2011). In this model, LSS implementation follows given blueprints of a desired end-state and implementation strategy, and the organization sticks to the plan. These blueprints could be copied from other companies or imposed by consultants. Also later in the process, if confronted with a problem or issue, the organization turns to authoritative resources (consultants, textbooks, best practices) and implements their suggestions, rather than figuring out a solution itself.
- Constructive mechanisms, such as adaptive and dialectical learning. The pattern is comparable to the teleological and dialectic processes in the typology of Poole (2004). In this model, the organization discovers new insights itself as part of the deployment process.

6.3.2. Operational definitions and coding

Following guidelines for case-study research in operations management (Stuart et al., 2002; Barrat et al., 2011), we proceed now by translating the research question to a number of alternative models, and we specify how they are linked to the raw observations that we analyzed.

We aim to reconstruct the sequence of events that constitute the implementation process at the company under study. The correct level to address this question is not the level of LSS projects and the application of LSS techniques by Black and Green Belts in them. Instead, this question pertains to the macro level of organizational actions (Arumugam et al., 2014). To obtain a relevant selection of events, at the organizational level, we reconstruct the implementation process as it unfolded from the point of view of the organization's LSS Core Team, who are the people managing the implementation.

In view of the research question, namely to what extent learning mechanisms drive the implementation process, the events that we study are occasions where the Core Team could learn. Conceptualizations of learning such as March and Olsen (1976) and Levinthal and March (1981) identify the process as follows: actors undertake actions, resulting in outcomes. Actors evaluate the outcomes, and this assessment is reflected in how the course of action is adapted (the response). The elements of an event, therefore, are a course of action (action), an evaluation (outcome assessment), and a conclusion embodied in a response (Figure 6.1).

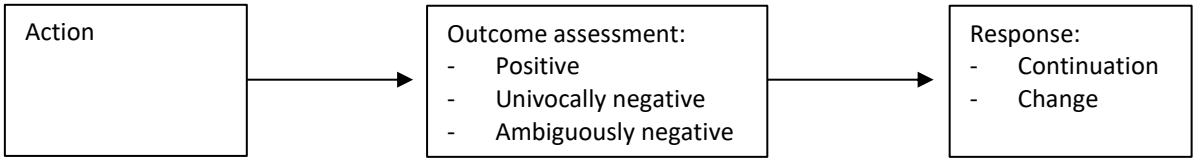

Figure 6.1: Model of an event

In reconstructing the implementation process at the company under study, we identified events by first searching in the sources for occasions where the LSS Core Team evaluated whether some course of action was going well or not. From there, we established:

- Action: what were the earlier decisions, policies and initiatives being evaluated?
- Outcome assessment: were the outcomes evaluated as positive (the action goes well and without negatives; this helps the LSS initiative forward) or as negative (the course of action has negative outcomes)? We also established whether this was seen so univocally, or whether there was ambiguity or dispute in the organization about the evaluation.
- Response: does the ensuing course of action amount to a continuation of the actions or policies (addition, elaboration, expansion), or to a change (reduction, revision, termination)?

Each event, reconstructed following the model above, was next coded in terms of five alternative patterns, which we describe and define below and summarize in figure 6.2.

Programmatic change: The change is driven by prescriptive motors. Actions and responses are executed as prescribed by the program or by outside sources, irrespective of outcomes. Our coding scheme recognizes two variants:

- Positive programmatic change ("Copy lessons from authoritative sources successfully"). Actions appear to work as anticipated, as reflected in a positive assessment, and the

response is a continuation. This pattern is comparable to compulsory behavior or compulsory learning in Van de Ven et al. (2017).

- Persistent programmatic change ("Persist in a course of action even if it appears not to work"). Actions do not appear to work and are assessed as negative, but this negative outcome is denied or ignored and the course of action is continued nevertheless. For example: there is no response, or maybe an appeal or call to action but without real deeds (only words); disputes and ambiguity are left unresolved, are abandoned or ignored. This pattern is comparable to persistent behavior in Van de Ven et al. (in press).

Learning process: The process is constructive instead of prescriptive: the organization learns that some actions do not work (outcome assessment is negative) and experiments with new ideas instead (response is change). Our coding scheme distinguishes two types of learning:

- Adaptive learning. The organization tries out ideas, unequivocally finds that some of them don't work, and changes its course of action (plan-do-check-act, trial-and-error). For example: the organization starts with a few pilot projects, sees how it goes, and adjusts procedures on the basis of the results. Adaptive learning is comparable to a teleological process in Poole's (2004) typology, and behavioral learning in the organizational learning literature, for example (Argote and Miron-Spektor, 2011).
- Dialectical learning. There is dispute about how outcomes should be evaluated or interpreted. This happens as actors' reason from different logics, value systems or interpretative schemes. By dialogue, a resolution is forged that synthesizes the various points of view. The model is comparable to a dialectic process in Poole's (2004) typology and conflictive change in Van de Ven and Sun (2011).

The criterion for demarcating adaptive from dialectical learning is whether a response is the synthesis or resolution between conflicting interpretations and evaluations of multiple actors. An event is coded as adaptive learning if there is no dispute about interpreting or evaluating outcomes, or if such dispute is settled by simply accepting the views of one actor. An event is coded as dialectical learning if different actors have different interpretations or evaluations, and if these multiple views are synthesized in the response. This distinction reflects common models of adaptive/behavioral learning, for example (Argyris and Schon, 1996).

Contextual change: Acknowledging that some events in real processes cannot be understood from the rationality of a long-term purpose such as LSS, we include a fifth pattern in the coding scheme to account for such events. Events are coded contextual change if a response implies a change not because an action is going badly, but motivated by exogenous goals or no apparent goal at all. For example, a LSS project is stopped, not because it is going poorly, but because of some exogenous event (e.g., the customer discontinues the product that the project aims to improve). This pattern is comparable to a garbage-can process or organized anarchy (Cohen et al., 1972; Poole, 2004). Events coded as contextual change were relatively rare in our analysis and turned out to be irrelevant for the question under study.

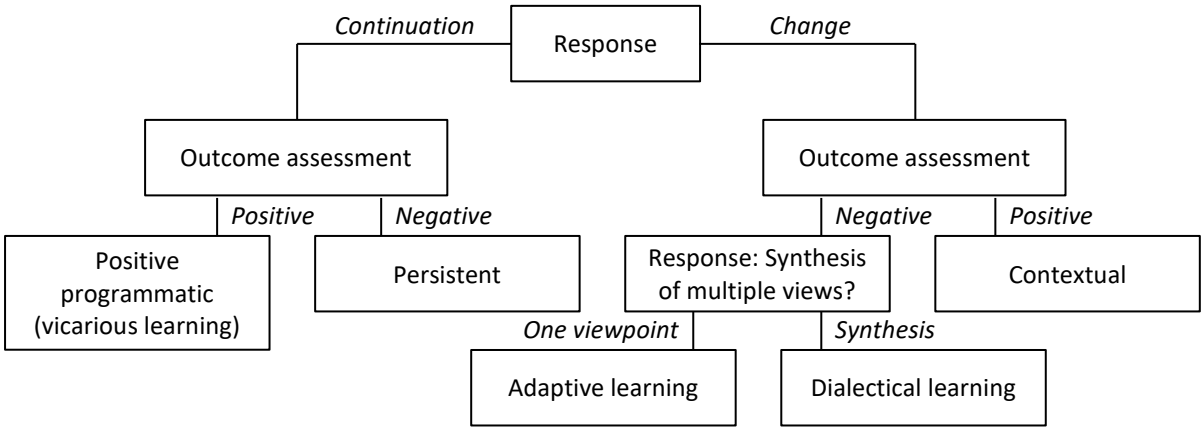

Figure 6.2: Scheme for coding events in five patterns depending on the outcome assessment and response

The constructive mechanisms of adaptive and dialectical learning embody true learning by discovery, where actors respond to feedback when they try out ideas. The prescriptive mechanism of positive programmatic change is sometimes seen as a form of learning called vicarious or compulsory learning (Huber, 1991; Noe et al., 2014). For events coded as one of these three learning processes, we articulated what new insights the company acquired.

We grouped events chronologically in waves of the Green Belt training. There are roughly one or two waves per year, and these are key and highly visible events of the deployment of LSS, thus establishing a natural subdivision of the process into epochs. Our analysis resulted in 220 reconstructed events (from Wave 0 in 2007 to Wave 7 in 2014). This is an example of a reconstructed event:

- Source: document [2.3]
- Action: “45 Green- and Black Belt projects started in Waves 1 and 2”
- Outcome assessment: “Progress of projects difficult to manage”, coded as: negative
- Response: “Improved structure for monitoring progress and scheduling reviews”, coded as: Change
- Event coded as: Adaptive learning (as there was no dispute about the outcome assessment)
- Lessons learned: “How to monitor and manage the progress of projects”

6.3.3. Sources

For reconstructing the sequences of events at the company under study, we used the following archival sources.

- We analyzed 144 editions of the bi-weekly newsletter. This internal periodical is edited by the LSS Core Team of the company. It has a reliable continuity (there are no substantial gaps from January 2007 until present, except for 2012). It addresses both positive and negative developments related to the LSS initiative.
- We analyzed the minutes and management presentations of the LSS Core Team (48 documents).

After a first analysis based on these archival documents, we gathered additional evidence aimed at corroboration and triangulation:

- We corroborated our reconstruction and coding of events by means of semi-structured interviews with the LSS Deployment Leader and another member of the Core Team.
- We verified factual statements about the company, and the context and development of LSS, by requesting documented evidence for claims and stated facts. In particular, we sought for evidence for the claimed results of the LSS implementation, such as statistics about the success and results of individual projects, written comments by customers, and we also reviewed the quality of 82 completed Green- and Black Belt projects.
- We corroborated our emerging interpretation of events by means of structured interviews with the LSS Deployment Leader, another Core Team member, a Black Belt and the director of technology (and former group leader). Interviewees were asked to articulate

in detail their perception of what the company had learned, what the relative importance in this process was of the five alternative patterns in figure 6.2, and whether they believe that the lessons could have been learned from external sources. Thereupon, we asked interviewees to comment on our emerging interpretation and conclusions.

- We probed for instances of political and cultural conflict between factions in the organization, and political and cultural misfit between LSS and the organization (based on descriptions in figure 6.2) (Ansari et al., 2010).

We set up a system for documenting the chains of evidence, where each source (archival documents; protocols, notes and transcripts of interviews; other documents) obtained a unique identifier, and a source key links our analysis, discussion and conclusions to the sources that support them. The coding scheme was modified a number of times, based on advancing insights, and the events were re-coded each time by two authors. The changes in the last rounds of coding were minor (modifications in fewer than 3 events).

One of the authors has extensive experience as a consultant and trainer in the field of LSS in this type of high-tech companies. Such interactional expertise is claimed to be crucial in interpreting and evaluating the events that happen and the views that are expressed by actors (Langley et al., 2013). This author was also involved as a consultant and trainer at the company under study during the entire implementation process, and therefore, had acquired detailed and first-hand knowledge about the company, the people working in it, and the events that occurred.

6.4. Case description

We present in this section the narrative of the LSS implementation at the company under study. As agreed with the company's management, we will not disclose the company's name, but instead, we call it Comp-NL. We describe the context and launch of the LSS initiative, and the strategic goals that the company pursued. Then we describe new structures and procedures that the organization needed to develop, and lessons that it learned about its management style. Finally, we discuss how values and beliefs changed and how the later waves developed.

6.4.1. New product development at Comp-NL

The company that we study has a large product development and engineering group in The Netherlands, which is the subject of study ("Comp-NL"). There is a similar group in the US, and since the company acquired other businesses, there are also smaller engineering groups elsewhere in Europe that Comp-NL collaborates with loosely. The company has production sites in Asia, Latin America and Europe. Comp-NL designs high-volume technical devices for the automotive industry in particular. For managing the product-development process, Comp-NL and the other engineering groups use a tollgate structure named NPD (New Product Development). A typical NPD project takes 4 to 36 months and involves 1 to 4 design engineers, a process engineer, a quality official, a purchaser and a marketer.

At the start of the LSS initiative, in 2007, Comp-NL has been quite successful and profitable. But especially the German car manufacturers insist on better and more structured control of the quality and reliability of designed products. One customer refers to "Zufällig gute Produkte" (good products due to fortuity), a catchphrase that is later used frequently to motivate the LSS initiative.

6.4.2. Strategic development and learning new skills

Originally, the purpose of the LSS initiative is described as achieving "low ppm's". By improving engineering rigor, Comp-NL aims to deliver better designed products, in the sense that they have lower failure rates in the field and during manufacturing. Low ppm or single-digit ppm refers to failure rates substantially below the current 50 parts per million (ppm). This is needed to keep customers satisfied and is also claimed to reduce production and warranty costs. In addition, by dealing with potential failure modes early in the design process, problems after the start of production are claimed to be reduced substantially.

LSS is presented as a largely technical and rigorous approach that "guarantees low ppm's". This pursuit, consistently described as "from cowboys to engineers" by Comp-NL, remains largely intact over the course of the implementation process. What this ambition pertains and how it should be shaped, however, changes considerably. Already in Wave 2, Comp-NL learns that the original perception of LSS as "a universal method that guarantees low ppm's" is unrealistic. Instead, Comp-NL finds that it needs to develop tailor-made approaches itself for improving product reliability. In addition, Comp-NL learns that the pursuit entails many other new skills as well. The company needs to learn how to manage

projects, how to lead strategic initiatives, how to collaborate with customers, how to obtain focus in the company's efforts, and many more lessons. Also, Comp-NL learns that its original exclusive focus on improving the design of new products is untenable. From Wave 2 onwards, the LSS initiative is expanded to projects that improve existing products, the original name of Design for LSS (DfSS) is changed for LSS, and from Wave 3 onwards the company also starts projects focusing on process improvement in non-technical departments.

In the course of 7 waves, Comp-NL learns by trial and error which LSS techniques are useful (such as statistically designed experiments, failure modes and effects analysis and measurement system analysis). Also, by trial and error Comp-NL's engineers learn how best to apply these techniques in the sort of projects that they run. Comp-NL seeks in vain advice from consultants and other companies in search for a strong approach for the complete identification of potential failure modes in product designs, but it ends up developing and improving its own approaches by a long process of adaptive learning.

6.4.3. Development of management procedures and organizational structures

LSS is characterized as a parallel-meso structure for achieving improvement (Schroeder et al., 2008). Its mode of working is mainly in the form of projects, scoped to last 3 to 6 months, and led by a LSS Black or Green Belt. These projects are initiatives on the tactical (meso) level, and constitute a form of organization parallel to the organization's normal hierarchy and operating routines.

In August 2007, Comp-NL starts with the first wave of 25 Green and 3 Black Belts. The Green Belts take an 8 days' course, delivered in-house but by an external consultant. The Black Belts take an external course. During the training, which is spread over a time span of 5 months, trainees apply what they learn in a first LSS project. To complete the training and qualify as certified Green or Black Belt, candidates need to complete two projects successfully, with minimal results of k€20 (of k€50 for the Black Belts) annual revenues per project. The blueprint for the organization of LSS in waves and projects was suggested by an external consultant, and mirrors common practice in the industry. However, Comp-NL has to figure out itself a way of combining the NPD structure for design projects, and the LSS structure for LSS projects. Over the course of eight years, Comp-NL considers various forms, where at one extreme NPD and LSS are kept as separate structures. On other moments

integration is tried, where LSS techniques are integrated in the NPD structure, and LSS projects are seen as sub-projects of the larger NPD projects. After more hectic and dialectical learning processes in the first waves, from Wave 5 onwards the company starts to institutionalize and incorporate many of the learned lessons in a revised "NPD 2.0" structure by a process of adaptive learning. In order to internalize some of the more advanced LSS techniques Comp-NL invents the position of Tool Experts. These are engineers who take ownership over the expertise of a specific LSS technique. Comp-NL develops this position and other organizational structures in sequences of trial and error. In its mature stage (Wave 3 and further), the LSS initiative is coordinated by a LSS Core Team, working closely together with the Tool Experts, external consultants and trainers, and maintaining contacts with LSS communities and other companies. The Core Team reports to a Steering Team, consisting of top managers of Comp-NL. There are informal collaborations with LSS development in the American division of the company. Comp-NL, being a design engineering organization, was accustomed to organize its work in the form of projects, and project management was not seen as a challenging issue when the first LSS projects started. This domain, however, turns out to be critical in getting the LSS initiative going, and also appears to be the area where the most learning cycles occur. After almost all projects stagnate in the first two waves, Comp-NL starts to develop procedures and documents for project selection, progress reviews and project closures by a process of trial and error. After much iteration, by Wave 4 the company has turned project management into an efficient routine and effective procedures and structures are in place. In the course of the first waves, the company becomes aware that the selection of projects is crucial: projects that are not important or urgent enough will get stuck. Acting on that lesson turns out easier said than done, however, and the company finds that effective procedures and structures are not enough.

6.4.4. Leadership and people management

Throughout the 7 waves, the toughest struggle for Comp-NL is to get momentum in the LSS projects. The Core Team actively pursues to learn about the issues and administers a number of surveys among engineers. The company identifies many of the causes for stagnation and finds countermeasures. Early attempts focus on project management, and from Wave 3 onwards effective procedures for managing the projects individually and as a portfolio are at a mature stage.

Comp-NL learns that it does not sufficiently focus its activities, and as a consequence, priorities are diffuse and rapidly change, making it difficult to retain momentum in long-term initiatives. As a matter of fact, the company becomes aware that it lacks the knowledge to determine what the priorities should be, and experiments with initiatives to establish the main opportunities for improvement. Also, the company learns that the group leaders, to whom the Green Belts report, should assume a much more active role in coaching and managing the Green Belts. Comp-NL experiments with various role allocations, where sometimes the group leaders are made responsible for the selection of appropriate projects and for achieving sufficient progress, and sometimes these responsibilities are assigned to the Green Belts themselves. In addition, the organization learns that the group leaders and Comp-NL's management should adopt a much more decisive management style, where clear choices are forced. Group leaders are taught the principle either to invest time in a project or else stop it. The company learns that a more laissez-faire style of management is not effective and also top management experiments with the practice to resolutely stop initiatives that do not get momentum. The company learns to establish rewards for engineers who invest their time in the long-term goal of failure prevention. This policy is needed to counterbalance the recognition that the "heroic firefighters" get, who fix problems reactively after they surface. Also, the company learns that it cannot expect its engineers to master sufficient skills in time management, and instead, that they need coaching in learning such skills.

All of these improvements make a big difference, and after Wave 2 the momentum of projects increases. But especially when economic developments put much pressure on the engineers' time, after Wave 4, building momentum in the projects remains a tough struggle. Only slowly does the company become aware to some extent that the struggle is driven by a difficult trade-off between short-term and long-term ambitions, both of which compete for the time of the engineers. On the one hand, engineers are needed in the factories to keep the operation running and help scale up to meet demand, while on the other hand the LSS initiative requires engineers to invest their time in the projects to improve the reliability of product designs. The trade-off is a variant of the exploration/exploitation trade-off that many technological companies face (March, 1991). Comp-NL never seems to fully realize the consequences of the trade-off, nor does it learn how to translate this awareness into

effective policy. Even in the later waves, there is no real strategy or direction for dealing with this challenge.

6.4.5. Values and beliefs

The value of more rigorous design ("From cowboys to engineers") becomes widely accepted. This is one of the most valuable results of the LSS initiative. The belief is enacted in what engineers do, translated to procedures and goals and reflected in the reward and recognition systems. The accepted values and beliefs include the adoption of a structured way of working (LSS's DMAIC and DMADV roadmaps), the belief that a design review is not a "test to pass" but an "opportunity to learn", and the acknowledgement that claims should not be motivated by "story-telling" but by evidence. But over time, the company also becomes more aware of the consequences of rigor: as described above, there is a hard trade-off between the long-term ambition of rigorous engineering and the short-term pressures of the operation.

6.4.6. The later waves

In 2008 and 2009 (during Wave 2) the global economic crisis hits the company's sales hard, and momentum for the LSS implementation is very low. Budgets are withdrawn, Green Belt courses are postponed for 1.5 year, and many Green and Black Belts leave the company. In the second half of 2010 (during Wave 4), the economic circumstances totally reverse, and Comp-NL faces a peak in demand that it can barely meet. Consequently, there is much pressure on the time of engineers for operational tasks.

The later waves witness a change of perception from LSS as a mainly technical program that should be rolled out, to an adventure that needs time and cannot be charted from the start, but gets shaped along the way, and whose benefits are in the long run. The later waves are characterized by a systematic sequence of adaptive learning cycles in which procedures and policies are improved step by step, but without the main breakthroughs that characterize Wave 2 in particular.

At the moment of writing, Comp-NL has started Wave 8. The positive results of LSS are generally acknowledged in the company and summarized as follows:

- Techniques and skills for state-of-the-art, rigorous engineering have been widely and deeply internalized by the organization; this is seen as a big step in professionalization ("From cowboys to engineers"). LSS techniques such as statistically designed experiments and structures such as DMAIC were not used in the company before 2007, and are now widely mastered and applied routinely. They are applied in the Green Belt projects, but even more in other initiatives and projects, where they result in better decisions. From around 200 engineers who took the Green- or Black Belt training, 159 passed an external LSS exam administered by a university (some candidates after multiple attempts). The successful internalization of rigorous engineering and the wide and routine application of techniques are evident in a review of 82 completed LSS projects conducted by one of the authors.
- A vision and model have been developed for improving product design in the long run. Most lessons and techniques from LSS have been integrated in the NPD 2.0 structure for product development.
- Many LSS projects have been successful (113 at the moment of writing), with substantial results approved by management, and the application of LSS principles and techniques in NPD projects has even more impact. Projects are started and conducted in a much more goal-directed manner, with specific benefits in mind, and the results are documented in a much more accessible manner.
- PPM's have been reduced by a factor 4 to 5. Management is however not satisfied and believes that the occurrence of trouble late in the development projects is still too high.
- The four results above have also been acknowledged and valued explicitly by customers.

6.5. Results and discussion

Having established a solid understanding of the particular case under study, we proceed in this section to try to explain what we observed from the perspective of management theory.

6.5.1. Roles of the individual change patterns at Comp-NL

There has been a balance in the implementation process between programmatic and learning patterns (see Table 6.1). In adopting a generic practice such as LSS, it is natural to expect that an organization learns many lessons by simple copy-paste behavior from outside sources. This is the positive programmatic mechanism, which is sometimes seen as a form of learning called vicarious or compulsory learning (Huber, 1991; Noe et al., 2014), and table 6.1 confirms that it is a substantial part of the implementation process. It is the traditional and perhaps most common form of learning in organizations, where employees passively acquire knowledge and skills deemed appropriate in the organization for direct transfer to their jobs (Noe et al., 2014). The main external sources for vicarious learning of the LSS Core Team at Comp-NL were consultants (three consulting firms were involved), the trainer of the Green- and Black Belt courses, LSS communities, and other companies implementing LSS. In cases where the adopted practices did not appear to work, the Core Team did not generally persist in programmatic behavior: Instances of the persistent programmatic pattern are relatively rare, especially after Wave 1. Looking closer at instances of this pattern, we find no examples of square denial or persistent behavior driven by power dynamics (managers committing stubbornly to failing courses of action to avoid loss of face, or biases for negative feedback; cf. Van de Ven et al. (2017). Rather, the problem and its causes were usually acknowledged, but either nobody came up with a plausible solution, or more often, there simply were too many other issues for the Core Team to take care of, and therefore, issues were simply abandoned for lack of time.

Table 6.1 makes it clear that programmatic copying from outside sources is useful for implementing LSS, but that it falls far short as the only mechanism to rely on in managing the implementation process. Instead, the Core Team frequently applied the true learning patterns of adaptive and dialectical learning, where actors learn not by copy-pasting from elsewhere, but by discovering and inventing insights themselves. Adaptive learning has been the dominant form: the LSS Core Team has learned most lessons by experimenting and

iterating through learning cycles. For some of the aspects of LSS, such as the procedures and documents for the project reviews, Comp-NL went through as many as a dozen iterations.

		Programmatic		Learning			
		Positive	Persistent	Adaptive	Dialectical	Contextual	**Total**
Wave 0	1/2007 – 8/2007	10	9	9	4	2	**34**
Wave 1	8/2007 – 1/2008	4	0	8	0	0	**12**
Wave 2	1/2008 – 2/2010	18	5	27	28	9	**87**
Wave 3	2/2010 – 8/2010	5	0	7	2	0	**14**
Wave 4	9/2010 – 4/2011	7	3	3	2	0	**15**
Wave 5	4/2011 – 9/2012	4	1	9	6	0	**20**
Wave 6	12/2012 – 10/2013	12	1	6	3	0	**22**
Wave 7	4/2014 – 12/2014	5	2	8	1	0	**16**
Totals:		**65**	**21**	**77**	**46**	**11**	**220**

Table 6.1: Reconstructed and coded events by wave

Many instances of adaptive learning occurred in response to (partial) misfits between standard LSS practices and the organization's needs, goals or structures. In such cases, Comp-NL first had to learn that there was a misfit, and thereupon had to learn how the practice should be adjusted to fit the situation at Comp-NL. Some of the LSS techniques that the company adopted required adjustments so specific for Comp-NL that it is unlikely that they could have been copied from generic sources. For example, after fruitless attempts to find a satisfactory approach in the LSS community for a complete identification of failure modes in product designs, Comp-NL ended up developing such approach itself. It is likely that a general method such as LSS needs situation specific adaptations, and therefore, that its adoption implies a process of adaptive learning. This is consistent with studies of the diffusion and adaptation of practices (Ansari et al., 2010; Rerup and Feldman, 2011; Bresman, 2013) and is driven by a trade-off between a practice's generality versus its specificity and usefulness (Fensel and Motta, 2001; De Mast and Lokkerbol, 2012).

Adaptive learning also occurred when prescriptions in the LSS literature were not operational and specific enough to allow easy copying. LSS principles such as 'Stop non-urgent projects' and 'Decisions should be based on evidence' are abstract and complex, and Comp-NL needed learning cycles to discover how to translate them to tangible behaviors and structures. The complexity of some of the skills that Comp-NL needed to learn makes it unlikely that an organization could master them in a programmatic fashion.

Instances of dialectical learning were relatively rare. This may be specific for Comp-NL for a number of reasons. Dialectical confrontation is often driven by political or cultural tension between factions in the organization, or between the LSS initiative and the organization. In Comp-NL, such political or cultural tensions were very rare and mild. The sole example given by interviewees concerned the use of LSS templates for documenting project results, as these were experienced as a bit donnish by some group leaders. In general, LSS's principles and values were quickly embraced, however. The story is in sharp contrast to the implementation of LSS at 3M (Canato et al., 2013). At 3M there was a cultural clash between the LSS values of rigor and control, and 3M's ambition and culture of radical innovation. Both 3M and Comp-NL are product development organizations, but contrary to 3M, development at Comp-NL is incremental innovation, and apparently, LSS fits well with such culture. Also, Comp-NL is active in the automotive industry, which enforces a culture of control and rigor when it comes to quality and reliability, thus establishing a culture in which LSS fits well.

A second explanation for the modest occurrence of dialectics is that Comp-NL is dominated by people with a technical background, who tend to be task-oriented and intrinsically motivated by the technical challenges in their jobs. Mostly, people genuinely had the company's interests in mind, with little influence of ulterior agendas. Green and Black Belts see LSS as "a practical method, without political connotations, that helps them in doing their work" (as a Black Belt explains in an interview). Thirdly, there is the noteworthy role of the Deployment Leader HV and his Core Team colleague CZ. During the entire implementation process (2007–2014) HV and CZ have dominated all communication about LSS, not so much as autocratic leaders, but more as a hub in the communication network. This position "at the center of the structural holes" in the organization allowed them to function as "brokers" (Burt, 2004). We believe that this role partly explains the relatively modest occurrences of dialectical learning. There was not much direct confrontation between factions. Rather, everyone would talk to HV or CZ, they would moderate conflict and translate various points of view, synthesize ideas, and then try them out in a form that turns the process into adaptive learning. CZ describes this role as: "lubricant in cases of friction". Such brokers are a catalyst to the learning process. While the long-term continuity and extent of especially HV's commitment are exceptional, such broker role is in our experience typical for leaders of LSS deployments.

6.5.2. Evolution of the implementation process over time

Table 6.1 and a qualitative analysis of the underlying events reveal a pronounced evolution over the course of eight waves. Waves 0 and 1 were characterized by a rather optimistic and programmatic deployment. Core problems were on the radar (projects not getting momentum; unclear how to 'guarantee' low ppm's), but the way they were addressed was not nearly penetrating or powerful enough. Then in Wave 2 there was a thickening of events (87 events in Wave 2, against on average 19 events in the other waves), and a lot of dialectics (31% of the events in Wave 2 were coded dialectical learning, against 13% on average for the other waves). The deployment seemed stuck, make-shift solutions were no longer accepted, and the company seemed to confront the hearts of problems and not to shy away anymore from tough measures. From Wave 3 onwards, based on a new vision and with essential modifications in organizational structures in place, learning proceeded in a more incremental manner and without much dialectic. For example, the development of NPD 2.0 in the later waves comes across as a productive and organized form of learning.

This pattern of how the implementation process unfolded fits the punctuated equilibrium model of Tushman and Romanelli (1985) and Romanelli and Tushman (1994). This model states that organizations tend to be in an inert state of equilibrium. Attempts to develop the organization by tentative initiatives, pertaining to only a few domains of organizational activity, do not really accumulate in substantial change, and instead, the organization remains stuck in the equilibrium state. When sufficient pressure and urgency build up, a burst of discontinuous changes may be triggered, which involve nearly all key domains of activity, and these bursts achieve substantial transformation of the organization. Punctuated equilibrium theories have emerged in a variety of scientific fields, such as biology and psychology, and include Thomas Kuhn's familiar model of scientific revolutions (Gersick, 1991).

Equilibrium states are restrained by a set of fundamental choices and notions called deep structures (Tushman and Romanelli, 1985; Tushman et al., 1986; Gersick, 1991), such as core values, strategy, power distribution and organizational structures. The deep structures of Comp-NL at the time of Waves 0 and 1 presented a number of impediments to the ambitions of LSS. Examples include the company's inability to establish priorities and maintain focus on them, the Green Belts' inability to manage their time, the laissez-faire style of management, habits of collaboration with customers, and a culture that rewarded fire-fighting but failed to

acknowledge rigorous engineering aimed at preventing problems in the future. The equilibrium in those early waves was also characterized by the notion that LSS could be adopted successfully largely by copying best practices from outside, the choice to limit LSS to the design of new products only, and the relatively one-sided focus on the mastering of Six Sigma's techniques and procedures.

Attempts to develop the organization from there were confined to a narrow range of organizational activity. Table 6.2 presents the lessons that Comp-NL learned in events coded as positive programmatic (vicarious learning), adaptive learning and dialectical learning. We categorized these new insights by the domain of organizational activity that they pertain to. We used these categories:

- Strategy: Comp-NL's strategic goals and focus, and programs to get there
- Organizational structures: Allocation of tasks to departments and positions; procedures, processes and systems
- Management and people: Behaviors and styles of managers; human resources management
- Values: Core values and beliefs in the organization
- LSS: LSS program management, the Green- and Black Belt projects, courses, tools and LSS procedures

We observe that the Core Team's learning in Waves 0, 1 was largely restricted to LSS itself. The ambitions and activities of LSS, however, were dependent on and intertwined with other domains of activity, and incremental attempts to improve the first without also fundamentally changing the others turned out to be futile. This is in agreement with the punctuated equilibrium model, which predicts that transformations do not happen when change initiatives are restricted to a limited number of organizational domains (Tushman et al., 1986; Romanelli and Tushman, 1994), because of such deep and self-sustaining interdependencies. Over the course of Waves 1 and 2, tension started to build up, as more and more Green Belts were trained, but the projects continued to stagnate, results failed to appear, and the remedies that the Core Team tried in order to get the projects going persistently did not work. The punctuated equilibrium model assumes that such build-up of pressure and urgency is required to overcome the forces that sustain the equilibrium, and initiate changes of a much more radical nature.

	Strategy	Structure	Management	Values	LSS	**Totals**	**Entropy**
Wave 0	0	1	0	3	26	**30**	0.20
Wave 1	0	0	0	0	15	**15**	0.00
Wave 2	14	8	15	8	62	**107**	0.54
Wave 3	1	0	4	0	12	**17**	0.33
Wave 4	1	0	0	0	14	**15**	0.11
Wave 5	2	2	4	1	16	**25**	0.48
Wave 6	0	0	1	1	22	**24**	0.15
Wave 7	0	2	1	0	11	**14**	0.28
Totals:	**18**	**13**	**25**	**13**	**178**	**247**	

Table 6.2: Overview of the domains of the organization that new insights pertain to, and the degree of dispersion (entropy) over the five domains

When tension finally had built up sufficiently, a burst of rapid and radical changes started to happen in Wave 2. Besides the much larger number of events in Wave 2, the dynamics were also different in that the occurrence of dialectical learning was much higher (see Table 6.1), which is a sign of conflict, confusion, and a break-down of the status quo. Moreover, the new insights that the Core Team acquired were not limited to LSS itself, but pertained to a wide range of organizational activity. Table 6.2 quantifies the spread of learned lessons over the five domains of activity by the entropy. This is a statistical measure for the dispersion of classifications (Harris, 1988) and is calculated from the row proportions $p_{mn} = {}^{c_{mn}}/_{t_m}$ (with c_{mn} the cell counts in table 6.2, and t_m the row totals, where m and n index the rows and columns in table 6.2). The entropy of row m is $e_m = -\sum_{n=1}^{5} p_{mn} \log p_{mn}$. For classifications in five categories, entropy ranges from 0.00 (when all classifications are concentrated in a single category, as in Wave 1) to 0.56 (when 19 classifications are dispersed uniformly over the five categories). Note in table 6.2 that entropy is nearly maximal in Wave 2 (0.54 against a maximum of 0.56), reflecting that new insights addressed a wide range of domains. This is in line with the punctuated equilibrium model, which predicts that the bursts of radical, discontinuous change that transform an organization involve change on (nearly) all of the key dimensions of organizational activity (Romanelli and Tushman, 1994). In Wave 2, Comp-NL learned that the laissez-faire style of group leaders and top management hamper LSS's ambitions, and that leadership and acknowledgement are needed to change the balance between fire-fighting and rigorous engineering. Comp-NL learned that the attainment of LSS's ambitions required a "foundation" of other structures and practices as well. Comp-NL developed a model for establishing priorities for initiatives in

the company. HRM policies were improved with a model for skills management, and Comp-NL learned that engineers need coaching in time management. In other words, an interrelated and interdependent tangle of entrenched patterns, reaching far wider than the LSS initiative, became transformed in Wave 2.

These new structures and notions set the arena for developments in the later waves. Waves 3 and 4 were more incremental, both in terms of numbers of events (Table 6.1) and the concentration of new insights on the domain of LSS itself (Table 6.2). Wave 5 reveals another episode where insights spanned nearly all domains of organization activity (entropy is 0.48), without the burst of events witnessed in Wave 2 however (merely 20 events). This appears a reaction to pressure that had started to build up in Wave 4, when projects again started to stagnate. The underlying problem was the organization's inability to handle the trade-off between short- and long-term ambitions, where operational tasks and the LSS projects were competing for the limited time of the engineers. The problems became acute in Wave 4, when the economic tide reversed and sales rose sharply. In this wave the transformational forces did not appear to overcome the conservative forces, however, and in Waves 5, 6 and 7 the problem appeared to be stuck in equilibrium. The new status quo appears to be that the Green Belt projects are seen as less important and emphasis has shifted to the application of LSS's principles and techniques in the NPD projects. For many, this status quo is acceptable.

To put table 6.2 in context, note that the global economic crisis hit the company hard during Wave 2. An analysis of the records shows that the effect of the economic situation on LSS was that activities were delayed or postponed, which is reflected in the long duration of Wave 2. Besides this stretching out over a longer period of time, there was no strong qualitative effect on the unfolding of the implementation process, and in particular, the longer duration of Wave 2 cannot in any way explain the large number of events that occurred in it. This reading is confirmed by interviewees, who cannot give examples of effects of the economic crisis on the development of LSS other than delay and postponement.

6.5.3. Reach and nature of the changes

Originally, Comp-NL had mostly technical associations about LSS and maybe a change of values and beliefs: new analysis techniques and an embracing of engineering rigor would enable the company to "guarantee low ppm's". But in fact, the company had to learn many other things as well, such as the wide-reaching lessons of Wave 2. Thus, the extent of change instigated by LSS at Comp-NL is not incremental and cumulative, but instead fundamental transformation (Romanelli and Tushman, 1994) and strategic change (Nadler et al., 1995). They are not changes in the system, but changes of the system (Tushman et al., 1986). The impression emerges that adopting LSS is not an add-on or plug-in of best practices and new skills that are integrated in an organization's existing deep structures. Instead, realizing LSS's ambitions and turning the new skills into results appears to require a more fundamental change in an organization's deep structures themselves, because these deep structures imply impediments that hamper LSS in fulfilling its ambitions. These impediments are often hidden when a LSS initiative starts, and LSS lays them bare or even amplifies them. For example, a hidden impediment at Comp-NL was the inherent strain between short-term operational tasks for the engineers and the long-term ambition of rigorous engineering. This fundamental problem became exposed more and more from Wave 5 onwards as it hampered LSS's ambitions. In similar vein, LSS is likely to expose organizational inabilities, such as an inability for an organization to focus its efforts, or an inability to remain committed to a chosen course of action sufficiently long to allow it to bear fruit, or an inability to organize decision processes such that rational decisions emerge. Often, such impediments involve a sensitive impasse on politically challenging issues. Examples include:

- Some labor-intensive organizations aim to improve the cost structure of their operation by adopting LSS, but this goal gets bogged down in an impasse if firing personnel is undesirable in the organization's core values. Achieving LSS's goals may require the organization to address the impasse and is likely to involve fundamental transformation.
- In some organizations the goal of performance improvement has the precarious consequence that the status quo in power positions or autonomy needs to be broken. Again, achieving LSS's goals is likely to require a fundamental transformation.

These examples show that the transformation of an organization's deep structures that is required to allow LSS to realize its ambitions is often radical, wide-ranging and politically challenging.

Why did the burst of radical transformation happen in Wave 2, rather than in Waves 0 or 1? Could these transformations have been planned and executed in programmatic fashion, right from the start of the implementation, by adopting best practices from other companies that implemented LSS? We believe not. First, implementation models in the practitioners' literature mostly do not bring across the awareness that an organization's deep structures need to be fundamentally transformed (Lameijer et al., 2017). Therefore, an organization first needs to discover itself by trial-and-error that an incremental implementation without transformation is unlikely to work. Second, an organization's deep structures and the impediments that they imply for a LSS initiative are idiosyncratic. Therefore, an organization needs to discover these impediments itself, and invent good ways of transforming them. This probably requires a few initial waves in which the organization learns. Third, we believe that radical transformation, confronting sensitive impasses, and challenging the status quo, are difficult to achieve without a build-up of tension and urgency. The persistent problems and stagnation in Waves 0, 1 and 2 at Comp-NL may have been needed in order to create sufficient tension to break the status quo.

6.5.4. Linking our findings to LSS literature

Although we did not find scientific literature explicitly linking LSS implementation to punctuated equilibrium theory, many findings in the literature can be explained from this perspective. Our conclusion, that a successful implementation of LSS requires a far-reaching transformation of an organization's deep structures, agrees with many studies of critical success factors. Anand et al. (2009) emphasize that LSS's ambitions necessitate a supportive organizational infrastructure, and that interdependencies among elements of such infrastructure may make an implementation focusing on only a narrow selection of them ineffective. McAdam and Lafferty (2004), studying the implementation at Seagate, observe that LSS's ambitions were impeded by structures in the organizational context: "These problems show that LSS is not the ultimate panacea for organizational ills and that both complex people and process issues must be addressed."

A culture with values such as data-based decision making and a focus on customers is seen as a critical success factor for LSS (Arumugam et al., 2014) and references therein, and Linderman et al., (2010). It follows that if an organization's deep structures do not support such values, a successful implementation requires a fundamental transformation. Other

domains of the organizational infrastructure that may need transformation include an organization's HRM policies and IT infrastructure (McAdam and Lafferty, 2004; Arumugam et al., 2014). Our case study suggests that such transformations do not occur incrementally, but as a punctuated equilibrium.

Many studies of LSS implementation stress the importance of top management leadership (Arumugam et al., 2014; Linderman et al., 2010). This fits well with the literature on punctuated equilibrium models, which also emphasizes the importance of top leadership initiative to build up sufficient tension to break the status quo (Tushman et al., 1986). Also poor financial performance may help to overcome inertia, and this is indeed consistent with Swink and Jacobs (2012), who found that loss-making firms benefit more from LSS, perhaps because the poor financial performance creates urgency for change.

Swink and Jacobs (2012) also found, in a wide and thorough study of the returns of LSS initiatives, that it takes at least 2 to 3 years before the benefits of LSS become manifest. This pattern is consistent with our interpretation, where the very first waves are smothered in organizational inertia, and LSS's ambitions are attained only after a burst of radical transformations after the initiative has been on its way for some time.

6.6. Conclusions

The implementation of LSS at the organizational level is often portrayed in the practitioners' literature as programmatic (copy-pasting of a fixed and generic blueprint) and cumulative (new skills and practices are added to the organization and integrated in its culture and strategy). Such programmatic implementation processes are attractive. They are simple (linear, stepwise, controlled and of limited scope) rather than complex (confusing, difficult to predict and control, confronting multidimensional messes of interrelated and sensitive issues). They may better fit the comfort zone and experience of management and deployment leaders, and avoid challenges such as politically sensitive impasses and unexplored territory. They seem modest in the efforts and resourcefulness that they require.

We find that this portrayal is misconstrued. The realization of the ambitions of LSS requires a more radical transformation, where impediments in the organization's deep structures are discovered and altered, and this transformation will impact a wide range of domains of organizational activity. Such radical transformation does not occur in an incremental,

accumulative fashion, but instead, follows the familiar punctuated equilibrium model where the implementation goes through an episode of inert equilibrium, meanwhile building up tension, and thereupon experiences a burst of radical, penetrating and wide-reaching changes. Further, the process is driven, naturally, by adopting practices from outside sources, but at least as important are lessons that the organization needs to discover itself by adaptive and dialectical learning.

A practical implication of this conclusion is that organizations should not be mistaken in believing that they can buy LSS off the shelf, or hand over the implementation to consultants. Instead, they should be aware that the implementation largely depends on the resourcefulness and learning efforts of the company's own management and professionals.

A second implication is that organizations should not be mistaken in believing that LSS can meaningfully be implemented as an add-on, or a plug-in, to the existing organization; such approach is likely to be smothered by individual, group and organizational inertia. Instead, LSS's ambitions, to be fulfilled by the Green- and Black Belt projects, probably require a transformation of many of the organization's deep structures. The conclusion also has ramifications for the question of what is a realistic duration for implementing LSS. Based on our findings we suggest that LSS should not be started as a tactical initiative (implementation takes less than two years). Such time span is too short for meaningful results of the learning process to emerge. Conceiving, instead, the implementation as a strategic change (implementation lasts two to five years) acknowledges that the biggest breakthroughs in learning happen in Wave 2 or thereabout; after these breakthroughs the initiative comes in a more mature stage involving mainly incremental and relatively well controlled adaptive learning. Finally, a LSS initiative could also be construed as continuous learning (implementation "never ends"), rather than episodic change (Seo et al., 2004). This conception acknowledges that this process of incremental learning may continue quite long and remain valuable.

How should such implementation process be managed? For one, our study confirms the claim of Tushman and Romanelli (1985), who observe that processes of organizational transformation are idiosyncratic and that "organizations do not evolve through a standard set of stages." Advice for managing the implementation process, therefore, should not be programmatic. Instead, a deployment team should anticipate that the implementation

process cannot be charted from the start. The adoption of LSS is managing and navigating a learning process involving time consuming and tedious cycles of trial and error. Not only the implementation strategy and the targeted end-state should be open to reconsideration as the organization learns, but even the organization's deep structures. This demand quite a lot from the organization's own resources, resourcefulness and perseverance, and executive leadership is needed in many aspects of the change. Tushman et al. (1986) emphasize that, to overcome forces sustaining inertia, a compelling and forceful notion is needed of the external condition that makes the transformation necessary or attractive. Implementing LSS for its own sake, or motivated by a vague appeal to a generic ambition ("world-class quality") is unlikely to create sufficient momentum. It should be anticipated that most of the planning and learning does not happen in Wave 0, but two or three waves down the process, and that there will be a phase with a lot of dialectics, chaos and rapid change. The broker role of a deployment leader can catalyze such learning process.

We discuss some academic implications of our study. Scientific studies of interventions such as LSS, Lean and Total Quality Management encounter a persistent anomaly. Results of the adoption of such models vary widely across firms that adopt them, and literature cannot explain or identify the factors that account for these differences (Voss, 1992; Powell, 1995; Bhasin and Burcher, 2006). The current research, designed as a process study, is not suited to establish such explanation, which would require a variance study. This detail-rich qualitative study of one such process, however, does suggest a proposition that presents itself for further study. Our conjecture is that the fate of a LSS initiative is largely determined once tensions have built up after a few first waves (in Wave 2 at Comp-NL). One way it can go at such juncture, is that the built-up tensions are not enough to overcome the forces sustaining the equilibrium, and therefore, that a burst of radical transformation fails to occur. Deep structures then will continue to impede LSS's ambitions, results will continue to disappoint, and the initiative fades out or is abandoned. The other way it can go, is that the status quo is broken, and management is able to navigate the organization through an episode of penetrating and wide-reaching transformation. This requires courage, perseverance, and skills. Our proposition is that the fate of LSS initiatives critically depends on the balance of opposing forces at such juncture, and in case the driving forces overpower

the conservative forces, on an organization's ability to endure the ensuing radical and complex learning process and bring it to a good end.

In the introduction we described the notion that LSS's DMAIC method embodies the conviction that improvement is driven by learning processes, and in fact, projects that aim to implement a fixed and given solution without first learning about the problem's causes are not considered legitimate LSS projects (Snee and Hoerl, 2003; De Mast and Lokkerbol, 2012). In view of this, the prevalent portrayal of LSS's implementation as a programmatic roll-out of a fixed and given blue-print in the practitioners' literature is therefore not only misguided; it is also a touch ironical.

7. Summary of implementing LSS in organizations

Due to a variety of reasons such as increased competition, resource scarcity and transparency in price and quality for buyers, organizations are increasingly focused on efficiently delivering high quality services and products. Consequently, in recent years we see an increase in the popularity of operational excellence methods that are applied in a variety of businesses and industries. This thesis focuses on operational excellence following the Lean Six Sigma (LSS) method.

7.1. Implementing LSS in organizations

LSS comprises Lean and Six Sigma, and both are methods to improve operations. Lean is focused on the elimination of waste and aligning and synchronizing the pace of operations in a value chain or process. The complementary statistical Six Sigma methods are focused on defect- and variability reduction in business processes. The combined LSS method has evolved from a manufacturing discipline into a widely studied and applied business improvement initiative. Most of the research on LSS is focused on quantitative tools and project management techniques and after early 2000 we see an increase in the implementation of LSS in several industries outside manufacturing, such as finance and healthcare. As the popularity of implementing LSS grows, questions about implementing LSS in organizations arise. These questions transcend the LSS knowledge on quantitative tools and project management techniques, and this is where we aim to contribute.

In this thesis we study key questions about implementing LSS in organizations at two levels of analysis. The first level of analysis is the LSS project which we will name LSS project implementations. The second level of analysis is the implementation of LSS as strategic organizational change initiative which we will name LSS implementation at the organizational level. The chapters in this thesis stem from published researches on LSS project implementations by Lameijer et al. (2016a; 2016b; 2018) and on LSS implementation at the organizational level by Lameijer et al. (2017) and De Mast et al. (2017).

7.2. Motivation

Previous research into LSS project implementations recognized the importance of commitment and support from people (such as management, employees and improvement specialists) and later studies confirmed that success of LSS projects and adoption of LSS

attributes is indeed determined by employee attitudes and perceptions. Nevertheless, we find that the effect of implementing LSS projects on employee perception and attitude remained scarcely addressed in the literature and this is what we investigate in chapter 2. Additionally, early research identified the clarity of project goals as an important reason for LSS project implementation failure. Unclear project objectives results in diverging views of the same project by project leaders, managers and employees and we believe that the resulting ambiguity does not contribute to positive attitudes to LSS projects or adoption of LSS attributes. Therefore we investigate what LSS project objectives are most common and present generically applicable LSS project definitions for multiple industries in chapter 3. Based upon the research in chapter 3 we discuss the suitability of LSS project implementations in the public sector in chapter 4 as this industry is, in contrast to the manufacturing, finance and healthcare industry, relatively new to LSS implementations.

At the organizational level we find that the academic literature does not offer a systematic approach to the implementation of LSS as a strategic organizational change initiative. There are few studies on implementing LSS in organizations that provided fragmented success factors. Instruction, guidance or specific models for the implementation of LSS are scarce and therefore we have identified and reviewed the current knowledge on LSS implementation at the organizational level in chapter 5. From this we learned that the current knowledge on implementing LSS is rather generic and therefore has a limited applicability for organizations looking to implement LSS as a strategic organizational change initiative. Most importantly we find that organizational learning patterns in LSS implementation processes are required to make the LSS method suitable for individual organizations, and these are not addressed in current LSS implementation literature. Therefore we have studied organizational learning dynamics in LSS implementation processes in chapter 6, and found how a LSS implementation process unfolds and what organizational learning patterns underlay the implementation process.

7.3. Methods

The researches in this thesis are set up as qualitative multiple-case studies. Each of the researches are structured by within case analysis that provides detailed write-ups and coding of the explanatory variables for each case, to get intimately familiar with the cases and discover patterns. The pre-defined explanatory variables that we look for and code in the

cases of study are based upon existing literature. Coding the explanatory variables in the cases allows for cross-case analysis, were we compare the coded explanatory variable categories and look for similarities- and differences between cases. Finally, we have compared the findings with external theory and place the findings in existing theory (Eisenhardt, 1989).

For each chapter the unit of analysis is different but the research protocols share similarities. Chapter 2 takes the LSS projects in five organizations as units of analysis and investigates these five cases by in-depth semi-structured interviews, which are documented and coded according to the pre-defined explanatory variables. Chapter 3 takes 312 previously executed LSS projects as units of analysis, investigates these project definitions in detail, and subsequently codes the pre-defined explanatory variables. In chapter 5 we have investigated 20 LSS deployment and maturity models and coded a total of 11 explanatory variables per case. Chapter 6 takes one organization as unit of analysis and here we investigated and coded over 144 editions of the bi-weekly newsletter, the minutes and management presentations of the LSS Core Team (48 documents) and corroborated the coding of events by means of semi-structured interviews.

In all the researches, transparency and repeatability is dealt by amongst others (1) a clear description of the sampling strategy, (2) coding procedure and (3) enclosure (upon request) of the within case analysis (Barrat et al., 2011). Validity is addressed by means of structuring the researches according to the chain of evidence (Stuart et al., 2002). Finally, thorough documentation of all the research and interviews is done in accordance with the guidelines for reproducible research and is available as supplementary material (Voss et al., 2002).

7.4. Results and recommendations

The research presented in this thesis has led to findings and recommendations on implementing LSS projects and implementing LSS as strategic organizational change initiative at the organizational level.

7.4.1. Results and recommendations on implementing LSS at the project level

In chapter 2 we find that when implementing LSS projects there are several factors that have an effect on the attitude of managers and employees towards LSS projects.

- First we find that in a negative organizational context with unfavorable market conditions, LSS project are interpreted as a means to reduce costs and perceptions relate to fear and resistance. In the opposite more positive organizational context with more favorable market conditions, the improvement aspect of LSS projects will receive most attention and this thesis shows that management needs to deal consciously and continuously with this cost bias problem. Best practices seem to entail at least (1) being clear up-front about the objective of the LSS project implementation and (2) decoupling cost saving expectations from LSS project implementation in communication and practice.
- Second, the framing of LSS project implementations by the involved actors is quite narrow compared to many LSS attributes that are applied in LSS projects. We find that attempts to broaden the perception of the LSS projects to include much more than, for instance, only improvement strategies and standardization have a positive effect on the perception of LSS projects.
- Third, we find a distinction between quick wins (gained from discrete LSS project application) and long-term goals (targeted by a more involved approach) in LSS project implementations. Our research suggests that while the Six Sigma project approach can have a larger and more immediate effect, the drive required to keep the initiative going after initial management-initiated projects comes from a gradual and bottom-up implementation of LSS at the shop floor.

In chapter 3 we find that when implementing LSS projects in the organization, there are several factors that influence the clarity of LSS project definitions for all those involved, such as management, employees and specialists.

- First we find that there is ambiguity about the contribution of LSS projects to strategic focal points. For instance, the analyzed LSS project definitions correspond to all of the five performance dimensions but flexibility. We believe this is because the variety in meaning for the definition of flexibility is broad and overlaps with other dimensions. Hence, flexibility should be made specific in LSS project definitions to capture the actual project objective and provide clarity for the LSS practitioner and stakeholders.
- Second, the generic LSS project definitions in all four performance dimensions are failing to address CTQ's that measure the performance beyond the borders of the organization. For instance, generic project definitions try to capture external (customer) opinions by

measuring internal signals of unsatisfied customers (complaints). We urge LSS practitioners to consider the end-user when setting the project objective and CTQ's to ensure actual improvement instead of problem signal reduction.

- Third, in the sample of LSS project definitions, a wide variety of strategic focal points are identified and these are not clearly related to an organization's general accounting measures, which are a common measurable representation of an organization's strategic levers. This is problematic as the contribution of LSS projects to strategic focal points is thereby unclear for those involved.

In chapter 4 we explore if and how the nature of an industry determines the suitability for LSS project implementation, based upon the research on LSS projects from multiple industries in chapter 3. This chapter is a discussion paper in response to a conference contribution on the application of statistical thinking in political processes. We present a short discussion on the suitability of LSS project implementations in the public sector and conclude that there is no significant hurdle to implement LSS projects in the public sector.

7.4.2. Results and recommendations on implementing LSS at the organizational level

In chapter 5 we have studied the quality and usefulness of LSS deployment and maturity models that offer advice on LSS implementation as strategic organizational change initiative at the organizational level. These models exist in academic literature and practitioner publications.

- We find that established principles in the literature on organizational development are not properly reflected in LSS deployment and maturity models, and that their theoretical grounding is rather unsatisfactory. The advice offered through almost all models is rather sketchy, hinting at what should be achieved but failing to offer specific, operational advice on how to do this.
- All studied models are describing LSS implementation processes as generic. The desired end-state of implementation is not open to adjustment, but rather it is fixed and given, copied from best-practices such as Toyota and General Electric. Implementation support for practitioners would be more useful if it acknowledged that deployment processes are partly idiosyncratic and difficult to plan, and if it offered more support for constructive organizational learning that is needed to adjust LSS to one's organization.

- Our assessment of the quality and usefulness of the existent advice for implementing LSS marks a clear need for deployment support of a more useful and better grounded nature.

In chapter 5 we conclude that the implementation of LSS is often portrayed as programmatic (copy-pasting of a fixed and generic blueprint) and cumulative (new skills and practices are added and integrated in the culture and strategy) and in chapter 6 we find that this portrayal is misconstrued.

- We find that the realization of the ambitions of LSS requires a more radical transformation, where impediments in the organization's deep structures are discovered and altered. Such radical transformation does not occur in an incremental, accumulative fashion, but instead, follows the familiar punctuated equilibrium model where the implementation goes through an episode of inert equilibrium, meanwhile building up tension, and thereupon experiences radical and wide-reaching changes.
- The process of implementing LSS is driven, naturally, by adopting practices from outside sources, but at least as important are lessons that the organization needs to discover itself by adaptive and dialectical learning. Therefore organizations should not be mistaken in believing that they can buy LSS off the shelf or hand over the implementation to consultants. Instead, they should be aware that LSS implementation largely depends on the resourcefulness and learning efforts of company- management and professionals.
- Advice for managing the implementation process, therefore, should not be programmatic. Instead, a deployment team should anticipate that the implementation process cannot be charted from the start. The adoption of LSS is managing and navigating a learning process involving time consuming and tedious cycles of trial and error.

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8. Samenvatting van het implementeren van LSS in organisaties

Door een verscheidenheid van redenen, zoals toegenomen concurrentie, schaarste van grondstoffen en toegenomen transparantie in prijs en kwaliteit voor kopers, zijn organisaties in toenemende mate gericht op het efficiënt leveren van kwalitatief hoogwaardige diensten en producten. Als gevolg zien we in de laatste jaren een toename in de populariteit van 'operational excellence' methoden, die in een verscheidenheid van bedrijven en industrieën worden toegepast. Dit proefschrift richt zich op operational excellence volgens de Lean Six Sigma (LSS) methode.

8.1. Implementeren van LSS in organisaties

LSS bestaat uit Lean en Six Sigma, en beide zijn methoden om de operationele bedrijfsvoering te verbeteren. Lean is gericht op het verwijderen van verspilling in processen door het balanceren en synchroniseren van het tempo van de operaties in een waardeketen of proces. De complementaire statistische Six Sigma methode is gericht op het verminderen van fouten en verhogen van de voorspelbaarheid van bedrijfsprocessen. De gecombineerde LSS methode is geëvolueerd van een methode voor productiebedrijven naar een uitgebreid bestudeerde en toegepaste operationele verbetermethode. Het grootste deel van het onderzoek naar LSS is gericht op kwantitatieve instrumenten en project management technieken en na het begin van 2000 zien we een toename in de toepassing van LSS in verschillende sectoren buiten de fabrieksomgevingen, zoals de financiële sector en de gezondheidszorg. Nu de populariteit van LSS toeneemt, ontstaan er meer vragen over de implementatie van LSS in organisaties. Deze vragen overstijgen de LSS kennis over kwantitatieve instrumenten en project management technieken, en dit is waar we willen bijdragen.

In dit proefschrift bestuderen we belangrijke vragen over het implementeren van LSS in organisaties op twee niveaus van analyse. Het eerste niveau van analyse is het LSS project, en dat noemen we LSS project implementatie. Het tweede niveau van analyse is de implementatie van LSS als strategisch verander initiatief en dat noemen we implementatie van LSS op organisatie niveau. De hoofdstukken in dit proefschrift komen voort uit gepubliceerde onderzoeken over LSS project implementaties door Lameijer et al. (2016a; 2016b; 2018) en over LSS implementatie op organisatieniveau door Lameijer et al. (2017) en De Mast et al. (2017).

8.2. Motivatie

Eerder onderzoek naar LSS project implementaties erkende het belang van de inzet en steun van mensen (zoals het management, medewerkers en specialisten). Latere studies bevestigden dat het succes van LSS projecten inderdaad mede wordt bepaald door de houding en perceptie van werknemers. Toch vinden we dat het effect van LSS project implementaties en werknemer houding en perceptie nauwelijks in de literatuur word geadresseerd en dit is wat we onderzoeken in hoofdstuk 2. Daarnaast identificeerde eerder onderzoek dat de duidelijkheid van de doelstellingen van het LSS project een belangrijke reden is voor het mislukken van LSS project implementaties. Onduidelijke LSS projectdoelstellingen resulteren in uiteenlopende interpretaties over hetzelfde project door projectleiders, managers en medewerkers en wij geloven dat de resulterende onduidelijkheid niet bijdraagt aan een positieve houding ten opzichte van LSS projecten of de adoptie van LSS attributen. Daarom onderzoeken we wat de meest voorkomende LSS project doelstellingen zijn en presenteren generiek toepasbare LSS project definities, geschikt voor meerdere industrieën in hoofdstuk 3. Op basis van onderzoek naar LSS project implementaties in meerdere industrieën in hoofdstuk 3 bespreken we de geschiktheid van LSS project implementaties voor de publieke sector in hoofdstuk 4. Deze sector is, naast de productie- en financiële sector en gezondheidszorg, relatief nieuw voor LSS project implementaties.

Op organisatorisch niveau vinden we dat de wetenschappelijke literatuur een systematische aanpak voor de implementatie van LSS als strategisch organisatie verander initiatief niet aanbiedt. Enkele studies over de implementatie van LSS in organisaties bieden gefragmenteerde succesfactoren voor LSS implementatie. Instructie, begeleiding of specifieke modellen voor de implementatie van LSS zijn schaars en daarom hebben we de huidige kennis over LSS implementatie op organisatie niveau geïdentificeerd en bestudeerd in hoofdstuk 5. Hieruit leren we dat de huidige kennis over de implementatie van LSS vrij generiek is en daarom een beperkte toepasbaarheid heeft voor organisaties die LSS als een strategisch organisatie verander initiatief willen implementeren. Bovendien ontdekken we dat organisatorische leerpatronen in het LSS implementatieproces vereist zijn om de LSS methode geschikt te maken voor individuele organisaties, en dit wordt niet als zodanig geadresseerd. Daarom hebben we organisatorische leerpatronen bestudeerd in een LSS

implementatie proces in hoofdstuk 6. Zo ontdekken we hoe een LSS implementatie zich ontvouwt en welke organisatorische leerpatronen het proces bevat.

8.3. Onderzoeksmethoden

De onderzoeken in dit proefschrift zijn opgezet als kwalitatieve meervoudige casus studies. Elk onderzoek is gestructureerd door een per-casus analyse, welke bestaat uit een gedetailleerde vastlegging van informatie over de casus en codering van onderzoeksvariabelen (of verklarende variabelen) om zo patronen te kunnen ontdekken. Deze vooraf gedefinieerde onderzoeksvariabelen zijn opgesteld aan de hand van de bestaande literatuur. Codering van deze onderzoeksvariabelen maakt een vergelijkende analyse tussen verschillende casussen mogelijk, om zo verschillen en overeenkomsten tussen casussen te vinden. Ten slotte worden de bevindingen met de bestaand theorie vergeleken en zodoende in de bestaande theorie geplaatst (Eisenhardt, 1989).

Voor elk hoofdstuk is de eenheid van analyse verschillend en het onderzoeksprotocol vergelijkbaar. Hoofdstuk 2 neemt LSS projecten in vijf organisaties als eenheden van analyse en onderzoekt deze vijf gevallen middels uitvoerige semigestructureerde interviews, die daarna zijn vastgelegd en waarin de vooraf gedefinieerde onderzoeksvariabelen worden gecodeerd. Hoofdstuk 3 neemt 312 uitgevoerde LSS projecten als eenheden van analyse, onderzoekt de LSS project definities in detail en codeert vervolgens de vooraf gedefinieerde onderzoeksvariabelen. In hoofdstuk 5 hebben we 20 LSS implementatie en maturiteit modellen onderzocht en gecodeerd middels een totaal van 11 onderzoeksvariabelen. Hoofdstuk 6 neemt één organisatie als eenheid van analyse en onderzoekt 144 tweewekelijkse nieuwsbrieven, de notulen en presentaties van het LSS kernteam (48 documenten) en bevestigt de daarop volgende codering van de gebeurtenissen door middel van semigestructureerde interviews.

In alle onderzoeken worden transparantie en reproduceerbaarheid geadresseerd door onder andere (1) een duidelijke beschrijving van de steekproef strategie, (2) de codeerprocedure en (3) het bijsluiten van (op aanvraag) uitgebreide per casus analyses (Barrat et al., 2011). De validiteit van de onderzoeken wordt gewaarborgd door het structureren van de onderzoeken volgens de keten van bewijs (Stuart et al., 2002). Tot slot zijn alle onderzoeken en interviews gedocumenteerd volgens de richtlijnen voor reproduceerbaar onderzoek en zijn beschikbaar als aanvullend materiaal (Voss et al., 2002).

8.4. Resultaten en aanbevelingen

Het onderzoek in dit proefschrift heeft geleid tot bevindingen en aanbevelingen voor implementatie van LSS projecten en de implementatie van LSS als strategisch verander initiatief op organisatorisch niveau.

8.4.1. Resultaten en aanbevelingen voor de implementatie van LSS op projectniveau

In hoofdstuk 2 ontdekken we dat bij de implementatie van LSS projecten er verschillende factoren van invloed zijn op de houding van managers en medewerkers ten opzichte van LSS.

- Ten eerst vinden we dat in een negatieve organisatorische context met ongunstige markt omstandigheden, LSS projecten worden gezien als kostenbesparend middel en worden ontvangen met angst en weerstand. In de tegenovergestelde positievere organisatorische context met meer gunstige marktomstandigheden zal het verbeteringsaspect van LSS projecten de meeste aandacht krijgen en dit proefschrift laat zien dat het management bewust en voortdurend moet omgaan met het kostenbesparende uiterlijk van LSS projecten. De aanbevelingen is om ten minste (1) vooraf duidelijk te zijn over de doelstellingen van LSS project implementaties en (2) om kostenbesparingsdoelstellingen van LSS projecten te ontkoppelen, in de communicatie en in de praktijk, ten minste onder management niveau om zo onrust en weerstand te voorkomen.
- Ten tweede, de perceptie van LSS instrumenten die in LSS projecten worden toegepast is vrij nauw bij de betrokkenen. Daarom zal continue inspanning benodigd zijn om de perceptie van LSS projecten uit te breiden naar meer dan bijvoorbeeld alleen het reduceren van verspilling en verhogen van standaardisatie omdat dit een positief effect heeft op de houding ten opzichte van LSS projecten.
- Ten derde vinden we een verschil tussen korte termijn verbetering (na een losstaand LSS project) en het realiseren van lange-termijn organisatie verbeterdoelen middels LSS project implementaties. Ons onderzoek suggereert dat, terwijl Six Sigma projecten een groter en meer direct effect kunnen hebben, het momentum dat nodig is om de LSS implementatie gaande te houden na de eerste management geïnitieerde projecten afkomstig is van een meer geleidelijke en ‘bottom-up’ implementatie van LSS.

In hoofdstuk 3 vinden we dat bij LSS project implementaties in organisaties er verschillende factoren zijn die de helderheid van LSS projectdoelstellingen beïnvloeden voor betrokkenen, zoals management, medewerkers en specialisten.

• Ten eerste vinden we dat er onduidelijkheid bestaat over de bijdrage van LSS projecten aan strategische doelstellingen. Bijvoorbeeld, de geanalyseerde LSS projectdefinities komen overeen met alle vijf prestatiedimensies die er zijn, behalve flexibiliteit. Wij geloven dat dit komt omdat de variatie in betekenis voor de definitie van flexibiliteit breed is en overlap heeft met andere dimensies. Het is daarom belangrijk om flexibiliteit te concretiseren in LSS project definities om zo het eigenlijke doel van een LSS project te vangen en daarmee duidelijkheid voor de LSS consultant en stakeholders te realiseren.

• Ten tweede, de LSS project definities in alle vier overige prestatiedimensies slagen er niet in om prestatie indicatoren (CTQ's) buiten de grenzen van de organisatie te adresseren. Bijvoorbeeld, generieke project definities proberen de (externe) klant tevredenheid te vangen door het meten van interne signalen van ontevreden klanten (klachten). Wij dringen er bij LSS consultants op aan om de eindgebruiker of de klant te overwegen bij het bepalen van de projectdoelstellingen en CTQ’s om zo daadwerkelijke verbetering te realiseren, in plaats van het probleemsignaal te reduceren.

• Ten derde, in de steekproef van LSS projectdefinities, wordt een breed scala aan strategische doelstellingen geïdentificeerd en de meeste daarvan zijn niet duidelijk te relateren aan algemene boekhoudkundige prestatie indicatoren van een organisatie. Dit is problematisch omdat een meetbare bijdrage van LSS projecten aan strategische doelstellingen daardoor onduidelijk blijft voor betrokkenen.

In hoofdstuk 4 onderzoeken we of- en hoe de aard van een industrie de geschiktheid voor LSS project implementatie bepaalt, gebaseerd op het onderzoek naar LSS project implementaties in meerdere sectoren in hoofdstuk 3. Dit hoofdstuk is een discussieartikel in reactie op een bijdrage aan een conferentie over de toepassing van statistisch denken in politieke processen. We presenteren een korte discussie over de geschiktheid van LSS projecten in de publieke sector en concluderen dat er volgens ons geen significante belemmering zijn om LSS projecten in de publieke sector te implementeren.

8.4.2. Resultaten en aanbevelingen voor de implementatie van LSS op organisatieniveau

In hoofdstuk 5 bestuderen we de kwaliteit en de bruikbaarheid van LSS implementatie en maturiteit modellen met advies over LSS implementatie als strategisch verander initiatief op organisatie niveau. Deze modellen komen uit wetenschappelijke literatuur en praktijk publicaties.

- Ten eerste vinden we dat gevestigde principes in de literatuur over organisatie ontwikkeling niet goed weerspiegeld worden in de LSS implementatie en maturiteit modellen, en dat de theoretische onderbouwing van deze modellen onbevredigend is. Het advies dat deze modellen bieden is in bijna alle gevallen onduidelijk. Modellen zinspelen op wat zou moeten worden bereikt met een LSS implementatie, maar specifieke en operationele adviezen over hoe dit te bereiken mist in deze modellen.
- Alle bestudeerde LSS implementatie en maturiteit modellen presenteren LSS implementaties als generieke processen. De gewenste eindsituatie van de implementatie is niet beschreven als iets dat open staat voor aanpassing, maar gegeven en veelal gekopieerd van voorbeeldimplementaties zoals bij Toyota en General Electric. Implementatieadvies voor LSS consultants zou nuttiger zijn als het erkende dat implementatieprocessen deels eigenzinnig en moeilijk te plannen zijn, en als het meer advies bood over organisatorische leerprocessen die nodig zijn om LSS passend te maken voor de organisatie.
- Ons onderzoek naar de kwaliteit en bruikbaarheid van de bestaande LSS implementatie adviezen markeert een behoefte aan nuttiger LSS implementatieadvies, ondersteund door beter bewijs.

In hoofdstuk 5 concluderen we dat de uitvoering van LSS vaak wordt gepresenteerd als programmatisch (het knippen-en-plakken van een generieke blauwdruk) en cumulatief (nieuwe vaardigheden en werkwijzen worden stapsgewijs toegevoegd aan de organisatie en geïntegreerd in de cultuur en strategie). In hoofdstuk 6 vinden we dat deze presentatie niet klopt.

- We vinden dat het realiseren van LSS ambities een radicale transformatie vereist, waarbij belemmeringen in de diepere organisatiestructuren moeten worden ontdekt en gewijzigd. Zulke radicale verandering komt niet op een incrementele en accumulatieve manier, maar in plaats daarvan in het bekende ‘punctuated equilibrium’ (ofwel ‘doorbroken evenwicht’) model. Daarbij gaat de organisatie tijdens de implementatie van LSS door een periode van

evenwicht dat wordt gekenmerkt door inertie (er vindt geen werkelijke verandering plaats). Ondertussen bouwt de noodzaak voor verandering zich op waarna een uitbarsting resulteert in radicale, doordringende en breed- ingrijpende veranderingen.

• Het LSS implementatie proces wordt enerzijds gedreven door het overnemen van praktijken uit externe bronnen. Anderzijds vonden we dat een organisatie ook zelf de te leren lessen moet ontdekken, door organisatorische processen van adaptief en dialectisch leren. Een praktische implicatie van deze conclusie is dat LSS implementaties in een organisatie niet 'uit het schap' kunnen worden gekocht of volledig kan worden overgedragen aan externe LSS consultants. Sterker, bij een LSS implementatie is de organisatie grotendeels afhankelijk van de eigen vindingrijkheid en leerinspanningen.

• Advies voor het besturen en beheren van LSS implementaties zou daarom niet programmatisch van aard moeten zijn. In plaats daarvan denken wij dat een LSS implementatie team moet verwachten dat het implementatie proces niet vanaf het begin voorspeld kan worden. Het implementeren van LSS is voornamelijk het besturen en begeleiden van een organisatorisch leerproces waarbij tijdrovend en terugkerende cycli van leren-door-doen moeten worden doorlopen.

Curriculum Vitae

Bart Lameijer was born on Sunday the 2nd of November 1986 in Sassenheim, the Netherlands. He was raised in a small municipality (Noordenveld) in the Netherlands. He attended secondary school in Groningen in 1999 and in 2004 he commenced his Bachelor in Commerce program at the Hanze University of Applied Sciences in Groningen. He has graduated in Brisbane, Australia by delivering a pragmatic advice on Greenfield foreign market entrance for an educational counseling service. In 2009 he enrolled as Business Administration student at Tilburg University and in 2011 he has graduated cum laude with a master thesis about the impact of environmental strategies on firm performance.

Thereafter in 2011, he commenced as management trainee in the corporate management traineeship at ABN-AMRO bank in the Netherlands. After various national and international commercial and consulting projects, he decided to pursue a career in operations improvement. He enrolled for the Lean Six Sigma program at the University of Amsterdam and since 2014 he has been working for ABN-AMRO bank as Lean Six Sigma (LSS) Black Belt and subsequently as Master Black Belt. In these roles he has trained and coached LSS consultants on LSS methods and in LSS projects, led the implementation of several LSS projects and worked in deployment teams for the implementation of LSS as an organizational change initiative both in the Netherlands and Germany. In the meantime he has been a PhD candidate at the University of Amsterdam at the department of Operations Management. That is where he has studied the implementation of LSS in organizations at the project- and the organizational level, under the supervision of- and together with Ronald Does and Jeroen de Mast, which resulted in this thesis.

As hobbies Bart likes to do sports, such as windsurfing, running, basketball, squash and speed cycling. Other favorite activities include reading and playing the piano.

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