

Critical Success Factors (CSFs) for Lean Six Sigma
(LSS) Implementation and Its Impact on the Performance
of Electronic Manufacturing Services (EMS) Industries

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Research report in partial fulfillment of the requirements
for the degree of DBA

Universiti Sains Malaysia

2010

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr. K.Jayaraman for his invaluable guidance in helping me with this research. Special thanks also go to Associate Professor T. Ramayah and Associate Professor Dr. Suhaiza for their kind assistance and consultancy in my study. My sincere thanks to all the lecturers in the DBA program.

I also want to thank my family for their patience, support and encouragement during the period of my study. I am also grateful to my friends for their help and encouragement. Lastly, I wish to accord my appreciation to all the respondents who had so kind to respond my questionnaire in time.

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LIST OF ABBREVIATIONS

LSS	LEAN SIX SIGMA
SS	SIX SIGMA
LM	LEAN MANUFACTURING
TQM	TOTAL QUALITY MANAGEMENT
CSFs	CRITICAL SUCCESS FACTORS
DMAIC	DEFINE, ANALYSE, IMPROVE AND CONTROL
SMEs	SMALL MEDIUM ENTERPRISES
EMS	ELECTRONIC MANUFACTURING SERVICES
TPS	TOYOTA PRODUCTION SYSTEM
OEM	ORIGINAL EQUIPMENT MANUFACTURING
MBB	MASTER BLACK BELT
BB	BLACK BELT
GB	GREEN BELT
IVs	INDEPENDENT VARIABLES
DVs	DEPENDENT VARIABLES
MV	MODERATOR VARIABLE

ABSTRAK (MALAY)

Faktor Penentu Kejayaan (CSFs) Dalam Pelaksanaan Lean Six Sigma (LSS) dan Kesannya Terhadap Pencapaian Syarikat Industri Electronic Manufacturing Services (EMS)

Banyak industri antarabangsa EMS seperti Flextronics, Jabil, Celestica, Plexus, Venture dan SCI Sanmina telah mendirikan tapak kilang di Asia, Amerika dan Eropah. Industri EMS ini menyediakan tapak outsourcing untuk industri OEM bagi pengurangan kos operasi. LSS adalah antara satu program yang diiktirafkan oleh industri EMS dalam pengurangan kos. Namun begitu, ada banyak faktor yang mempengaruhi kejayaan program LSS. Tujuan kajian ini adalah untuk menganalisis faktor penentu kejayaan (CSFs) untuk pelaksanaan LSS dan kesannya terhadap prestasi syarikat industri EMS. Penelitian ini menggunakan kajian kuantitatif dengan kuesioner terstruktur. Populasi kajian ini merangkumi enam syarikat multinasional EMS (Flextronics, Jabil, Celestica, Plexus, Venture dan SCI Sanmina); yang melaksanakan program LSS dan mempunyai pelbagai tapak kilang beroperasi di Malaysia and di seluruh dunia. Empat kuesioner dalam softcopy akan dihantar melalui email dan disasarkan kepada pengamal LSS seperti MBBs, BBs dan LSS Champions. Pengajian ini menilai peranan sembilan CSFs dalam pelaksanaan program LSS. Dari keputusab kajian, pengurusan penglibatan dan komitmen; sering komunikasi dan penilaian keputusan LSS; keberkesanan latihan LSS program dan pertubuhan LSS dasbor telah disahkan secara statistik mempengaruhi kejayaan pelaksanaan LSS dan prestasi syarikat. Kesan moderating kepercayaan dan budaya organisasi juga disahkan tidak nyata. Model kajian ini telah mendedahkan panduan praktikal dan pengurusan implikas dan sementara itu, batasan kajian dan arah kajian lanjutan juga disarankan.

ABSTRACT

Critical Success Factors (CSF's) for Lean Six Sigma (LSS) Implementation and

Its Impact on Company Performance of

Electronic Manufacturing Service (EMS) Industries

Many multinational EMS industries such as Flextronics, Jabil, Celestica, Plexus, Venture and SCI Sanima have set up their site operation plants in Asia, America and Europe. These EMS industries have provided outsourcing platform for the OEM industries to outsource their products for cost reduction. LSS is among the programs recognized by the EMS industries for cost reduction. Anyhow, there are a lot of factors are affecting the success of LSS program. The objective of this study is to analyze the critical success factors (CSFs) for LSS implementation and its impact towards company performance of EMS industries. This study employed quantitative survey with structured questionnaires. The population of this study will be six multinational EMS companies (Flextronics, Jabil, Celestica, Plexus, Venture and SCI Sanmina), which are implementing LSS program and having multiple sites operating in Malaysia and across worldwide. Each site will be sending out four questionnaires in softcopy through email and targeted to site LSS practitioners such as MBBs, BBs and LSS Champions. This research studies the role of nine CSFs for LSS implementation success. Of these CSFs, management engagement and commitment, effective LSS training program, established LSS dashboard, frequent communication and assessment on LSS result are found to be statistically significant and affecting LSS implementation success. The moderating effect of organization belief and culture is also being found insignificant. This research model serve as a practical guide, managerial implication and limitations of the study are highlighted and further research directions are also suggested.

Chapter 1

INTRODUCTION

1.1 Introduction

This chapter introduces the research outline of the study. The chapter begins with an overview of the Lean Six Sigma (LSS), followed by identify the critical success factors (CSFs) for LSS implementation and its impact on the operational and organizational performance of Electronic Manufacturing Services (EMS) companies. Besides that, this chapter also includes the problem statement, research objectives and research questions. The key terms and significance of the study will also be elaborated.

1.2 Research Background

Lean and Six Sigma (SS) have been marketed as a new organizational change and improvement method, particularly as a cost reduction mechanism (Achanga *et al.*, 2006; Hoerl *et al.*, 2004; Edward and John, 2005). Recently, there have also been efforts to promote LSS (George *et al.*, 2003; Edward and John, 2005; Brett and Queen, 2005; Caldwell *et al.*, 2005). Lean and Six Sigma are two of the most effective business-improvement techniques available today (Spector, 2006). LSS is a method that can help publishing companies to deal with globalization and competitive market by improving its operational efficiency and effectiveness (George, 2003; Hoerl *et.al*, 2004).

The implementation of Lean Manufacturing (LM) and Six Sigma (SS) initiative is believed to harbor enormous difficulties (Denton and Hodgson, 1997). Hayes (2000) discussed that successful corporate initiatives like LM, should be properly planned

prior to implementation. Holland and Light (1999) asserted that in attempting to implement any productivity improvement drive in any organization, a business should have a clear vision and strategy in forecasting a project's likely costs and duration.

The identification of CSFs will encourage companies' consideration when companies are developing an appropriate implementation plan (Mann and Kehoe, 1995). Authors and practitioners such as Ohno (1988), Womack *et al.* (1990), Womack and Jones (1996), Liker (1997), and Shah (2002) have explained the impact of LM on organizational performance. The interest on lean production is mostly based on the empirical evidence that it improves the company's competitiveness (Billesbach, 1994; Oliver, 1996; Lowe, 1997). The primary goal to introduce any lean production program in a shop, factory or company is to increase productivity, reduce lead times and costs, improve quality, etc. (Sriparavastu and Gupta, 1997). However, according to Ahlström and Karlsson (1996), it is not always easy to justify the implementation of a lean production program due to productivity decreases in the early implementation stages which are strongly discouraged under the traditional management accounting systems. Therefore, some intermediate indicators are needed to assess the changes taking place in the effort to introduce lean production. Some scholars, like Ahlström and Karlsson (1996) have developed operational models based on the conceptual framework created by Womack *et al.* (1990) and on case studies in manufacturing companies. Other scholars have studied the diffusion of lean production strategies within manufacturing companies (Avella, 1999).

With the notable exception of White (1999) and Conner (2001), most of the publications have tended to focus on the premise of large sized enterprises only

(Bozdogan *et al.*, 2000; Cook and Graser, 2001; Murman *et al.*, 2002). However, there appears to be little empirical evidence in publications on the implementation of lean practices and the factors that might influence them in SMEs (Bruun and Mefford, 2004). LSS is a method that can help financial institutions to improve operational efficiency and effectiveness (George, 2003; Snee and Hoerl, 2003), by combining the strengths of lean thinking and SS. Since lean does not possess the tools to reduce variation and provide statistical control and SS does not attempt to develop a link between quality and speed (Su *et al.*, 2006), the application of the combined tool LSS offers useful solutions that can lead to greater efficiency and better quality in the financial services industry (de Koning *et al.*, 2008).

There are literatures regarding TQM practices and organizational performances in the context of Malaysia but review of literature has not identified any studies that have undertaken a comprehensive and comparative analysis of LSS practice and company performance of EMS companies in the context of Malaysia. With this reasoning, there is a need for further research to establish a setting of reference to analyze the LSS practices by EMS companies that operate in Malaysia and to assess the relationship between the impact of LSS implementation and company performance of EMS companies in Malaysia and across worldwide.

1.3 Research Problem

Many companies are implementing LSS program targeting to improve company performance. Anyhow, not many companies can benefit from this program as the implementation is not executed effectively. Motorola, where SS was developed in the 1980s, was honored with the Malcom Baldrige award, and prior to this date in three

consecutive years, Motorola had spent \$170 million on workers' education and training. As a result, Motorola saved \$2.2 billions in reducing cost of poor quality (such as reduced scrap, rework, warranty costs, etc.). Other companies such as AlliedSignal, Citibank and Sony, have also succeeded in SS implementation (Antony and Banuelas, 2001). However, not all companies can claim to have had the same benefits. According to David Fitzpatrick, worldwide leader of Deloitte Consultant's Lean Enterprise practice:

... fewer than 10 per cent of the companies are doing it to the point where it's going to significantly affect the balance sheet and the share price in any meaningful period of time.

Most of these companies fear that implementing LSS is costly and time consuming (Achanga *et al.*, 2006). Although LM and SS are becoming a popular technique for productivity and quality improvement, manufacturing industries are still not certain of the cost of its implementation and the likely tangible and intangible benefits they may achieve. These contrast results making LSS implementation a complex and central process, where the CSFs in the implementation of LSS must be recognized. Beside, not many empirical researches have been performed on assessing the CSFs for LSS implementation and its impact on company performance. This study should be explored as this will assist local Malaysia Small Medium Enterprises (SMEs) to understand the CFSs for LSS implementation success that will help to improve company performance.

1.4 Research Objectives

With the competitive environment being faced by the EMS companies, cost saving and continuous improvement activities are the focus area for the companies to grow. Despite of it, LM and SS are two important business strategies that must be implemented by the EMS companies. The CSFs for successful implementation of LSS program need to evaluate and study in detail in hoping this program can bring significant cost reduction and improvement in order to drive the companies into higher profitability and business growth, and to strive towards company operational excellence. The objective of this research is to identify the CSFs of LSS implementation, to evaluate its impact on the operational performance and organizational performance of EMS companies. Beside, this research also evaluates the moderating effect of organization belief and culture between CSFs (independent variables) and operational/organizational performance (dependent variable) of EMS companies.

1.5 Research Questions

This research attempts to answer the following research questions:

1. What are the Critical Success Factors (CSFs) for successful LSS implementation of the EMS industries?
2. What is the impact of the LSS CSFs on the company performance of the EMS industries?
3. Is Organizational Belief and Culture moderate the relationship between CSFs and company performance of EMS industries?
4. What are the practical guides for the LSS implementation success?

1.6 Significance of the Study

This study offers a theoretical model in developing an integrated model toward investigating the relationship between CSFs of LSS, LSS effectiveness as expressed by the operational performance and LSS success as expressed by the organizational performance. The significance of this research stems from the realization of CSFs for implementation success of LSS within EMS industries. The results would provide EMS companies and other local Malaysia small medium enterprises (SMEs) with indicators and guidelines for implementation success of LSS concepts and methodology. LSS implementation is not totally zero cost program and company need to invest certain investment and will foresee some obstructions prior to obtain the gain and benefits from this program. LSS program is similar as change management program and need to formula proper strategies in order to success. This will avoid the companies after investing certain investment and effort in LSS program without improving operational and organizational performance of the company. With the success of LSS program in place, the companies will remain competitive and growth along economy cycle.

1.7 Definition of the Terms

The following definitions of the terms are used in this research study.

Lean Manufacturing (LM): Lean manufacturing is another name attributed to the Toyota production system (TPS). It focuses on the elimination of waste and just-in-time manufacturing that results in minimized inventory for work-in-process and finished goods. It also results in the pulling of material from downstream operations only when needed and encompasses a culture of teamwork and strong focus on serving the customer with high quality and low cost products in short delivery times.

LM is coined lean because it uses half of the resources, to include human effort, tooling cost, engineering time, manufacturing space, and half the time to develop a new product, as mass production (Womack *et al.*, 1990; Liker, 1997).

Six Sigma (SS): Six Sigma is a business management strategy, initially implemented by Motorola that today enjoys widespread application in many sectors of industry. SS seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and variation in manufacturing and business processes. SS is a strategy for a goal of 3.4 defects per million products made (Gnibus and Krull, 2003).

Lean Six Sigma (LSS): LSS evolved out of the idea that LM and SS methods complement one another, and together, the two systems can accomplish far more than either system could achieve alone. Lean helps reduce waste, six sigma helps reduce variation, and however either does not reduce the other. LSS can be used to eliminate waste and attain statistical control by reducing variation (Smith, 2003).

Toyota Production System (TPS). The Toyota production system is a method of manufacturing that was invented by Taiichi Ohno (1912-1990). It was invented out of necessity and has as its main objective the elimination of waste and increased organizational efficiency through improved quality cost and responsiveness (Ohno, 1988).

Critical Success Factors (CSFs): CSFs are the essential things that must be achieved by the company or which areas will produce the greatest “competitive leverage”.

They emphasize that CSFs are not objectives, but are the actions and processes that can be controlled/affected by management to achieve the organization's goals. They also state that the CSFs are not static, but depend on a combination of where the organization is and where it wants to be (Brotherton and Shaw, 1996).

Master Black Belt (MBB). A master black belt has the highest level of expertise in the SS methodologies. Individuals at this level teach, coach, and mentor the lower-level black belts, green belts, and yellow belts. These top educators in SS are mentors and coaches for the project leaders and project teams (Breyfogle *et al.*, 2001; Pyzdek, 2003).

Black Belt (BB). A black belt is a technical project team leader with expertise in using the SS methodology and statistical analysis techniques for process improvement. BBs are a full-time resource dedicated to the SS initiative (Breyfogle *et al.*, 2001; Pyzdek, 2003). With LM and SS evolving into LSS, BB is also the project team lead for LSS.

Green Belt (GB). A green belt is a project leader and/or process expert trained in the use the SS methodology but weaker in the statistical analysis techniques for process improvement. GBs are a part-time resource dedicating approximately 30% of their time toward SS initiatives, and they integrate SS into their daily job duties (Breyfogle *et al.*, 2001; Pyzdek, 2003).

Yellow Belt (YB). A yellow belt is a data collector and team member on a process improvement project team. Yellow belts are the members of the process improvement

teams led by BBs or GBs. They are subject matter experts in the process that the project is to improve and are assigned by the champion at team formation (Breyfogle *et al.*, 2001).

Lean Sigma Champion. A Lean Sigma Champion is a trained leader and process owner. Some champions also participate in the LSS Steering Committee. Their role as Champion is to select LSS projects, assign project leaders and teams, align resources, remove barriers, and review LSS projects at phase reviews (Breyfogle *et al.*, 2001; Pyzdek, 2003).

Operational Performance. Operational performance reflects the performance of internal operation of the company in terms of cost and waste reduction, improving the quality of products, improving flexibility, improving delivery performance; and productivity improvement (Salaheldin, 2008).

Organizational Performance. Organizational performance measured by financial measures such as revenue growth, net profits, profit to revenue ratio and return on assets, and non-financial measures such as investments in R and D, capacity to develop a competitive profile, new products development, market development and market orientation (Salaheldin, 2008).

1.8 Organization of Remaining Chapters

This research is presented into six chapters. The chapter one provides introduction, research background, research problem, research objective, research questions, and significance of the study and definition of the terms. Chapter two provides literature review on LM, SS and LSS, the benefits of LSS program as well as comparison

between TQM, LM and SS. The integration of LSS is introduced and the link between CSFs of LSS is explored in relationship to its impact on operational performance and organizational performance of companies. Beside, the theory of the study being reviewed and Malaysia EMS industry trend being explored. Chapter three provides a theoretical framework for the study and hypotheses statement development. The explanation of CSFs and the elements of respective CSFs being elaborated. Chapter four illustrates the research design; methodology used for data collections, questionnaires design and data analysis techniques to test the variables. Chapter five will present the analysis done for the study such as factor, reliability, hierarchical regression analysis and also the findings of the study. Chapter six will discuss the interpretation and recapitulation of the study, implications of the findings, limitations of the study and suggestion for future research. It then concludes the whole research.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

For better understanding of the present study, a comprehensive search of previous literature has been undertaken. As such, this chapter was organized in the manner to give an overview of literature, identify CSFs in more literature and study the relationship between CSFs of LSS is explored in relationship to its impact on operational performance and organizational performance of companies.

2.2 Lean Manufacturing (LM)

The concept of LM can be traced to the Toyota Production System (TPS), a manufacturing philosophy pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo (Inman, 1999). Lean is defined by Womack and Jones (1994) as the systematic removal of waste by all members of the organization from all areas of the values stream. A systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection. Lean is often referred to as a cost-reduction mechanism (Achanga *et al.*, 2006; Bicheno, 2000). Lean strives to make organizations more competitive in the market by increasing efficiency, decreasing costs incurred due to elimination of non value-added steps and inefficiencies in the processes (Motwani, 2003), as well as reducing cycle times (Sohal and Egglestone, 1994) and increasing profit for the organization (Claycomb *et al.*, 1999). An organization can achieve these results while not sacrificing effectiveness (Monden, 1981) if it produces exactly what is needed in the right amount when it is needed (Kannan and Tan, 2005; Monden, 1981). Lean

manufacturing is aimed at the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management (Phillips, 2000).

The approach to Lean is based on mapping and analyzing the activities in the processes. In Lean terminology, this is value stream mapping (Womack and Jones, 1994; Worley and Doolen 2006). The value stream includes all activities needed to produce the product. The value stream represents the “flow of value” to these organizations. The analysis is primarily based on identifying activities that add value to the product or activities that can be classified as Muda – the Japanese word for waste (Worley and Doolen, 2006). Waste can be found in all activities in the value stream, especially where the product moves from one department to another (Womack and Jones, 1994).

Taj and Berro (2005) claim that many manufacturing companies waste over seventy percent of their resources. Jones *et al.* (1997) claim that for many organizations less than ten percent of activities often are value adding and as much as sixty percent do not add any value at all. Similarly, Bhasin and Burcher (2006) claim that implementing Lean can reduce waste by forty percent. Seven typical examples of waste are: overproduction, waiting, transportation, inappropriate processing, excess inventory, unnecessary motion, and defects (Endlsey *et al.*, 2006; Bhasin and Burcher, 2006).

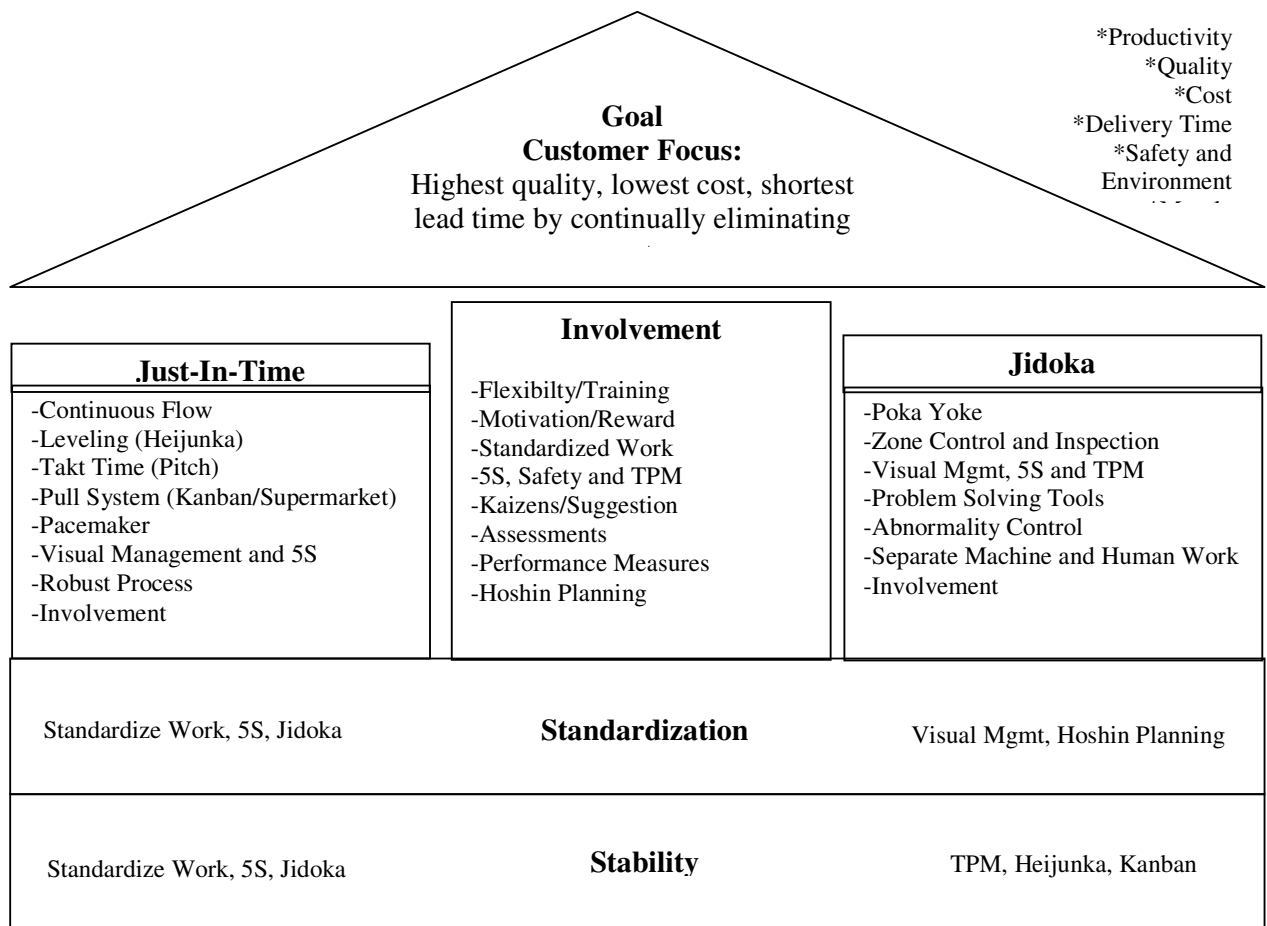
Lean is also described as a pull system. The system promotes conditions necessary to manufacture high-quality products to meet market demand with relatively small levels

of inventory. Holding costs are diminished because materials do not arrive until needed and items are only produced to meet the forecasted demand. As a result, “companies have substantially cut lead times, drastically reduced raw material, work-in-process and finished goods inventories, and effectively increased asset turnover” (Claycomb *et al.*, 1999). Thus, there are five basic steps in the lean process (Nave, 2002; Snee, 2004 and Womack, 2006):

- (1) define value and all of the value added features in a given process;
- (2) identify the “value stream,” the chronological flow of activities that add value – people are visual by nature, and they place value on seeing a process flow visually;
- (3) force the activities to flow without interruption. Any non-value adding activities should be removed or minimized (in the case that non-value adding activities are required, their impact to the process is minimized);
- (4) allow the customer to “pull” the product or service through the process, akin to JIT manufacturing; and
- (5) continuously pursue perfection of the process by revisiting the steps again in a continuous loop. Go through the aforementioned steps repeatedly to ensure that the process is as improved as it can be.

Lean activities have to part of a system, an integrated series of parts with a clearly defined goal with each activity with a clearly defined objective. These activities are interdependent and each activity fits into the operating system while interacting with each other. Figure 2.1 below shows the “House of lean” model describes the lean activities integrated in the system (Sanjay, 2008).

Figure 2.1: House of Lean



Source: (Sanjay, 2008)

2.3 Six Sigma (SS)

Motorola was the first company to launch a SS program in the mid-1980s (Rancour and McCracken, 2000). In 1988, Motorola received the Malcolm Baldrige National Quality Award, which led to an increased interest of SS in other organizations (Pyzdek, 2001). Motorola, the company usually recognized as one of the original developers of SS, decided in the 1980s that the traditional quality levels, measuring defects in thousands of opportunities, were not satisfactory (Arnheiter and Maleyeff, 2005). Based on the ideas of statistical process control, Motorola defined “Six Sigma” as 3.4 defects per million opportunities. SS was further developed in the 1990s,

among other places at General Electric. The development included the needed cultural change associated with the method (Hoerl *et al.*, 2004; Revere *et al.*, 2004).

The purpose of SS is to reduce cost by reducing the variability in the processes which leads to decreased defects. SS is a method to improve process capability and enhance process throughput (Nave, 2002). SS is also hailed as a method to reduce waste, increase customer satisfaction, and improve financial results (Revere *et al.*, 2004). By using statistical methods, organizations are able to understand fluctuations in a process, which will allow them to pinpoint the cause of the problem. Improving the process by eliminating root causes, and controlling the process to make sure defects do not reappear (Pojasek, 2003) should ideally provide long-term benefits to the firm (Bisgaard and Freiesleben, 2004).

Pande *et al.* (2000) mean that the organization also must clarify the different roles required and their different areas of responsibility in order to be successful with a SS program. According to Magnusson *et al.* (2003), the hierarchy of responsibilities and the roles are: Champions and Sponsors, Master Black Belts, Black Belt, Green Belt, White Belt. Sanders and Hild (2000) claim that SS organizations often have standardized training courses, ranging from comprehensive courses for Black Belts to basic courses for White Belts and Yellow Belts.

Table 2.1 below shows a comparison of defects per unit, parts per million to sigma values.

Table 2.1: Defects per Unit Conversion

Defects Per Unit Conversion		
DPU	PPM	SIGMA
0.6977	697,700	1
0.308733	308,733	2
0.066803	66,803	3
0.0062	6,200	4
0.00233	2,330	5
0.0000034	3.4	6
0.000000019	0.019	7

A thought process map tool that links SS Define, Measure, Analyze, Improve, Control (DMAIC) and problem solving model is described in the table 2.2 below. The table shows relationship between a thought process map and the SS's DMAIC model (Namita, 2004)

Table 2.2: Thought Process Map

Leading Questions	DMAIC	Results
What does the customer need ?	Define	Document key information about the project
Does the company understand its processes ?	Measure	Understand the entire problem
How does a company measure progress ?	Analyze	Gather the data required
Does a company sustain the gain ?	Improve	Act on fact and analysis
Does a company have the discipline to answer the questions ?	Control	Implement the solution

Source: (Namita, 2004)

The first methodology used to improve an existing process can be divided into five phases (Pyzdek, 2003; Magnusson *et al.*, 2003). These are:

(1) **Define.** Define which process or product that needs improvement. Define the most suitable team members to work with the improvement. Define the customers of the

process, their needs and requirements, and create a map of the process that should be improved.

(2) **Measure.** Identify the key factors that have the most influence on the process, and decide upon how to measure them.

(3) **Analyze.** Analyze the factors that need improvements.

(4) **Improve.** Design and implement the most effective solution. Cost-benefit analysis should be used to identify the best solution.

(5) **Control.** Verify if the implementation was successful and ensure that the improvement sustains over time.

The second methodology is often used when the existing processes do not satisfy the customers or are not able to achieve strategic business objectives (Eckes, 2001). This methodology can also be divided into five phases; define, measure, analyze, design and verify (Magnusson *et al.*, 2003). Over time, SS evolved (Arnheiter and Maleyeff 2005). SS includes designing, improving, and monitoring business processes (Revere *et al.*, 2003). It has become multifaceted, encompassing everything from simple process improvement to broad initiatives, such as project management, change management, leadership, culture change, rewards and compensation, defect definition, teaming, and problem solving (Goodman and Theuerkauf, 2005).

2.4 Lean Six Sigma (LSS)

Lean six sigma combines the Lean and SS approaches to focus on improving quality, reducing variation, and eliminating waste. LSS, a combination of Lean and SS principles began in the late 1990's and is emerging as a powerful principle. Majority of applications of LSS has been in the private sector, mostly in manufacturing arena,

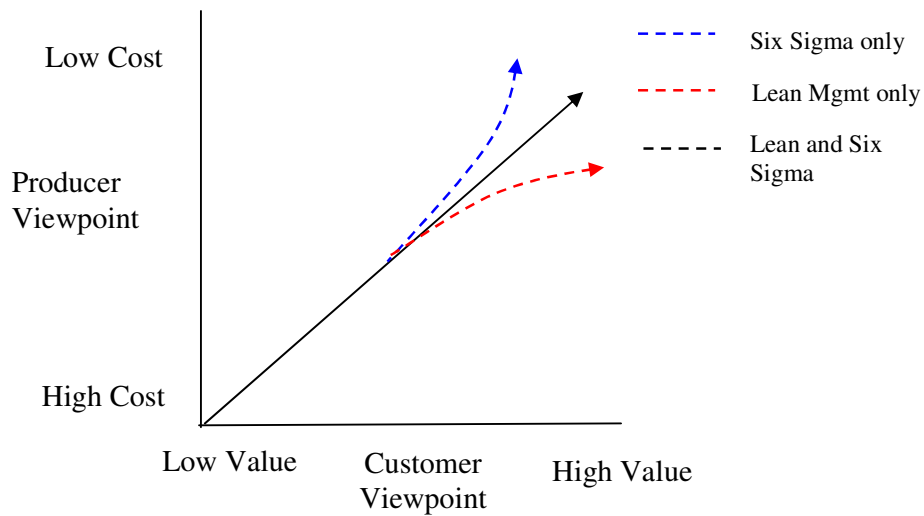
though many Lean and SS experts suggest use of these tools and principles in non manufacturing sectors such as software development, service industry, education, transactional industry such as accounting and order processing, material procurement and new product development (Bossert and Grayson, 2002).

Both LM and SS have evolved into comprehensive management systems. In each case, their effective implementation involves cultural changes in organizations, new approaches to production and to servicing customers and a high degree of training and education of employees, from upper management to the shop floor. As such, both systems have come to encompass common features, such as an emphasis on customer satisfaction, high quality, and comprehensive employee training and empowerment (Arnheiter and Maleyeff, 2005). The term LSS has recently been used to describe a management system that combines the two systems (Sheridan, 2000). From the two system as Sheridan mentioned below, if only either one initiative such as LM and SS only implemented in one company, the value that customer will obtain to be stagnant at certain period as well as the producer cost saving to be gain will be saturated. Together with both initiatives to be implemented as one program, the value of customer and the cost saving of the producer will be keep improving.

Figure 2.2 summarizes the nature of improvements that may occur in organizations that practice LM or SS, and the corresponding improvements that an integrated program could offer (Sheridan, 2000). The horizontal axis represents the customer's perspective of value, including quality and delivery performance. The vertical axis represents the producer's cost to provide the product or service to the customer. Under either system, improvements will be made, but these improvements will begin to level

off at a certain point in time. With SS alone, the leveling off of improvements may be due to the emphasis on optimizing measurable quality and delivery metrics, but ignoring changes in the basic operating systems to remove wasteful activities. With LM alone, the leveling off of improvements may be due to the emphasis on streamlining product flow, but doing so in a less than scientific manner relating to the use of data and statistical quality control methods.

Figure 2.2: Nature of competitive advantage



Source: (Sheridan, 2000)

2.5 Similarities and Differences between Total Quality Management (TQM), Lean and Six Sigma (SS)

In this section, some similarities and differences between TQM, Lean and SS are presented in Table 2.3 (Roy *et al.*, 2006). The overall similarities and differences between the concepts, regarding origin, theory, process view, approach, methodologies, tools, effects and criticism, are also presented.

2.5.1 Origin and Theory

Even though TQM, lean and SS have the same origin (the quality evolution in Japan), the concepts have developed differently. TQM became a very popular notion in the beginning of the 1990s among researchers and practitioners in order to describe how organizations should work to obtain better performance and customer satisfaction. TQM is often associated with the prominent figures within the field of quality management, for example, Deming and Juran, but they have in general not used the term TQM. The success with SS at Motorola and with lean at Toyota is a main reason for these concepts to spread to other organizations. In contrast to SS and lean, no organization was the origin to the term TQM. A notable difference between SS and lean is that Motorola labelled SS, see Rancour and McCracken (2000), while authors in the field, Womack *et al.* (1990), labelled the lean concept. George *et al.* (2004) claim that the main difference between SS and lean is that the previous focuses more on accomplishing no defects; while the latter is a better choice when one wants to improve process flow and eliminate waste. TQM also has elements of accomplishing no defects and eliminate waste, but with the main objectives to increase external and internal customer satisfaction with a reduced amount of resources (Hellsten and Klefsjö, 2000).

2.5.2 Process View and Approach

The improvement projects in a SS program are conducted in a wide range of areas and at different levels of complexity in order to reduce variation, see Magnusson *et al.* (2003). When the project members have reduced the variation in a process, and hence achieved the business goals, increased the profit or lowered the cost, this improvement is visualized to the top managers at the company. Often some of the top

managers are also involved in the performed improvement projects. As a result, the SS program receives necessary support from the top managers at the company, as the managers recognize the economical impact of it. This could be one explanation for the documented successes of SS compared with TQM. Lean, on the other hand, is a discipline that focuses on process speed and efficiency, or the flow, in order to increase the customer value; see George *et al.* (2004). In LM, project groups are usually the approach to perform the necessary improvements. While SS and lean focus on performing improvements mainly through projects, TQM has sometimes a different approach. TQM emphasizes the commitment and involvement of all employees (Bergman and Klefsjö, 2003). In TQM, there is also, like SS and lean, a strong focus on processes. It is the authors' opinion that the main objectives of the process work within TQM are to alternatively improve and uniform the processes.

2.5.3 Methodologies

Hellsten and Klefsjö (2000) argue that TQM contains a number of methodologies. However, the improvement cycle is one of the most widespread methodologies in TQM, according to Evans and Lindsay (1996). The improvement cycle is composed of four stages: Plan, Do, Check, Act (PDCA). In SS there are two major improvement methodologies, one for already existing processes and one for new processes, see above. The lean principles could in this context be regarded as a methodology. The principles of lean are: understanding customer value, value stream, analysis, flow, pull and perfection. There are many similarities between the improvement cycle in TQM and the methodologies of SS; i.e. the methodologies are cyclical and consist of similar phases. One could argue that the methodologies in SS are a further development of the improvement cycle, which first was developed by Shewhart and

Deming. The lean principles are different compared to the methodologies in TQM and SS, as they are not cyclical in nature and are not focused on how to perform improvements.

2.5.4 Tools

Deming stated that about ninety six per cent of the problems are built into the system and that individual employees can only control about four per cent. The purpose of most improvement efforts is to use data in a proper way in order to find out what is wrong with the system and hence improve the system. In SS, lean and TQM, there are many different tools that could be used in order to find out what is wrong with the system. TQM normally consists of tools that have either a statistical or an analytical base. Among others, the seven quality control tools and the seven management tools are frequently applied in TQM. In general, SS program has been successful at integrating advanced improvement tools with the methodologies. The tools range from design tools to management tools and from very simple tools to more advanced statistical tools. During the training program in SS, one learns how to choose the most appropriate tool and how it should be applied. In addition, one must verify the selection in order to assure that the appropriate tool was chosen. In general, SS program has successfully emphasized the statistical part in quality management. In lean, a variety of tools are available for reducing or eliminating waste. In summary, the tools in the lean concept are more analytical in nature compared to the more statistical tools used in TQM and SS (Anderson *et.al.*,2006)

2.5.5 Effects

The main objective with TQM is to increase the customer satisfaction (Hellsten and Klefsjo, 2000). Moreover, it has been shown that organizations that have successfully implemented TQM outperform similar organizations regarding a number of financial indicators (Hendricks and Singhal, 1997; Eriksson and Hansson, 2003). On the other hand, Ingle and Roe (2001) argue that in a SS program, the projects are selected in such a way that they are closely tied to the business goals or objectives. The company's business goals are normally set in such a way that customers' needs will be satisfied. Before starting a SS project, one must prove that the improvement will result in economical savings for the company. This results in the fact that all improvements in a SS program are economically justified (Anderson *et al.*, 2006).

However, it is the authors' opinion that SS does not necessarily improve customer satisfaction to the same extent as a successful TQM program. The reason is that a SS program primarily emphasizes the economical savings and secondly the customer satisfaction. When starting a lean project with the objectives to reduce the lead time of a process, one first analyses the customer's demands of the process. Hence, the objectives of the improvement, besides reducing the lead time, are also to increase customer satisfaction. In addition, increased productivity and an inventory reduction are common effects of successful lean projects (Anderson *et al.*, 2006).

2.5.6 Criticism

The main criticism against TQM is that there is a widespread confusion concerning what TQM really means (Hellsten and Klefsjo, 2000). In addition, a number of failures of organizations trying to implement TQM have been documented. In more detail, a number of organizations have put a large amount of resources on

implementing TQM, but with no tangible improvements achieved. According to Magnusson *et al.* (2003), there is a difficulty in SS program to exceed the customer's needs and hence increase the customer satisfaction. To avoid this problem some companies use voice of the customer tools in their define phase. Klefsjö *et al.* (2001) claim that SS program fail to create conditions in order to involve everyone, which is more emphasized in the TQM literature. Furthermore, in SS training program one can only start a project which gives a certain amount of savings. This project is often executed in the department of the project members. The project normally leads to an improvement in the department of the project members, but due to the performed change another department can experience deterioration. As a result, SS is sometimes accused for not having a system view. The main criticism against lean is the lack of flexibility the concept offers (Dove,1999), and that the concept actually can lead to delays for the customers (Cusumano,1994). There is also a discussion going on whether lean, which was developed for manufacturing and distribution situations, is applicable in all industries. Mast (2004), on the other hand, argues that SS can be applied in a wide range of areas, including both manufacturing and service industries. The summary of similarities and differences between TQM, Lean and Six Sigma presented in table 2.3.