Prioritization of Lean Six Sigma Success Factors using Pareto Analysis

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Abstract. In the era of Globalization and technological intervention, organizations are forced to innovate the product and deliverer at a competitive price in the shortest possible time. Hence the organizations have to adopt drastic and quick changes to improve productivity at optimum resources by adopting emerging strategies. Lean Six Sigma (LSS) has grown as one of the continuous improvement strategies in the recent past, evolving from the merger of Lean philosophy and Six Sigma methodology. Lean aims to reduce waste, whereas Six Sigma mainly focuses to reduce the variation. However, the implementation of LSS and sustenance of it is a massive challenge for the organizations. Therefore, this paper aims to understand and to explore the factors responsible for successful implementation of LSS from the literature. The eleven success factors are prioritized as vital few through Pareto analysis. Top Management commitment and involvement, Training and Education, Cultural change, Project Management skills, and link LSS with the business strategy analyzed as the five most significant factors in implementing LSS. This study will help the academicians, researchers, and professionals explore the factors as a research domain and implement LSS more smoothly.

Keyword: Lean Six Sigma, Success factors, Pareto analysis

1. Introduction

Since the Industrial Revolution, the world has changed a lot and continued to be changing more & more with the drastic pace of technological development, innovation, and interventions in the manufacturing sector and the service sector. Organizations experience stiff global competition due to the rapid changes and are compelled to innovate and adopt the new technology in the product and services. ‘Quality’ of product and services has emerged as one of the crucial requirements for the organizations, along with cost and delivery. Henceforth, strategies evolved over a period and adopted by the organizations in the last few decades.

Lean Six Sigma (LSS) is one strategy, which has evolved worldwide as a continuous improvement strategy in the last twenty years [1]. Lean and Six Sigma methodology came into existence separately in the last century and became popular improvement strategies. Based on the ample research and literature, both the methodologies focus on product and process improvements, particularly in the last twenty years [2]. According to Laureani and Antony, “LSS is a business improvement methodology that aims to maximize shareholder value by improving quality, speed, customer satisfaction, and costs: it achieves this by merging tools and principles from both Lean and Six Sigma” [3]. Sambo and Dalu reported that large-scale industries successfully employed such strategies compared to small and
medium scale industries because of structured and robust decision-making approaches [4]. Small and Medium-scale Enterprises (SMEs) lacks in the implementation of such continuous improvement strategies due to the constraint of resources in general [5]. Therefore, it is evident to explore the factors responsible for successful implementation of strategies like LSS in industries and studying their importance through research. The current study's primary focus is to identify the factors for successful implementation of LSS from the literature and finding out the vital few factors through Pareto analysis.

This paper is organized as follows. The research methodology is stated in the second section. The third section summarized the success factors for LSS implementation through a literature study. Analysis of factors through the Pareto principle is presented in the fourth section. The last section discusses the managerial implications of the current study with concluding remarks.

2. Research Methodology

Through this paper, an attempt is made to understand and to point out the factors for successful implementation of LSS in industries. The methodology followed for the current study includes a three-step approach, i.e., planning, conducting, and analysis & reporting. The planning part covers the study's objective and the selection of databases for the study. The articles were searched from the Scopus database, focusing on the study's objective, and articles published between 2005-2019. The keywords searched were "Lean Six Sigma," "critical success factors," "enabler," and "driver" in the title, in abstract, and keywords of the article. Fifty-three articles were found from the search. The selected articles were further screened based on the inclusion and exclusion parameters. The only peer-reviewed articles published in peer-reviewed academic journals are included in the study. Articles written in English considered for the study as English is used as a medium for communication worldwide. The conference papers, editorial notes, preface, books, reports, thesis, and working papers were excluded from the study, which has reduced the number of articles to thirty. The authors examined the selected articles in detail and, based on the study's relevance, finally considered twenty-two articles for further study. The research methodology followed is shown in figure 1.

**Figure 1. Research Methodology**
3. Literature Study

The historical developments in LSS and the gist of success factors for LSS implementation are presented in this section.

3.1. Evolution of Lean Six Sigma

The majority of the Japanese industries experienced numerous difficulties after the Second World War like deficiency of capital, skilled work-force, and restricted assets. One such industry was automobile manufacturer Toyota Motor Cooperation. Eiji Toyoda and Taiichi Ohno visited Ford’s plant in the USA to develop competitive manufacturing capabilities. However, Toyota developed its production system known as the Toyota Production System (TPS). TPS’s prime focus was on quality product, waste elimination, and reduced delivery time at the lowest cost [6]. Through TPS, the company achieved flexibility in production, reduction in inventory, defects, with minimal human efforts [7]. Through the research study, i.e., the International Motor Vehicle Programme of Massachusetts Institute of Technology, the term 'lean' first came into existence and was first coined by Krafcik [8,9]. However, globally, it got the attention through a book titled “The Machine that Changed the World” by Womack et al. [10]. Womack and Jones identified the five lean principles as customer-defined value, optimizing the value stream, smooth single piece flow through eliminating waste, pull concept, and perfection in product [11].

In the mid-1980s, Motorola, one of the US electronic product manufacturers, observed a higher defect rate compare to Japanese firm and created a structured statistics-based methodology known as Six Sigma methodology [12]. The prime focus was to minimize the variation in the products. The problem-solving methodology was four stages, i.e., Measure, Analyse, Improve and Control (MAIC) [13]. Motorola estimated a reduction in the defects by 94% on semiconductor products in six years from 1987 [14]. Later, Jack Welch adopted the Six Sigma program at General Electric and added one stage as Define (D) in the approach made it as DMAIC [15]. Since its inception, the Six Sigma methodology has been widely adopted in industries with broader application areas. Antony (2007) stated three generations of the Six Sigma developments in the implementation in his article. The first generation focused on reducing variation and defects. The second generation focused on improving performance through cost reduction and better product design, and the third generation focused on value creation for its stakeholders [16]. Due to the tremendous success of the Six Sigma program at Motorola and General Electric, plenty of US organizations adopted the Six Sigma program, such as Bank of America, DuPont, Commonwealth Health Corporation, Dow Chemical, 3M, Ford, American Express, and US Military [17].

Lean emphasis getting the things with the right quantity to the right place, at the right time, in the right quality through eliminating waste, whereas Six Sigma methodology emphasizes on minimizing the variation (defects) and understand the customer requirements. Despite great success, it was reported that Lean was not suitable for multi-facet problems, which demands statistical analysis, and all problems could not be resolved through the Six Sigma project [17]. Henceforth, an integrated approach from both the popular methodologies, i.e., Lean and Six Sigma, evolved in the early part of the twenty-first century termed "Lean Six Sigma"[18]. Taghizadegan defined LSS as “a business strategy in which the focus is to improve the bottom line and increase customer satisfaction”[19]. LSS has been widely adopted to enhance the quality of products and processes and profitability by the manufacturing and service industries since its inception [20]. Therefore, LSS emerged as a research domain and got attention from the researchers, academicians, and practitioners on aspects like frameworks, success and failure factors, and applicability in diverse filed.

3.2. Lean Six Sigma Success Factors

The emergence and importance of LSS and the research methodology adopted in the current study are explained in the previous section. This section attempts to identify the success factors for LSS implementation from the literature. According to Rockart (1979), the ‘Critical Success Factor (CSF)’ is the critical piece of information to the decision-makers to solved problems based on the
Different researchers termed the CSFs as vital issues comprehensively. A study on 'Success Factors' by Daniel in 1961 [21], Boynton and Zmud (1984) stated that the CSFs are critical issues for future success [22]. Different researchers termed the CSFs as enabler [23], driver [24], determinants [25], and facilitators [26]. Table 1 reports the various identified success factors from the literature for further analysis.

### Table 1. Lean Six Sigma Success Factors

| Sr. No. | LSS Success Factors                                                                 | Reference Number |
|--------|-------------------------------------------------------------------------------------|------------------|
| 1      | Awareness                                                                           | [27] [28] [29] [3] |
| 2      | Benchmarking                                                                        | [30]             |
| 3      | Communication / Effective sharing – result sharing                                   | [27] [31] [32] [33] [30] [1] [3] [34] [35] |
| 4      | Competencies of Master Black Belt, Black Belt                                        | [34]             |
| 5      | Continuous improvement                                                              | [27]             |
| 6      | Cultural change / Quality Driven culture                                            | [27] [28] [31] [32] [33] [36] [30] [37] [1] [38] [3] [34] [35] |
| 7      | Customer focus (participation, integration, satisfaction)                            | [27] [31] [30] [39] [38] |
| 8      | Employee knowledge & Skills                                                         | [27] [28] [33] [37] [40] |
| 9      | Employee retention                                                                  | [30]             |
| 10     | Employee satisfaction                                                               | [30]             |
| 11     | Extending LSS to supply chain / suppliers                                           | [28] [32] [33] [30] [37] [1] |
| 12     | Financial capability & accountability                                               | [41] [34] [42] |
| 13     | Focus on results                                                                    | [27]             |
| 14     | Formation of cross-functional teams/Team work                                        | [28] [36] |
| 15     | Information and knowledge sharing                                                    | [42]             |
| 16     | Inventory Control                                                                   | [30]             |
| 17     | IT and innovation                                                                   | [32]             |
| 18     | Leadership                                                                          | [27] [28] [32] [36] [41] [30] [39] [3] [42] |
| 19     | Linking Lean Six Sigma to the Business strategy                                     | [27] [28] [31] [32] [33] [36] [30] [37] [40] [1] [3] [42] |
| 20     | Linking Lean Six Sigma to customers                                                 | [28] [32] [33] [36] [30] [37] [1] [3] [42] |
| 21     | Linking Lean Six Sigma to employees                                                 | [28] [32] [33] [30] [37] |
| 22     | LSS projects selection/prioritization                                              | [3] [42] |
| 23     | Maturity level of LSS deployment                                                    | [27] [29] |
| 24     | Organisation infrastructure                                                         | [28] [31] [32] [37] [40] [1] [3] [42] |
| 25     | Prior implementation of quality improvement programs                               | [38]             |
| 26     | Process Management                                                                  | [30]             |
| 27     | Product Design                                                                      | [30]             |
| 28     | Project prioritization, Project Management Skill                                    | [27] [28] [31] [32] [33] [30] [41] [37] [40] [43] [1] [3] [34] |
| 29     | Resource allocation & Financial resources                                           | [27] [29] |
| 30     | Reward system, Recognition system                                                   | [27] [28] [33] [30] [34] [35] [42] |
| 31     | Role of Quality department                                                          | [30]             |
| 32     | Selection of top talented people                                                    | [31] [41] [3] [42] |
| 33     | Strategic planning                                                                  | [27]             |
| 34     | Supportive performance management and IT systems                                    | [38]             |
| 35     | Top Management Commitment and Involvement                                           | [27] [28] [31] [32] [33] [36] [30] [29] [37] [40] [1] [38] [3] [34] [35] [42] |
| 36     | Top-down & bottom-up project selection                                             | [38]             |
| 37     | Training and Education                                                              | [27] [28] [31] [32] [33] [36] [30] [29] [37] [40] [43] [1] [38] [3] [34] [35] [42] |
| 38     | Understanding tools / techniques / methods                                           | [32] [33] [30] [37] [1] |
| 39     | Vision and Plan Statement                                                           | [1]             |
4. Pareto Analysis of Success Factors

The identified LSS success factors through literature study are further analyzed through Pareto analysis. Pareto analysis is one of the quality control tools also adopted in the execution of LSS projects. Italian economist Vilfredo Pareto came up with the concept of 'vital few, trivial many,' also known as the '80-20' rule. Through Pareto analysis, a vital few are identified with significant impact as trivial many for the quality-related issues and helps to prioritize. The frequency of occurrence for the 39 extracted LSS success factors from 22 articles and percentage and cumulative frequencies calculated, as shown in table 2. The Pareto analysis of the LSS success factors can be easily understood from the figure 2.

Table 2. Calculation of Frequencies of LSS Success Factors

| Sr. No. | LSS Success Factors                                                                 | Frequency | Percentage of Frequency | Cumulative percentage of Frequency |
|---------|-------------------------------------------------------------------------------------|-----------|-------------------------|----------------------------------|
| 1       | Training and Education                                                             | 17        | 9.77                    | 9.77                             |
| 2       | Top Management Commitment and Involvement                                          | 16        | 9.20                    | 18.97                            |
| 3       | Cultural change /Quality Driven culture                                            | 13        | 7.47                    | 26.44                            |
| 4       | Project prioritization, Project Management Skill                                    | 13        | 7.47                    | 33.91                            |
| 5       | Linking Lean Six Sigma to the Business strategy                                    | 12        | 6.90                    | 40.80                            |
| 6       | Communication / Effective sharing – result sharing                                  | 9         | 5.17                    | 45.98                            |
| 7       | Linking Lean Six Sigma to customers                                                | 9         | 5.17                    | 51.15                            |
| 8       | Leadership                                                                          | 8         | 4.60                    | 55.77                            |
| 9       | Organization infrastructure                                                         | 8         | 4.60                    | 60.34                            |
| 10      | Reward system, Recognition system                                                   | 7         | 4.00                    | 64.37                            |
| 11      | Extending LSS to supply chain /suppliers                                           | 6         | 3.40                    | 67.82                            |
| 12      | Customer focus (participation, integration, satisfaction)                           | 5         | 2.90                    | 70.69                            |
| 13      | Employee knowledge & Skills                                                         | 5         | 2.90                    | 73.56                            |
| 14      | Linking Lean Six Sigma to employees                                                | 5         | 2.90                    | 76.44                            |
| 15      | Understanding tools / techniques / methods                                          | 5         | 2.90                    | 79.31                            |
| 16      | Awareness                                                                           | 4         | 2.30                    | 81.61                            |
| 17      | Selection of top talented people                                                   | 4         | 2.30                    | 83.90                            |
| 18      | Financial capability & accountability                                              | 3         | 1.7                     | 85.63                            |
| 19      | Formation of cross-functional teams/Teamwork                                        | 2         | 1.1                     | 86.78                            |
| 20      | LSS projects selection/prioritization                                               | 2         | 1.1                     | 87.93                            |
| 21      | Maturity level of LSS deployment                                                    | 2         | 1.1                     | 89.08                            |
| 22      | Resource allocation & Financial resources                                          | 2         | 1.1                     | 90.23                            |
| 23      | Benchmarking                                                                        | 1         | 0.6                     | 90.80                            |
| 24      | Competencies of Master Black Belt, Black Belt                                        | 1         | 0.6                     | 91.38                            |
| 25      | Continuous improvement                                                              | 1         | 0.6                     | 91.95                            |
| 26      | Employee retention                                                                  | 1         | 0.6                     | 92.53                            |
| 27      | Employee satisfaction                                                               | 1         | 0.0                     | 93.10                            |
| 28      | Focus on results                                                                    | 1         | 0.6                     | 93.68                            |
| 29      | Information and knowledge sharing                                                   | 1         | 0.6                     | 94.25                            |
| 30      | Inventory Control                                                                   | 1         | 0.6                     | 94.83                            |
| 31      | IT and innovation                                                                   | 1         | 0.6                     | 95.40                            |
| 32      | Prior implementation of other quality improvement programs                           | 1         | 0.6                     | 95.98                            |
| 33      | Process Management                                                                  | 1         | 0.6                     | 96.55                            |
| 34      | Product Design                                                                      | 1         | 0.6                     | 97.13                            |
| 35      | Role of Quality department                                                          | 1         | 0.6                     | 97.70                            |
| 36      | Strategic planning                                                                  | 1         | 0.6                     | 98.28                            |
| 37      | Supportive performance management and IT systems                                     | 1         | 0.6                     | 98.83                            |
| 38      | Top-down & bottom-up project selection                                              | 1         | 0.6                     | 99.43                            |
| 39      | Vision and Plan Statement                                                           | 1         | 0.6                     | 100.00                           |
| **Total** |                                                                                      | **174**   | **100**                 |                                  |
5. Managerial Implication
The analysis reveals the 11 success factors (28 percent) as 'vital few' accounted for 68 percent of the total. The most critical success factors of LSS implementation for an organization are "Training and Education," "Top Management Commitment and Involvement," "Cultural change," "Project Management Skill," "Linking Lean Six Sigma to the Business strategy," "Communication," "Linking Lean Six Sigma to customers," "Leadership," "Organisation infrastructure," "Reward system, Recognition system," and "Extending LSS to supply chain /suppliers." These prioritized 11 success factors provide meaningful insights to the professionals during the implementation of LSS.

6. Conclusion
An attempt is made to explore the factors responsible for successful implementation of LSS in an organization. The well-defined research methodology followed to get insights on LSS and identified the success factors from the literature study. Through Pareto analysis, the most important 11 success factors for LSS implementation are reported. Authors believe that these can be useful in preparing for a framework for LSS implementation for organisation in the future.

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