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# **A Global study into the reasons for Lean Six Sigma project failures: key findings and directions for further research**

Jiju Antony, Fabiane Letícia Lizarelli and Marcelo Machado Fernandes

Low success rate of improvement projects is one of the causes of the discontinuity of Lean Six Sigma (LSS) initiatives in companies. It is essential to identify and evaluate the reasons why LSS improvement projects fail in order to enable LSS, Lean, and Six Sigma sustainability. This paper presents the findings from a global survey conducted with 201 LSS experts around the world in both service and manufacturing sectors. The results of our study point out to significant failure rates for LSS projects and alert that projects had higher termination rates in *measure* and *analyze* phases (DMAIC – Define, Measure, Analyze, Improve and Control). Failures occur primarily at the corporate level. The main causes of project failures identified were lack of commitment by top management, resistance to change, inadequate rewards and recognition mechanisms, inconsistent monitoring and control of the projects, and poor communication. Our study shows that there are some minor differences in terms of ranking of these factors between manufacturing and service sectors but there is significant difference in terms of continent and belt level (Master Black Belts, Black Belts, and Green Belts).

**Keywords:** Six Sigma, Lean Six Sigma, Project Failures, Survey, Continuous Improvement

**Managerial relevance statement:** The findings have several implications for managing organizations that are implementing or supporting LSS. Firstly, the failure rate of LSS projects must be monitored, for trend analysis and elimination of the potential causes of failures. Secondly, management must be careful, especially in the *Measure* and *Analyze* phases, when the project is being carried out, and management must be aware of actions

at the corporate level to minimize the chances of projects failing. Attention in the *Measure* and *Analyze* phases can direct measures such as better communication among team members and choice of team members with the appropriate skills and problem-solving knowledge, causes of project failures that may be associated with the project's termination in these phases. The third implication is that management should create mechanisms to decrease the chances of project failures by understanding the factors and the variables that lead to them. Actions that can be taken are, increasing commitment on behalf of the top management to project planning and execution, creating mechanisms to reduce resistance to employee change, creating reward policies, and creating better communication mechanisms among project stakeholders.

## 1. Introduction

Lean Six Sigma (LSS) is a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved results [1]. It seeks to improve the bottom-line results of organizations in hard-cash savings and to create value for customers and shareholders [1], [2]. LSS differs from other quality management approaches in its structure and organization [3] as LSS aligns the cultural aspects of Lean with the data driven approach of Six Sigma (SS) [4]. LSS created a holistic improvement methodology - derived from integrating Lean and SS and their toolboxes - in which the main goal is continuous improvement through a robust and systematic problem-solving methodology called DMAIC (Define-Measure-Analyze-Improve-Control) [1], [3], [4].

Many industries have adopted LSS methodology for continuous improvement [5], however, it is not easy to implement [6], since LSS is not immune from failure [5], [7]. Resistance is a main problem in implementing LSS or SS projects given lack in understanding and general disbelief as to the effectiveness of such projects [1], [8]. For

this reason, LSS critical success factors and failure factors are topics of interest to both researchers and managers alike [5], [9].

The low success rate of LSS projects is one of the causes that may lead to discontinuing LSS initiatives [3]. The failures of SS programs at the project level should be studied and analyzed [10]. Successful projects are usually the best way to reduce concerns surrounding LSS [1], [3]. Successful projects result in less doubt surrounding the implementation of the approach and also increase confidence [1]. The expectation of tangible benefits using continuous improvement approaches implies that projects must be successful [11], [12]. As such, LSS project failure is a concern that can easily deter its implementation [5].

An organization needs to have a project management system, a proper selection (including prioritization and classification), execution, and review system to ensure the long-term success of any continuous improvement approach [1], [13]. Another important aspect of project management is the sustainability of results and clear guidelines for the initial phases of DMAIC [7], [14]. Furthermore, there should be processes to guide and sustain improvement to reach project management objectives [14], such as project tracking and review, communication, recognition and reward, and training [1].

It is critical to understand how to reduce the risk of failure in continuous improvement projects like LSS [15], [13]. However, only a handful of papers have been published that studied the factors that lead to the successful completion of improvement projects [16], [17]. Studying the reasons why LSS projects fail is crucial to the performance of the overall LSS approach and to business excellence in general [18], [19].

Therefore, this study seeks to respond to the following research gaps: i) identify the reasons for LSS project failures, since literature focuses on the reasons for the success and failures of LSS programs [3], [7], [19], or projects success factors (e.g., [20],[21],

[22]); ii) contribute to the discussion on deploying LSS identifying the failure rates of LSS projects, which is one of the reasons why companies giving up LSS [1], [3], [5], [22]; iii) rank the project failure reasons, since there is an absence of this type of research [19], [23]; iv) eliminate the absence of global empirical studies in the theme [18], since this is the first empirical study with a global scope geared towards understanding the factors that lead to LSS project failures, and v) verify the impact of variables such as role in Belt system [24], sector [2], [25], [26], country development [2] and national culture [25] in the ranking of failure factors.

This paper focuses on the critical factors that lead to LSS project failures. This study presents a global research with LSS experts from service and manufacturing sectors containing responses from 201 participants. This study characterizes the rate and levels at which project failures occur, determines and ranks of the fundamental reasons behind LSS project failures via an empirical study and verifies variables that can alter the perception of these reasons, such as respondents' role in Belt system, sectors and national culture. This study can help senior managers and process improvement experts to reduce the risks associated with project failures and the costs associated with such failures.

The layout of the paper is as follows: Section 2 presents a literature review on the possible reasons and factors for LSS project failures; Section 3 details the research methodology used in this study; Section 4 reports the results and key findings, followed by a discussion in Section 5. Finally, Section 6 highlights the conclusions, managerial implications, limitations and suggestions for further research.

## 2. Literature Review

It is important to research project failures because they result in serious financial and non-financial losses that can impede the development of other potential projects [19]. Reducing failures in improvement projects can enable LSS, Lean, and SS sustainability

[3], [13]. Furthermore, learning from project failures can play a key role in planning and monitoring future projects [19].

LSS projects are quite different from other projects conducted by project managers in many organizations. There are only two types of projects which can be conducted in any organizational settings. The first type of projects are run by project managers where the solution is known right from the outset of the project (for instance, development of a new IT system). The second of projects are run by LSS professionals such as Green Belts (GBs), Black Belts (BBs) or Master Black Belts (MBBs) where the solutions are unknown to the problem (for example, the rework and scrap rate of a process is estimated to be 8% per month and this is costing an organization more than \$250k per annum). In the second type of projects, the root causes of the problem were not known and the purpose of the project is to reduce the scrap rate on a continuous basis [27]. LSS projects use a specific problem solving methodology (DMAIC) and associated relevant tools [27] and the projects need a wide variety of stakeholders [27].

The purpose of this section is to present the main reasons for LSS project failures based on a Systematic Literature Review (SLR). The SLR was conducted to answer the following question: What are the main reasons for Lean, SS or LSS project failures? The search was conducted in two databases: Scopus and Web of Science with no time limitation. Other papers on the subject that were cited in the references of this review were added. The protocol and results are presented in Table 1.

**Table 1: Summary of Systematic Bibliographic Review**

Data Base	Number of Documents*	Inclusion criteria: Journals papers	Selected (after reading the full paper)	Duplicated	Total
Scopus	411	174	19	11	21**
Web of Science		99	13		

\* String in title, abstract and keywords: ("continuous improvement" OR "six sigma" OR "Lean Six Sigma" OR "Lean") AND (failure) AND (Project \*)

\*\* The papers are: [3], [5], [7], [11], [12], [13], [15], [18], [19], [25],[28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38]

Table 2 presents the studies found in the SLR, its scope, main findings and gaps that helped in this research. It is noticeable that several studies focus on the reasons for failures or success of continuous improvement initiatives and not specifically on the success and failures of projects.

Table 2: Literature review about failures in LSS projects

Author and year	Scope (S) and Main Findings (MF)	Gap to present study
Anand et al. (2009)*	(S)To develop a conceptual model for predicting success of process improvement projects as a result of knowledge-creation practices. (MF) Knowledge-creation practices influence the success of process improvement projects.	Replicating the approach but employing larger samples.
Kumar et al. (2009)	(S)To focus on the importance of the project selection process and its role in the successful deployment of SS within organizations. (MF) The paper presents a hybrid methodology combining AHP with the PDM for SS project selection.	In-depth investigation of the selection of SS projects.
Snee (2010)*	(S)To assess LSS to identify important advances over the last ten to 15 years and discuss emerging trends. (MF) Deployment and sustaining improvements are major issues. Critical issues include working on improvement as a leadership development tool.	Trends: holistic improvement, CI culture, leader development using LSS experience, keeping a focus on the bottom line. Participant-observation studies. To link the reported barriers and success factors to concrete organizational impacts.
Pedersen and Huniche (2011)	(S)To examine the determinants of lean implementation in Danish public sector organizations. (MF) A number of factors within the structural and the negotiation context.	To verify other structured quality improvement initiatives, replications in other in services context and observe the maturity of the program.
Easton and Rosenzweig (2012)*	(S)To study the role of individual, organizational, team leader experience, and experience working together on a team (team familiarity) in the context of improvement teams. (MF) Team leader experience exhibits the strongest relationship with project success, followed by organizational experience. No relationship between individual experience or team familiarity and project success.	
Pamfiliea et al. (2012)*	(S)To demonstrate that organizations can obtain individual and organizational performance by using well trained leaders focused on continuous improvement (CI) that use LSS in driving employee synergy. (MF) There is a synergy between LSS, organization's objectives and performance measurement; the leadership may have a significant influence on their employees; employee motivation increases during the implementation of LSS projects.	Studies on leadership and employee motivation.
Psychogios, et al. (2012)*	(S)To investigate issues related to the application of LSS in a service industry. (MF) There are factors to the implementation: Top Management Involvement & Support, Quality-driven Organizational Culture, Quality-driven Training, Top Down & Bottom Up Project Selection	More emphasis on other service industries and sectors and to explore front line employees as well.
Singh and Khanduja (2012)	(S)DMAIC strategy of SS is briefly explained with focus on define (D)-phase, since its malfunctioning is one of the reasons of failure of SS particularly in SMEs. (MF) It highlights the framework for defining phase and defining tools and techniques. A road map for short-listing that the relevant definition tools have been carpeted.	To discuss other four phases of the DMAIC methodology.
Albliwi et al. (2014)*	34 common failure factors, such as: a lack of top management commitment and involvement, lack of communication, lack of training and education, limited resources and others.	To investigate countries (developed and developing), industries and organization sizes.
Singh and Khanduja (2014)	(S)The objective is to enlist the control phase and propose a more applicable methodology to execute operation controls. (MF) Part of a framework for control phase during SS implementation in small and medium sized enterprises.	Frameworks should be proposed for D-M-A-I phase to reduce the risk of failure of SS projects.
Laux et al.(2015)*	(S)To utilize critical success factors (CSF) and barriers for GB to completion of SS projects. (MF) GB have competing priorities, have	. The use of CSF to evaluate the SS project management through top management.

	time constraints and lack project management skills that reduce timely completion of SS projects.	
Salah (2015)	(S)To investigate project selection, prioritization and classification. (MF) It presents a model to select the proper projects of highest priority. It presents an integrated framework for CI, project selection, prioritization and other business blocks.	All CI projects should follow DMAIC and study project selection, prioritization and classification.
Vinodh and Swarnakar (2015)	(S)To select the optimal LSS project using hybrid fuzzy-based Multi-Criteria Decision-Making (MCDM) approach. (MF) The study integrated fuzzy DEMATEL–ANP–TOPSIS to select the optimal LSS project.	The method could be tested in several industrial scenarios.
Marzagão and Carvalho (2016)*	(S)To identify and understand the relationship between CSF for SS programs and its projects performance. (MF) Not all the claimed CSF are relevant for project performance, what could direct the effort of companies.	An analysis of the measurable results of a SS project portfolio.
Yousef and Hadi-Vencheh (2016)	(S)To compare prioritization methods. To select the optimal projects is important to reduce the risk of failure in SS. (MF) Multi-criteria decision-making (MCDM) techniques are more reliable in comparison with DEA, because decision-maker's point of view is more effective in MCDM techniques.	Comparison of different types of methods for prioritizing projects. Analyze the model in other contexts and countries.
Albliwi et al. (2017)*	(S)To critically assess the current status of LSS implementation in Saudi Arabian organizations. (MF) The implementation of LSS is still in the early stages considering factors such as years of deploying LSS, LSS infrastructure, level of awareness of LSS and impact of LSS on business functions.	Deeper analysis with interviews targeting Champions, MBBs, BBs and GBs.
Ambekar and Hudnurkar (2017)	(S)To identify the latent constructs of various barriers affecting SS implementation in Indian industries. (MF) The study proposes five constructs: role of top management, cultural change, expected attitude, availability of resources, and level of quality maturity, to overcome barriers in SS.	To verify if the constructs positively influences the success of SS project implementation.
McLean et al. (2017)	(S)To provide a systematic literature review detailing why CI initiatives within manufacturing environments may fail. (MF) The failures were grouped under eight core themes: Motives & Expectations, Culture & Environment, Management Leadership, Implementation, Training, Project Management, Employee Involvement, and Feedback & Results.	Development of an implementation framework through empirical research, mainly for small and medium organizations.
Yadav and Desai (2017)	(S)To identify and prioritize the barriers of LSS for its productive implementation. (MF) The study identifies 27 critical barriers that obstruct the LSS implementation. The barriers were categorized: strategy, technology, organizational, social-cultural and individual.	Prioritization of these barriers will help the practitioners to develop the strategies to tackle the barriers.
Parsnani and Deogaonkar (2018)	(S)To provide an in-depth analysis about the role of Leadership in SS methodology and the success or failure of the projects. (MF) Factors for SS success are top management involvement, to align the change initiative to the business strategy and goals, creating the organizational culture and providing the necessary resources.	Investigation of the involvement and support of management for the success of the projects.
Antony et al. (2018)	(S)To provide lean and SS professionals and researchers of tomorrow with Ten Commandments of LSS. (MF) The Ten Commandments: alignment of LSS with strategy, project selection, selection of top talent, leadership for LSS, effective training, reward and recognition system, LSS sustainability, linking LSS with organizational learning and Innovation, linking LSS with environmental management and LSS and Big Data.	Global study to evaluate the commandments using various leading academics and practitioners of Lean and SS topics.
DeSanctis et al. (2018)	(S)To study the effect of factors related to national culture and company characteristics of lean implementation barriers. (MF) National culture dimensions, such as Performance Orientation and Gender, influence lean management success. Factors of individuals such as Uncertainty Avoidance, Future Orientation and Institutional Collectivism also help to support a lean culture and overcome human and cultural barriers.	Investigation in companies from different sectors. To verify the impact of national culture in lean success and barriers.
García-Alcaraz et al. (2018)*	(S)To identify the relationships between managerial commitment, SS implementation strategy, investments in human resources and the economic benefits obtained. (MF) Managerial commitment is the basis for SS success, but requires an implementation strategy focused on customer needs, which must integrate training and teamwork. Managers must have a reward program.	To integrate other variables: management of knowledge generated and the communication and cooperation and investment made in education and training.



Hadi-Vencheh and Yousef (2018)	(S)A new data envelopment analysis (DEA) model to reduce the risk of failure in SS projects and linear discriminate analysis to examine the validity. (MF) The proposed model is a suitable tool for selecting SS projects. (S)It examines the key success and failure factors, benefits and quality tools influencing LSS initiatives deployment. (MF) Top management commitment, understanding the LSS methodology, tools and techniques, integrating LSS to business strategy, organizational cultural change and training and education were the top success factors.	To use imprecise numbers such as fuzzy numbers to smooth the challenge of exact forecasting the values of the projects' criteria.
Iyede et al. (2018)	(S)Identify the vital failure factors of LSS initiatives. (MF) The study identified 44 critical failure factors and ranked them through decision makers. In addition, the TOPSIS SIMOS approach ranked the vital failure factors enabling the management to avert the LSS initiative from failures.	Comparison of the factors to other countries. To use the TOPSIS SIMOS approach to health care, accounting and finances, logistics and public utilities.
Sreedharan et al. (2018)	(S)To present the results of a pilot survey highlighting the most common reasons for process improvement project failures. (MF) The main reasons for project failure include: resistance to change, lack of commitment and support from top management and incompetent teams	Investigation in several countries and types of companies (manufacturing and service).
Antony et al. (2019)	(S)To provide the top ten reasons of process improvement projects termination or failure to Lean and SS professionals and researchers. (MF) The top ten reasons: lack of commitment from top management; poor communication; incompetent team; inadequate training and learning; faulty selection of methodology and tools/techniques; inappropriate rewards and recognition system; scope creepiness; sub-optimal team size and composition; inconsistent monitoring and control; and resistance to change.	A global study to critically evaluate the reasons behind process improvement project failures based on a case-study approach.
Antony and Gupta (2019)	(S)To investigate the barriers of LSS and develop the interrelationship among them using interpretive structural modeling (ISM) and Cross Impact Matrix-Multiplication Applied to Classification (MICMAC). (MF) The ISM model indicates that insufficient management commitment and involvement, lack of resources, lack of training and education, lack of strategic thinking, lack of training funds are strategic factors.	Real-time execution of LSS barrier model at shop floor and structural equation modeling (SEM) can be adopted for validation of the present ISM model.
Singh et al. (2019)	(S)To expose the detailed review for benefits and challenges about implementation of LSS in business organization. (MF) It presents the critical barriers and benefits of LSS implementation in manufacturing, health care, human resource, financial and education.	Prioritization and domination of identified major barriers in various sectors individually.
Singh and Rathi (2019)	(S)The purpose is to answer the question why do organizations discontinue LSS initiatives? (MF) This study finds 11 factors: poor success rate, unrealistic expectations from LSS, unsustainable results, misuse of statistics, large tool set, unsupportive and uncommitted top management, lack of training and development, lack of synergy of LSS and business strategy, lack of link between LSS and customer needs, wrong projects selection and premature discontinuation of LSS experts.	Considering the low success rate of LSS projects, future studies should explore the failure rate in different sectors
Sony et al. (2019)	(S)To conceptualize a novel LSS framework, and further test it for practical implications.(MF) Focused gaps and shortcomings of the DMAIC framework for LSS project management. A novel approach to LSS project management by conceptualizing 'SDMMAICS' framework validated the in real world.	Validation of the SDMMAICS framework in services context.

\*Articles found to appear in the SLR article references

The causes of the low success rates for improvement projects may be due to various factors, ranging from poor project selection to a lack of managerial support [3]. Antony and Gupta [18] wrote an article based on the reasons/factors for LSS project failures. The reasons that were identified were then divided into the ten factors presented by Antony

and Gupta [18]. This current research presents each factor broken down into its root causes (variables) for a more detailed analysis of why improvement projects fail.

## 2.1 Failure factors of LSS projects

### *Lack of commitment and support from top management*

Successful projects require the commitment of top management to meet the defined objectives [18]. The results of improvement projects increase proportionally with the intensity of top management's involvement [26]. Top management commitment is vital for LSS deployment, and is a critical factor in implementing LSS, as a lack of commitment can result in imminent project failure [2], [5].

### *Poor communication practices*

Good communication contributes positively to developing continuous improvement projects [6]. Communication practices should be developed and applied during project development, given that gaps in communication are a limiting factor in project development [5], [18]. Simple practices can improve communication, such as conducting meetings with core team members [1]. Inadequate communication on the progress, development, driving, gains, and benefits brought about by LSS projects to the employees and stakeholders is a recurring problem in LSS project failures [28].

### *Incompetent teams*

The first step in project management is to properly select a project team. This is then followed by defining the project goals [13]. It is important to identify the right personnel before starting a project [1]. One specific problem, for example, is having the wrong people assigned to certain projects [1], [13]. Lack of adequately skilled team members is one main reason behind project failures [18], [29].

### *Inadequate training and learning*

Inadequate training is also a factor that can lead to LSS project failures [2], [3]. Training helps develop employee awareness, knowledge, and the hard/soft skills that are associated with LSS tools and practices [26]. Albliwi et al. [24] affirm that few organizations encourage employees to learn from each other's experiences, or from errors during the implementation process, much less from failed LSS projects. This learning process is a critical aspect.

#### *Faulty selection of a process improvement methodology and associated tools/techniques*

The results of improvement projects are achieved through the structured application of tools and techniques [7]. The integration of Lean and SS leads to a wide range of tools, and this can make it harder to understand and use them [13], [14]. In addition to properly choosing tools, adequate resource allocation is required to analyze, retrieve, and collect data that will be used as inputs for the tools. Furthermore, one of the main resources is time for teams to work on projects [1], [11], [18].

#### *Inappropriate rewards and recognition system/culture*

Motivation greatly impacts continuous improvement projects [6]. In order to maintain interest and motivation, employees should be rewarded for their efforts in improvement projects [39]. The lack of policies to recognize and reward success and appropriate recognition and rewards for project members are problematic for the progress of the project [2], [1], [28], [39].

#### *Scope creep*

The scope of an improvement project is an very important aspect, since it determines the results to be obtained, including the financial [12]. The project scope is one of the top factors that influences success for improvement projects [18], [19]. A poorly defined project scope is one of the main problems in managing improvement projects [1].

#### *Sub-optimal team size and composition*

Other reasons for project failures include sub-optimal or inadequate team size, and little to no optimization of the team size [1]. For example, an adequate team size is 4-6 members [1]. The team size should also consider the project scope, duration, and complexity [18]. Another important issue is the participation of key individuals, such as facilitators [1], MBBs for technical support [1] and people from the functional units[18].

#### *Inconsistent monitoring and control (lack of expert supervision)*

*Control* is the last phase of the DMAIC methodology, and contains activities that ensure the sustainability of project improvements by tracking key performance processes [29]. Consistently monitoring and controlling processes is key to the long-term sustainability of project benefits [11], [14]. Better LSS control helps avoid project failures, and management should be committed to making this happen [5]. Lack of process thinking and process ownership are two reasons for discontinued results and errors in correctly identifying improvements [29].

#### *Resistance to change (partial cooperation by employees)*

Resistance to change in LSS improvement projects can be extremely high and can occur at all levels [6]. To guarantee successful LSS deployment, organizations need to change their culture [2]. Employee motivation is essential for incorporating LSS into the company culture, especially when facing challenges, and managers should help in this process [6]. People must be authorized to apply changes if LSS is to be implemented effectively [31]. Reduced employee involvement is one major obstacle to organizational cultural change [6].

The factors and variables that were identified in the literature review are presented in Table 7.

## 2.2 Research Questions

The low success rate of LSS projects is an important factor for decisions in deploying or discontinuing LSS initiatives [1], [3], [5]. However, there are few empirical studies on this issue especially considering a global perspective [19]. LSS projects use a specific methodology (DMAIC) [13], [14], each phase assists and provides direction in project management [7]. Identifying the DMAIC phase in which the project ends can assist in identifying the reasons for failure. In addition to the failure phase, they can also help to identify the main reasons for these failures, since they can have problems on an individual level, team level or organizational level [19]. Therefore, the following research questions (RQs) have been proposed:

*RQ1: What is the percentage of unsuccessful LSS projects in the perception of experts?*

*RQ2: What is the percentage of termination of LSS projects at each phase of DMAIC?*

*RQ3: At what level do most LSS failures occur (project level, individual level, or corporate level)?*

There may be several reasons for failures in LSS projects [3], [18] and identifying and prioritizing the main reasons can help in eliminating their causes [19]. For a deeper analysis, we consider respondents' perspectives that may change the order of prioritization. The first analysis considers the perspective of the sector. There may be institutional and contextual factors that affect LSS application and projects, varying by sector i.e. the service, manufacturing, or even the public sector [26], since different organizations have specific complexities [26]. Another perspective of analysis is the respondent's role in the Belt system. These differences in perception can occur because MBBs are involved in project definition and selection, and developing training materials, managing the improvement team while mentoring BBs and GBs [40], [41], [42]. GBs are not required to have the same level of knowledge in the use of tools or leadership skills

since they assist BBs on major projects or lead teams in smaller and specific projects [40], [41], [42].

The culture and business conditions of developing and developed nations are different and this influences many factors regarding LSS deployment [43]. The level and rate of implementation of LSS practices are higher in developed economies and there are difficulties in implementing the LSS in developing countries [44], [45]. In addition, empirical studies are still limited in developing countries [43]. Developed and developing economies can be classified by country or continent [46]. Another factor that can influence respondents' perceptions is national culture, more specifically collectivism/individualism because the success of LSS projects and many tools and practices are inherently based on a group oriented working culture [25], [47]. Therefore, the following research questions (RQs) have been proposed:

*RQ4: What are the top five critical factors for LSS project failures?*

*RQ5: Is there a difference in the perceptions of critical factors among manufacturing and service experts?*

*RQ6: Is there a difference in the perceptions of critical factors based on the role of the respondent in the Belt system?*

*RQ7: Is there a difference in the perception of critical factors when considering the respondent's continent (South America, Asia or Europe), the country's level of development, or national culture of the given country (individualism/collectivism)?*

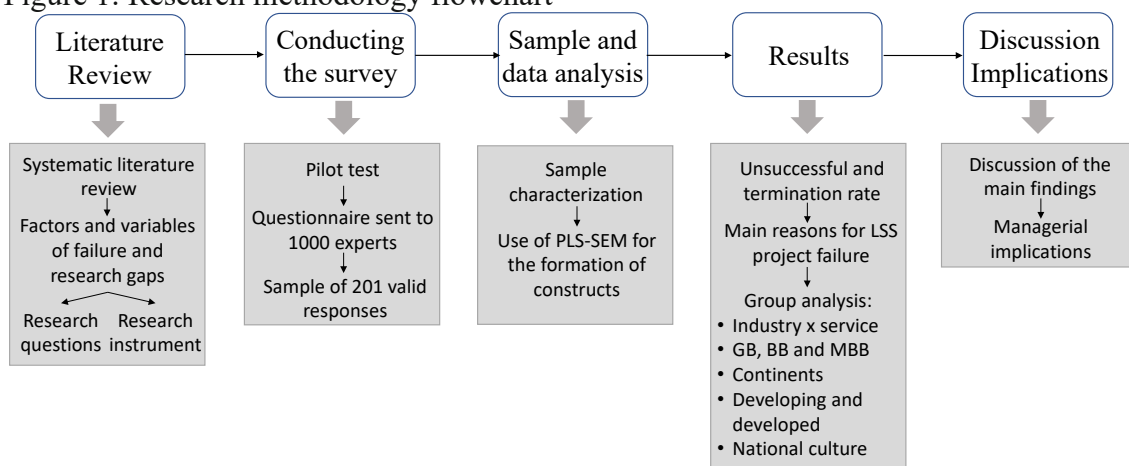
### 3. Research Methodology

The study conducted a literature survey, preparing and testing the survey, analyzing the sample and data, results, and discussion. The research steps are presented in the flowchart in Figure 1 and are explained in the subsequent subsections.

#### 3.1. Data collection

The research instrument used for data collection was a web survey directed to LSS experts. The pilot test of the survey questionnaire was developed with 6 academic professionals with experience in LSS for research and peer-reviewed papers on the subject, and with 3 practitioners with extensive experience in leading and participating in LSS projects, either BBs or MBBS. The pilot test allowed for the questions to be adjusted, in turn helping eliminate measurement errors (writing and understanding the questions) and ensuring that no constructs have been omitted [48].

Figure 1: Research methodology flowchart



The questionnaire was written in Google Forms, comprised of three parts: general participant information (sector, country, experience), characterization of the failure rate (moment of failure and failure rate), 51 statements about the main reasons for LSS project failures identified from the literature review. Statements relating to project failure were grouped into ten failure factors (constructs). The structure of part three of the questionnaire, i.e. the main constructs and variables, is presented in Table 7. A Likert scale, which is used extensively in research surveys of this type, from 1–5 (very rarely – very often) was used to measure the variables [49], [50].

The final web survey link was sent to 1000 experts that were identified in social networks as belonging to groups linked to LSS and having SS Belt training, following several studies in the area (e.g. [20], [32], [33], [37]). The sample included LSS specialists with

a minimum training level of GB and more than 1 year of experience in improvement projects. The objective was to select respondents who were able to answer the survey given their experience. After eliminating unanswered questionnaires and similar answers, a sample of 201 respondents was obtained.

### 3.2 Sample characterization

Table 3 shows the distribution of the respondent's characteristics. The sample is almost equally composed of respondents from the manufacturing sector (48.75%) and the service sector (50.25%). The sample had similar concentrations for the BB (38.3%) and MBB (38.8%) levels, and slightly smaller concentrations of respondents with a GB level (22.9%). Half of the sample had more than 10 year's experience in LSS projects, and 15% (31) of respondents had between 1-2 year's experience in LSS projects. The Belt level and the experience show that the sample group had extensive knowledge in LSS. The sample also had a greater concentration on more than 30 projects carried out and/or led at BB (21.3%) level.

Table 3: Distribution of expertise in LSS

		Industry	Service	Not Identified	Total
Respondents		99	100	2	201
Six Sigma Belt	Green Belt (GB)	25	21		46
	Black Belt (BB)	37	38	2	77
	Master Black Belt	37	41		78
Experience in LSS (years)	1-2 years	17	14		31
	3-5 years	19	16	1	36
	6-10 years	18	16		34
	More than 10 years	45	54	1	100
	More than 30 projects	25	34		59
Experience in LSS projects – Number of BB projects you participated in or led	1-2 projects	27	21		48
	3-5 projects	11	12		23
	6-10 projects	15	18	2	35
	11-20 projects	18	16		34
	21-30 projects	11	7		18
	More than 30 projects	17	26		43

Figure 2 shows the main sectors in which respondents had experience. The respondents that worked in the manufacturing were mainly from the automotive, chemical, and



pharmaceutical sectors. With respect to the service sector, 36 (17.9% of the sample) respondents were LSS or business improvement consultants. The number of different sectors (43 in total) shows the diversity of the sample, thus compiling different LSS application perspectives.

Figure 2: Sectors distribution in the sample

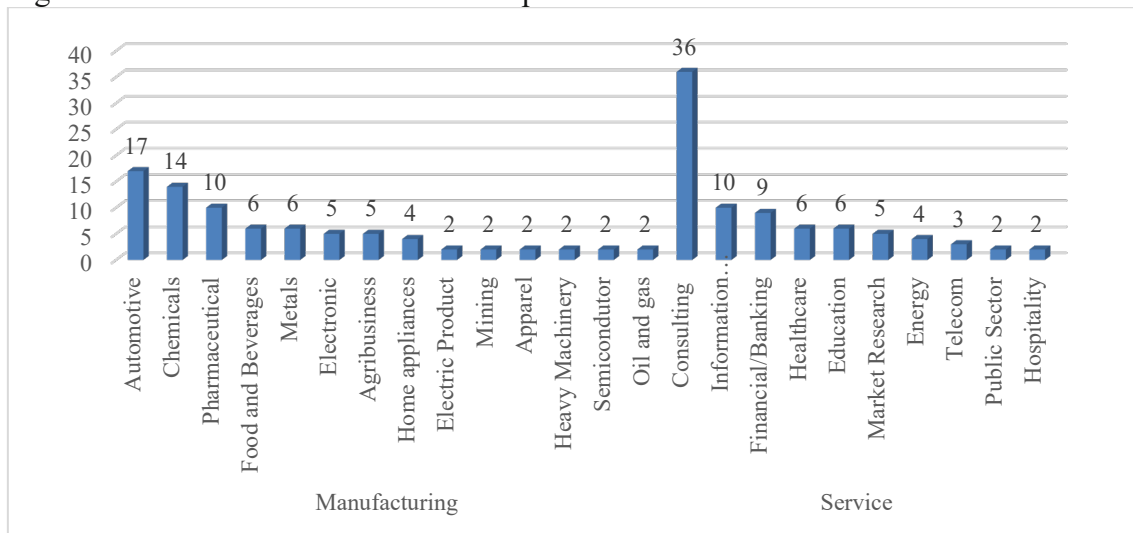
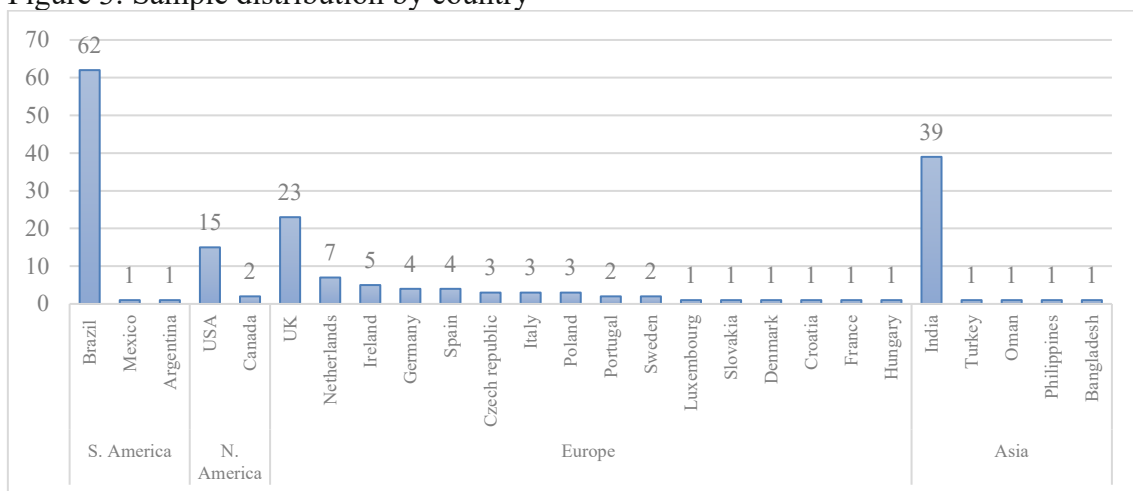


Figure 3 shows samples from four continents. 64 (31.8%) respondents were from South America, 17 (8.5%) from North America, 62 (30.8%) from Europe, and 43 (21.4%) from Asia. 15 respondents (7.5%) did not enter information about their country, indicating only that they act globally or omitted the information altogether.

Figure 3: Sample distribution by country



Respondents' countries were divided into developed and developing countries to allow for subsequent comparative analysis. We used information on gross national income

(GNI) per capita adjusted annually available from the World Bank [46], [51]. Developing countries have low and middle income, while developed countries have high income [51], [52]. Table 4 shows the sample separation in developing and developed countries.

Table 4: Stage of development

Stage of development	Countries	Number of respondents
Developing	Brazil, India, Mexico, Argentina, Turkey, Philippines and Bangladesh	106
Developed	UK, USA, Netherlands, Ireland, Germany, Spain, Czech Republic, Italy, Poland, Portugal, Sweden, Canada, Luxembourg, Slovakia, Denmark, Croatia, France, Hungary and Oman	80

The respondents' countries were divided in relation to national culture, in relation to the issue of individualism/collectivism, given that the projects are an activity carried out as a team. National collectivism culture is measured through the IDV culture scores provided by Hofstede (Table 5). The scores were divided in order to separate the most individualistic countries ( $IDV > 50$ ) and the most collectivist countries ( $IDV < 50$ ). As can be seen, there is a lot of similarity between tables 4 and 5.

Table 5: Stage of development

National culture	Countries (IDV)	Number of respondents
Individualistic	Brazil (38), India (48), Mexico (30), Argentina (46), Turkey (37), Philippines (32), Portugal (27), Croatia (33) and Bangladesh (20)	109
Collectivist	UK (89), USA (91), Netherlands (80), Ireland (70), Germany (67), Spain (51), Czech Republic (58), Italy (76), Poland (60), Sweden (71), Canada (80), Luxembourg (60), Slovakia (52), Denmark (74), France (71), Hungary (80) and	76

Note: Oman IDV was not found

### 3.3 Data analysis

The questionnaire was structured so that each of the LSS failure factors was observed by means of observable variables. This choice was made because the reasons for failure are abstract. It is possible to indirectly measure the overall concept of the factor by combining several items [50]. This ensures that measurement is more accurate and more likely to represent all of the different conceptual aspects [50]. It is possible to decrease the

measurement error, since it is less likely that all items will be poorly worded [50]. In the Structural Equation Modeling approach several measures are combined to form a single composite score - the score of the construct [50].

To identify the factor score, the Partial Least Square – Structural Equation Modeling (PLS-SEM) was chosen because PLS-SEM is considered to be the best approach for this purpose [53]. A disadvantage is that PLS-SEM parameter estimates are not optimal regarding bias and consistency [53], but an advantage is that it is suitable for analyzing data that does not follow a normal distribution [50]. PLS-SEM results in more precise estimates for factor scores, since they are calculated as exact linear combinations of the values of all the items associated with a construct [50], [53]. The scores are calculated by weighted composites of observable variables, which facilitates accounting for measurement error [50]. The scores allow researchers to easily prioritize factors and to identify differences for potential improvements and take managerial decisions [53].

To validate the reflective construct, and subsequently the scores, we used procedures to confirm internal consistence (composite reliability or Cronbach's  $\alpha > 0.6$ ), convergent validity (outer loadings  $> 0$  and Average Variance Extracted - AVE  $> 0.5$ ) and divergent validity (cross loadings, Fornell Larcker and Heterotrait-Monotrait – HTMT  $< 0.85$ ), to validate the measurement model through PLS-SEM [50], [54], [55]. The SMARTPLS 3.2.7 software program was used, which is a suitable software program for performing PLS-SEM analysis [50]. A disadvantage is that the PLS-SEM algorithm first optimizes measurement model parameters, thus, researchers have to validate the measurement models' characteristics [53]. Table 6 presents the validation by internal consistence and convergent validity. The divergent validity was validated using cross loadings, Fornell-Larcker and HTMT  $< 0.85$ . The constructs were therefore validated, and the unstandardized score is presented in Table 7.

It was necessary to conduct analysis between groups in order to answer the research questions. For these comparisons nonparametric tests were used to compare the groups (Mann-Whitney or Kruskal-Wallis) given the qualitative ordinal and non-normal distribution data that was analyzed [56].

Table 6: Internal consistence and convergent validity

Construct	Cronbach's Alpha*	Composite Reliability*	(AVE)**
Lack of commitment from top management	0.78	0.85	0.53
Resistance to change	0.84	0.88	0.60
Inappropriate rewards and recognition system	0.93	0.97	0.94
Inconsistent monitoring and control	0.79	0.87	0.62
Poor communication	0.90	0.92	0.63
Incompetent team	0.90	0.92	0.58
Inadequate training and learning	0.82	0.89	0.74
Sub-optimal team size and composition	0.83	0.87	0.53
Scope creep	0.83	0.90	0.75
Faulty selection of methodology and its associated tools	0.87	0.90	0.52

\*All values are > 0.7 threshold value

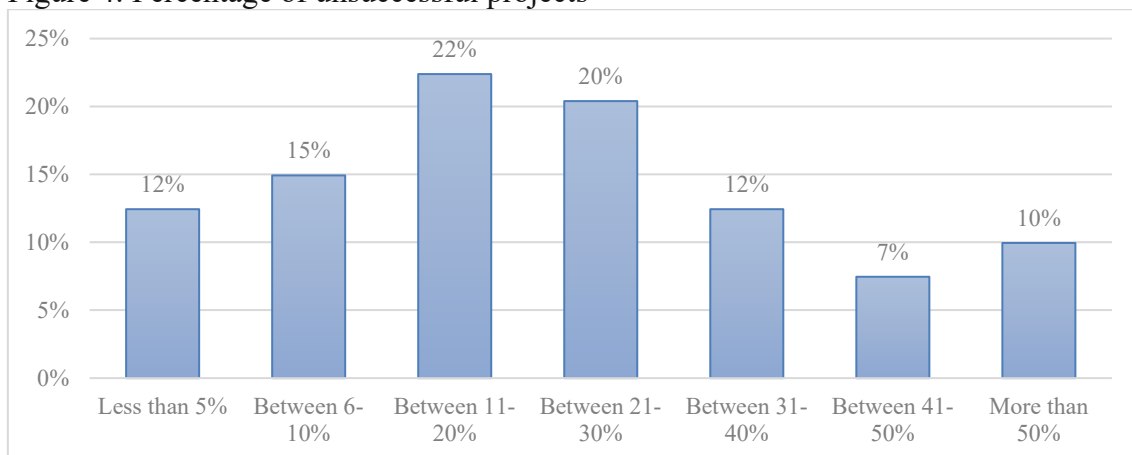
\*\*All values are > 0.5 threshold value

## 4. Results

### 4.1 Unsuccessful and termination rate

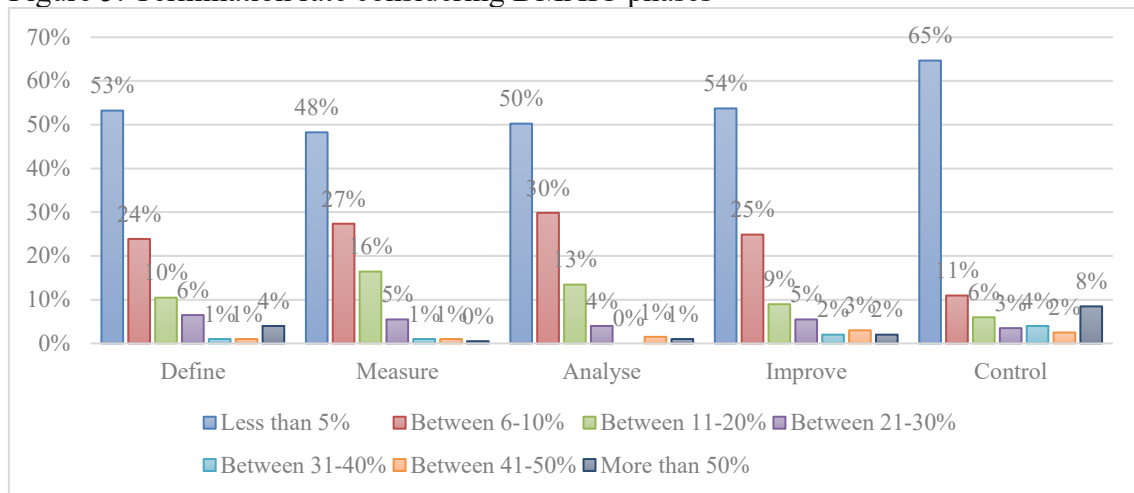
When asked about the rate of unsuccessful LSS projects (Figure 4), respondents said that between 11-20% (22% of sample) and 21-30% (20% of sample) of the projects had failed. This shows that there is a significant rate of unsuccessful projects, and further highlights the need for studies on the causes of failures.

Figure 4: Percentage of unsuccessful projects



The project termination rate was identified in the different phases of DMAIC (Figure 5). The highest concentration of responses was less than 5% for all phases. However, respondents (approximately 25% of the sample) pointed to project termination rates between 6-10%, in almost all phases except for *control* phase, where only 11% of the specialists measured termination rates between 6-10%. Additionally, 16% and 13% of respondents indicated that termination rates were between 11-20% in the *measure* and *analyze* phases. These phases require data, knowledge, and commitment from different areas within the company. This may lead to higher termination rates. *Control* phase had the largest number of respondents who said that less than 5% of projects were terminated in this phase (65%). This shows that the DMAIC cycle generates project maturity, and when it reaches this phase, it already has high added value and characteristics conducive for completion.

Figure 5: Termination rate considering DMAIC phases



#### 4.2 Main reasons for LSS project failure

When asked about the level at which LSS project failures occur, 42% of those sampled stated that it was at the corporate level, 31% stated that it was at the project level, and only 21% stated it was at the individual level. Identifying the causes of failures at the corporate and project level is essential for decreasing failure rates.

Table 7: Construct scores and mean of observable variables

Construct	Score Mean	Variables	Authors	Mean
Lack of commitment and support from top management (TM)	3.53	TM1 - Lack of TM commitment in project conceptualization (selection and prioritization)	[2], [3], [5], [11], [13]-[15], [18], [25], [26], [28], [33]-[36], [38]	3.71
		TM2 - Lack of TM commitment in project planning (resource allocation)	[11], [26]-[37]	3.64
		TM3 - Lack of TM commitment in project implementation (monitoring and controlling)	[23], [26]	3.50
		TM4 - Lack of sponsors commitment to aligning project objectives with the corporate strategy	[3], [11], [25], [26]	3.49
		TM5 - Lack of champions commitment to aligning project objectives with the corporate strategy	[3], [11], [25], [26], [32]	3.31
Resistance to change	3.24	CH1 - Lack of employee involvement in problem solving	[6], [19], [37]	3.10
		CH2 - Lack of immediate action of management to the causes of employee's resistance or underperformance	[1],[18], [26], [28]	3.44
		CH - 3 Employee's resistance to change	[2], [6]	3.58
		CH4 - There is no integration of the employees' opinions in DMAIC phases	[18], [37]	2.87
		CH5 - There are no strategies to convince resistant employees to maintain a positive attitude in improvement projects	[6], [18]	3.24
Inappropriate rewards system	3.22	RE1 - Lack of policies to recognize and reward success	[2], [26], [32]	3.23
		RE2 - Lack of appropriate recognition and rewards for project members	[2], [26], [28], [35], [39]	3.20
Inconsistent monitoring and control	2.94	CN1- There is inconsistent monitoring and control of the project processes by a process expert	[26], [29]	3.04
		CN2 - There is not a permanent process improvement expert for consistent monitoring and control	[18], [29]	2.95
		CN3 - Lack of a monitoring system designed to track the progress of a project in real-time	[1], [29], [39], [23]	2.93
		CN4 - The report of the project monitoring is not disseminated (visual display at the workplace, seminar, meeting, etc.)	[1], [26]	2.82
Poor communication practices	2.84	CM1 - Barriers in communication surrounding the project design and execution	[1], [5], [18]	2.85
		CM2 - Lack of development of communication practices during the project execution	[1], [18]	2.86
		CM3 - Lack of communication among project stakeholders	[5], [39]	3.10
		CM4 -Lack of communication about the progress of the project	[28], [37]	2.92
		CM5 - Poor communication (i.e., timeliness and usefulness information)	[5], [18]	2.88
		CM6 - Poor communication among team members (i.e. openness, discussion efficiency and effectiveness)	[18], [28], [37]	2.65
		CM7 - Lack of using information technologies for knowledge sharing across various projects	[20]	2.46
Incompetent team	2.83	TE1 - Lack of a common goal among team members	[13], [18]	2.83
		TE2 - Lack of adequately skilled team members	[1], [2], [5], [13], [21]	2.92
		TE3 - Lack of problem-solving knowledge by team members	[5], [20]	2.84
		TE4 - Lack of motivation on behalf of the team members	[6]	2.91
		TE5 - Lack of establishing and optimizing the project team based on detailed task descriptions and allocation analysis	[18], [22]	2.78
		TE6 - Lack of complementing skill among project members	[29], [30]	2.58
		TE7 - Lack of learning new skills to respond to changes	[29]	2.66
		TE8 - Lack of project leadership skills necessary to lead the team	[1], [2], [30]	3.18
Inadequate training and	2.82	TRA1 - Lack of strategies that support organic learning between projects	[18], [24]	2.73
		TRA2 - Not taking into account the characteristics of the team members in order to determine types of training and their content	[18]	2.74

		TRA3 – lack of continually review the links between skills, performance and training	[1], [37]	3.00
Sub-optimal team size and composition	2.81	SIZ1 - Inadequate size of the project team (scope, duration and complexity)	[1], [18]	2.67
		SIZ2 - There is no optimization for the team size	[1], [18]	2.43
		SIZ3 - Lack of time for better team cohesion	[7]	2.60
		SIZ4 - Lack of project facilitators to ensure management commitment	[1], [28]	3.32
		SIZ5 - Inadequate representation from relevant functional units in the project team	[18]	3.03
		SIZ6 Lack of participation from MBB in the team as senior coaches	[1], [30]	2.65
Faulty selection of process improvement methodology and its associated tools/techniques	2.77	MET1 - No selection of the methodology that best fits the problem	[28], [29]	2.82
		MET2 – No selection of tool/technique that best fits the problem	[1]–[3], [28], [29]	2.73
		MET3 - There isn't enough time to data collection in order to deploy tools and techniques effectively	[1], [18]	3.27
		MET4 - Tools are applied in the incorrect order	[18]	2.49
		MET5 - There is not enough time to implement the methodologies	[1], [11], [18]	3.19
		MET6 - There is overuse of tools and techniques	[3]	2.39
		MET7 - There is underuse of tools and techniques	[18]	2.60
		MET8 - Lack of tools and methods to identify operation failures	[18]	2.69
Scope creep	2.77	SCO1 - There is no collaboration between project champions and project leaders to define the scope of the project	[12], [18], [32]	2.81
		SCO2 - There is a lack of scope management techniques	[18]	2.84
		SCO3 - There is a lack of proper documentation for the scope of the project outlining the responsibilities of each member	[1], [18], [23]	2.68

The level of agreement with the 51 observable variables, associated with 10 different constructs as the main reasons for LSS project failures is shown in the Table 7. The “lack of top management commitment” is the construct with the highest score. This may explain why the corporate was pointed as the level at which most LSS projects fail. The second construct with highest mean was “resistance to change”. The third construct was “inappropriate rewards and recognition system/culture”, and this may also be related to corporate level, a consequence of corporate decisions. The fourth and fifth factors for were “inconsistent monitoring and control”, and “poor communication practices”, respectively.

#### 4.3 Group analysis

The first analysis between groups (Table 8) was done to observe if there were differences between the view of specialists who have experience in the manufacturing sector, and in the service sector. The only construct with differences was “scope creep”, where there was a higher mean and median in the opinion of service-experienced specialists.

Table 8: Mann-Whitney test between industry and service specialists

Construct	Industry (n=99)		Service (n=100)		p-value
	Score mean	Score median	Score mean	Score median	
Lack of top management commitment	3.49	3.60	3.56	3.59	0.59
Resistance to change	3.12	3.18	3.34	3.39	0.19
Inappropriate rewards and recognition	3.20	3.00	3.20	3.50	0.88
Inconsistent monitoring and control	2.89	3.00	2.96	3.00	0.84
Poor communication	2.72	2.72	2.92	2.95	0.15
Incompetent team	2.73	2.71	2.91	2.75	0.25
Inadequate training and learning	2.70	2.96	2.91	3.00	0.16
Sub-optimal team size and composition	2.70	2.71	2.90	2.88	0.07
Faulty selection of methodology	2.65	2.66	2.86	2.82	0.12
Scope creep	2.60	2.35	2.90	3.00	0.04*

\*Significant at 0.05 level

The second comparison considered the roles in the Belt system (Table 9). Analysis of the mean and median showed that the GBs tend to evaluate the factors as more problematic, distancing themselves, mainly from the opinion of MBBs. There is a statistically significant difference in: "resistance to change", "inconsistent monitoring and control", "poor communication", "incompetent team", "sub-optimal team size and composition" and "faulty selection of methodology". MBBs have a view that failure reasons related to "poor communication" and "incompetent team" are much less important, ranking them ninth and eighth, respectively. The factors "inadequate training", "sub-optimal team size", and "faulty selection of methodology" would be closer to the top rankings for MBBs. While for GBs "inadequate training and learning" is the reason with the least impact for LSS project failures, followed by "faulty selection of methodology", showing the differences in MBBs and GB perceptions. BBs present a view very similar to the general view of the study (Table 7), with a greater emphasis on "poor communication" and a small inversion between the positions of "faulty selection of methodology" and "sub-optimal team size and composition".



Table 9: Kruskal-Wallis test between GB, BB and MBB specialists

Constructs	Green Belt (n=46)		Black Belt (n=77)		Master Black Belt (n=78)		p-value
	Mean	Median	Mean	Median	Mean	Median	
Lack of top management commitment	3.54	3.60	3.60	3.63	3.46	3.56	0.70
Resistance to change	3.49	3.61	3.28	3.35	3.05	2.99	0.03*
Inappropriate rewards and recognition	3.35	4.00	3.14	3.00	3.21	3.25	0.57
Inconsistent monitoring and control	3.20	3.13	3.01	3.00	2.70	2.77	0.02*
Poor communication	3.03	3.04	3.08	3.14	2.49	2.43	0.00*
Incompetent team	3.03	3.01	2.98	2.84	2.56	2.46	0.01*
Inadequate training and learning	2.97	3.29	2.91	2.97	2.64	2.82	0.20
Sub-optimal team size and composition	3.04	3.21	2.83	2.71	2.66	2.72	0.06**
Faulty selection of methodology	2.98	3.04	2.84	2.83	2.58	2.63	0.06**
Scope creep	3.02	3.32	2.81	2.68	2.59	2.34	0.11

\* Significant at 0.05 level

\*\*Significant at 0.1 level

The third analysis looked at the difference in the opinions of experts from three different continents, South America, Europe, and Asia (Table 10). North America was not considered due to the low number of respondents. The main differences were that the Asian respondent group had a higher mean and median for the constructs than the other groups. This difference was statistically significant for the “poor communication”, “incompetent team”, “inadequate training and learning”, and "scope creep".

The “incompetent team” construct was higher than “poor communication” for both South America and Europe. For Asian respondents it was the fourth major reason for LSS project failures. "Inadequate training and learning" was the fifth major reason for LSS failures for Asian respondents, showing greater difficulty with team and training when compared to respondents from other continents. The “scope creep” factor, although higher for Asian respondents, was the least reason from all three continents.

A comparison was made between respondents from developing and developed countries (Table 11). The first difference is that the mean and median of respondents in developing countries is higher than in developed countries. The main differences from developed countries for the overview (Table 7) is that "poor communication" would be the ninth factor with the lowest mean, while "scope creep" would be the fifth factor in the ranking.

Respondents from developing countries considered the "incompetent team" factor as the fourth, while it would be the last for developed countries.

Table 10: Kruskal-Wallis test between specialists from distinct continents

Constructs	South America (n=64)		Europe (n=62)		Asia (n=43)		p-level
	Mean	Median	Mean	Median	Mean	Median	
Lack of top management commitment	3.46	3.60	3.53	3.58	3.77	3.81	0.23
Resistance to change	3.28	3.26	3.22	3.36	3.41	3.42	0.67
Inappropriate rewards and recognition	3.19	3.00	3.10	3.00	3.53	3.50	0.22
Inconsistent monitoring and control	3.06	3.01	2.79	2.76	3.18	3.22	0.11
Poor communication	2.98	3.19	2.58	2.63	3.20	3.29	0.00*
Incompetent team	3.00	3.00	2.60	2.57	3.28	3.23	0.00*
Inadequate training and learning	2.97	3.00	2.66	2.68	3.26	3.33	0.01*
Sub-optimal team size and composition	2.92	2.92	2.81	2.74	3.04	3.26	0.19
Faulty selection of methodology	2.86	2.95	2.78	2.76	2.92	3.11	0.64
Scope creep	2.66	2.66	2.67	2.66	3.12	3.00	0.02*

\* Significant at 0.05 level

Table 11: Mann-Whitney test between respondents from developing and developed countries

Construct	Developed (n=80)		Developing (n=106)		p-value
	Score Mean	Score median	Score Mean	Score median	
Lack of top management commitment	3.52	3.58	3.57	3.62	0.60
Resistance to change	3.19	3.29	3.33	3.35	0.39
Inappropriate rewards and recognition	3.02	3.00	3.33	3.50	0.08
Inconsistent monitoring and control	2.79	2.78	3.11	3.04	0.03*
Poor communication	2.58	2.61	3.06	3.23	0.00*
Incompetent team	2.55	2.46	3.12	3.10	0.00*
Inadequate training and learning	2.59	2.68	3.10	3.15	0.00*
Sub-optimal team size and composition	2.71	2.71	2.98	3.18	0.02*
Faulty selection of methodology	2.71	2.72	2.89	3.00	0.15
Scope creep	2.72	2.82	2.84	2.68	0.57

\* Significant at 0.05 level

The separation of respondents by national culture, considering individualism/collectivism, the results were very similar to separation by developed/developing countries. The Mann-Whitney test generated equal results.

## 5. Discussion

This study serves as the first explorative step towards understanding the main reasons and factors behind LSS project failures. Unlike other studies in existing literature, which focus on the critical factors for implementing improvement approaches, i.e. Lean (e.g., [35],

[25]), SS (e.g., [11], [20], and LSS (e.g. [9]; [2]), this study focuses on carrying out improvement projects. A more detailed analysis of the research questions shows the following findings:

44% of the LSS experts surveyed from around the world stated that between 11% and 30% of LSS projects fail. 10% of the experts surveyed said that this rate is higher than 50%, and only a small percentage of those surveyed said that this failure rate was less than 5%. Although several authors stress the importance of LSS project success for the overall approach [1] and point out low success rates [3], unsuccessful projects rates have not been clearly stated in existing literature, therefore, this study aids in clarifying this issue.

Regarding LSS project termination rates at each phase of DMAIC, the highest concentration of responses for all phases showed termination rates less than 5%. *Measure* and *analyze* phases should be given special attention due to the slightly higher project termination rates. Understanding the factors and reasons for project failures can help identify possible actions to improve these rates [12], [14], [29]. For example, the top management, could direct efforts to support *measure* and *analyze* phases.

42% of those sampled stated that most LSS failures occur at the corporate level. This can be explained by the factors that were considered to be the most critical, i.e. top management commitment, followed by resistance to change, and inappropriate rewards and recognition systems. These factors and reasons are largely related to actions at the corporate level, so respondents considered them to be the primary reasons for project failures.

This study also addressed the top five critical factors for LSS project failures. The empirical study identified that these top five factors were: lack of commitment and “support from top management”; “resistance to change”; “inappropriate rewards and

recognition systems”; “inconsistent monitoring and control”; and “poor communication” practices. In addition to enumerating the main factors, it was possible to identify the variables that contributed to the failures, making it easier for managers to avoid such failures. For example, variables that impact the constructs and that can explain failure rates, confirming findings in existing literature, are: lack of commitment in project conceptualization [2], [5], [18]; planning [11], [37]; implementation [23], [26]; employee resistance to change [2], [6]; a lack of policies to recognize and reward success [2], [32]; inconsistent monitoring and control of project [26], [29]; and a lack of communication among project stakeholders [5], [39].

There is an absence of studies that rank the reasons for LSS project failures. However, information such as that provided by Minitab [57] allows for a comparison of results. In the study of approximately 150 customers from nearly 100 different companies, 42 reasons for SS project failures were identified, but the top eight represented 62 percent of the total. Minitab states that the main reason is “no management support”, similar to the results found in this study [57]. Other reasons that appear in both cases are not enough training and a project scope that is too big, both occupying similar rankings [57]. The other reasons pointed out by the study also touch on issues that were identified in this paper: the project had no data or bad data, the project forced into DMAIC, the project was too small for DMAIC’s rigor, and the project solution was not implemented.

The last aspects studied were the results of the analysis between groups. An analysis by industry showed that there was a statistically significant difference ( $p\text{-value} < 0.05$ ) for the “scope creep” factor, which importance was higher for service experts. This is due to differences between projects across different sectors. It may be more difficult to collaborate between project champions and project leaders in the service sector, where there is a greater lack of scope management and documentation describing the

responsibility of each member. This fact corroborates the findings of [26], who stated that introducing LSS in the service industry may be more complex.

The analysis showed that there are statistically significant differences ( $p\text{-value} < 0.1$ ) in six factors when considering the level in the Belt system. In general, GBs affirmed that the factors were more problematic than MBBs. MBBs often have a broader view by taking on a coaching role in LSS projects [40], [41]. MBBs emphasize reasons geared to the practical nature of acquiring and using knowledge, tools, and methodology. The position and level of training in the Belt system alter the perception of the reasons for failures. GBs, with an execution position within the project, say that training and methodology are not important reasons for failures, while BBs have a broader view of project management, and cite deficiencies in this issue. Furthermore, GBs and BBs are immersed in projects [40]–[42], which causes them to perceive factors differently. The differences may be due to the positions held, the breadth of the project vision, and project experience, all characteristics reinforced in [40]–[42].

When analyzing the continent of the respondents, there was a statistically significant difference ( $p\text{-value} < 0.05$ ) in four factors: “poor communication”; “incompetent teams”; “inadequate training”; and “learning and scope creep”. Respondents from Asia said that these factors caused LSS project failures more than respondents from other continents, showing that the scenario differs according to continental characteristics. This shows that difficulties in deploying projects may vary more depending on the location of the company than, for example, the type of industry.

Deeper analyses in relation to differences in development and culture were obtained through tests considering developed and developing countries and the national culture represented by individualism/collectivism. Five factors differed ( $p\text{-value} < 0.05$ ), which allows us to infer that the perception of failures is greater in developing countries, as well

as the difficulty of implementing and conducting projects, showing the need to generate skills and motivation to conduct projects. Developing countries, with a more collective profile, considered "incompetent team", "inadequate training and learning", and "poor communication" as the most important reasons for project failures. It can be inferred that collectivist cultures can make respondents prioritize factors associated with progress, formation and group development. Results that corroborate similar views from other studies [25], [47].

## 6. Conclusions

This study answered a number of research questions via an empirical survey of 201 LSS experts with leadership expertise and participation in LSS projects around the world. The key findings indicate that experts affirm that LSS projects fail, projects are terminated in the various phases of DMAIC, and that there is more concern surrounding *measure* and *analyze* phases. We were able to identify the level at which project failures occurred, especially at the corporate level. Additionally, it was possible to identify the critical factors that lead to project failures. We also found that there is little difference in perception of failure factors among experts from the service sector vs. the manufacturing sector. These differences increase when considering issues such as the role in Belt system, and the culture and development where the respondents work. Therefore, issues such as hierarchy in LSS projects can lead to differing opinions as to the main failure factors. The development level and national culture may also influence failure factors, which can direct management actions to minimize these causes.

### 6.1 Managerial implications

The findings have several implications for managing organizations that are implementing or supporting LSS. Firstly, when LSS project failures are observed they must be monitored, analyzed, and documented. Thirdly, project leaders must be careful, especially

in the *Measure* and *Analyze* phases. Top management must be aware of actions at the corporate level to minimize the chances of projects failing. The fourth implication is that management should create mechanisms to decrease the chances of project failures by understanding the factors and the variables that lead to them. Actions that can be taken are, increasing commitment on behalf of the top management to project planning and execution, creating mechanisms to reduce resistance to employee change, creating reward policies and creating better communication mechanisms among project stakeholders.

## 6.2 Limitations and future research

The study was limited in several ways, as it did not compare other regions around the globe. We were also not able to identify specific differences between the manufacturing and service sectors. This may only be possible with a larger sample size, or with studies dedicated specifically to making these comparisons. Additionally, studies could be carried out to verify the causes of failures when considering project leaders, team members, and senior management. The study used the view of experts in the Belt system, but because it is exploratory and perception based, this study can generate biases towards the judgment of experts. Surveys generally do not allow for in-depth studies of project failures. Therefore, we cannot specifically comment on the occurrence of failures in greater detail from the perspective of stakeholders.

A qualitative investigation of cases would allow an in-depth analysis of projects that failed, making it possible to investigate the failure reasons. The focus could be to identify causes as potential triggers for the root causes of project failures. This qualitative investigation could approach companies with different contextual factors and levels of LSS maturity. This *in loco* investigation of these differences could allow further identification of the failure reasons.

We suggest that future research focus on studying the reasons for project failures from a business point of view by comparing qualitative and quantitative data. Qualitative investigation, together with the results presented in this study, can help create a model that considers the inter-relationship of failure factors, proposing and verifying the cause and effect relationship between them. The model could be formed using constructs and observable variables, and instead of a prioritization, the structural model would aim to confirm the relationships between the causes of failures. It may be possible, through statistical analysis, to identify the specific factors that can reduce project failures, including identifying differences in models for different sectors and company types.

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