Empirical Investigation of Lean Management and Lean Six Sigma Success in Local Government Organizations

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Abstract

Lean Management and Lean Six Sigma (LM/LSS) are improvement methodologies that have been utilized to achieve better performance outcomes at organizational and operational levels. Although there has been evidence of breakthrough improvement across diverse organizational settings, LM/LSS remains an early-stage improvement methodology in public sector organizations, specifically within local government organizations (LGOs). Some LGOs have benefited from LM/LSS and reported significant improvements, such as reducing process time by up to 90% and increasing financial savings by up to 57%. While the success of LM/LSS can lead to satisfactory outcomes, the risk of failure can also result in a tremendous waste of financial and non-financial resources. Evidence from the literature indicates that the failure to achieve the expected outcomes is likely due to the lack of attention paid to critical success factors (CSFs) that are crucial for LM/LSS success. Furthermore, research in this research area regarding characterizing and statistically examining the CSFs associated with LM/LSS in such organizational settings has been limited. Hence, the aim of this research is to provide a comprehensive investigation of the success factors for LM/LSS in LGOs.

The initial stage of this dissertation involved analyzing the scientific literature to identify and characterize the CSFs associated with LM/LSS in LGOs through a systematic literature review (SLR). This effort identified a total of 47 unique factors, which were grouped into 5 categories, including organization, process, workforce knowledge, communications, task design, and team design. The next stage of this investigation focused on identifying a more focused set of CSFs. This involved evaluating the strength of the effect (or importance) of the factors using two integrated approaches: meta-synthesis and expert assessment. This process concluded with a total of 29 factors being selected for the empirical field study. The final stage included designing and implementing an online survey questionnaire to solicit LGOs' experience on the presence of factors during the development and/or implementation of LM/LSS and their impact on social-technical system outcomes.

Once the survey was concluded, an exploratory factor analysis (EFA) was conducted to identify the underlying latent variables, followed by using a partial least square-structural equation model (PLS-SEM) to determine the significance of the factors on outcomes. The EFA identified three endogenous and five exogenous latent variables. The results of the PLS-SEM model identified four significant positive relationships. Based on the results from the structural paths, the antecedent Improvement Readiness (IR) and Change Awareness (CA) were significant and had a positive influence on Transformation Success (TS). For the outcome Deployment Success (DS), Sustainable Improvement Infrastructure (SII) was the only significant exogenous variable and had the highest positive impact among all significant predictor constructs. Furthermore, Measurement-Based Improvement (MBI) was significant and positively influenced Improvement Project Success (IPS).

Findings from this dissertation could serve as a foundation for researchers looking to further advance the maturity of this research area based on the evidence presented in this work. Additionally, this work could be used as guidelines for practitioners in developing implementation

processes by considering the essential factors to maximize the success of LM/LSS implementation. Given the diversity of functional areas and processes within LGO contexts, it is also possible that other public sector organizations could benefit from these findings.

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General Audience Abstract

Lean Management and Lean Six Sigma (LM/LSS) is an improvement methodology that is used by businesses and organizations to improve how they work and achieve better results. LM/LSS has been especially helpful in various organizations; however, the implementation of this improvement methodology has been limited by many challenges for public sector organizations, especially local government organizations (LGOs). The overall aim of this dissertation is to improve the success of LM/LSS implementation within the context of LGOs. More specifically, this dissertation systematically studied the critical success factors associated with LM/LSS success. Different research approaches, including research formulation, development, and testing techniques, were conducted to achieve the aim of this dissertation. Publications related to LM/LSS in LGOs have been rigorously analyzed to identify a comprehensive list of CSFs. To identify the most important factors, a meta-synthesis evaluation and expert survey assessment have been conducted. Following the refinement of the factors, a large-scale field study using a survey questionnaire has been designed and distributed to LGOs. Once the survey concluded, statistical methods that included Exploratory Factor Analysis (EFA) and Partial Least Squares-Structural Equation Modeling (PLS-SEM) were conducted. The former was used to identify the underlying latent variables, while the latter was conducted to examine the influence of the factors on social and technical outcomes. This dissertation could be used as a reference guideline helping practitioners to increase the success of LM/LSS implementation in LGOs. This dissertation can also guide scholars to potential research avenues that could advance this research area.

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Chapter 1: Research Overview

1.1 Introduction

Lean Production (LP) was derived from the Toyota Production System - coined as Lean Production by Krafcik (1988) - with the aim of eliminating waste and non-value added from targeted systems or processes (Robinson et al., 2012). LP follows five principles as characterized by Womack & Jones (2003): specifying customer value, identifying value stream for products and customers, creating continuous flow among activities, producing in response to customer demand (pull production), and continuous improvement. The five principles of LP were derived from an extensive five-year benchmarking study at the Massachusetts Institute of Technology (MIT), centered around automobile production. As an improvement methodology, LP is comprised of a set of practices, tools, and techniques, such as value stream mapping (VSM), 5S, 5 Whys, visual management, one-piece flow, and many others (Salah et al., 2010). Six Sigma - developed by Motorola Corporation - is a systematic methodology and data-driven approach using a structured framework known as DMAIC (define, measure, analyze, improve, and control) to reduce variability within processes (Kwak & Anbari, 2006). SS also has a unique set of tools/techniques, such as root cause analysis, statistical process control, and quality function deployment (Antony et al., 2003; Kwak & Anbari, 2006). Although each improvement methodology (i.e., LP and SS) includes a unique set of principles, tools, and techniques (Antony et al., 2003), their integration (known as Lean Six Sigma, or LSS) offers a systematic and coherent approach that has the potential impact to maximize the desired goals and minimize drawbacks associated with either (Arnheiter & Maleyeff, 2005; Pepper & Spedding, 2010). Using only Six Sigma may not remove all inefficiencies and non-value added in a process, just as relying exclusively on the LM doesn't fully regulate the process or eliminate variations statistically. Thus, some have argued that it is

beneficial to combine these methodologies to boost the target system/process efficiency and effectiveness significantly (Albliwi, 2017).

The widespread dissemination of LP/LSS across various organizational contexts suggests that this methodology is being utilized in systems fundamentally distinct from manufacturing (Soliman & Saurin, 2017). This could indicate the potential of LP/LSS to be effective in diverse settings, possibly yielding significant positive outcomes (Antony et al., 2016). Scholars have reported various outcomes of LP/LSS implementation across a wide range of sectors. Reducing lead time, saving cost, minimizing waiting time, improving resource efficiency, increasing employee morale and motivation, and better understanding customer satisfaction are a few examples of the impacts of LP/LSS discussed in education, financial services, airport operations, and healthcare (Balzer et al., 2016; Poksinska, 2010; Syltevik et al., 2018; Vashishth et al., 2019). Given the popularity of LP, it has been viewed and received in different terms across a variety of contexts and sectors, including Lean Management, Lean Thinking, Lean System, or more simply, Lean (Ahlstrom, 2004). This research employs the terms Lean Production (LP) and Lean Management (LM), in addition to the combined methodology referred to as Lean Six Sigma (LSS). Specifically, the earlier publications (e.g., conference papers) primarily utilized the terms LP and LP/LSS. However, in the manuscript (Manuscript #1) submitted to the International Journal of Lean Six Sigma, reviewers strongly suggested modifying the overarching term to "Lean Management," which was adopted. Thus, we use LP and LM interchangeably.

Resource constraints and high volume of demands place pressure on public sector organizations - e.g., the federal government, local government organizations, healthcare, and educational institutions - to utilize improvement philosophies, tools, and techniques from private sector organizations to ensure better performance (Abdullah & Kalianan, 2008; Antony et al.,

2017; Ibrahim et al., 2013; Radnor & Walley, 2008; Sreedharan et al., 2018). Local government organizations (LGOs), in particular, are locally-authorized organizations that administer and serve particular geographical regions (Sikander, 2015). LGOs differ from other organizations in that LGOs exist at a local level with a defined territory, develop laws and regulations with a degree of autonomy, perform specific powers for functioning and serving the public, generate income and incur expenses, and are administered by elected officials (Makinde et al., 2016). With the difficulties and challenges experienced by LGOs, LM/LSS has been advocated as a potential improvement methodology to achieve desired goals (Radnor & Walley, 2008), and has been a predominant improvement methodology in public sector organizations since 2000 (Andersson et al., 2020; Yuksel & Yuksel, 2010).

1.2 Research Problem

The application of quality management and other improvement concepts across various organizational settings has demonstrated significant potential in addressing a range of complex performance issues, including quality (Wartati et al., 2021). The LM/LSS methodology within LGOs has attracted increasing scholarly interest, though the pace of this attention remains slow. However, there is a lack of a holistic view to evaluate how this improvement methodology has contributed to LGOs. Furthermore, this area also experiences few to no studies with a particular focus on comprehensively studying and analyzing the critical success factors associated with LM/LSS in this organizational setting. More specifically, this research area has a lack of a holistic view of factors, features non-standard terminology, and shows a lack of factor operationalization. Furthermore, work to statistically examine these factors is another major gap. The lack of maturity in this research area calls for further investigation to assess the contributions of LM/LSS and identify a full breadth of CSFs followed by an empirical investigation to examine factors and their impacts on outcomes.

1.3 Research Objective

The overall objective of this dissertation is to study the evolution, contributions, and successful implementation of LM/LSS holistically and comprehensively in LGOs. This exploration aims to provide a holistic and in-depth analysis of LM/LSS methodology, emphasizing its transformative potential and efficacy in public sector contexts. More specifically, this dissertation aims to assess the current scholarly publications to evaluate the contribution of LM/LSS in LGOs. This assessment also provides practitioners and researchers with a clear understanding of the research gaps and areas of contribution. An objective of this dissertation is also to conduct a thorough investigation into the CSFs associated with the development and/or implementation of LM/LSS in LGOs, addressing a notable scientific research gap. These CSFs were identified through a rigorous review of the literature and subsequently evaluated for their importance by a set of experts in the field, ensuring their relevance and applicability. Following this validation, a cross-sectional field study was undertaken, employing statistical methods to test the impact of these identified factors on the outcomes of LGO systems. This empirical investigation is grounded in a robust theoretical framework that hypothesizes the relationships between these critical factors and system performance outcomes, aiming to offer empirical evidence and theoretical insights into the mechanics of LM/LSS success in LGOs. Through this multifaceted approach, this dissertation seeks to contribute significantly to the body of knowledge on LM/LSS in LGOs, offering actionable strategies for enhancing public service delivery and operational efficiency.

1.4 Research Contributions

This research contributes to the research area of LM/LSS in LGOs in several ways. First, due to the insufficient empirical examination of the impact of LM/LSS impact on LGOs, this research area has been explored through various lenses, including prominent scholars, benefits of implementing LM/LSS, and identified research gaps, among others. This comprehensive analysis

aims to provide a detailed overview of the current state of research and identify critical areas for further investigation. This approach is crucial for two primary reasons: (1) it aims to broaden the understanding of LM/LSS applications beyond traditional manufacturing sectors, with a particular emphasis on LGOs; and (2) it serves as a guide for researchers seeking to contribute meaningfully to this research area. Second, the reported CSFs in the literature are not well-studied (Alrezq, 2020a; Alrezq & Van Aken, 2022; Hoyle, 2019; Madsen et al., 2017; Rodgers et al., 2019). That is, studies vary in terms of how they report and discuss the factors, usually without a comprehensive list and operational definitions. Third, this research area has identified a large list of factors; thus, synthesizing the factors into the most important ones will likely increase the understanding among scholars and practitioners about which CSFs have the greatest impact on LM/LSS success. Fourth, a lack of advanced statistical analysis is another gap. Therefore, a theoretical framework that is grounded on existing evidence from the literature is developed and then empirically examined to investigate the interrelationships and impacts of factors on system outcomes. To the best of the researcher's knowledge, this proposed study is one of the earliest works that identifies and develops a comprehensive list of CSFs, followed by an empirical examination for LM/LSS success in LGOs. The findings from this dissertation can be used to further advance this research area by other researchers taking into account the gaps identified from the systematic literature review. Further, these findings can contribute to practice by practitioners in LGOs utilizing these findings on CSFs as they develop implementation strategies for LM/LSS. Lastly, this research could also support researchers and practitioners in other similar organizational settings, such as service organizations, to develop more successful implementation processes.

1.5 Definition of Key Terms

- Lean Production (LP)**:** an improvement methodology that utilizes a set of principles (or, philosophy) and tools/techniques to achieve improvement through increasing value and

minimizing waste. A number of other terms are also used in the practitioner and research literature, such as Lean Management, Lean Thinking, Lean Manufacturing, or more simply, Lean.

- Six Sigma (SS)**:** a data-driven improvement methodology that utilizes principles and tools/techniques to minimize variation and defects within processes.
- Lean Six Sigma (LSS**):** an integrated improvement methodology drawing upon key principles and tools/techniques from both LP and SS in order to maximize the benefits and outcomes realized.
- In this dissertation, the term Lean Production (LP) and Lean Management (LM) along with the integrated approach (i.e., Lean Six Sigma "LSS") are the improvement methodology of interest and are used interchangeably throughout the dissertation. In some of the earlier work published (i.e., conference papers), the term LP and LP/LSS were used. However, in the manuscript submitted to the International Journal of Lean Six Sigma, reviewers strongly suggested modifying the overarching term to "Lean Management," which was adopted. Thus, we use LP and LM interchangeably.
- Critical Success Factors (CSFs): factors that may influence LP/LSS success and performance outcomes, whether as positive influencers, such as enablers or facilitators, or as negative influencers, such as barriers, obstacles, or impediments. In this investigation, the aim was to define the most important success factors, thus termed Critical Success Factors.

1.6 Research Roadmap

This research developed a structured framework as a roadmap to achieve its expected goals. The roadmap developed for this research was divided into three phases: Research Framing, Variable

Reduction, and Model Development and Testing. The overall roadmap and steps conducted within each phase are shown in Figure 1.1.

Phase 1: Research Framing

The first phase was initiated to understand the area of interest (i.e., LM/LSS in LGOs) through two steps. First, a preliminary investigation (i.e., a scoping study) was conducted to investigate the literature on LM/LSS in LGOs to understand the evolution of this research area (Alrezq, 2020a, 2020b). Second, the literature was characterized to assess the status of this research area in a comprehensive manner, identify research opportunities (Alrezq & Van Aken, 2022, Manuscript #1), and identify the CSFs (Alrezq et al., 2023, Manuscript #2).

Phase 2: Variable Reduction

The variable (or CSF) reduction in this phase was achieved through two approaches. Based on the preliminary findings reported by Alrezq (2020a), a comprehensive list of factors for LM/LSS in LGOs was identified using a systematic literature review (Alrezq et al., 2023, Manuscript #2). The identification and extraction of factors followed the same type of process used in other research areas studying CSFs, such as Gonzalez Aleu (2016) and Keathley-Herring (2016)**.** To narrow down the number of factors to the most important ones and justify inclusion in the larger empirical field study (i.e., Phase 3), two parallel paths were used: a meta-synthesis evaluation (Harry & Alrezq, 2022, Manuscript #4) and an expert survey (Alrezq & Van Aken, 2023, Manuscript #5).

Phase 3: Model Development and Testing

The last phase was performed to test hypotheses about the inter-relationship of factors on outcomes (both technical and social system outcomes). To achieve this goal, a theoretical framework based on continuous improvement literature and other models within this research area was developed (Alrezq, 2022, Manuscript #3). A cross-sectional field study was conducted to statistically evaluate the CSFs on outcomes (Manuscript #6). Figure 1.1 shows the overall roadmap for this research.

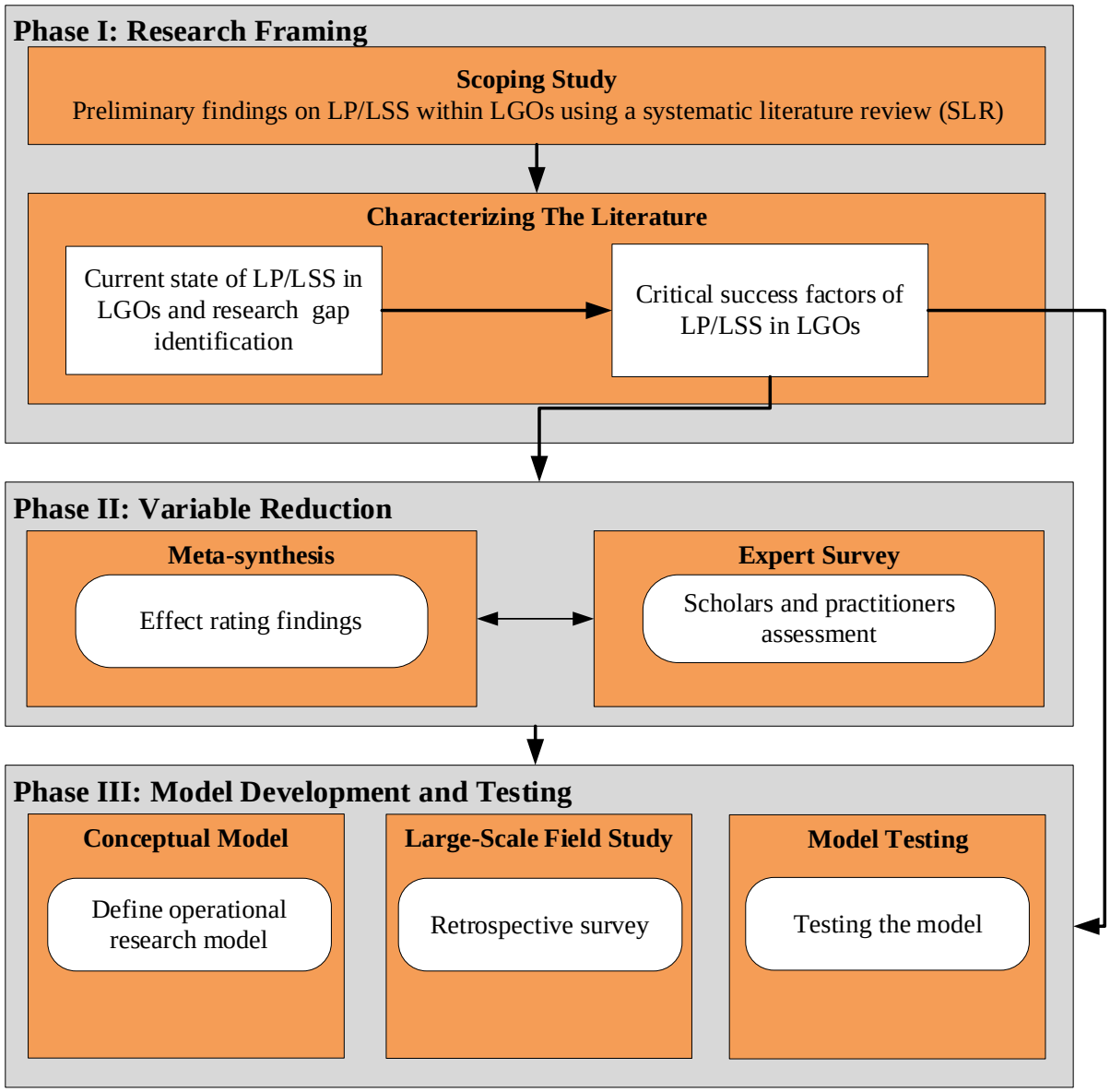

Figure 1.1. Research roadmap.

1.7 Overview of the structure of the dissertation

This dissertation follows a "manuscript-style" structure, where each chapter corresponds to a paper that describes the different facets and activities in this research. These chapters comprise both conference proceedings and journal articles, some of which are under review or in preparation for submission. This research began by conducting an initial analysis in the context of LM/LSS in LGOs. This preliminary investigation was performed to understand the evolution of this research area (i.e., LM/LSS in LGOS). Following the preliminary analysis, a full-depth and rigorous

analysis was conducted to holistically evaluate the current status of this research area (Manuscript #1). Based on the findings from the previous manuscript, a further investigation with a focus on the CSFs was executed (Manuscript #2). An operational model was then developed to hypothesize the relationships between the CSFs and outcomes (social and technical outcomes) (Manuscript #3). Due to the large number of CSFs identified from the literature, meta-synthesis and an expert survey were used to synthesize the set of CSFs and identify a more focused subset for empirical study (Manuscript #4 and Manuscript #5, respectively). An empirical field study utilizing an online survey questionnaire was then conducted targeting LGOs with experience in LM/LSS, including those in the U.S. and outside the U.S. (Manuscript #6). The last chapter concludes the dissertation and identifies overall research insights derived from different research phases and activities. More detailed information about each manuscript is described below, with supplementary details available in the Appendix.

1.7.1 Manuscript #1: Systematic Literature Review of Lean Management in Local Government Organizations

The goal of this publication is to investigate and document the current status of LM/LSS development and implementation within the context of LGOs. Adopting a systematic literature review (SLR), this study identified 53 relevant publications and rigorously analyzed the final set to discover different aspects that include:

- Documenting the major outcomes/benefits of using LM/LSS in LGOs. This analysis reported 15 outcomes focused on process/operations, eight outcomes focused on employees, six outcomes focused on organization, and three outcomes focused on customer.

- Investigating the research methods (both data collection and data analysis methods) utilized by scholars contributing to this research area. This investigation provides further understanding of how this area is maturing in terms of the research methods used.
- Identifying prominent authors and research collaborations within the research community. The outcomes of this analysis found that there are relatively few prominent contributors to this research area and a lack of scholarly collaborations across those who conduct and publish research in this area.
- Analyzing the evolution of LM/LSS publications in the research literature in order to understand how frequently scholars are contributing to this area and to what extent this area is attracting new scholars over time.
- Identifying opportunities for future research representing gaps in the current research literature on LM/LSS in LGOs. This analysis identified eleven distinct themes for future research opportunities. Addressing these themes (i.e., gaps) can support the advancement of LM/LSS in LGOs, both through advancing the maturity of research in this area and thus, improving LM/LSS practice through more rigorous research.

This manuscript was submitted to the *International Journal of Lean Six Sigma (IJLSS)*. The primary contributors to this manuscript include Mohammed Alrezq (who conducted the SLR and performed the analysis along with writing the manuscript) and Dr. Eileen Van Aken (who supervised the development and refinement of the research as doctoral advisor). Both authors are affiliated with Virginia Tech. This manuscript was originally submitted to IJLSS in 2022, and the authors were notified it had been accepted in 2023. However, after hearing no feedback on when the paper would appear and contacting the editor multiple times, we were informed that it was

being sent to additional reviewers. Thus, at the current time, the manuscript is under the third round of review.

1.7.2 Manuscript #2: Lean Production and Lean Six Sigma Success in Local Government Organizations

This manuscript presents the comprehensive findings of a second systematic literature review (SLR) conducted in this dissertation, which has as a primary objective to identify and analyze the CSFs essential to the success of LM/LSS. This publication was motivated by the need to investigate the CSFs based on the evidence of the scientific gaps identified by Alrezq & Van Aken (2022, Manuscript #1). This SLR was designed and executed encompassing three major search concepts. The three search concepts related to LM/LSS, LGOs, and CSFs. This SLR differed from the first one (in Manuscript #1) in that it utilized a third search concept explicitly focused on CSFs, whereas the first SLR used only two (related to LM/LSS and LGOs). For each of these concepts, a diverse set of search terms was used to ensure a broad capture of relevant literature. From the vast array of initial findings, which totaled 8,454 results, a stringent screening process was applied. This involved a careful assessment of 2,464 titles and abstracts to determine their relevance and alignment with the study's objectives. From this rigorous assessment, 44 publications were deemed most relevant and were subjected to further analysis. The Thematic Analysis framework, renowned for its depth and qualitative orientation, was the chosen method for this phase. Through a structured six-step process, the data was methodically examined, coded, and categorized. This deep dive into the literature led to the identification of 47 distinct CSFs, each highlighting a particular aspect integral to the success of LM/LSS in LGOs. Recognizing the importance of clarity and consistency, operational definitions were subsequently formulated for each of these unique factors. This can serve to ensure that future researchers and practitioners have a clear understanding of the

terms and can apply them consistently. To further enhance the depth of the analysis, a co-occurrence network of the CSFs was conducted. This analysis was instrumental in understanding the possible interrelationships and dependencies among the identified CSFs. Such insights are invaluable as they provide insights on how certain factors are interrelated. The final set of the CSFs was systematically grouped into six categories, namely: Organization, Communication, Workforce, Task Design, Team Design, and Process. Each category provides a lens through which the complexities and nuances of LM/LSS success factors can be viewed, offering both scholars and practitioners a structured framework to approach and understand the domain. The primary contributors to this manuscript included Mohammed Alrezq, Virginia Tech (who conducted the SLR, performed the analysis along with writing the manuscript), Dr. Eileen Van Aken, Virginia Tech (who supervised the development and refinement of the research as doctoral advisor), and Dr. Heather Keathley, University of Central Florida (who advised the research as a doctoral committee member and who provided contributions to writing the manuscript).

1.7.3 Manuscript #3: Critical Success Factors for Lean Production: A Conceptual Framework-based Literature Review

Based on the identified factors from Alrezq et al. (2023, Manuscript #2), a theoretical framework that hypothesizes the relationships among factors and outcomes was developed. The development of the conceptual model was grounded in the continuous improvement and organizational research literature. The model included five categories, each including a relevant number of factors. The outcome variables were adopted from existing studies that focused on performance measurement and continuous improvement. This paper was presented and published as a conference proceeding at the 2022 American Society for Engineering Management Annual Conference. The author of this paper was Mohammed Alrezq, Virginia Tech (who conducted the literature review, developed

the conceptual model, and served as lead writer of the paper). In addition, Dr. Eileen Van Aken, Virginia Tech supervised the development and refinement of the research as doctoral advisor to the primary author.

1.7.4 Manuscript #4: Assessment of Critical Success Factors Using a Meta-synthesis Evaluation

This publication describes the implementation of the meta-synthesis approach, a method specifically employed to refine and distill the final set of the CSFs as previously identified by Alrezq et al. (2023, Manuscript #2). Meta-synthesis serves as a systematic review technique and uniquely combines both quantitative and qualitative research studies, ensuring a comprehensive and meticulous analysis of study variables. To assess the 47 CSFs using the meta-synthesis approach, the evaluation process was conducted based on three criteria that encompassed the frequency of factors, degree of importance (i.e., operationalized as a large effect), and the quality of publications. Upon integrating these three criteria, the overall effect rating for each CSF was determined. This rigorous methodology categorized the CSFs based on their effects: 14 factors emerged as having a large effect, 21 factors were discerned to have a medium effect, and 12 factors were identified as having a small effect. This paper was presented and published as a conference proceeding at the 2022 Institute of Industrial and Systems Engineers Annual Conference and Expo. The authors of this paper were Kimberly Harry and Mohammed Alrezq (both from Virginia Tech), who contributed equally to this work. Their collaborative efforts encompassed conducting the literature review, developing the meta-synthesis framework, and conducting the research analyses. In addition, Dr. Eileen Van Aken, Virginia Tech supervised the development and refinement of the research as doctoral advisor to both primary authors.

1.7.5 Manuscript #5: Synthesizing Success Factors for Lean and Lean Six Sigma: An Integrated Approach of Meta-synthesis and Expert Assessment

This publication focused on identifying the important CSFs that are crucial for the effective development and/or deployment of LM/LSS within LGOs. Specifically, this publication leveraged a comprehensive list of 47 CSFs previously analyzed by Alrezq et al. (2023, Manuscript #2). To synthesize these factors, this study employed two approaches in parallel that included a meta-synthesis and an expert assessment. The meta-synthesis approach was adapted from a framework originally developed by (Harry & Alrezq, 2022, Manuscript #4). For the expert assessment, an online survey questionnaire was designed and distributed to scholars and practitioners identified from the literature review in Manuscript #2. Once the survey concluded, the results were used to calculate the overall mean scores for each factor. Then, the results were distributed uniformly to define the strength of effect ratings for each factor as a small effect, medium effect, and large effect. To determine the overall integrated effect rating based on the meta-synthesis and the expert survey, a heat chart was developed to segment key regions as an overall integrated large effect, overall integrated medium effect, and overall integrated small effect. The outcomes of integrating the two approaches (i.e., the meta-synthesis and the expert survey) yielded a total of 29 factors as having a large effect. The primary contributors to this manuscript included Mohammed Alrezq, Virginia Tech (who developed and executed the survey and performed the data analysis along with writing the manuscript) and Dr. Eileen Van Aken, Virginia Tech (who supervised the development and refinement of the research as doctoral advisor).

1.7.6 Manuscript #6: Analysis of Lean Management and Lean Six Sigma in Local Government Organizations Using Partial Least Squares-Structural Equation Model

This manuscript describes the activities within this dissertation to rigorously examine the statistical significance of the CSFs on LGOs' outcomes (both social and technical system outcomes). Thus, the list of factors identified by Alrezq & Van Aken (2023, Manuscript #5) was tested empirically using a cross-sectional field study. More specifically, a survey questionnaire was developed that encompasses four main sections. The survey's structure was intentionally designed to include: items measuring the outcomes of implementing Lean (LM/LSS), items measuring the presence and effect of the CSFs during the planning and/or implementation phases of LM/LSS, items designed to gather detailed background information about the participants, and, finally, a section that asked participants for referrals to further enrich the study's data pool. Despite initial receiving 152 responses (which was less than 1 percent of the target population), a strict screening process was employed, yielding 67 responses that were valid and suitable for in-depth analysis. To analyze these responses, exploratory factor analysis and the partial least squares-structural equation modeling technique were employed. These statistical models allowed for the identification of underlying latent variables and enabling the study to test the hypothesized impact of the critical success factors with greater precision. The quantitative investigation discovered that four of these factors exhibited a significant and positive effect on the outcomes of LGOs, highlighting their pivotal role in the successful application of LM/LSS within such organizational contexts. The primary contributors to this manuscript were Mohammed Alrezq, Virginia Tech (who developed the survey instrument, executed the survey, and performed the analysis along with writing the manuscript), Dr. Eileen Van Aken, Virginia Tech (who supervised the overall development and

refinement of the research as doctoral advisor), and Heather Keathley-Herring (who reviewed the statistical analyses and provided recommendations for enhancements).

Table 1. Summary of the status of each manuscript.

Chapter & Manuscript #	Title	Authors	Journal/Conference	Status
Chapter 2, Manuscript #1	Systematic Literature Review of Lean Production in Local Government Organizations	Alrezq and Van Aken	International Journal of Lean Six Sigma	Under the third round of review
Chapter 3, Manuscript #2	Lean Production and Lean Six Sigma Success in Local Government Organizations	Alrezq,Van Aken, & Keathley-Herring	Engineering Management Journal	Planned for submission by June 2024
Chapter 4, Manuscript #3	Critical Success Factors for Lean Production: A Conceptual Framework-based Literature Review	Alrezq	Proceedings of the American Society for Engineering Management 2022 International Annual Conference	Published
Chapter 5, Manuscript #4	Assessment of Critical Success Factors Using a Meta-synthesis Evaluation	Harry and Alrezq	Proceedings of the Institute of Industrial and Systems Engineers Annual Conference & Expo 2022	Published
Chapter 6, Manuscript #5	Synthesizing Success Factors for Lean and Lean Six Sigma: An Integrated Approach of Meta-synthesis and Expert Assessment	Alrezq and Van Aken	International Journal of Industrial Engineering and Operations Management	Planned for submission by late April 2024
Chapter 7, Manuscript #6	Analysis of Lean Management and Lean Six Sigma in Local Government Organizations Using Partial Least Squares-Structural Equation Model	Alrezq, Van Aken, & Keathley-Herring	International Journal of Operations and Production Management	Planned for submission by July 2024

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Chapter 2: Manuscript # 1 – Systematic Literature Review of Lean Management in Local Government Organizations

2.1 Manuscript copyright transfer agreement

This manuscript was submitted to the International Journal of Lean Six Sigma in February 2022 and received minor revisions in March 2022. The manuscript was revised and re-submitted later in March 2022. In September 2023, the manuscript received a second round of minor revisions, and it was revised and re-submitted in October 2023. In February 2024, the manuscript received a third round of minor revisions and has been re-submitted in March 2024. This chapter (Manuscript #1) will not be submitted to any other journal while it is under review with the International Journal of Lean Six Sigma. Citing any information from this manuscript should verify the status of this publication to obtain the correct citation information by contacting the corresponding author: Mohammed Alrezq, alrezq@vt.edu.

2.2 Structured Abstract

Purpose – The purpose of this study is to analyze the literature on Lean Management and Lean Six Sigma (LM/LSS) in local government organizations (LGOs).

Design/methodology/approach – A systematic literature review (SLR) was conducted to extract the most relevant academic publications on LM/LSS in LGOs. ProQuest, Web of Science, and Engineering Village were utilized to obtain the publication set. Studies were then analyzed based on author characteristics, research design characteristics, and content characteristics.

Findings – The SLR yielded 53 academic publications. The primary finding is that this research area has recently received an increase in attention within these types of organizations. While this research area attracts new scholars every year, there remains insufficient collaboration across different research groups. Research methods, outcomes, and future research areas were also investigated to comprehensively evaluate the literature and specify new research opportunities.

Research limitations/implications – Although the SLR is a rigorous research methodology used to gather relevant publications, it is limited to the chosen information sources (i.e. platforms) to obtain the publications. Therefore, the researchers used multiple sources to maximize the likelihood of capturing publications related to this topic.

Originality/value – This study adds value to the research community through its detailed characterization and analysis of the existing research literature on LM/LSS within LGOs, an area that remains largely unexplored in the academic literature. By providing a rigorous understanding of the current status of this research area, this work responds to a notable gap. The review of the existing literature suggests that this effort represents the first comprehensive examination of the research literature on the evolution of LM/LSS, specifically focusing on LGOs as the primary application unit of interest.

Practical implications – The insights presented here provide a foundational reference for researchers interested in investigating and exploring future research opportunities associated with LM/LSS in LGOs.

Keywords: Lean management, Lean six sigma, Local government, Public organizations, Systematic literature review

Paper type: Literature review.

2.3 Introduction

In recent years, the requirements to have more efficient and effective resource management have become a major call within public sector organizations (Cannaerts *et al.*, 2020; Holzer and Ballard, 2021, p. 304). Public sector organizations encounter challenges in which restructuring and reforming have become necessary to maintain expected outcomes (Antony *et al.*, 2018; Pedersen and Huniche, 2011). As Snyder and Peters (2004, p. 2) argue: "With the public's demand for greater service at lower costs, no organization has the luxury of being wasteful." While the term "public sector organizations" encompasses different organizational types, such as federal/central governments, local governments, education, and healthcare organizations (Mitchell, 2011; Sreedharan *et al.*, 2018), local government organizations (LGOs), in particular, are locally authorized organizations that administer and serve particular geographical regions (Sikander, 2015). Because of the complexity in governmental systems among countries and the variations in size and structure of LGOs, scholars have defined LGOs from different perspectives (Amakihe *et al.*, 2017; Bowman and Kearney, 2011, pp. 24–27). However, the Office for Public Administration in the United Nations defines local governments as "a political sub-division of a nation (in a Federal or State system), which is constituted by law and has substantial control of local affairs including the power to impose taxes as well as exact labour for prescribed purposes" (as cited in Makinde *et al.*, 2016, p. 307). LGOs differ from other organizations in that LGOs exist at a local level with a defined territory, develop laws and regulations with a degree of autonomy, perform specific powers for functioning and serving the public, generate income and incur expenses, and are administered by elected officials (Makinde *et al.*, 2016).

Due to the shared difficulties - such as financial expenditures, operational performance, and efficiency - in LGOs and other public sectors, significant pressure has been placed on these organizations (Abdullah and Kalianan, 2008; Antony *et al.*, 2017; Sreedharan *et al.*, 2018); thus, in response, they have sought ways to save costs, increase quality of services, and reduce waste (Radnor and Walley, 2008). To overcome these inefficiencies, scholars have proposed and discussed alternative approaches by adopting principles, tools, and techniques from private sector organizations (Radnor and Walley, 2008; Rodgers and Antony, 2019). Lean Management (LM) has been advocated as a potential improvement methodology to achieve desired goals (Radnor and Walley, 2008) and has been a predominant improvement methodology in public sector organizations since 2000 (Andersson *et al.*, 2020; Yuksel and Yuksel, 2010).

Lean Management (LM) and Six Sigma (SS) are improvement methodologies that share common goals for continuous improvement (Salah and Rahim, 2019). LM (other terms of Lean Management include, for example, Lean Production, Lean Thinking, or Lean) is widely recognized as deriving from the Toyota Production System with the aim of minimizing activities that add no value to the end user (Arnheiter and Maleyeff, 2005). SS, on the other hand, was developed by Motorola with the goal of statistically minimizing variation or defects within processes (Arnheiter and Maleyeff, 2005). SS was further modified by General Electric, which defined a structured framework known as DMAIC that stands for define, measure, analyze, improve, and control (Salah

and Rahim, 2019). Although each improvement methodology (i.e. LM and SS) includes a unique set of principles, tools, and techniques (Antony *et al.*, 2003), their integration offers a systematic and coherent approach that has the potential impact to maximize the desired goals and minimize drawbacks associated with either methodology – this integration is known as Lean Six Sigma (LSS) (Arnheiter and Maleyeff, 2005; Salah and Rahim, 2019). The main interest of this study is LM, but because the organizations reflected in the current research literature that was reviewed for this paper utilized LM and the integrated approach (i.e. LSS), both improvement methodologies were considered (referred to as "LM/LSS" to represent the overall improvement methodology).

Although LM/LSS originated in manufacturing-based environments, the literature has reported their evolution beyond this context (Bateman *et al.*, 2014; Radnor, 2010). For example, LM/LSS have been extended to healthcare, finance, airports, and educational institutions (Jasti and Kodali, 2015; Singh and Rathi, 2019). The benefits of utilizing this methodology range from objectively-measured outcomes, such as reducing lead time, saving cost, and minimizing waiting time, to subjectively-measured outcomes, such as increasing employee morale and motivation, and better understanding customer satisfaction.

With the potential positive impact of LM/LSS in manufacturing and beyond, LGOs also experienced satisfactory outcomes in a variety of aspects. Reducing processing time, eliminating waste, financial savings, and employee and customer satisfaction are a few examples of LM/LSS benefits in LOGs (Furterer and Elshennawy, 2005; Madsen *et al.*, 2017). This improvement methodology has also been applied in different units of analysis, such as policing force (Antony *et al.*, 2019), financial departments (Furterer and Elshennawy, 2005), housing departments (Kumar and Bauer, 2010), and waste recycling (Tortorella *et al.*, 2018). The literature presents a growing shift in scholars' attention to engage and contribute to LM/LSS in LGOs, especially in the last few years (Alrezq, 2020a). While the increase in publications is a positive signal to further advance the area, there is a paucity of systematic analysis on literature with LGOs as the primary organization of interest. This lack of analysis may distort understanding the knowledge generated by scholars and their contributions (Xian and Madhavan, 2014).

To achieve the aims of this work, the systematic literature review (SLR) method was used as a research methodology, based on Tranfield *et al.* (2003) to analyze the existing scholarly documentation of LM/LSS on LGOs. An SLR is a rigorous and systematic search approach following a structured search protocol to capture relevant publications that address research questions (Tranfield *et al.*, 2003). After relevant publications were identified (as described in the following section), three dimensions were utilized to analyze the literature: publication and author characteristics, research design characteristics, and content characteristics. These three dimensions were selected based on a framework proposed by Keathley-Herring *et al.* (2016) to assess the maturity of a research area or a field. The analysis of publication and author characteristics included publication trends over time, new authors per year, prominent authors, and author collaboration. The research design characteristics dimension consisted of investigating research methods used (i.e., data collection and data analysis methods) used in the literature. The examination of content characteristics identified the most commonly-reported outcomes in the LM/LSS applications documented in the literature and specified directions for future work. The research questions of this study are as follows:

RQ1. Publication and author characteristics: To what extent has the literature evolved over time in this research area? How many new authors are contributing to this subject? Who are the experts contributing to LM/LSS in LGOs? To what extent are authors collaborating in this area?

RQ2. Research design characteristics: What research methods are used for data collection and data analysis?

RQ3. Content characteristics: What are the most commonly-reported outcomes of LM/LSS in LGOs? What are the key future directions in this area?

The rest of the paper is organized into three sections: research methodology (including the SLR process), results and discussion (describing the three dimensions), and conclusions.

2.4 Research Methodology

Reviewing literature is driven by many purposes, for example, assessing the breadth of a research area or a field, understanding the theoretical background, and utilizing existing scholarly documents to answer particular research questions (Okoli and Schabram, 2010). An SLR is a structured, systematic, and repeatable research methodology for finding, reviewing, and synthesizing existing evidence that has been documented by researchers, scholars, and practitioners (Okoli and Schabram, 2010). The SLR method was further described by Tranfield *et al.* (2003, p.209) as a "fundamental scientific activity." There has been an increase in the use of SLRs in the literature on improvement methodologies, highlighting the value an SLR brings. Some researchers have found it helpful in finding gaps, issues, and opportunities; adding value to understanding emerging research fields (or areas); or enabling the identification of the conceptual content of a field and advancing theory development (Ali and Phan, 2022; Gaikwad and Sunnapwar, 2020; Hietschold *et al.*, 2014). In more recent evolving fields, such as Industry 4.0, Ali and Phan (2022) argue that an SLR helps to address the lack of knowledge regarding existing research and areas needing further investigation, which can lead scholars to ignore important and emerging research topics or to unintentionally replicate existing studies. In this study, the SLR was adapted from Tranfield *et al.* (2003) and used to analyze the literature through five main steps (see Figure 1). The main steps from "a" through "d" are described in detail in the following sections, while "e" is described in the analysis of the research questions in the Results section. This study builds upon previous work conducted by Alrezq (2020a, 2020b) through searches in two additional platforms (or databases) to capture more relevant publications.

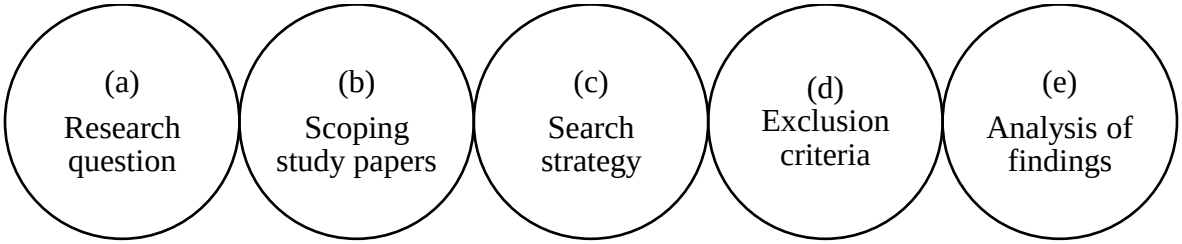


Figure 2 (Figure 1, Manuscript #1) Overview of the SLR steps

a) Problem Definition and Research Questions

Due to the growing attention on this improvement methodology and the lack of a systematic evaluation of the literature on these types of organizations, the SLR was used to rigorously analyze the role of LM/LSS applications in LGOs. Answering the previously-defined research questions and characterizing the literature in a systematic manner provide greater insight into the growth and contributions of LM/LSS and support the need for documenting scholarly output.

b) Scoping Study Papers

The SLR started with a free search through different platforms and journals (e.g. Google Scholar, ResearchGate, and ProQuest) to identify suitable scoping study papers. The identified scoping study papers had to have used LM or LSS as the primary improvement methodology within an LGO. Six scoping study papers were identified: Bakar *et al.* (2017), Fletcher (2018), Furterer and Elshennawy (2005), Kregel and Coners (2018), Madsen *et al.* (2017), and Suarez Barraza *et al.* (2009). These scoping study papers were used to obtain initial insights about the research area and understand the overall emergence and development of LM/LSS in LGOs. These papers were also used to develop the search concepts and search terms.

c) Search Strategy

Once the scoping study papers were selected, a set of search concepts and terms was developed. The scoping study papers were utilized to identify the initial terms and phrases that can be used as search terms for the two search concepts (i.e. search terms related to LM/LSS and LGOs, as shown in Table I). The defined search terms for both concepts consisted of synonyms and common terms appearing in the literature and the scoping study papers. The search strategy was designed to be sensitive rather than precise. The decision to adopt a more sensitive search as a strategy is useful in reducing the probability of missing related studies, but the trade-off is that it may lead to retrieving more non-relevant ones (Higgins and Green, 2008, p. 130). Because this is apparently the first examination of the research literature on LM in LGOs, we felt it was best to use a more sensitive vs. a precise search. The first set of search terms in the search concepts (see Group 1 in Table I) consisted of synonyms for LM and LSS; the concept of LM included 11 terms while LSS has four different terms. The second set of search terms consisted of 18 synonyms for LGOs (see Group 2 in Table I). The search terms were tested multiple times to ensure they sufficiently captured the relevant publications on the chosen platforms. Once the final set of search terms for the two search concepts was identified, three platforms were selected: ProQuest, Web of Science, and Engineering Village. ProQuest was utilized as it is a reliable source with publications covering a broad range of domains. Web of Science also covers high-quality academic publications, and Engineering Village has access to more conference proceedings and additional journals.

The Search terms in Group 1 were adjusted to be searched everywhere in the publications except full text. This setting forces the search engine to look for the search terms in the title, abstract, and keywords defined by the authors. This setting ensures capturing publications that have a primary focus on LM/LSS. The second group was adjusted to search everywhere to capture publications that used the search terms defined in Group 2 even if they were not in the title, abstract, or keywords. The Boolean operator "OR" was used between search terms for each group to capture papers containing any terms separated by the operator. The operator "AND" was used across the two groups to capture all publications containing the two search terms. Asterisks were

also utilized to capture the different derivatives in the search terms. In addition, this study has no restriction on time limiter. To ensure the search terms were reliable and sufficient for capturing relevant publications across the three platforms, the capture rate was evaluated. As a result, the six scoping papers were captured with the defined search strategy, resulting in a 100% capture rate.

Search category	Explanation
LM/LSS	**Group 1: Search terms for LM/LSS** Lean, lean system, lean management, lean thinking, lean production, lean manufacturing, lean enterprise, lean operation, Toyota production system, TPS, lean office, Lean Sigma, Lean Six Sigma, LSS, L6S
LGOs	**Group 2: Search terms for LGOs** Municipality, local government, local council, municipal government, town government, county government, state government, city government, governmental operation, municipality sector, local authority, city council, municipal council, district council, town hall, city office, local government office, local government council
Platform	ProQuest, Web of Science and Engineering Village
Boolean operators	Boolean operators OR within each search concept (i.e. Lean production OR lean six sigma); AND across the two search concepts (e.g. Lean production AND local government)

Table 2 (Table I, Manuscript #1) Systematic literature review search strategy

d) Exclusion Criteria

Once the search strategy was finalized, the search concepts were executed in the three platforms. A total of 2,331 publications were retrieved as raw results followed by executing the exclusion criteria defined in Table II. At an early stage of obtaining the raw results, 731 non-academic publications, 72 publications not written in English, and 168 duplicates were eliminated. After applying the initial limitations (i.e. Exclusion Criteria 1–3), 1,360 publications were further examined against the remaining exclusion criteria (i.e. Items 4–9 in Table II).

	Exclusion Criteria	Publications Removed	Percentage
1	A publication not academically focused	731	32
2	A publication not written in English	72	3
3	Duplicate (within or across platforms)	168	7
4	A publication not directly related to the scope of the study	877	38
5	A publication not accessible	1	0.04
6	A publication discusses LGOs without directly studying an improvement methodology	131	6
7	A publication discusses an LGO but LM/LSS were not the improvement methodology of focus	8	0.30
8	A publication discusses LM/LSS in other types of organizations (e.g. healthcare, manufacturing, etc.)	281	12

9	A publication discusses an LGO, but LM or LSS was not sufficiently the improvement methodology of focus	13	0.08

Table 3 (Table II, Manuscript #1) Exclusion criteria developed for this study

The fourth exclusion criterion eliminated 877 publications unrelated to this topic. While the search terms used in this study are widely accepted and utilized in the literature, some search terms (e.g. Lean, TPS, and LSS) appeared in other fields with completely different meanings. For instance, the search term "lean" is used in natural gas systems, while TPS and LSS are abbreviations in traditional public schools and lower secondary schools, respectively. Therefore, approximately 38% of the publications were not directly related to the topic of interest. Next, one publication was not accessible although the researchers utilized supplementary databases (Google Scholar and a university library database) for publications not available in full-text. Sixth, 131 publications focusing on LGOs were removed. These publications usually studied LGOs as the organization of focus without directly studying LM/LSS. The seventh and eighth exclusion criteria eliminated 8 and 281 publications, respectively. As mentioned previously, this study focused on LM/LSS within LGOs; thus, publications that utilized other improvement methodologies (such as Six Sigma only or Total Quality Management) or studied other types of organizations (e.g. healthcare, manufacturing, or federal government) were not in the scope of this study. The last exclusion criterion removed 13 publications that discussed LGOs but in which LM/LSS was not sufficiently the improvement methodology of focus. Finally, four identified publications were similar in the set. One journal article by Furterer and Elshennawy (2005) was published from a dissertation (Furterer, 2004) and one conference proceeding (Jaaron and Backhouse, 2010) was extended to a journal paper (Jaaron and Backhouse, 2011). Therefore, only journal publications were considered among the four similar publications to avoid duplicating results. The publications excluded based on each exclusion criteria are summarized in Table II. After this process, 47 relevant publications were identified. However, this SLR was initially conducted with one platform (Alrezq, 2020a, 2020b), and was extended by extending it to two additional platforms (Alrezq, 2021). Thus, to update this SLR for more recent publications, the same search terms (see Table I) were re-run, and three recent additional publications were captured. Further, as described later in the Results section, an analysis of prominent authors in this research area was conducted. Based on the identified set of prominent authors, three papers published by several prominent authors were found that were a fit, but were not captured in the SLR because they referred to more detailed organizational sub-units within LGOs and specific tools/techniques of LM/LSS. However, they were added to the final paper set because of their relevance to the topic of interest. Thus, the final set of papers used for this study is 53 publications (a full list of references is available upon request).

The final set of publications was drawn from multiple platforms, which makes the SLR a more robust search strategy (than traditional literature review) for analyzing the literature (Higgins and Green, 2008, p. 69). An interesting finding about the final set was that far more publications were identified uniquely from ProQuest (27 publications) than Engineering Village (4) or Web of Science (3). The remaining publication set overlapped between two or three of the platforms. The unique number of publications for each platform and the overlap between them are shown in Figure 2.

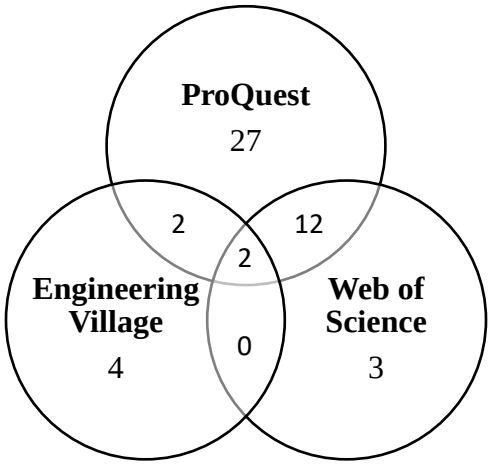


Figure 3 (Figure 2, Manuscript #1) Indexed platforms of the final publications

2.5 Results

This study analyzed publication and author characteristics, research design characteristics, and content characteristics. Therefore, to answer these research questions, the last step (i.e. "e") in the SLR process is presented in the following sections.

2.5.1 Publication and Author characteristics

Publication and author characteristics were analyzed using four criteria. First, the evolution of LM/LSS in LGOs and new authors per year were investigated respectively followed by identifying prominent authors and then assessing the collaboration in the research community.

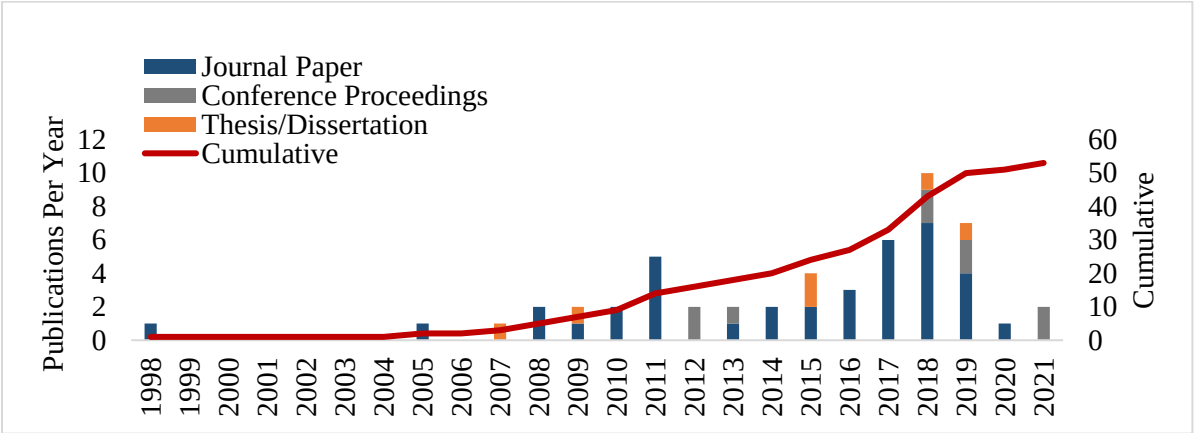


Figure 4 (Figure 3, Manuscript #1) Frequency of publications per year

Studying annual scholarly production and the appearance of new authors reveals how the literature and researchers' interests evolve in a particular area. For this analysis, frequency charts were employed to identify the potential trend. The final set of 53 publications on LM/LSS in LGOs covered approximately two decades ranging from 1998 to 2021 (see Figure 3). Furthermore, the 2.5.1publication set contained 38 journal publications, nine conference proceedings, and six

theses/dissertations. This evidence shows an overall trend of rising output. However, the total publications between 1998 and 2010 only accounted for 17% of the publication set while the period between 2011 and 2021 accounted for 83% of the total publications, as shown in Figure 3. Despite the slight decline in 2016, there was clearly a gradual growth of publications from 2015 until the highest peak in 2018. The analysis also revealed that approximately 57% of the publication set was published between 2015 and 2019, including 22 journal publications, four conference proceedings, and four theses/dissertations. Such recent growth suggests that this area is less mature, as compared to other research areas or fields, and there are opportunities to advance the knowledge of LM/LSS within these organizations.

Following the analysis of publications over time, authors who contributed to this subject were analyzed to evaluate the quantity and emergence of new authors. This analysis investigated how this area triggers researchers and to what extent new authors are participating in it. Based on the 53 publications, a total of 109 unique authors were identified between 1998 and 2021 with the exception of certain years with no publications (see Figure 4). The quantity of new authors in a given year ranged from a minimum of 1 to a maximum of 27 with an average of 6.4. Furthermore, 15% of the authors contributed to this area during the first decade (i.e. between 1998 and 2010) while 85% emerged in the second, with 61% of the authors ranging between 2015 and 2021. In a parallel observation, Figures 3 and 4 reveal a similarity in the trend overtime. That is, in each year, there was at least one publication and a new author. This may indicate this research area is still evolving and attracting new scholars frequently. Although only 9.2% of the authors had more than one publication in the final set, it is helpful to further analyze prominent authors and collaborations within this research community.

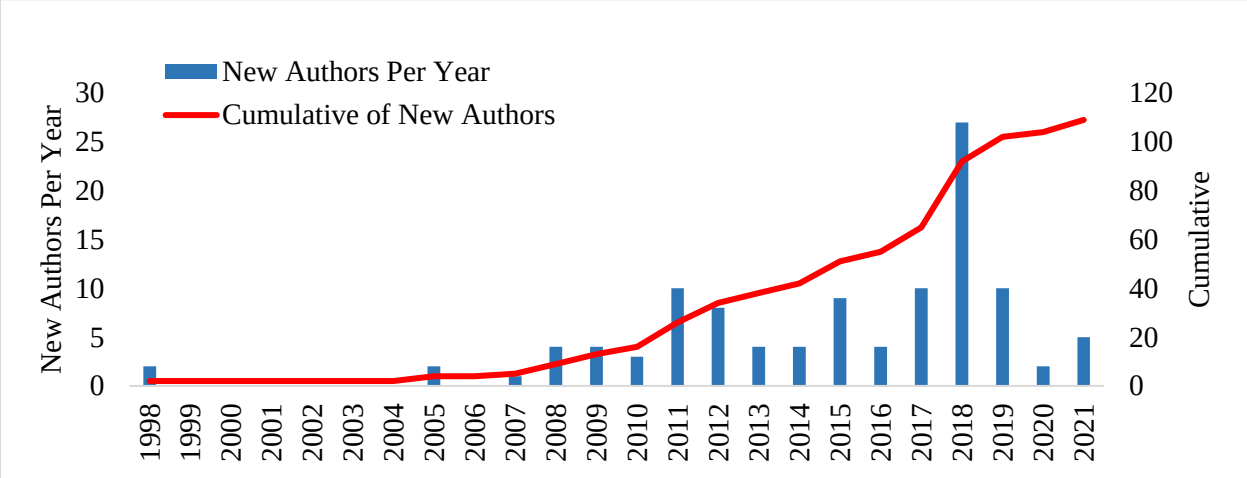


Figure 5 (Figure 4, Manuscript #1) Frequency of new authors per year

The second criterion investigated in this section is to recognize prominent authors. It is a common practice among scholars to use the number of publications as an indicator for identifying a set of experts in a field or subject. However, in addition to the number of publications, this study also adopted equitable fraction sum (as described and demonstrated below) from Gonzalez Aleu and Van Aken (2017) to further evaluate author impact. Based on the publication set, eight authors

were identified with more than one publication. These authors—in descending order—were: J. Antony (6 publications), B. Rodgers (6), P. Ingelsson (3), I. Bäckström (3), M. Gustavsson (2), E. Pedersen (2), M. Huniche (2), A. Halvarsson (2), E. Cudney (2), and M. Barraza (2). Although this set of authors began evolving, LM/LSS in LGOs might not be their primary area of interest. As discussed in the literature section, the application of LM/LSS is expanding across diverse organizational types (manufacturing and beyond); thus, the identified set of authors are likely interested in the improvement methodology and further attempt disseminating the applications of LM/LSS across a wider range of organization types. Next, author impact was analyzed using the citation equitable fraction sum per author. This indicator was measured for each author using the following steps:

1- The total number of citations for each of the 53 publications was obtained from Google Scholar (i.e. citations obtained up through March 2022).
2- The citation per year for each publication was calculated by dividing the total publication's citations over the number of years in print (e.g. if a publication had 24 citations and was published in 2019, then 24 citations across the four years (i.e. 2019, 2020, 2021, and 2022) would yield six citations per year).
3- Each author was assigned a citation equitable fraction sum (if a publication had 10 citations per year and was written by two authors, each author received five citations).
4- The citation equitable fraction sum was determined by aggregating the citations per author for all publications written by the same author.

Based on the citation equitable fraction sum, the authors with a score of 5 and above—in descending order—were: J. Antony (27.12), B. Rodgers (27.12), E. Cudney (16.39), E. Pedersen (13.17), M. Huniche (13.17), S. Furterer (8.28), A. Elshennawy (8.28), M. Barraza (7.39), J. Arlbjørn (6.64), P. Freytag (6.64), H. Haas (6.64), T. Smith (5.83), and S. Dahlgaard-Park (5.83). Based on the two indicators, the six most prominent authors (appearing across the two criteria) were: J. Antony and B. Rodgers (each having six publications and a 27.12 citation equitable fraction sum), E. Pedersen and M. Huniche (each having two publications and a 9.14 citation equitable fraction sum), and E. Cudney and M. Barraza (each having two publications and 16.39 and 7.39 citation equitable fraction sums, respectively). The assessment of prominent authors using different criteria assists in comprehensively identifying authors who are not only frequent publishers, but also influencers, within this area.

Given that approximately 77% of the final publications had more than one author (while 23% had a single author), analyzing co-authorship helps to discover the structure of the interrelationships and interactions between prominent authors and research groups in this area (LM/LSS in LGOs). Therefore, a social network analysis (SNA) - a visual representation of direct and indirect interaction between entities or groups of entities (Hansen *et al.*, 2011, pp. 31–51) - was used to analyze the collaboration between authors. The SNA was built using NodeXL, a software embedded in Excel template and developed by Social Media Research Foundation (Smith *et al.*, 2009). As the focus of this analysis was to identify the interactions between individuals and across research groups, only publications with two or more scholars were considered for this analysis (i.e. 41 publications). The entire network visualization of this collaboration between scholars is presented in Figure 5. Each node (i.e. the circles in Figure 5) represents an author, and

the size of the node reflects the number of publications each author produced. Similarly, the vertices (i.e. the edges represented by lines) indicates the collaboration/co-authorship in a given publication between two or more authors, with thicker edges representing more frequent collaboration. As mentioned previously, the main purpose of the SNA is to discover the interactions between scholars; thus, only publications with two and more authors were considered for this analysis. Therefore, author information from 41 publications was extracted and their interactions were built in NodeXL using indirect graphs (i.e. all edges are two-way connected). Furthermore, the Wakita-Tsurumi algorithm was used due to its computational speed and flexibility in identifying modularity of a community structure, which in this case was the structure of the research groups in the network (Wakita and Tsurumi, 2007). The SNA was analyzed using three indicators: number of collaborations between scholars, betweenness centrality, and graph density.

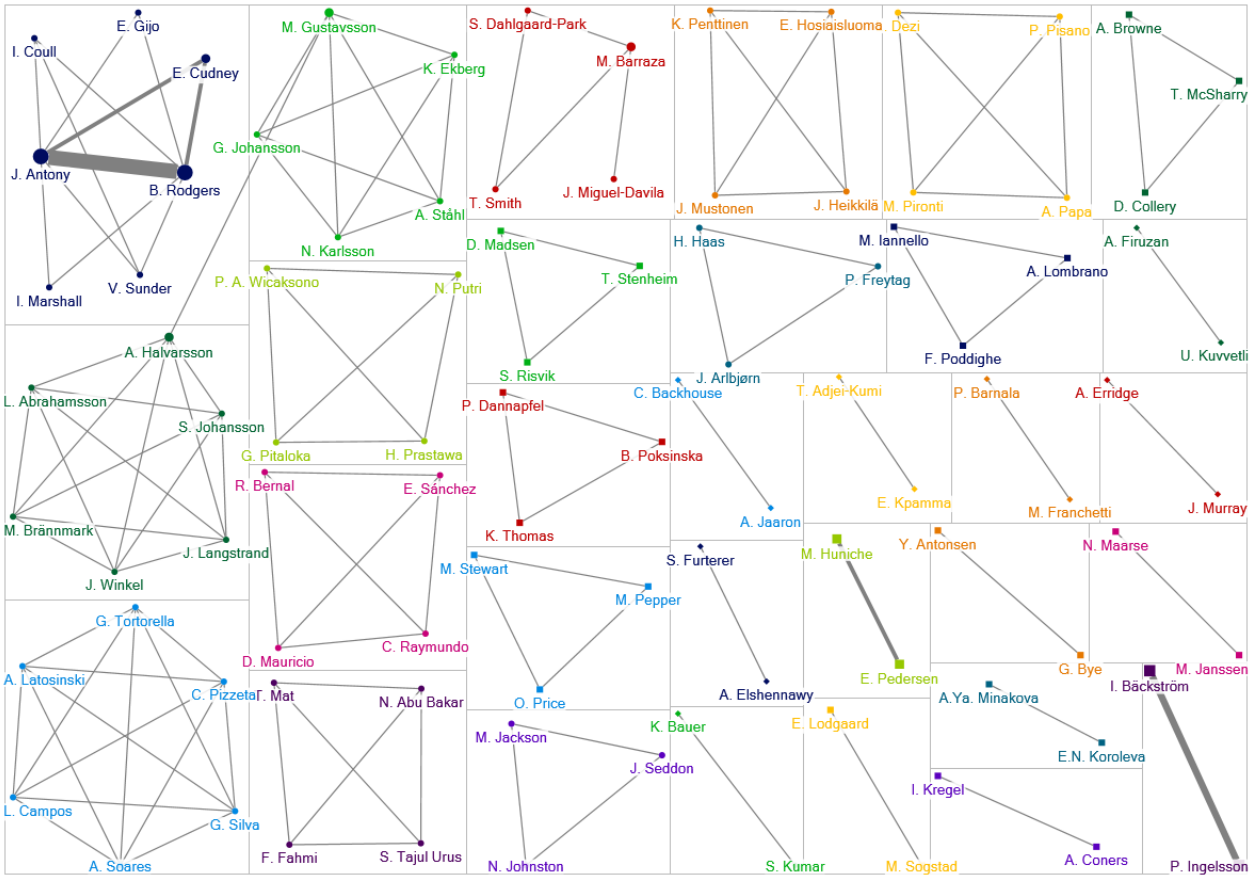


Figure 6 (Figure 5, Manuscript #1) Network analysis of collaboration between scholars and research groups

First, after implementing the algorithm, a total of 31 research groups with 97 nodes and 122 unique edges emerged (see Figure 5). Therefore, the pairs of authors who collaborated the most, represented with thicker edges in order from highest to lowest collaborations, were J. Antony and B. Rodgers (who collaborated on six publications), I. Backstrom and P. Ingelsson (who collaborated on three), E. Cudney (who collaborated on two), and M. Huniche and E. Pederson (who collaborated on two). Furthermore, each box in Figure 5 indicates a research group, which

clearly shows that most of the research groups published only once. This finding may indicate this research area may not be the central focus, but as noted earlier, prominent authors (with two or more publications) may begin to be the main contributors to this subject. It was also observed that ten of the collaborative publications among those identified as prominent authors were published between 2015 and 2019. This recent attention to collaboration supports the idea that this area may become the focus or most interesting area of research for those identified as prominent authors. Second, betweenness centrality was implemented to identify the important authors collaborating with other individuals or groups in the network, i.e. individuals acting as a "bridge spanning" (Hansen *et al.*, 2011, pp. 79–94). Betweenness centrality is calculated based on the shortest paths between nodes/authors (Otte and Rousseau, 2002). Based on the 31 research groups, there were two authors who collaborated with two different research groups (A. Halvarsson and M. Gustavsson, with betweenness centrality scores of 25 and 24, respectively). The next highest betweenness centrality scores were J. Antony and B. Rodgers (each having a score of 4.5). Finally, the lowest betweenness centrality score was M. Barraza (a score of 2). From a network perspective, structural holes are a gap between two or more groups of entities, or in other words, are a missing bridge (Hansen *et al.*, 2011, pp. 31–51). This scenario was reflected in Figure 5, which shows an observable lack of interactions across research groups or individuals connecting research groups except the four authors acting as bridges in this network. The third criterion - known as graph density in social networks - was utilized to assess the connectedness of the network (Otte and Rousseau, 2002). Therefore, graph density measures the level to which a given network is completely connected (Otte and Rousseau, 2002). In other words, each node in a network is connected to other nodes with no isolated ones. Graph density for an indirect network is calculated as the product of the number of actual edges and 2, divided by the possible number of edges (Hansen *et al.*, 2011, pp. 79–93). The graph density score ranges between 0% and 100%, where 60% and above is a threshold for a dense graph, as described and demonstrated by Oladimeji *et al.* (2020). In this study, the graph density score is approximately 2.62%, indicating a limited level of collaborative efforts between authors or research groups. Collaboration can strengthen the dissemination of knowledge in a field and can provide strong evidence to practitioners considering adopting LM/LSS by sharing knowledge and experience of scholars through co-authorship.

2.5.2 Research Design Characteristics

Analyzing research design characteristics help to assess the research methods used and understand how the subject area (i.e. LM/LSS in LGOs) has developed. Given that 53 papers in the final set represented academic publications following a structured research methodology, the research methods of each publication were identified and categorized into two groups that included data collection and data analysis methods for a comprehensive analysis (see Figure 6).

Based on the final paper set, 21 unique research methods were extracted that involved nine methods used for data collection and 12 for data analysis. It is worth mentioning that each unique data collection and data analysis method is not mutually exclusive. For example, a given publication may use both interviews and a survey/questionnaire for data collection and then utilize both descriptive statistics/summary and regression analysis simultaneously. The data collection methods among publications ranged from a minimum of 1 to a maximum of 6 methods. Similarly, data analysis methods ranged from 1 to 5 methods. Figure 5 reveals that the most frequent methods

used for data collection were interview (24 publications), organizational document review (17), and survey/questionnaire (17). A similar trend can be seen in the data analysis methods, which primarily consisted of qualitative/content analysis (29) and descriptive statistics/summary (18). The reported methods for data collection also showed a lack of analyzing the literature in a systematic manner (such as SLRs), which further justifies our initial motivation in this work.

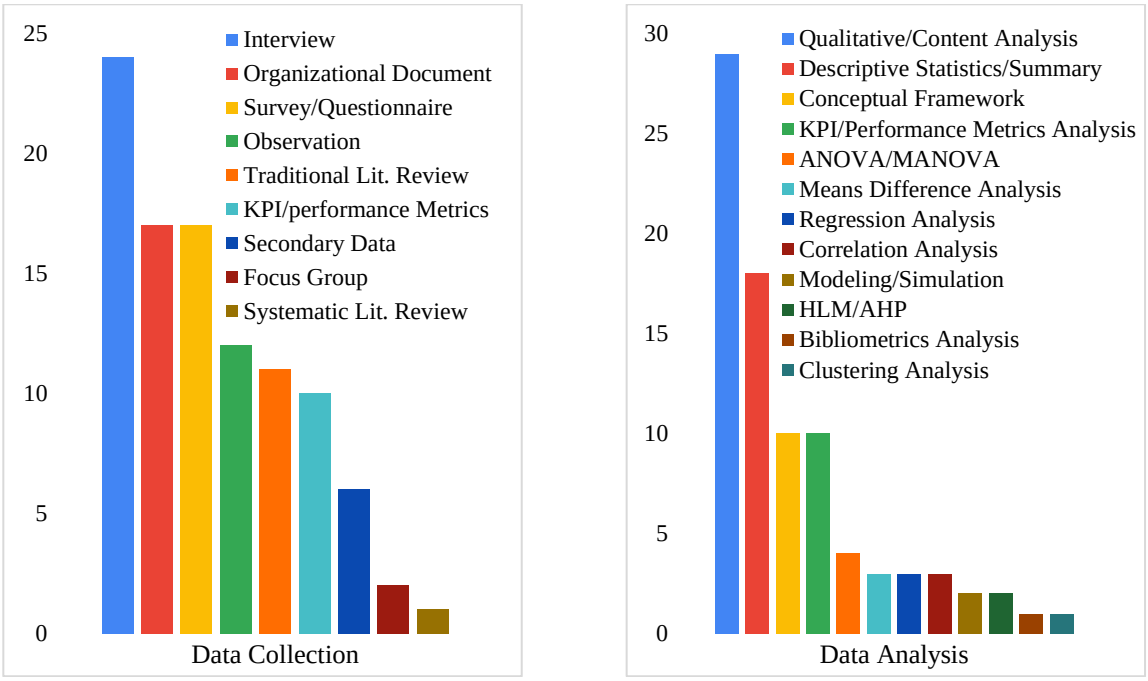


Figure 7 (Figure 6, Manuscript #1) Most commonly-used research methods for LM/LSS in LGOs

A further analysis of research methods revealed that approximately 53% of the publication set used more than one method for data collection, and 47% used more than one for data analysis. The use of non-mutually exclusive methods expanded our interest to examine the co-occurrence of methods for data collection and data analysis (see Figure 7). Figure 7 shows a matrix divided into three quadrants including all the identified methods (items 1 through 9 represent data collection methods and items 10 through 21 represent data analysis methods). Going clockwise from the top left, the first quadrant shows the methods used for data collection, the second shows the co-occurrence of methods used for data collection and data analysis, and the third shows the methods used for data analysis. The most commonly-paired data collection methods were interview with organizational document, observation, or survey/questionnaire followed by organizational document with observation. On the other hand, the most commonly-paired data analysis methods were qualitative/content analysis with descriptive statistics/summary or conceptual framework. Examining the co-occurrence of the most utilized data collection methods with data analysis shows that interview, organizational document, observation, and traditional literature review are usually examined using qualitative/content analysis. The following most frequent pairs of methods are survey/questionnaire often explored using descriptive statistics/summary or qualitative/content analysis. Furthermore, KPI/performance metrics were usually analyzed with KPI/performance metric analysis. These methods were mostly used with an actual improvement in a measured

outcome environment (i.e. actual utilization of LM/LSS in an organization or a sub-unit within an organization). The evaluation revealed that a wide range of empirical data collection methods are often adopted, such as an interview or survey/questionnaire, but basic analysis methods are typically used, such as descriptive statistics/summary. While the diversity of methods may contribute positively to this research area, further efforts need to employ evidence-based sources, such as advanced statistical techniques to strengthen the rigor of this research or KPI/performance metrics in conjunction with KPI/performance metric analysis.

Research Methods	Items	1 Traditional Lit. Review	2 Systematic Lit. Review	3 KPI/Performance Metrics	4 Focus Group	5 Interview	6 Organizational Document	7 Secondary Data	8 Observation	9 Survey/Questionnaire	10 Bibliometrics Analysis	11 Modeling/Simulation	12 Descriptive Statistics/Summary	13 Qualitative/Content Analysis	14 Means Difference Analysis	15 Regression Analysis	16 Clustering Analysis	17 HLM/AHP	18 ANOVA/MANOVA	19 Correlation Analysis	20 Conceptual Framework	21 KPI/Performance Metric Analysis
Traditional Lit. Review	1	–		1		1		1		1			2	8							4	1
Systematic Lit. Review	2		–								1			1								
KPI/Performance Metrics	3			–	1	3	1		2	2			2	1	1	1	1	1	1			10
Focus Group	4				–	1	2	1	2	2				1				1				1
Interview	5					–	15	2	9	8			6	18	2			1			7	3
Organizational Document	6						–	3	8	5		1	3	12	1			1			4	1
Secondary Data	7							–	2	1			4	4		1				1	1	
Observation	8								–	3		1	3	8				1			1	2
Survey/Questionnaire	9									–		1	12	7	3	1		2	1	2	2	2
Bibliometrics Analysis	10										–			1								
Modeling/Simulation	11											–										
Descriptive Statistics/Summary	12												–	7	2	3	1	1	2	3	2	2
Qualitative/Content Analysis	13													–							6	1
Means Difference Analysis	14														–							1
Regression Analysis	15															–	1		1	1		1
Clustering Analysis	16																–		1			1
HLM/AHP	17																	–	1			1
ANOVA/MANOVA	18																		–			1
Correlation Analysis	19																			–		
Conceptual Framework	20																				–	
KPI/Performance Metric Analysis	21																					–

Figure 8 (Figure 7, Manuscript #1) Co-occurrence of research methods used with LM/LSS in LGOs

2.5.3 Content Characteristics

The outcomes of LM/LSS in LGOs were investigated to identify the benefits of this improvement methodology. A total of 28 papers (out of the 53) reported the benefits achieved by implementing LM/LSS and were thus used for this analysis. The synthesis began by extracting the outcomes identified in the 28 publications, resulting in 135 unique entries. These entries were then coded and categorized based on their affinity or inherent similarity through an iterative process. On

average, each publication approximately reported five outcomes. Thus, the final set of benefits identified contained 31 unique outcomes (see Figure 8). These outcomes were also categorized based on the nature of focus. That is, 15 outcomes focused on process/operations (red), eight outcomes focused on employees (green), six outcomes focused on organization (blue), and three outcomes focused on customer (orange).

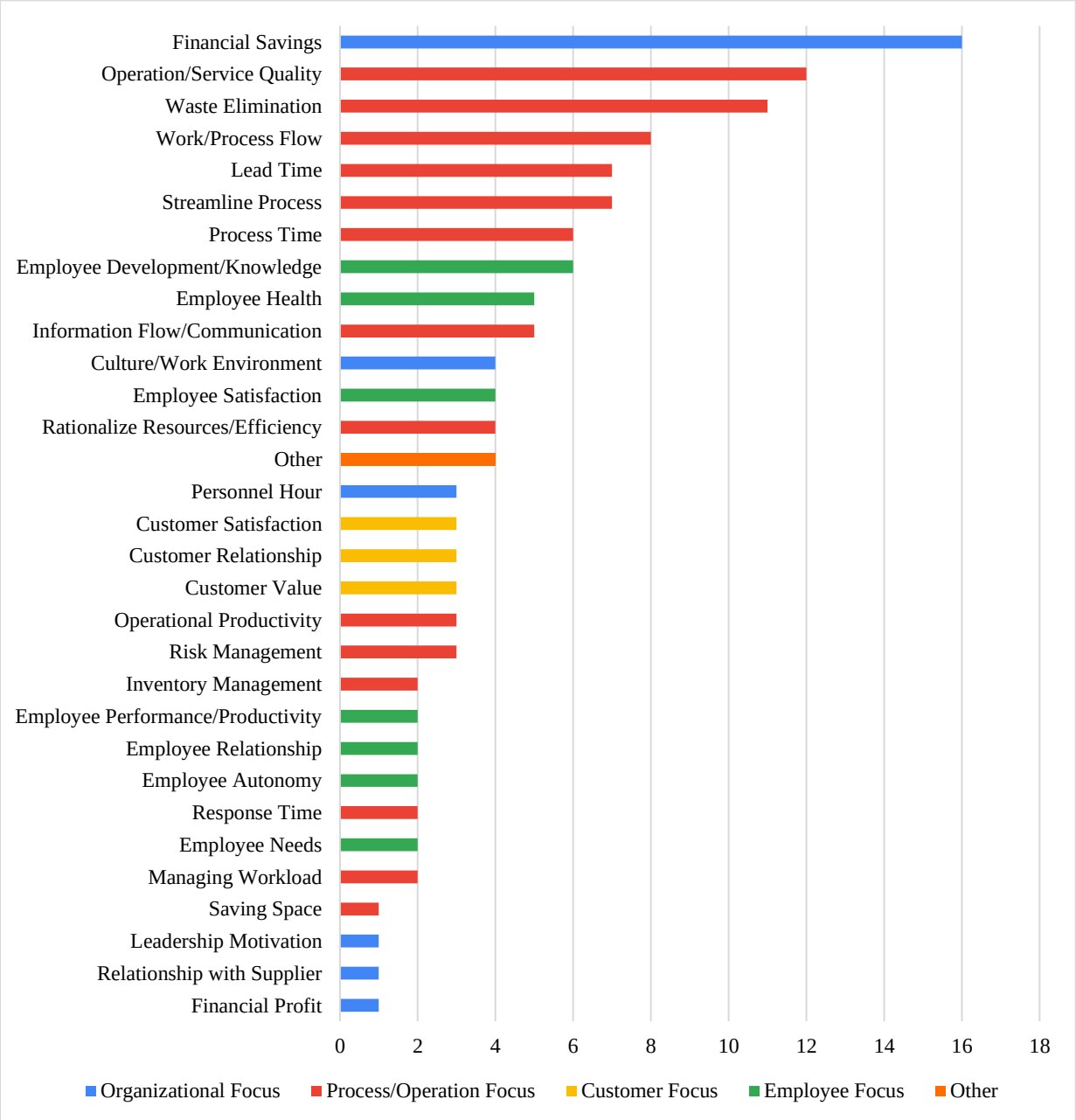


Figure 9 (Figure 8, Manuscript #1) LM/LSS outcomes in LGOs

Based on the evidence, the frequency of outcomes ranged from 1 to 16, with financial savings being the most commonly-reported outcome (or 57% of the total publications, out of the 28 in the publication set). With the evidence obtained from the sampling publications, LGOs benefited

greatly from this improvement methodology in controlling expenses. Furthermore, out of the 31 outcomes identified, 14 (approximately 45%) concentrated on the process/operations segment. The five highest reported outcomes within process/operations were operation/service quality (12 publications), waste elimination (11), work/process flow (8), lead time (7), and streamline process (7). This might reveal that LGOs experience considerable waste and there are many opportunities to tighten processes using LM/LSS (Fletcher, 2018; Yuksel and Yuksel, 2010). Furthermore, the final set also reported subjectively-measured outcomes, for instance, employee health, culture/work environment, and employee and customer satisfaction. These social aspects may help to convince those who are resistant toward LM/LSS and increase the likelihood of expanding it to more levels across an organization. Further, this finding also supports the literature by clarifying the impact of LM/LSS on LGOs. One of the interviewees reported by Fletcher (2018, p. 261) stated: "[LSS] application is more widely spread than many people realize, but there has not yet been enough documented evidence showing precisely how beneficial the use of Lean Six Sigma in public service really is." Similarly, a study conducted by Antony *et al.* (2017, p. 1409) also concluded that there has not yet been an evidential base" showing how beneficial" LSS has been in these types of organizations to date. Thus, the identification of the benefits (or outcomes) of LM/LSS in this study may play a role in addressing this lack of awareness and encouraging LGOs' officials to realize the positive impact of this improvement methodology. Finally, the insights derived from the analysis of outcomes could help leaders in LGOs in creating the foundation needed before initiating implementation of LM/LSS. More specifically, these findings can help leaders create buy-in from stakeholders and employees by clearly communicating the types of outcomes that could potentially be improved by implementing LM/LSS, based on what has been reported in the research literature. For example, it could help manage expectations of stakeholders and employees to help them understand that there is the potential to improve costs (the most frequently-reported outcome), but also to realize many process and operational improvements. Although customer-focused and employee-focused outcomes have been less frequently reported in the literature, and thus, may be considered to be less likely to occur, it may be important for stakeholders to understand that these types of outcomes are indeed still also possible.

2.5.4 Future Research Directions

One of the primary reasons for utilizing the SLR is to identify research gaps and outline avenues for future research to direct interested parties to advance a particular research area (Fisch and Block, 2018; Munn *et al.*, 2018). Thus, this study identified potential gaps related to LM/LSS in LGOs based on the evidence obtained from the final publication set.

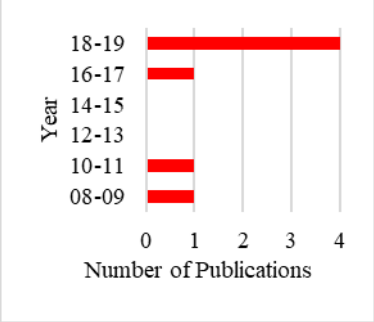
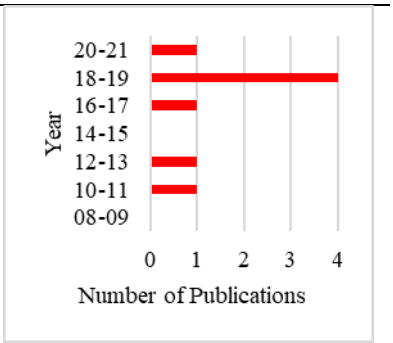
In the final publication set, an in-depth review was conducted for each publication to inductively identify potential future areas. A total of 25 publications (47% of the final set) identified further directions for research on LM/LSS in LGOs. Given the various directions for future work within each publication, a total of 61 unique statements was extracted from the 25 publications. Thus, on average, two future directions were recommended per publication. The extracted statements for research opportunities were identified from future work or conclusion sections for each publication. After extracting the statements, an iterative process was conducted to aggregate the statements into themes representing their overall meaning. Thus, the 61 statements extracted from the 25 publications were structured into 11 themes (see Table III).

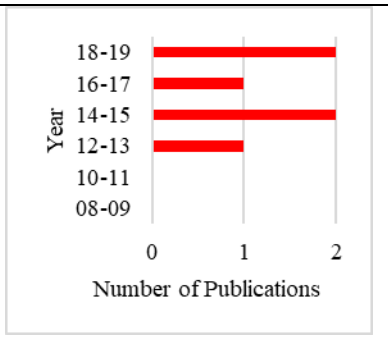
The aggregated statements within each theme were shortened, describing their main content. The structure of themes - in descending order - was categorized into research design/methodology (9 statements), LM/LSS impact/benefits (9), treatment/additional variables (8), organizational strategic approach (7), tools/techniques of LM/LSS (7), critical success factors (6), case studies (5), LM/LSS with other management/change management approaches (3), functional units (3), additional organizational types (3), and geographical context (1). Furthermore, the timespan was also placed within each theme representing the frequency of publications suggesting new directions. The overall range of publications suggesting future directions was between 2008 and 2021.

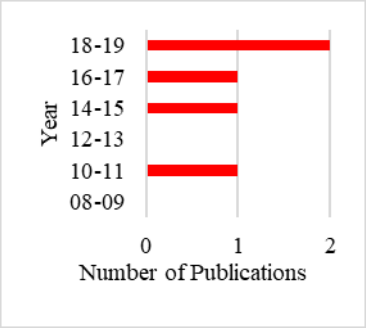
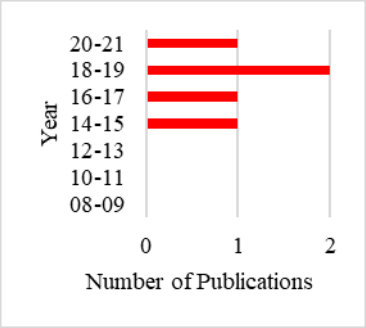
Although Table III was structured into meaningful themes, it can be further classified into three broad categories. The first is concerned with LM/LSS content, such as examining the critical success factors of LM/LSS in LGOs; studying the influence of new variables or further examining studied variables; integrating LM/LSS with other management approaches; evaluating the impact of this improvement methodology on different system outcomes, for instance, technical or social outcomes; planning and implementing at strategic levels; understanding LM/LSS tools and techniques within the context of LGOs; and further evaluating and developing supply chain management strategies. The second category is related to empirical studies of LM/LSS in different organizations and geographical regions. The third category represents the research design. A wide range of research methodologies that included case studies, qualitative research, quantitative research, longitudinal research, and mixed methods are still ideal routes for researchers to carry on and advance this improvement methodology within LGOs. As mentioned previously, the overall evolution over time of the final set of 53 publications captured in this study ranged between 1998 and 2021. However, the publications suggesting future research directions started in 2008, with approximately 68% of publications suggesting future directions appearing in the last five years. This suggests scholars are concerned about LM/LSS in LGOs and are proposing recommendations to advance this area, which may positively influence the maturity level.

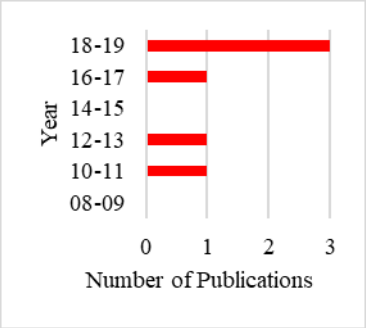
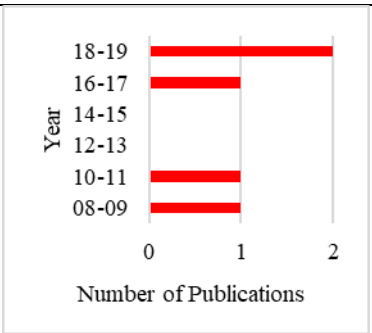
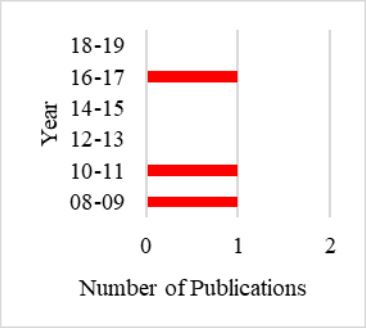
This review provides overall insights regarding the still-early developmental stage of LM/LSS in LGOs. As noted, the analysis of future research areas highlights the opportunities for researchers to address gaps and advance the maturity of LM/LSS adoption and implementation in LGOs, such as more empirical research design approaches (e.g. case studies, including multiple case studies, or survey questionnaire with more advanced statistical analysis methods enabling hypothesis-testing). Addressing these methodological gaps in the current research literature in future research studies could yield deeper insights into the effectiveness of LM/LSS in LGOs, ultimately, increasing the likelihood of successful implementation.

Themes	Research gaps and references	Research gaps overtime

Research Design/Methodologies	*Data collection method/strategy*: Collect real-time data to capture variation within processes to help decision-makers eliminate variation for improvement (Tortorella *et al.*, 2018); *Mixed methods*: Conduct a study on the relationship between organizational culture and LM/LSS implementation using a mixed-method approach (Gityforoze, 2018); *Action research*: Use action research to reduce failure demand as an impact of LM/LSS (Masters, 2009); *Longitudinal design*: Use longitudinal methods to measure outcomes (e.g. tangible and intangible) (Hoyle, 2019); More ideally works with a longitudinal approach (Price *et al.*, 2018); Longitudinal studies are needed to monitor LM/LSS implementation over time (Madsen *et al.*, 2017); *Qualitative studies*: Examine the relationship between organizational culture and LM/LSS implementation using qualitative methods approach (Gityforoze, 2018); Carry out qualitative research (i.e. interview) (Madsen *et al.*, 2017); Further examine the applicability of LM/LSS through a qualitative research approach (Loader, 2010).	
LM/LSS Impact/ Benefits	More case studies that demonstrate the benefits of LM/LSS in policing services (Rodgers *et al.*, 2019); More studies that demonstrate the elimination of non-value added activities caused by organizational culture (i.e. bureaucracy) (Kuvvetli and Firuzan, 2019); Study the effect of LM/LSS implementation on organization stakeholders (i.e. employees) (Tortorella *et al.*, 2018); Measure the impact of LM/LSS on soft values/measures, such as empathy, integrity, and influence (Ingelsson and Bäckström, 2017); Provide more detailed descriptions of LM/LSS intervention with other management practices to understand the impact on different stakeholders (i.e. employees, employer, and customers) (Brännmark *et*	

	al., 2012); Conduct more rigorous studies on the cost of LM/LSS (Pedersen and Huniche, 2011); Examine the benefits of LM/LSS (Pedersen and Huniche, 2011); Further investigation if experienced-based learning of LM/LSS makes it impossible to implement a system-wide improvements for solving problems in complex organizations (Antonsen and Bye, 2020); Explore how the benefits of LM/LSS vary in policing services and other organizations, such as city councils (Antony et al., 2019).	
Treatment/Additional Variables	Assess variables that contribute to the success of Kaizen event execution (i.e. Kaizen team characteristics), such as participant number , age, gender, race, GS payscale, and kaizen experience (Hoyle, 2019); Examine kaizen event durations, when the event occurred, and the budget of each event for insight on the rate of success and percent of change (Hoyle, 2019); Effective organizational learning is one factor contribute to implementation of LM/LSS, thus exploring the relationship between LM/LSS deployment and organizational learning can provide more insights (Gityforoze, 2018); Develop a survey by examining the value respect for people (Bäckström and Ingelsson, 2016); Further research on what influences co-worker health (Bäckström and Ingelsson, 2015); Study the commitment of employees and managers in governmental settings (Maarse and Janssen, 2012); Test a different model of organizational culture on the relationship between organizational culture and LM/LSS implementation (Gityforoze, 2018); Test quantitatively the causal relationships among variables found in the kaizen project conceptual scheme (KPCS) with respect to operational efficiency, citizen satisfaction, and legitimacy of public image (Suárez-Barraza and Miguel-Dávila, 2014).	

Organizational Strategic Approach	There is a lack of literature on how to start the journey toward LM/LSS (Flores Garcia, 2015); The effectiveness of LM/LSS implementation with respect to organizational perceptions (Madsen *et al.*, 2017); Fully adopt across organizational levels (Loader, 2010); Lack of evidence on how the voice of customer is captured in change, leadership supports toward continuous improvement culture, and staff training and rewarding (Rodgers and Antony, 2019); Alignment with organizational strategy for sustainable implementation (Rodgers and Antony, 2019); Importance of more holistic implementation across organizations (Rodgers and Antony, 2019); Lack of use of Hoshin Kanri (Policy Deployment) to align LM/LSS with organizational goals (Antony *et al.*, 2019).	
Tools/Techniques of LM/LSS	Lack of information on how to adapt LM/LSS tools/techniques to the characteristic of public sectors (Flores Garcia, 2015); Explore other LM/LSS tools/techniques that may fit into the environment of public sectors (Flores Garcia, 2015); Examine LM/LSS tools/techniques to better understand the improvement methodology in policing services (Rodgers *et al.*, 2019); Better understand how LM/LSS tools are chosen, applied, and combined in practice (Madsen *et al.*, 2017); Further understand which combinations of tools are more effective (Madsen *et al.*, 2017); Addressing problems created by NPM reform through utilization of LM/LSS tools/techniques (Antonsen and Bye, 2020); Develop toolkit for policing services to help use the right tools for right problems (Antony *et al.*, 2019).	

Critical Success Factors	Examine the critical success factors in federal organizations (Hoyle, 2019); More publications of case studies demonstrating the challenges of LM/LSS applicability in policing services (Rodgers *et al.*, 2019); Main pitfalls associated with LM/LSS implementation in municipality sectors can provide insight to help LM/LSS users (Madsen *et al.*, 2017); Identify factors (i.e. contextual factors) mediate lean implementation (Brännmark *et al.*, 2012); Participant-observations studies can provide more insight on factors that shaping LM/LSS implementation (Pedersen and Huniche, 2011); Explore how the challenges of LM/LSS vary in policing services and other organizations, such as city councils. (Antony *et al.*, 2019).	
Case Studies	Need to demonstrate the applicability of LM/LSS through case studies in policing services (Rodgers *et al.*, 2019); Collect and analyze a larger number of case studies on LM/LSS in LGOs to further understand the applications and identify similarities and differences (Kregel and Coners, 2018); Further exploration of LM/LSS in policing as a change for improvement (Smith, 2016); Conduct more empirical case studies (Suarez Barraza *et al.*, 2009); With the awareness of, belief, and the experience with LM/LSS, there is a need to further examine the applicability of LM/LSS (Loader, 2010).	
LM/LSS with other Management /Change Management Approaches	Examine the relationship between the value respect for people and other organizational change approach (i.e. appreciative inquiry) (Bäckström and Ingelsson, 2016); Study LM/LSS with other system methodologies in supporting policy initiatives (Jackson *et al.*, 2008); More empirical research on the integration and limitations of LM/LSS with SCM services (Stentoft Arlbjørn *et al.*, 2011).	

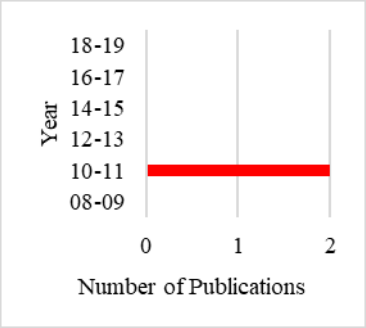
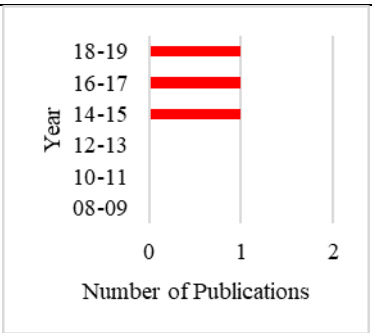
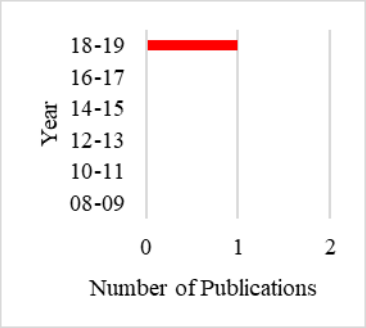
Functional Units	Assess the level of practice of LM/LSS philosophy, principles, and tools within supply chain management services in LGOs (Stentoft Arlbjørn *et al.*, 2011); investigate relationships between local authority procurers and supplier consortia (Loader, 2010); Further develop supply chain management strategies for efficient cost and services in other service organizations (Stentoft Arlbjørn *et al.*, 2011).	
Additional Organizational Types	Further monitor soft values/measures (such as empathy, integrity, and influence) in different organizations (Ingelsson and Bäckström, 2017); Further work on LM/LSS in other LGOs with different sizes and structures (Price *et al.*, 2018); Test kaizen project conceptual scheme (KPCS) with a greater number of kaizen projects in other LGOs (Suárez-Barraza and Miguel-Dávila, 2014).	
Geographical Context	Examine the relationship between organizational culture and LM/LSS implementation using organizational culture models in other counties at local and national levels within the U.S. (Gityforoze, 2018).	

Table 4 (Table III, Manuscript #1) Scientific gaps of LM/LSS in LGOs suggested by scholars

2.6 Conclusions

This study utilized three platforms to study and document the current status of LM/LSS in LGOs through three dimensions.

The first dimension analyzed was related to the publication and author characteristics. The evidence suggested that there was a general increase in trend of the publications and an emergence of new authors. While this may have a positive impact on the maturity of this research area, the collaboration across research groups was less documented and less frequent within each group (i.e., cluster) in Figure 5. The majority of the publication set included more than an individual author which is one element of collaboration. However, developing a stronger network of collaboration across research groups can lead to a more rapid dissemination of LM/LSS and an increase of knowledge for better diffusion through the collaboration. The following dimension assessed the research methods. While there is a diverse range of research methods used for data collection and analysis, a limited number of advanced statistical analysis techniques and hypothesis testing were documented. Depending on the investigated problems and processes, LM/LSS may not require complicated tools for basic improvement (Antony, 2011; Prakash *et al.*,

2021); however, due to the complexity associated with LGOs (Krings *et al.*, 2006), more rigorous research methods are encouraged to better evaluate uncertainties related to a successful LM/LSS implementation. The third dimension sought to document the outcomes and specified directions for future work in this improvement methodology. Among the 31 outcomes (see Figure 8), financial savings is the most commonly-reported benefit. Furthermore, the benefits of LM/LSS were not only limited to measurable outcomes (e.g. processing time and lead time), but also reported the effect on subjectively-measured outcomes, such as employees and customer satisfaction. The last dimension identified directions for future work for LM/LSS within LGOs, which is an advantage of using the SLR to justify and guide scholars and practitioners for further contributions.

Continuous improvement programs and organizational change initiatives have both been reported to have a high failure rate, approximately 60-90% and 80%, respectively (Burnes, 2005; Dooyoung *et al.*, 1998). The analysis of this study revealed the recency of an increased attention of LM/LSS within LGOs; thus, investigating the critical success factors (CSFs) is an opportunity for future research (which was one of the identified themes in the future work section). This investigation is critically vital to synthesize the literature and bring those CSFs into attention followed by an empirical examination of the relationship and influence of these CSFs on system outcomes.

Finally, SLR studies inherently have some limitations. While this study developed two search concepts and used a sensitive search strategy to increase the likelihood of obtaining more publications, there might be other publications that fall within this concept but used different search terms. Furthermore, this study was also limited to three platforms; hence, other publications may be indexed in other platforms. Lastly, only academic publications that were written in English were considered in this study.

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Chapter 3: Manuscript # 2 – Lean Production and Lean Six Sigma Success in Local Government Organizations

3.1 Manuscript preparation

Chapter 3 (Manuscript #2) has been formatted following the submission guidelines for the *Engineering Management Journal*, including text format, citation styles, figure color, and references. Further refinements to the manuscript may be made prior to submission.

3.2 Abstract

Lean Production and Lean Six Sigma (LP/LSS) have garnered significant attention due to the potential impact this improvement methodology has on performance outcomes across various organizational settings. LP/LSS emerged in the early 2000s in public sector organizations, specifically in local government organizations (LGOs). However, despite the widespread recognition of LP/LSS, there remains a paucity of research concerning the critical success factors (CSFs) of LP/LSS success in the LGO context. This study aims to identify and analyze the CSFs associated with LP/LSS in LGOs. Over 8,000 studies were initially captured and analyzed using a systematic literature review methodology, which yielded 44 relevant empirical studies published between 1998 and 2021. Out of 47 CSFs identified in these publications, the five most reported factors were: L*eadership support/commitment*, *Organizational culture*, *Employee attitude*, *LP/LSS training and education, and Employee engagement*. Although these factors are common to most organizational change processes, several factors were less reported in other organizational settings, such as *organizational experience, target system complexity, politics/regulations constraints, external consultant knowledge of LGO processes, patience for results,* and *contextualization/customization of LP/LSS*. This study contributes to enhance practice and serve engineering managers to efficiently manage LP/LSS processes in LGOs for better improvement outcomes. Additionally, this study provides a source for future research in a similar organizational context, such as federal government organizations, healthcare, and higher education institutions.

Keywords: Lean Production, Lean Six Sigma, Local Government Organizations, Critical Success Factors, Public Sector Organizations, Continuous Improvement

3.3 Introduction

Public sector organizations are crucial to the quality of life and economic growth in countries

(Psomas et al., 2017; Rodgers & Antony, 2019). In recent decades, there have been large-scale changes and challenges in public and private sector organizations (Drohomeretski et al., 2014). In the context of public sector organizations, dynamic changes - such as global competitiveness, financial austerity, and social and political demand for better performance - have compelled organizations to perform more efficiently and effectively with limited resources (Abaidoo & Blankenberger, 2022; Andersson et al., 2020; Lodgaard & Sogstad, 2021; Psomas et al., 2017).

Public sector organizations have become aware of the need to adopt alternative ways of thinking to achieve improvements in performance outcomes in terms of cost, quality, speed, and service (Abaidoo & Blankenberger, 2022; Lukrafka et al., 2020). Lean Production (LP) and Lean Six Sigma (LSS) - collectively referred to as LP/LSS for simplicity in this study - have emerged as a potential improvement methodology to address those needs (Andersson et al., 2020; Antony et al., 2017; Martin, 2018). While the origin of LP/LSS was rooted in manufacturing, Deming (2000) asserted that quality improvement is beneficial for any organization that provides a product or service. In other words, quality improvement is relevant to all sectors despite the nature of functionality (Rodgers et al., 2019). LP - derivatives of the term include Lean Manufacturing or Lean Thinking - is based on a philosophy that seeks to achieve improvements in the most cost-effective manner, with the emphasis on improving value and reducing waste (Dahlgaard & Dahlgaard-Park, 2006). Womack et al. (1990) defined Lean in this context as a "dynamic process of change, driven by a set of principles and best practices aimed at continuous improvement" (Albliwi et al., 2015, p. 665). Toyota Production Systems pioneered the lean philosophy and practices under the leadership of Taiichi Ohno (Albliwi et al., 2015; Maleyeff et al., 2012; McDonald et al., 2002). However, the term "Lean" was coined by Krafcik (1988), and has since become a popular improvement methodology (Womack et al., 1990). LSS merged in the 2000s

based on two popular and well-known improvement methodologies, LP and Six Sigma, the latter of which focuses on variation reduction to reduce the occurrence of defects and other errors (Maleyeff et al., 2012; Timans et al., 2012). This integrated approach (i.e., LSS) provides a comprehensive framework that combines rigorous data analysis with effective process improvement methodologies, leading to significant enhancements in efficiency, reduction in waste, and overall improvement in quality and operational performance (Arnheiter & Maleyeff, 2005; Salah et al., 2010).

Due to the positive impact of LP/LSS, there has been growing interest in the continuous improvement literature to understand LP/LSS in public sector context. (Rodgers & Antony, 2019) surveyed the literature on continuous improvement methodologies in public sector organizations between 2000 and 2017. Their results revealed a growth in publications, especially between 2011 and 2017, for which about 60% of the final paper set used Lean alone. The suitability of LP/LSS in public sector organizations has likewise been discussed (Antony et al., 2017; Rodgers et al., 2019). The potential for the application of LP/LSS in LGOs is significant, given the diverse range of services they provide (Fletcher, 2018). The impact of LP/LSS in different functional areas within LGOs has been demonstrated through empirical evidence. One example is the implementation of LSS in a financial department of an LGO by Furterer and Elshennawy (2005), which resulted in reduced processing time, improved standardization, and reduced instances of human error. Antony et al. (2019) found that the use of LSS in policing services can create cost effective processes, boost employee morale, and improve workforce engagement. Alrezq and Van Aken (2022) conducted a comprehensive analysis of the literature on LP/LSS in LGOs and characterized the reported benefits into 31 unique outcomes that were grouped into process/operations, employees, organization, and customer. Studies often refer to the term “public

sector" as a combination of different sector types, such as federal/national government, local government, healthcare, and higher education, or particular functional areas, such as fire services, emergency services, police, and social welfare (Drotz, 2014; Fryer et al., 2007; Mitchell, 2011; Sreedharan et al., 2018); however, this study focuses on local government organizations (LGOs) as the primary unit of analysis.

LGOs represent a locally authorized government organization that is responsible for monitoring and serving the public within a specified territory (López et al., 2020; Sikander, 2015). LGOs are the most dynamic, innovative, and organizationally diverse level of government. LGOs employ more people, offer more direct services, and serve as the primary point of contact between the government and the public (Newell et al., 2004). In the U.S., LGOs account for significant expenditures and employment. There are roughly 90,500 LGOs in the U.S., employing about 19.7 million (over 6% of the population) with an expenditure of $1.3 trillion (Grundy, 2020; Urban Institute, n.d.). Recent studies revealed that about 27 U.S. states have employed LP/LSS approaches, or more generally, continuous improvement initiatives (Kim, 2022). For example, the state of Arizona developed a continuous improvement program in 2012 to deliver more efficient and effective operations statewide (https://results.az.gov/). Their recent fiscal report highlighted many benefits of LP utilizations across functional areas, including up to $7 million in rental savings; a 32% increase in the job market; an 80% reduction in waiting times for food, medical, and cash assistance; and a 72% reduction in fingerprint clearance processing time (Belec et al., 2022).

While LP/LSS has the potential to positively impact problems experienced by LGOs, there are numerous challenges that may prevent the realization of the full potential and anticipated results of this approach. These challenges are referred to as Critical Success Factors "CSFs" in this

study. According to a survey from 2008, about 74% of manufacturing organizations in the U.S. were struggling with LP or not meeting their expected objectives. Albliwi et al. (2014) argued that failures experienced in organizations were not due to weaknesses in the continuous improvement methodology but, rather, due to a lack of considering the CSFs. Thus, clarifying the CSFs for LP/LSS in LGOs is a vital way to potentially maximize the success of this methodology. Further, based on an analysis conducted by Alrezq and Van Aken (2022), there was a great need to more completely identify the CSFs for this research area (LP/LSS in LGOs). Studying CSFs has long been a topic of interest among researchers and practitioners (Netland, 2016). Rungasamy et al. (2002) defined CSFs as "those factors essential to the success of any program or technique, in the sense that, if objectives associated with the factors are not achieved, the application of the technique will perhaps fail catastrophically" (p. 218). CSFs from a LSS perspective could thus be seen as a core set of variables that must be considered during implementation, otherwise, the implementation process might encounter challenges and fail to meet the expected goals (Albliwi et al., 2014).

The purpose of this study is to identify and examine CSFs for LP/LSS in LGOs using a systematic literature review (SLR) (Tranfield et al., 2003). An SLR is a systematic and rigorous search protocol that follows a sequential series of steps that analyze studies from various sources to address questions of interest. This methodology has been utilized within the field of engineering management to analyze and synthesize existing research on various topics, such as Kaizen events (Glover et al., 2014), supply chain (Lehyani et al., 2021), augmented reality (Nelson & Keathley, 2021), and engineering team performance (Hindiyeh et al., 2023). Previous research has identified SLRs as an emerging advanced methodology in the engineering management field (Keathley et al., 2016). Therefore, this study contributes to the systematic literature review in engineering

management by investigating the CSFs for LP/LSS within the LGO context. Moreover, this investigation provides a comprehensive set of CSFs that should improve practice and enable engineering managers to understand pivotal areas that potentially maximize the successful implementation process of LP/LSS. Furthermore, this study also encourages engineering management researchers to adopt this set of factors and study their significance to relevant organizations with similar characteristics.

3.4 Research Methodology

An SLR is a well-structured methodology that acquires published evidence from various sources or platforms (Cook et al., 1997; Higgins & Cochrane Collaboration, 2019). For this study, the SLR process was adopted from Tranfield et al. (2003) and consisted of five steps: problem definition and research questions, scoping study papers, search strategy, exclusion criteria, and analysis of findings. The following sections describe each step.

3.4.1 Problem Definition and Research Question

Alrezq and Van Aken (2022) identified the need to extract, characterize, and define the CSFs for LP/LSS in LGOs. Therefore, this study was aimed at understanding this research area by characterizing a comprehensive set of CSFs concerning LP/LSS in the LGO context, with the goal of aiding these organizations in effectively improving their processes. Therefore, the research questions developed for this study are as follows:

R.Q.1 What are the critical success factors that contribute to the effective development and implementation of LP/LSS in LGOs?

R.Q.2 To what extent do these CSFs manifest in other organizational settings?

R.Q.3 How are these CSFs interrelated?

The final set of publications (identified through the SLR) was utilized to extract and identify a comprehensive list of CSFs. Next, this set of factors was compared with other factors experienced in other organizational types. This was followed by the development of a co-occurrence network to understand the interrelationships among the factors, based on the final set of papers.

3.4.2 Scoping Study Papers

Past studies on this subject area were used to develop a suitable set of scoping study papers (Alrezq & Van Aken, 2022). In addition, a traditional literature review was undertaken to identify empirical publications that were focused on LP/LSS in LGOs and reported or discussed relevant factors. Informed by previous studies, this SLR process began with an open search for scoping study papers. This process yielded nine scoping study papers: Bakar et al. (2017), Fletcher (2018), Franchetti & Barnala (2013), Kregel & Coners (2018), Kumar & Bauer (2010), Madsen et al. (2017), Pedersen & Huniche (2011), Suarez Barraza et al. (2009), Tortorella et al. (2018). These nine empirical scoping papers ultimately focused on LP/LSS and discussed the CSFs associated with this improvement methodology, which provides insight into the advancement of this research area and how the CSFs have been reported in the literature. These scoping papers were also used to shape the development of the initial search concepts (i.e., search terms for this study).3.4.3 Search Strategy

After the scoping study papers were identified, an initial set of the most common terms used in the literature were collected. Thus, three search concepts consisting of three categories (i.e., LP/LSS, LGOs, and CSFs) were developed (see Exhibit 1). The first search concept (see Category 1 in Exhibit 1) is a pool of synonymous terms related to the improvement methodology (i.e., LP/LSS) used with this study. A total of 20 search terms were compiled that included different terms widely used in scientific publications. These 20 terms included 15 terms related to LP, while

five terms were relevant to the integration (i.e., LSS). A Kaizen term was also added as it is a common LP-based practice (Van Aken et al., 2010). The second search concept (presented in Category 2 in Exhibit 1) consisted of search terms related to LGOs. This category included a total of 20 terms. The high number of derivative search terms in this category could be interpreted as revealing the lack of consistency among researchers in studying and contributing into this area. Thus, it may indicate a lack of maturity in this research area. Further, the term "public administration" was also used to expand the search and capture studies that refer to LGOs as public sectors (as described in the introduction). The third search concept focused on terminologies and synonyms of CSFs. In addition to the scoping study papers, other studies that focused on CSFs in different areas, such as continuous improvement and performance measurement systems (e.g., Gonzalez Aleu, 2016; Keathley-Herring, 2016), were reviewed to develop a robust set of CSFs. Thus, 25 synonymous terms of CSFs were collected (see Category 3 in Exhibit 1). In this study, the search strategy was designed to be sensitive rather than precise. This determination is helpful to maximize capturing relevant publications despite the probability of getting more non-related studies (Higgins & Green, 2008).

Once the search terms for the three categories were developed and finalized, they were executed in four platforms: ProQuest, Web of Science, Scopus, and Engineering Village. These four platforms were selected due to their popularity in covering a wide range of publications that include journal publications, conference proceedings, and theses/dissertations. Multiple testing of the three search concepts were evaluated in the finalized platforms to adjust and maximize the search efficiency in capturing relevant studies. The first search category was executed to search through title, abstract, and keywords defined by the authors. This execution sharpens the functionality of the search engine to bring publications with a primary focus on LP/LSS. The

second and third categories, on the other hand, were adjusted to be searched throughout the full text. Due to the high variations in terminologies used for LGOs and CSFs, this setting supports this study in capturing publications that not only mentioned or used the search terms in title, abstract or keywords, but also throughout the body of publications. The Boolean operator "OR" and "AND" were also implemented. The former was utilized to retrieve studies containing any terms spread by the operator, while the latter was used across the three categories to capture all papers containing the three search terms. The capture rate is a common assessment used with SLR studies to ensure the robustness of a search setting or strategy and it has been demonstrated in SLR studies, such as Gonzalez Aleu & Van Aken (2016). Capture rate evaluates how efficient and reliable a search setting is in obtaining the most relevant papers by evaluating the rate of captured scoping study papers. Therefore, the search strategy developed for this study was able to capture the nine scoping study papers, resulting in a 100% capture rate.

Table 5 (Exhibit 1, Manuscript #2) Systematic Literature Review Search Protocol

Concept	**Description**
LP/LSS	**Category 1**: Lean sigma, lean six sigma, LSS, lean, lean system, lean management, lean thinking, lean production, lean manufacturing, lean enterprise, lean operation, toyota production system, TPS, Lean office, L6S, kaizen, lean kaizen, lean-kaizen, L6σ, and LP
LGOs	**Category 2**: Municipality, local government, local council, municipal government, town government, county government, state government, city government, governmental operation, municipality sector, local authority, city council, municipal council, district council, town hall, city office, local government office, local government council, legal sector, and public administration
CSFs	Category 3: barrier, obstacle, difficult, challenge, enabler, constrain, success, critical success factor, indicator of success, hurdle, pitfall, success factor, blockage, impediment, determinant, inhibitor, CSF, fail, issue, factor affecting, limit, critical success, affect, determinant factor, and supporting factor
Platform	ProQuest, Web of Science, Scopus, and Engineering Village

Boolean operators	Boolean operators OR within each search concept (e.g., Lean production OR lean six sigma); AND across the three search concepts (i.e., Lean production AND local government AND barrier)

3.4.4 Exclusion Criteria

Once the search concepts and search strategy were finalized, the four platforms were used to identify relevant publications to the scope of this study. The initial results yielded a total of 8,454 raw results. This study developed strict exclusion criteria (a total of 13 exclusion criteria in Exhibit 2) that only considered empirical studies focused on LP/LSS in LGOs and discussed CSFs. Thus, the raw results were examined against the exclusion criteria developed for this study (see Exhibit 2). To process the raw results, two exclusion criteria (i.e., non-academic and non-English written publications) were applied at an early stage of the SLR process followed by a third criterion (i.e., duplicates). Thus, 5,615 non-academic and non-English written publications were eliminated followed by a further elimination of 375 duplicates. After applying the initial limitations, 2,464 publications were further evaluated against the remaining exclusion criteria (exclusion criteria 5-13 in Exhibit 2).

Table 6 (Exhibit 2, Manuscript #2) Exclusion Criteria Developed for this Study

	Exclusion Criteria	**Publications Removed**
1	A publication not academically focused and not written in English	5,615
2	Duplicate (within or across platforms)	375
3	A publication not directly related to the scope of the study	1,568
4	A publication not accessible	1
5	A publication discusses LGOs without directly studying an improvement methodology	134
6	A publication discusses an LGO, but LP/LSS were not the improvement methodology of focus	7
7	A publication discusses LP/LSS in other types of organizational settings (e.g., healthcare, manufacturing, etc.)	599
8	A publication discusses LP/LSS on an LGO, but CSFs are not sufficiently addressed	21

9	A publication discusses the literature on LP, SS, LSS for trends, issues, and proposing frameworks	88
10	A publication discusses LGOs but LP/LSS is not sufficiently the focus	15
11	Duplicate publications (a conference proceeding published in a journal outlet with no additional findings)	1

The next exclusion criterion eliminated non-related studies to the subject of interest. That is, a total of 1,568 publications were removed. This is the largest number of items excluded compared to other exclusion criteria, with approximately 63% (out of 2,464) of publications being removed. The appearance of a high volume of non-relevant studies is due to the sensitive search strategy used and the diverse number of search terms. It appears that some search terms were usually used in other fields with different meanings. For example, the term "lean" has a corresponding use with different meanings in chemical processes and agricultural studies. Similarly, the abbreviations of LSS and TPS refer to, for example, library schools and traditional public schools, respectively. Next, although the researchers utilized different sources (e.g., open platforms, such as Google Scholar and a school library system) to obtain non-accessible full text, one publication was excluded based on the fourth exclusion criterion. The fifth and sixth exclusion criteria identified publications that focused on LGOs as the primary focus, but with no improvement methodologies described or used other improvement methodologies (such as Total Quality Management and Six Sigma). Thus, 134 and 7 publications were eliminated, respectively. Next, the seventh exclusion criterion eliminated studies that focused on improvement methodologies but centered primarily on other types of organizations (e.g., manufacturing and healthcare). This exclusion criterion eliminated 599 studies. The eighth exclusion criteria identified 21 publications that were removed as they did not sufficiently address CSFs as a central topic. Ninth, the search terms developed for this study involved commonly-used terms in literature related to this subject area. Thus, the search strategy retrieved publications that studied this improvement methodology, such as reviewing literature for trends, issues, and developing frameworks. Therefore, 88 publications were excluded. The tenth exclusion criterion removed 15 publications that discussed LGOs but in which LP/LSS was not sufficiently the improvement methodology of focus. Finally, two identified

publications in the set were found to be similar, as a conference proceeding (Jaaron & Backhouse, 2010) was extended to a journal paper (Jaaron & Backhouse, 2011). As a result, to avoid duplicating results, the journal publication was considered in this study. The final set of excluded studies is summarized in Exhibit 2.

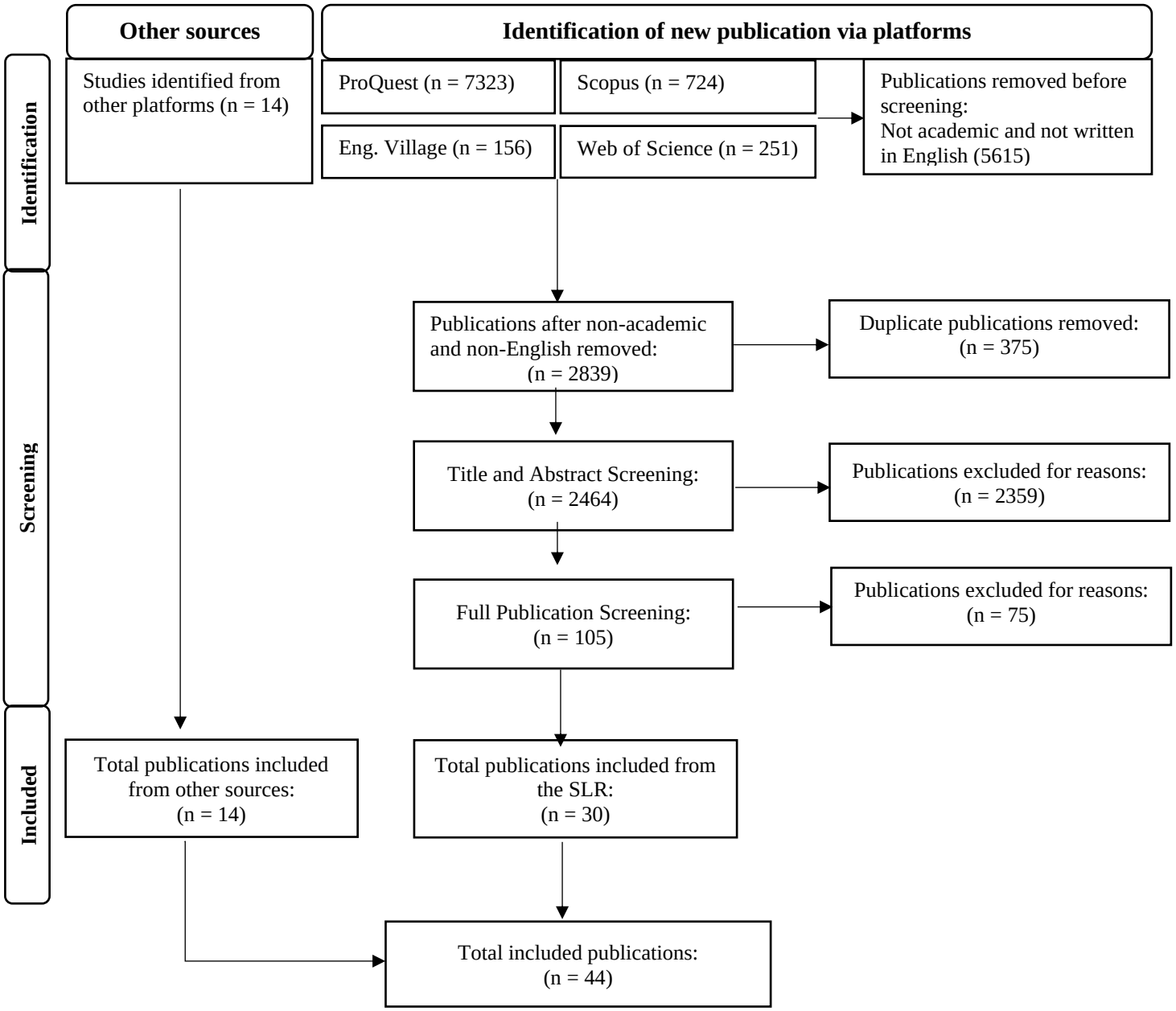
In total, this SLR process yielded a final publication set of 30 studies (a list of these publications is available upon request from the authors) that were used in the final pool for the analysis. An SLR as a research methodology is often limited to the search concepts and terms used and mechanisms selected to locate the relevant studies. This limitation is widely acknowledged in literature across different research areas (Emiliano de Souza et al., 2022; Nelson & Keathley, 2021). Further, this limitation may also omit relevant publications for analyzing a research area or field. To address this limitation and maximize the final pool for this study, other relevant publications from other platforms—such as Google Scholar, ResearchGate, and Academia—were further investigated. Publications that align with the goal of this study (i.e., specifically those empirically designed with a focus on LP/LSS in LGOs and offered sufficient discussion on the CSFs) were selected. This additional search resulted in identifying 14 papers that were added to the final pool. That is, the final set of papers used in this study included 30 publications from the SLR and 14 papers from other sources, for a total of 44 publications (see Exhibit 3). The flow of this SLR can be divided into four main steps: acquiring the raw results, applying the initial exclusion criteria, screening titles and abstracts, and reading full text. Exhibit 3 is a PRISMA flow chart that demonstrates the steps of this SLR process.

3.4.5 Analysis of Findings

The last step of the SLR process is referred to as the analysis of findings. Thus, the results and discussion section provide a detailed analysis of the final publication set (44 publications). The analysis sections began by assessing the evolution of the final publication set to understand how this research area is emerging.

Subsequently, the focus shifts to the CSFs, with the analysis divided into four subsections: firstly, detailing the use of Thematic Analysis for extracting the CSFs; secondly, discussing the CSFs identified in this research area; thirdly, comparing these CSFs with factors reported in other sectors; and finally, employing network analysis to examine the interrelationships among the CSFs.

Figure 10 (Exhibit 3, Manuscript #2) PRISMA Framework of the SLR Process Developed for this Study

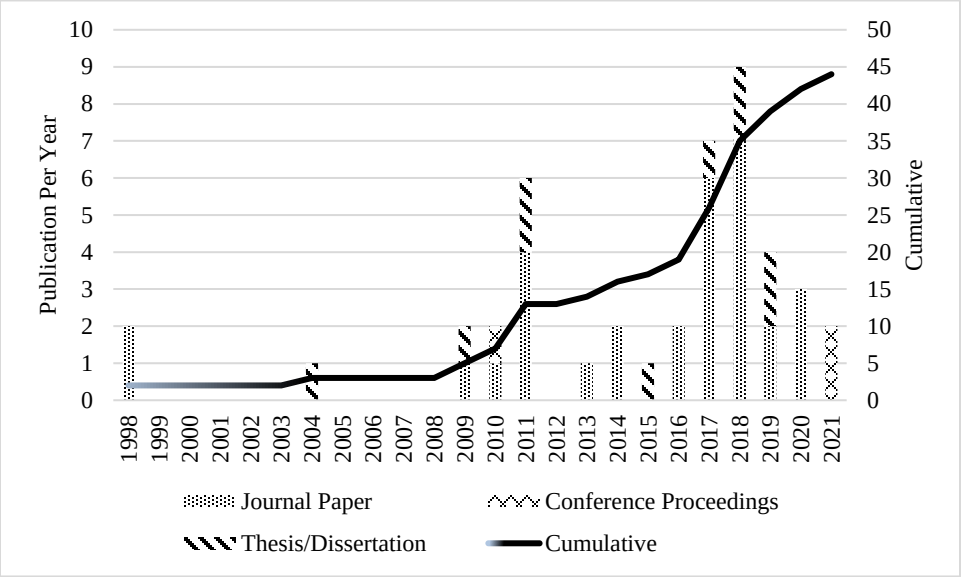


3.5 Results and Discussion

3.5.1 Publications Trends

Studying year-wise publication helps to understand how this research area is advancing and how it attracts the interest of scholars. The final set included empirical publications that ranged between 1998 to 2021 (see Exhibit 4). Furthermore, the publication set is composed of 31 journal publications, three conference proceedings, and ten theses/dissertations. Based on the captured studies, there is an overall increased trend, especially in the last few years (2017 and onward). Furthermore, the number of publications in the last five years represents 57% of the total publications set (or 25 out of 44 publications). This recent increase might suggest that this research area is not saturated yet, and that there are still areas of opportunities to contribute. Another interpretation of this growing trend is that academics and practitioners may have recognized the importance of developing and implementing LP/LSS in handling challenges for major improvement at operational and organizational levels within LGO settings. Finally, the literature revealed that the emergence of this methodology in public sectors (including LGOs) started around 2000 (Andersson et al., 2020; Yuksel & Yuksel, 2010); thus, Exhibit 4 depicts a clear summary of the overall evolution of this research in the last two decades.

Figure 11 (Exhibit 4, Manuscript #2) Number of Publications Per Year



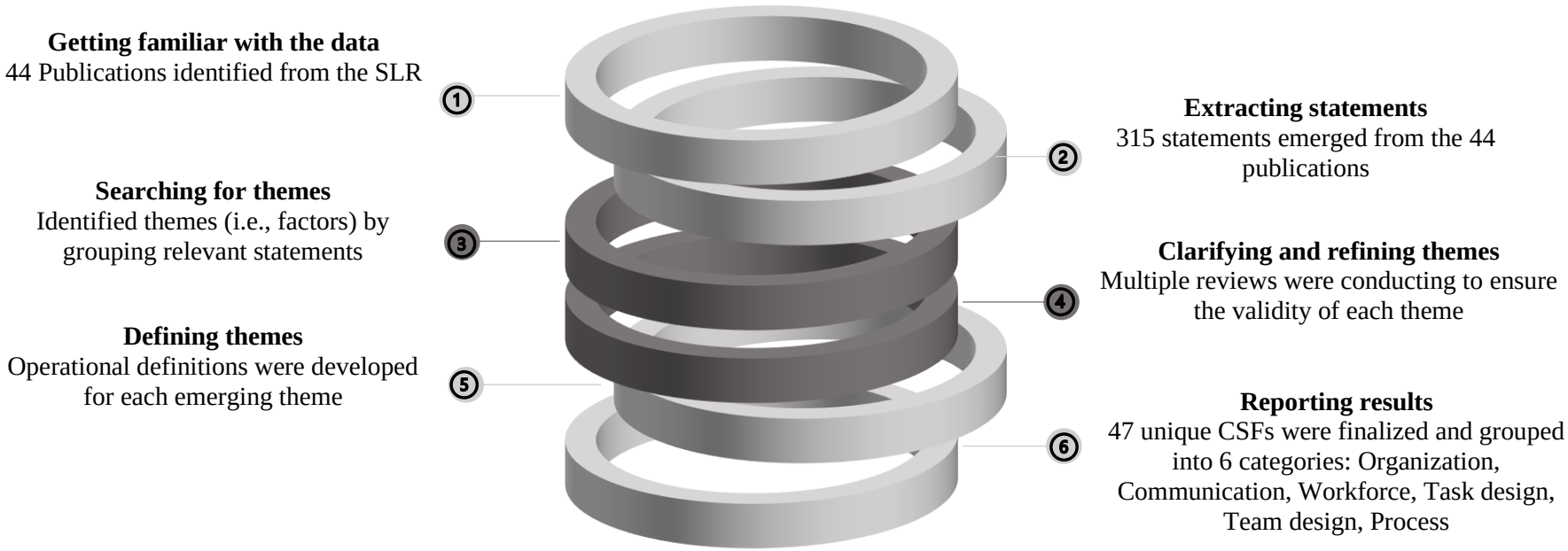
3.5.2 Thematic Analysis for the Critical Success Factors Identification

To conduct a structured process for extracting the CSFs, Thematic Analysis (TA) was adopted from Braun and Clarke (2006). TA is a method used to analyze and report themes within qualitative data (Braun & Clarke, 2006). The process of TA includes six steps: getting familiar with the data, extracting and developing initial codes (or statements), searching for themes, clarifying and refining themes, defining themes, and reporting results (Braun & Clarke, 2006).

To begin the process, the first step is to get familiarized with the data set. The data set in this case was the final paper set captured from the SLR (i.e., 44 empirical publications). This step was accomplished through reading the full publications during the SLR screening process. The following step was to extract the initial CSFs statements. An in-depth review of the final set was made, in which each paper was read in detail and the relevant statements were extracted accordingly. Within this step, only factors that were mentioned in the findings, results/discussions, and conclusions sections were identified and counted once, regardless of whether they had a positive or negative orientation. The third step was to search for themes among the extracted

statements. Thus, the researchers developed potential themes (i.e., factors) by clustering the relevant statements guided by previous research (Alrezq, 2020). The fourth step was to clarify any disagreement with the themes. Studies varied in terms of discussing and reporting the CSFs with the same meaning. This might be due to the low maturity level in this research area. Therefore, multiple reviews were conducted to ensure the validity of each statement to their corresponding themes (i.e., factors). This process is in alignment with the recommendation by Braun and Clarke, (2006) in which the process of TA is "not a linear" but instead a "recursive process" (p. 86). Once all statements were placed in their relevant themes (i.e., factors), an operational definition for each theme was developed in the fifth step. Grouping relevant CSF statements in one place helped reveal how a given factor was reported and discussed in the literature with different terms so that an appropriate operational definition was developed. Further, factors were operationalized using a neutral orientation to avoid duplication. The last step was to report the final findings about the emerging themes (i.e., the CSFs). Exhibit 5 depicts a summary of the six steps used for the TA process to identify the CFSs from the final paper set.

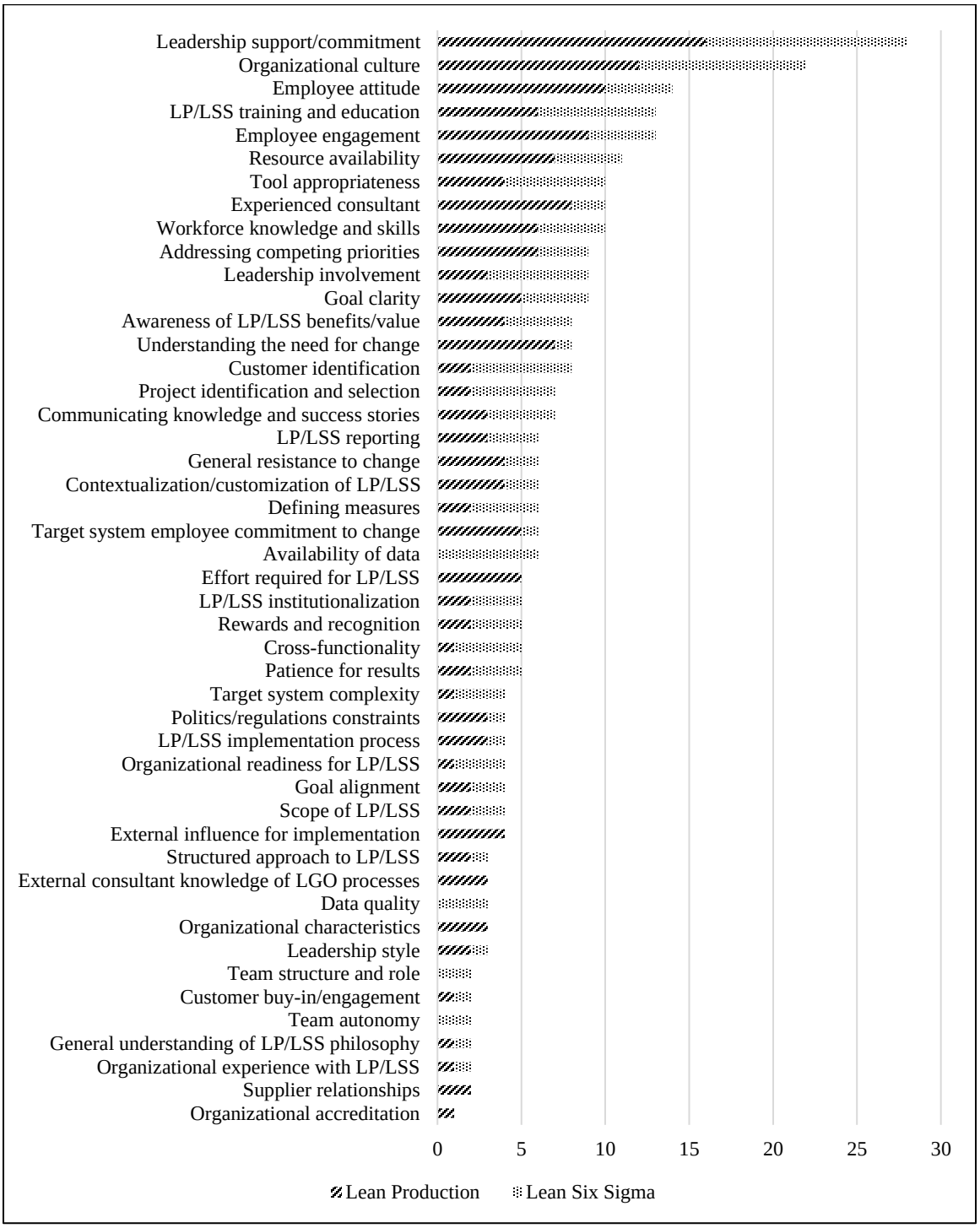
Figure 12 (Exhibit 5, Manuscript #2) Thematic Analysis Steps for CSF Identification



3.5.2.1 Critical Success Factors Identified for LP/LSS in LGOs

After completing the TA, 315 statements were compiled and clustered based on their relevance to the appropriate CSFs. That is, the 315 statements were clustered into 47 unique CSFs (see Exhibit 6). Due to the high number of factors identified from the literature, factors were further grouped into five main categories (see Exhibit 9). These categories - in descending order - were: organization (21 factors or 44% of the total factors), process (11 factors or 23%), workforce knowledge and skills (5 factors or 11%), communication (4 factors or 8.5%), task design (4 factors or 8.5%), and team design (2 factors or 2.4%). The operational definition of each CSF is shown in Exhibit 9. The CSF extraction process was qualitative in nature. Qualitative data analysis is limited by subjectivity due to researcher bias, which is often a concern in qualitative data analysis. Therefore, to mitigate the effect of this subjectivity, multiple steps were taken that included working in iteration to continuously evaluate and refine the analysis and conducting regular meetings with the research team to review the results and resolve any disagreement. These steps strengthened the validity of the final set of factors and minimized any effect of bias. In the following sections, the CSFs identified were further analyzed and discussed using three criteria. First, the frequency of factors based on the literature was investigated, followed by a discussion of the five most frequent factors, after which a social network analysis was developed to investigate the interconnections among the factors.

Figure 13 (Exhibit 6, Manuscript #2) Frequency of Critical Success Factors in the Literature for LP/LSS Success in LGOs



Due to the broad set of factors identified from the literature, the frequency of factors was used to analyze the final set. Frequency is a commonly-used metric to gain insights into factors that are most often reported in the literature (e.g., Gonzalez Aleu & Van Aken, 2016). Based on evidence obtained from the literature, the frequency of CSFs ranged from a minimum of 1 to a maximum of 28; thus, on average, each paper identified approximately seven CFSs (or 2.2% out of 315 statements). The most frequent CSFs identified from the literature - in descending order - were: *leadership support/commitment* (with a frequency of 28 across the 44 papers, representing 64% of the final set), *organizational culture* (frequency of 22), *employee attitude* (frequency of 14), *LP/LSS training and education* (frequency of 13), and *employee engagement* (frequency of 13). The two highest factors (i.e., *leadership support/commitment* and *organizational culture*) were consistent with previous studies as being among the top ranked and most important factors across different improvement approaches (Laureani & Antony, 2012) - such as Six Sigma (Antony & Banuelas, 2002) and Total Quality improvement (Aquilani et al., 2017) - and in different service organizational types - such as healthcare (Swarnakar et al., 2021), financial, and educational institutions (Antony et al., 2012). Previous studies have recognized these two as potentially predominant in a wide spectrum of change initiatives (Dempsey et al., 2022; Fernandez & Rainey, 2006; Oakland & Tanner, 2007).

3.5.2.2 Top Five CSFs Emerged in this Research Area

Studies have emphasized the critical importance of *leadership support/commitment* due to the power and authority leaders have in managing change (Sony et al., 2019). Snee (2010) affirmed that *leadership support/commitment* should focus on supporting improvement through eliminating obstacles, allocating resources, reviewing progress in a continuous manner, and recognizing the efforts and contributions of involved parties. Despite the importance of this factor, LGOs often

suffer from leadership change (i.e., leadership appointment through elections) that may limit top-level ownership and impact LP/LSS efforts (Kuvvetli & Firuzan, 2019; Suarez Barraza et al., 2009).

The second most frequent factor identified in this research area was *organizational culture*. LP/LSS should not be seen only as a set of tools and techniques but instead as a shifting in mind-set and striving for creating a culture of continuous improvement for long-term sustainability (Alnadi & McLaughlin, 2021). Thus, it is vital to align LP/LSS with the *organizational culture* to sustain successful LP/LSS (Paro & Gerolamo, 2017). However, when LP/LSS takes place in an organization, it is often a challenge to identify measurable parameters to evaluate how close a given organizational culture is to an ideal lean culture (Paro & Gerolamo, 2017). Thus, studies have developed various models - such as the Competing Value Framework (CVF) that includes four types of organizational culture: Clan, Hierarchal, Adhocracy, and Market cultures (Cameron & Quinn, 2011) - to measure and understand an organization's culture. Gityforoze (2018), for example, empirically studied the relationship between three factors (i.e., senior management support, the use of statistical methodology, and LSS infrastructure) and the four types of organizational culture (i.e., CVF) in an LGO. The outcomes of this study confirmed a strong relationship between the three factors and one of the organizational culture types (i.e., Clan culture). Clan culture can be described as a climate in which collaboration or sense of togetherness, loyalty, commitment, and communication are valued (Gityforoze, 2018; Lee et al., 2021). Despite the limitations with Gityforoze's (2018) study, some lessons can be gleaned. For example, the results showed a relationship between senior management support and organizational culture (i.e., Clan culture). This suggests that leadership is essential in creating a supportive and open culture for LP/LSS. The culture of LP/LSS is best supported by leaders showing a genuine interest,

establishing a climate of open communication, and supervising and acting on key goals (Alnadi & McLaughlin, 2021; Gityforoze, 2018). Further, creating a continuous improvement culture entails empowering employees for improvement and waste elimination (Poksinska et al., 2013); thus, treating mistakes as opportunities for improvement is essential to support LP/LSS success (Alnadi & McLaughlin, 2021). It is not surprising how Leadership support/commitment and Organizational culture are highly interconnected (as further described in the network analysis section) due to how frequently they are mentioned in continuous improvement and change management literature. However, more empirical investigation could be conducted on cultural components that support LP/LSS success in LGOs.

Next, *employee attitude* was recognized as the third most frequent CSF in this research area. In general, attitude toward change encompasses an individual's cognition about change, affective reactions to change, and behavioral tendency toward change (Vakola & Nikolaou, 2005). Scholars have characterized employee attitude (or response) toward change into positive attitudes (i.e., strongly supportive of change and considering it essential for organizational success) and negative attitudes against change (Piderit, 2000). Thus, change might be received by employees as an opportunity with excitement or with anger and fear (Vakola & Nikolaou, 2005). To manage change, employees should be influenced in a way that creates enthusiasm and acceptance (Allaoui & Benmoussa, 2020). For example, Ainul Azyan et al. (2017) studied two private organizations that utilized LP and compared how one outperformed the other in terms of influencing employees' attitudes toward LP through setting regular meetings for sharing ideas and feedback. Employees are an essential asset for LP/LSS journey; thus, negative attitudes toward this improvement methodology should be addressed to determine their root causes and eliminate their effects (Allaoui & Benmoussa, 2020).

LP/LSS training and education emerged as the fourth most frequent factor. Several studies have discussed its significance on the overall success of LP/LSS (Antony & Banuelas, 2002; Glover et al., 2014; Singh & Rathi, 2021). Given the role this factor plays, studies have revealed that training is better accomplished through a project-based approach rather than traditional classes and exercises (Montgomery, 2016; Snee, 2010). This type of training strategy may include a simple improvement initiative to help trainees be technically oriented on how to utilize LP/LSS tools and techniques in real practice (Montgomery, 2016). This approach may potentially lead to a number of benefits, including immediate results to the business, trainees taking real-world projects more seriously, and improving training components by aligning them to the organization's priorities (Snee, 2010). LP/LSS training and education within LGOs was addressed as a solution of many obstacles and challenges; therefore, it helps in disseminating skills and capabilities among people to support the success of this improvement approach (Dey, 2014; Furterer, 2004; Kumar & Bauer, 2010).

Finally, the fifth most common CSF was *employee engagement*. Operations management literature has proposed that the success of improvement methodologies (e.g., Total Quality Management, Just-in-Time, etc.) depend on employee engagement (Marin-Garcia & Bonavia, 2015). Continuous improvement literature has likewise emphasized the vital role this factor plays in successful outcomes (Alhuraish et al., 2017; Marin-Garcia & Bonavia, 2015; Vadivel et al., 2021). Employees are the ones who make continuous improvement happen; thus, through participation, employees can further understand the nature of organizational problems and develop appropriate solutions (Teimouri et al., 2016; Zu & Fredendall, 2009). Further, employee engagement in decision-making increases knowledge about the core problem and helps define and prioritize solutions that improve efficiency, job satisfaction, and overall organizational

commitment (Teimouri et al., 2016). Engagement also provides employees with different competitive advantages, such as decreasing the ambiguity of their role, a sense of empowerment, communication between departments, and mitigating culture resistance (Alhuraish et al., 2017; Antony et al., 2021). In addition, LGOs have experienced the importance of employee engagement through participation in decision-making and performing LP/LSS activities (Gityforoze, 2018; Jaaron & Backhouse, 2011; Suarez Barraza et al., 2009).

While this research area has identified the five most frequent factors, there are other less frequent yet crucial factors for LP/LSS, such as *customer identification, organizational experience, target system complexity, external consultant knowledge of LGO processes, patience for results, politics/regulations constraints,* and *contextualization/customization of LP/LSS*. For example, organizational experience with other quality improvement programs (e.g., TQM and SS) potentially contribute to a successful implementation due to their capabilities and commitment to change (Juliani & de Oliveira, 2021; Psychogios et al., 2012). Snee (2010, pp. 9–10) argued that "Each approach builds on previous approaches adopting the effective aspects of previous approaches and adding new concepts, methods and tools to remove limitations that have been identified." A foundational principle of LP is the specification of value (Womack & Jones, 2003), with this value being defined by customer desires, a concept emphasized by Radnor et al. (2006). This requires the identification of customers to accurately understand their perceived value. In most of LP/LSS initiative, customer identification is essential for undertaking actions that create value and ensure customer satisfaction (Abaidoo & Blankenberger, 2022). However, in the context of LGOs, this task of customer identification is challenging due to the diversity of stakeholders and the wide range of services involved (Kumar & Bauer, 2010; Price et al., 2018). Addressing the complexity of target systems is another crucial factor related to LP/LSS implementation. This

involves an in-depth understanding of workflow and interdependencies. Often these organizations face a complex environment and value creation to a broad spectrum of stakeholders (Price et al., 2018). Thus, Radnor (2010) highlights the significance of systems thinking in public services, emphasizing a holistic approach rather than focusing on individual process segments. This approach is particularly important in service organizations where human elements play a pivotal role in engaging their knowledge to drive process improvement. In the implementation of LSS within local government organizations, patience for results is another key fundamental factor when embracing a new culture, such as continuous improvement. Literature suggests that setting realistic expectations for results early in the establishment of a continuous improvement culture is crucial (Alosani, 2020; Ingelsson & Bäckström, 2017). Dey (2014) highlights that transforming an organization through LP/LSS demands patience over an extended period. Hence, when implementing this methodology, it is essential to allow sufficient time for systems/processes to yield the expected results. This patience not only applies to waiting for outcomes but also in developing an employee mindset that integrates LP/LSS principles and tools/techniques into daily activities.

3.5.2.3 Comparing the Critical Success Factors Across Sectors

The CSFs identified in this area (i.e., LP/LSS in LGOs) were further compared and contrasted to the factors found in other application domains to gain insight into which factors are more commonly represented across different organizational sectors. This comparison was not intended to be comprehensive but was conducted simply to understand what factors are consistently viewed as more important. Therefore, four studies that focused on identifying CSFs in two different sectors were selected (see Exhibit 7). Selection criteria were determined by the studies' focus on organizational-level analysis and their documentation of CSFs. The sectors included

manufacturing (Albliwi et al., 2015; Robertsone et al., 2021) and healthcare (Jain & Ajmera, 2019; Patri & Suresh, 2018),. The studies focused on identifying factors for LP/LSS.

Table 7 (Exhibit 7, Manuscript #2) Comparison of Critical Success Factors Across Sectors

CSFs related to LP/LSS in LGOs	**Manufacturing**		**Healthcare**	
	1	**2**	**3**	**4**
Leadership support/commitment	√	√	√	√
Organizational culture	√		√	√
Employee attitude		√		√
Employee engagement	√		√	√
LP/LSS training and education	√	√	√	√
Resource availability	√	√		√
Goal clarity			√	√
Awareness of LP/LSS benefits/value		√		
Communicating knowledge and success stories				√
Project identification and selection		√		
Defining measures	√			
General resistance to change			√	
Cross-functionality			√	√
Rewards and recognition	√			
Effort required for LP/LSS		√	√	
Target system complexity	√			
General understanding of LP/LSS philosophy	√			

Note: the numbers refer to the following sources: (1) Robertsone et al. (2021), (2) Albliwi et al. (2015), (3) Patri & Suresh (2018), (4) Jain & Ajmera (2019)

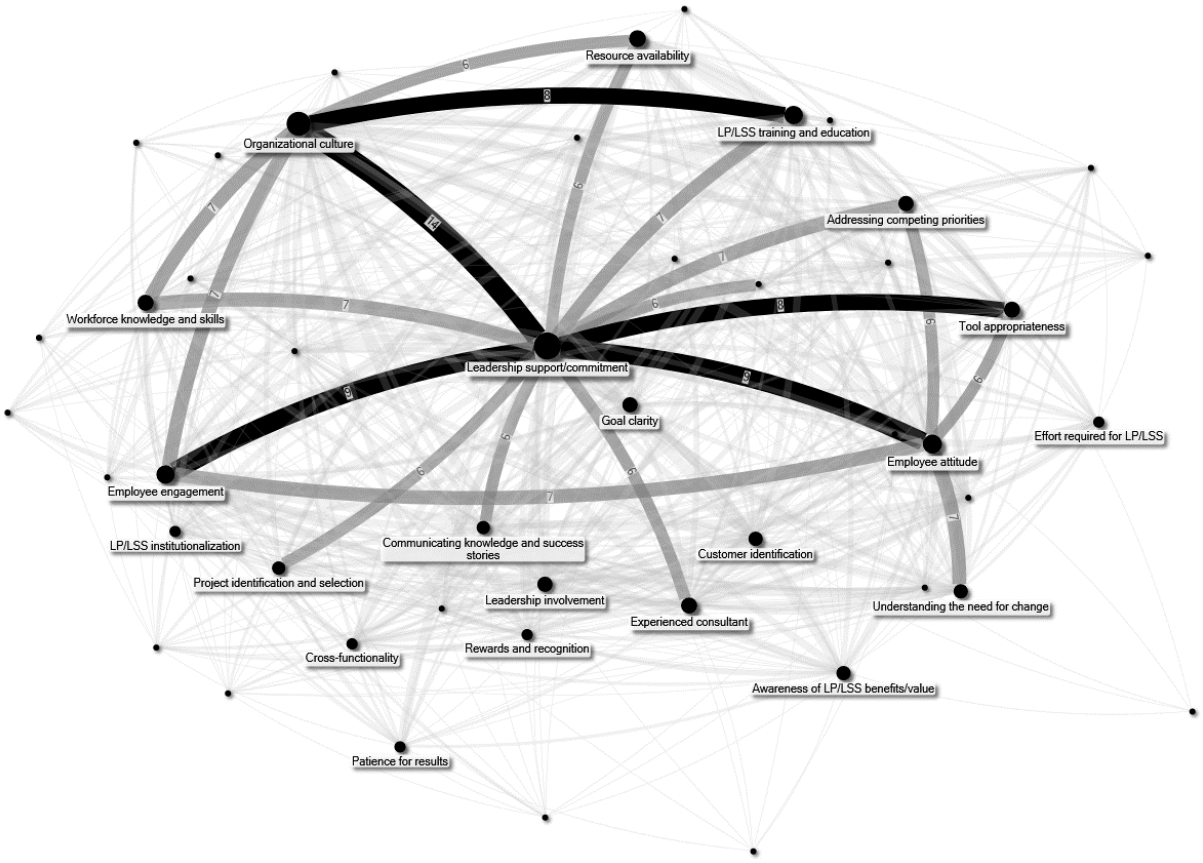
Out of the 47 factors identified for LP/LSS success in LGOs, 17 factors (or 36% of the 47 factors) were reported in the selected organizations (see Exhibit 7). The top factors that emerged were Leadership support/commitment, Organizational culture, Resource availability, and LP/LSS training and education. Leadership support/commitment and Organizational culture (as discussed previously) commonly influence the success of any initiative or change, including LP/LSS. LP/LSS training and education and Resource availability were the next most observed across sectors. This could imply that any new change or initiative may require organizational members to be knowledgeable and skilled; thus, organizations must invest (financially and non-financially) in supporting people through training and education (Kokkinou et al., 2021). Due to the limitations

of this comparison review, some of the remaining factors might not be unique to LGO settings but are commonly reported with LP/LSS development and/or implementation, such as Project identification and selection, Goal clarity, LP/LSS reporting, and Cross-functionality.

3.5.2.4 Analysis of the CSFs Using Network Analysis

Due to the frequency of the CFSs and their co-occurrences across the studies captured in this SLR, it was crucial to investigate their connections. Therefore, a social network analysis - a software embedded in Excel template and developed by Social Media Research Foundation (Smith et al., 2009) - was used. The entire network visualization is presented in Exhibit 8. Each node (i.e., represented as a circle in Exhibit 8) depicts a factor, and the size of the node reflects the number of publications that discussed or reported a given CSF. Similarly, the vertices (i.e., the edges represented by lines) indicate two given factors were studied together, with thicker edges representing more frequent co-occurrences. The SNA produced 636 unique edges and 47 nodes. The thickness of the edge ranged between 1 and 14. The edges were further classified based on the edge's thickness into three groups: edges with a thickness of 5 or below represented 88% (or 323 out of 636 edges), edges with a thickness of 6–7 represented 2.3% (15 out of 636), and edges with a thickness of 8 or more represented 0.79% (or 5 out of 636). Due to the high connections among nodes, the network was colored for clarity: light silver (for edges with a thickness of less than 5), gray (for edges with a thickness between 6 and 7), and black (for edges with a thickness over 8). The network was also condensed so that nodes (i.e., factors) with a frequency of seven or more are presented.

Figure 14 (Exhibit 8, Manuscript #2) Network Analysis for Co-occurrence of CSFs



The network reveals insightful results that depict interesting connections among the factors. Based on the degree centrality (DC) - the number of connections a given factor has to other factors (Hansen et al., 2011) - the highest factors, in descending order, were: Leadership support/commitment (with a DC of 45), Organizational culture (44), Employee attitude (40), Employee engagement (40), Goal clarity (39), and Resource availability (38). While the top four factors (based on DC) had already appeared among the top five factors based on frequency in the literature, Goal clarity had not. Nevertheless, Goal clarity was the fifth most connected factor to others based on the DC. This reveals some of the advantages of utilizing different approaches (e.g., SNA) to analyze the interconnection among the CSFs and gain a sense of their influence on each other. Furthermore, the network articulates how factors were simultaneously discussed or reported

together. The highest co-occurrences were between Leadership support/commitment and Organizational culture (co-occurring in 14 papers). Past studies on quality improvement emphasized the influence of leadership on culture (Waldman et al., 1998); thus, successful leadership establishes a culture that supports and accelerates LP/LSS (Laureani & Antony, 2018). The high co-occurrences between these two CSFs suggest leadership is a fundamental factor for LP/LSS success through culture transformation. LP/LSS training and education was also connected to Leadership support/commitment (co-occurring in 7 papers) and Organizational culture (co-occurring in 8 papers). Therefore, one possible strategy to install an LP/LSS culture is through leadership support by building the necessary knowledge and skills through training and education. In addition, Employee engagement was connected to Leadership support/commitment (co-occurring in 9 papers) and Organizational culture (co-occurring in 7 papers). This connection among the three factors might suggest that the culture of improvement could be developed by leadership through Employee engagement. Employees are both process owners and experts who interact with the system (or targeted process). Therefore, engaging employees in decision making facilitates their participation and makes them feel their opinions and feedback are valued, which align with LP/LSS philosophy and principles (Jaaron & Backhouse, 2011; Suarez Barraza et al., 2009).

Table 8 (Exhibit 9, Manuscript #2) Critical Success Factors for LP/LSS Success in LGOs

Category	Factor	Operational definition	Frequency
Organization	Leadership support/commitment	Extent to which Leaders demonstrate commitment and buy-in for LP/LSS.	28
Organization	Organizational culture	Extent to which the organizational culture is open and supportive of LP/LSS philosophy and principles.	22
Organization	Employee attitude	Extent to which employees buy-in and accept LP/LSS.	14

Process	Employee engagement	Extent to which employees from areas targeted are involved and engaged in LP/LSS.	13
Workforce	LP/LSS training and education	Investing in and providing the education/training required to develop the workforce knowledge/skills needed to support LP/LSS.	13
Organization	Resource availability	The amount of financial and non-financial resources allocated to support LP/LSS, including money, people, equipment, etc.	11
Workforce	Workforce knowledge and skills	Extent to which people in the organization had adequate knowledge, skills, and competencies to support LP/LSS.	10
Workforce	Experienced consultant	Availability of an experienced professional (within or from outside the organization) with sufficient knowledge of LP/LSS to support facilitation, coaching, and implementation.	10
Process	Tool appropriateness	Extent to which the LP/LSS tools and techniques used for analysis and problem solving are appropriate.	10
Task design	Goal clarity	Extent to which the goals and aims of LP/LSS are clear and understood across the organization.	9
Organization	Leadership involvement	Extent to which leaders are involved throughout the development and implementation of LP/LSS.	9
Organization	Addressing competing priorities	Extent to which solutions are developed for other priorities that may compete with LP/LSS for resources and attention.	9
Task design	Customer identification	Extent to which customers of processes targeted for improvement are clearly identified.	8
Communication	Understanding the need for change	Extent to which a clear and compelling need for change is communicated throughout the organization.	8
Communication	Awareness of LP/LSS benefits/value	Extent to which the value and benefits associated with LP/LSS are clearly understood by those across the organization.	8
Communication	Communicating knowledge and success stories	Extent to which LP/LSS best practices and success stories are shared across the organization.	7
Organization	Project identification and selection	Identification, prioritization, and selection of specific LP/LSS	7

		initiatives/projects having the most benefit to the organization.	
Organization	Availability of data	Extent to which data needed to analyze and understand the targeted processes/systems are available.	6
Process	Target system employee commitment to change	Extent to which employees in areas targeted for LP/LSS commit to changes made to processes.	6
Organization	Defining measures	Extent to which relevant performance measures that track and monitor the progress of improvement are defined and implemented.	6
Process	Contextualization/customization of LP/LSS	Extent to which LP/LSS tools and techniques are customized and adapted to fit and align with the organizational context.	6
Organization	General resistance to change	Extent to which there is a lack of resistance to changes made as a result of LP/LSS.	6
Process	LP/LSS reporting	Extent to which stakeholders receive reporting on progress and activities of LP/LSS.	6
Communication	Patience for results	Extent to which people in the organization have the necessary patience for improvements in results to be realized.	5
Team design	Cross-functionality	Extent to which teams used to develop and implement LP/LSS include individuals from cross functional areas.	5
Organization	Rewards and recognition	Extent to which recognition and rewards are provided to organizational members who contribute to LP/LSS goals and success.	5
Process	LP/LSS institutionalization	Extent to which LP/LSS is deployed throughout the organization, including various organizational levels and units.	5
Process	Effort required for LP/LSS	Extent to which the amount of time and effort devoted to LP/LSS development and implementation is appropriate and feasible.	5
Organization	External influence for implementation	Extent to which the organization is influenced to implement LP/LSS due to external factors, such as government requirements or other external pressures.	4
Process	Scope of LP/LSS	Extent to which the scope of LP/LSS development and implementation	4

		within the organization is appropriate and feasible.	
Task design	Goal alignment	Extent to which LP/LSS is aligned with organizational goals and priorities.	4
Organization	Organizational readiness for LP/LSS	Extent to which the organization has the pre-conditions to be ready for LP/LSS, including a clear vision for LP/LSS and effective communication.	4
Process	LP/LSS implementation process	Extent to which execution of LP/LSS follows a gradual and flexible process, with pilot testing, staged implementation, etc.	4
Organization	Politics/regulations constraints	Extent to which any external regulations and requirements are aligned with LP/LSS.	4
Task design	Target system complexity	Extent to which the workflow, interconnections, and interdependencies in processes targeted for improvement are routine and not complex.	4
Organization	Leadership style	Extent to which leaders' style and approach are aligned with LP/LSS.	3
Organization	Organizational characteristics	Extent to which planning activities address the key organizational characteristics for successful LP/LSS, such as size and the unit of analysis.	3
Organization	Data quality	Accuracy, validity, and reliability of the data used by the organization to support LP/LSS.	3
Workforce	External consultant knowledge of LGO processes	Extent to which any external consultant used is familiar with processes and context of LGOs to translate and adapt concepts and tools/techniques.	3
Process	Structured approach to LP/LSS	Extent to which a structured approach is used to develop and implement LP/LSS.	3
Organization	Supplier relationships	Extent to which supplier relationships relevant to processes being targeted for improvement are established.	2
Organization	Organizational experience with LP/LSS	Level of previous organizational experience with LP/LSS such as through prior projects/initiatives.	2
Workforce	General understanding of LP/LSS philosophy	Extent to which people in the organization have a clear understanding of the principles and concepts associated with LP/LSS philosophy.	2

Process	Team autonomy	The level of decision-making authority and autonomy given to employees working on LP/LSS.	2
Organization	Customer buy-in/engagement	Extent to which customers and other stakeholders buy-in to LP/LSS and are appropriately engaged in LP/LSS.	2
Team design	Team structure and role	Extent to which teams used to develop and implement LP/LSS have clearly defined roles and responsibilities.	2
Organization	Organizational accreditation	Extent to which recognition and experience gained from accreditation activities support LP/LSS.	1

3.6 Implications for Engineering Managers

A successful LP/LSS methodology can improve processes, reduce waste, increase efficiency and effectiveness, reduce costs, and free up resources to allocate to other priorities. This can result in improved services for the community and increased public trust in government organizations. The findings of this study have significant implications for both engineering managers and engineering management researchers. The set of CSFs identified for LP/LSS serves as a valuable reference source for engineering managers and decision-makers seeking to bring innovative approaches, such as LP/LSS, to drive excellence in LGOs. By identifying the CSFs, it enables engineering managers to determine the essential components that are crucial for a successful development and implementation of LP/LSS, and ensures the right steps are taken to avoid wasted efforts and resources. These CSFs also help to set the foundation for a successful intervention of LP/LSS, therefore, enabling LGOs to achieve the expected outcomes. While the top five most frequent factors are acknowledged for their importance in this research area and across different organizational sectors, the less frequent factors (e.g., target system complexity, contextualization/customization of LP/LSS, and organizational experience), possessing particular relevance to LGOs, should not be overlooked. Acknowledging and carefully considering these factors is crucial for ensuring successful outcomes in the context of LGOs. For engineering

management researchers, this study contributes to the body of knowledge by addressing a literature gap in this research area (i.e., the CSFs for LP/LSS in LGOs) and provides a set of factors based on a rigorous literature survey. Thus, the findings can allow engineering management researchers to develop new research avenues to support LP/LSS in LGOs or public sector organizations in general.

3.7 Conclusions

LP/LSS is a popular improvement methodology that expanded from manufacturing to being developed in service organizations, including LGOs. However, LP/LSS is influenced by a set of factors that could serve as crucial variables for receiving a full potential outcome. This study contributed in addressing a literature gap - proposed by Alrezq and Van Aken (2022) - related to the CSFs associated with LP/LSS in LGOs. More specifically, this study has identified and analyzed a comprehensive list of CSFs that potentially influence the implementation of LP/LSS in LGOs. Four different platforms (i.e., ProQuest, Web of Science, Scopus, and Engineering Village) were utilized to conduct the SLR and collect relevant studies. Because this research area is still evolving, publications from other sources were added to the final pool. In total, this study analyzed 44 empirical publications.

Based on the final set, 47 CSFs were identified and then categorized into six groups: Organization (21 factors), Workforce (5), Process (11), Communication (4), Task design (4), and Team design (2). The evidence implies that the success of LP/LSS in LGOs is dependent on a combination of a set CSFs, with leadership support/commitment and organizational culture among the most critical. To maximize the success of this methodology, leaders should provide clear and consistent support for LP/LSS and establish a culture of continuous improvement. Effective engagement with employees or process owners is crucial, as they are the ones directly involved in

LP/LSS processes and can therefore provide valuable insights and feedback. This engagement could also eliminate barriers toward change based on employee attitude, as Exhibit 8 reveals a strong connection between employee attitude and employee engagement. Another key factor is having a well-trained workforce with the skills and knowledge to implement and maintain the principles of LP/LSS.

3.7.1 Study Limitations and Future Work

This study was limited to the selected platforms used to perform the SLR and only considered academic publications in English. Thus, it might have missed other relevant publications to the topic of interest, although using multiple platforms helped mitigate this limitation. The limitation inherent in this study could be an opportunity for future work. More specifically, analyzing practitioner case studies could be useful to provide more insights into other significant factors. While this study developed a potential set of factors associated with LP/LSS success in LGOs, further research could focus on evaluating which of the identified CSFs are important based on an expert survey assessment. Additionally, conducting an empirical field study would be valuable to statistically analyze which of the factors have significant effects on system outcomes.

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Chapter 4: Manuscript # 3 – Critical Success Factors For Lean Production: A Conceptual Framework-Based Literature Review

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4.1. Manuscript copyright transfer agreement

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4.2 Abstract

Quality management concepts have been applied in many different settings to solve various and complex quality problems. In particular, Lean Production and Lean Six Sigma (LP/LSS) are improvement methodologies that have been utilized for continuous improvement in manufacturing and service contexts. However, the diffusion of LP/LSS applications is still evolving in public sector organizations, and more specifically in Local Government Organizations (LGOs). The development and implementation of LP/LSS in LGO settings encounters many challenges (referred to as critical success factors in this work) which may limit the achievement of performance outcomes. This research area is also limited in terms of developing frameworks (or models) that examine the impact of factors on system outcomes. Thus, the purpose of this work is to investigate research design methods (i.e., data collection and data analysis methods), quantitative studies, and then develop a conceptual framework that conceptually hypothesizes the relationship between a set of potential significant factors on technical and social system outcomes. This work could be a starting point for scholars and practitioners to further develop and test other models with other potential outcomes to advance the maturity of this research area for best practices. This development of a framework also helps support the literature to understand the influence of factors on system outcomes for LP/LSS success.

Keywords

Lean production, lean six sigma, framework, success factors, systematic literature review, local government, public organizations

4.3 Introduction

Quality improvement methodologies, such as Lean Production and Lean Six Sigma (LP/LSS), have been widely used to address many challenges related to quality (Wartati et al., 2021). LP/LSS has been developed and implemented in various organizational settings, including manufacturing and service-based organizational environments (Antony et al., 2019; Vamsi Krishna Jasti & Sharma, 2014). Further, LP/LSS are best known for engineering processes and identifying the root causes of issues related to non-value-added activities for better performance outcomes, for instance, lead time, efficiency, cost, and customer value (Improta et al., 2019; Melton, 2005). While LP/LSS is predominant improvement methodology in manufacturing research literature (Wartati et al., 2021), this improvement methodology also has been observed in public sector organizations, especially in local government organizations (LGOs).

The development and implementation of LP/LSS are often associated with difficulties and challenges (referred to in this work as critical success factors "CSFs") that may hinder achieving full potential benefits. Scholars have widely

addressed these CSFs in different organizational settings and developed quantitative models to study the effect of these factors on outcome success (Chiarini & Brunetti, 2019; Gonzalez Aleu, 2016; Noori, 2015). However, the evolution and development of LP/LSS in LGOs is still at an early stage of maturity with a lack of quantitative models (or conceptual models) to study LP/LSS success with a rigorous and comprehensive set of factors. Thus, this work aims to address this gap by proposing a preliminary conceptual framework that subjectively hypothesizes the impact of the CSFs on system outcomes. The CSFs used in this work were identified based on a previous effort (Author, 2022). To achieve the goal of this work, a systematic literature review (SLR) was used to analyze empirical publications in this research area. The SLR is a concrete review process used to analyze scientific studies on a research area (or field) in a systematic manner (Tranfield et al., 2003). Prior to developing the preliminary conceptual framework, this work analyzed the research design methods and discussed quantitative models developed in this area. Thus, this work aims to address the following research questions:

R.Q.1 What are the commonly-used research methods for data collection and data analysis?

R.Q.2 What are the quantitative models developed within this research area (LP/LSS in LGOs)?

R.Q.3 What is the appropriate preliminary conceptual framework to support this research area?

The rest of the paper is organized into three sections: research methodology (including a brief discussion about the SLR process), results and discussions (describing and discussing the analysis to answer the research questions), and conclusions.

4.4 Research Methodology

Literature review is defined as "the process of conducting surveys of previously published material" (Hedges & Cooper, 2009, p. 4). This definition implies that a literature review might not be necessary driven to generate new findings; however, it is more leaning to understand or evaluate a research area (or field) based on existing evidence (Hedges & Cooper, 2009). Answering a specific research question and evaluating/assessing methodologies used within a research area are a few examples of purposes motivating scholars to conduct a literature review (Hedges & Cooper, 2009; Okoli & Schabram, 2010). Thus, the goal of this work is to analyze the evidence in this research area (i.e., LP/LSS in LGOs) using the Systematic Literature Review (SLR) (Tranfield et al., 2003). The SLR is a rigorous research methodology that follows a structured search protocol to acquired relevant publications on a topic of interest (Tranfield et al., 2003). The structured protocol that the SLR follows provides a trustworthiness and reliability to a study (Leite et al., 2020). The SLR also has been widely used due to the transparency and ability to collect relevant publications from various sources of information (Cronin et al., 2008; Higgins & Cochrane Collaboration, 2019). In this work, the SLR was conducted through six steps: defining research questions/problems, identifying scoping study papers, developing search strategy, applying exclusion criteria, collecting data, and analyzing the findings (Tranfield et al., 2003). Each of the steps performed in the SLR is briefly described as follows:

a. *Research question/problem definition*: The goal of this work is to investigate (or answer the previously defined research questions) the research design methods, quantitative models, and then develop a preliminary conceptual framework that hypothesizes a set of defined success factors on system outcomes.
b. *Scoping study papers*: Ten papers that focused on LP/LSS in LGOs and reported and discussed at least one CSF were gathered. These scoping study papers were utilized to further understand this research area and develop initial research concepts.
c. *Search strategy*: Three search concepts/terms were compiled that included synonymous terms for LP/LSS, LGOs, and CSFs. These search terms were adopted and developed from previous works (Alrezq, 2020a, 2020b, 2021). Once the search terms were determined, four platforms (ProQuest, Web of Science, Scopus, and Engineering Village) were selected to run the search terms. These four platforms were selected due to their richness in indexing relevant papers. As discussed previously, collecting publications from multiple sources supports the comprehensiveness and rigor of synthesizing the literature (Higgins & Cochrane Collaboration, 2019). This search strategy produced over 8,000 publications.
d. *Applying exclusion criteria*: Thirteen exclusion criteria were developed, defined, and applied to identify the relevant publications and narrow down the initial raw results (i.e., 8,000 papers). The execution of the exclusion criteria was undertaken in three steps: limiting the initial results to academic and English publications, removing duplications, reviewing titles and abstracts, and reviewing the full publications. This process yielded 44 empirical publications that were considered for analysis in this work.

4.5 Results and Discussion

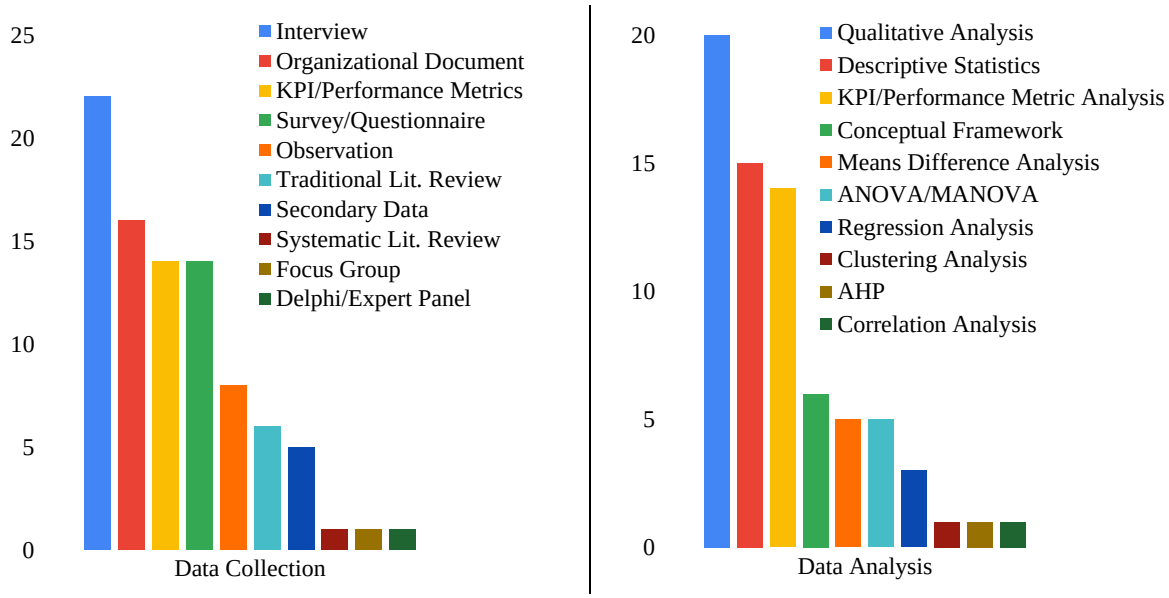
The last two steps with the SLR (i.e., collecting data and analyzing the findings) are described with the following subsections. First, the research design methods were analyzed to identify methods used for data collection and data

analysis. Second, the quantitative studies identified within this research area were discussed followed by the development of the preliminary conceptual model along with the hypothesized relationship between the CSFs and system outcomes.

4.5.1 Research design methods

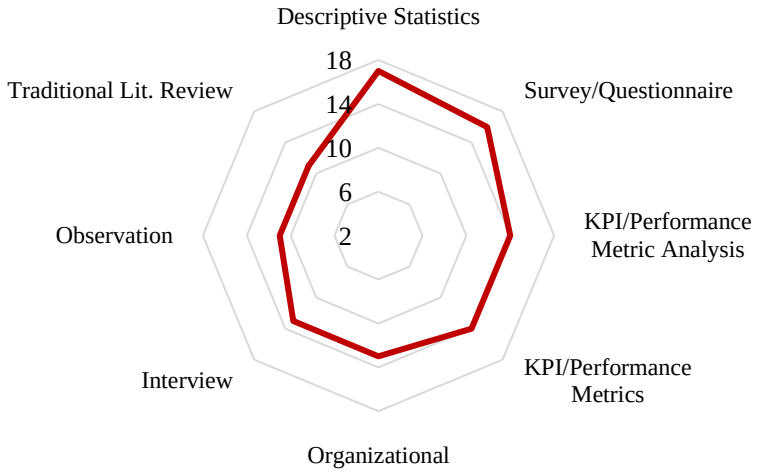
The analysis of research design methods helps to understand to what extent this research area has been evolved in terms of common methods used for data collection and analysis. Research design refers to the structure of a study that guides the process for data collection and analysis (Ali et al., 2021). Thus, the final set of papers (i.e., 44 papers) were analyzed to identify the commonly-used methods. In total, 300 statements were extracted through the analysis process and then divided into two main sets that encompass data collection and data analysis methods with a total of 20 unique research methods (see Exhibit 1). It is important to note that the research methods (i.e., data collection and data analysis) described in this work are not mutually exclusive. That is, a given paper may perform multiple research methods simultaneously. For example, a paper may use interview and observation to collect the necessary information, and then utilized qualitative analysis. Therefore, based on the evidence obtained from the final set, the most four research methods used for data collection—in descending order—were interview (22 papers), organizational documents (16), KPI/performance metrics (14), and survey/questionnaire (14). Similarly, the most common three research methods used for data analysis—in descending order—were qualitative analysis (20), descriptive statistics (15), and KPI/performance metric analysis (14). The analysis of the research methods indicates that this research area is more qualitatively analyzed, whereas few studies performed some descriptive statistical analysis.

Figure 15 (Exhibit 1, Manuscript #3) Research Methods Used for LP/LSS in LGOs.



To further analyze the extracted 20 research methods (i.e., data collection and data analysis), degree centrality (DC) was utilized to understand the predominant research methods that is conjunctly used with the other methods. DC counts the total number of connections/links to a vertex, i.e., a research method (Hansen et al., 2011). Therefore, a social network analysis was performed using NodeXL, a software embedded in Excel template and developed by Social Media Research Foundation (Smith et al., 2009). Based on the results, the DC scores ranged from a minimum score of 3 (correlation analysis) and to a maximum of 18 (descriptive statistics). For clarity, this work depicts the highest eight research methods (see Exhibit 2). The most frequent two research methods that were simultaneously used with other methods were descriptive statistics (having DC score of 17) and survey/questionnaire (16) followed by KPI/performance metric and KPI/performance metric analysis (each having DC score of 14) and organizational document and interview (each having DC score of 13).

Figure 16 (Exhibit 2, Manuscript #3) Most Used Research Methods based on Degree Centrality.



Due to the non-mutually exclusive use of the research methods (i.e., data collection and data analysis), the co-occurrence of methods was also analyzed (Exhibit 3). This analysis further synthesizes the research methods to identify the most commonly-paired of methods used for data collection and data analysis. Exhibit 3 depicts a matrix divided into three segments (top left shows the co-occurrence of methods used for data collection, top right shows the co-occurrence of methods used for data collection and data analysis, and lower right shows the co-occurrence of methods used for data analysis). Further, items ranged from 1 through 10 represent data collection methods, whereas items ranged from 11 through 20 represent data analysis methods.

The first segment (top left) shows that the most commonly-paired data collection methods were *interview* with *organizational document*, *survey/questionnaire*, and *observation* followed by *organizational document* with *observation*. Similarly, the most commonly-paired of methods for data analysis (lower right) were *descriptive statistics* with *qualitative analysis* and *qualitative analysis* with *conceptual framework*. Investigating the co-occurrence of methods for data collection and data analysis (top right) indicates that *interview*, *organizational document*, *observation*, and *survey/questionnaire* were often analyzed using *qualitative analysis*. Further, *KPI/performance metrics* also paired with *KPI/performance metric analysis*.

Qualitative research is defined by Strauss and Corbin (1990) as "any kind of research that produces findings not arrived at by means of statistical procedures" (Golafshani, 2015, p. 600). Quantitative research, however, investigates the causal explanation, prediction, and hypothesis testing (Golafshani, 2015). While each approach (i.e., qualitative and quantitative) has their strengths and weaknesses, their rigor could be more efficient when used together, i.e., triangulation of research methods (Henrique & Godinho Filho, 2020). Among the final paper set, 61% (out of 44 papers) employed more than one data collection method, while 43% used more than one data analysis method. Thus, the triangulation methods for data collection was often used in conducting empirical research in this research area which helps to strengthen a study's credibility and validity (Ali et al., 2021).

Figure 17 (Exhibit 3, Manuscript #3) Research Methods Co-occurrence.

	Research Methods	Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Data Collection Methods	Traditional Lit. Review	1	–		2		1	1	1	1	2		1	3	1				1			2
	Systematic Lit. Review	2		–							1	1	1		1				1			0
	KPI/Performance Metrics	3			–	1	2	1		2	2		2	1	1	1	1	1	1			14
	Focus Group	4				–	1	1		1	1							1				1
	Interview	5					–	14	3	7	9		6	18	2			1			5	2
	Organizational Document	6						–	2	6	4		4	11	1			1			4	1
	Secondary Data	7							–	1			3	3		1				1	1	
	Observation	8								–	3		3	6				1				2
	Survey/Questionnaire	9									–	1	9	6	5	1		1	2		1	2
	Delphi/Expert Panel	10										–	1	0	1				1			
Data Analysis Methods	Descriptive Statistics	11											–	5	3	3	1		2	1	1	2
	Qualitative Analysis	12												–							4	1
	Means Difference Analysis	13													–				2			1
	Regression Analysis	14														–	1		1	1		1
	Clustering Analysis	15															–		1			1
	HLM/AHP	16																–				1
	ANOVA/MANOVA	17																	–			1
	Correlation Analysis	18																		–		
	Conceptual Framework	19																			–	
	KPI/Performance Metric Analysis	20																				–

4.5.2 Quantitative models developed within LP/LSS in LGOs

Based on analyzing the final publications set, only three studies (6% of the total) developed statistical analysis models to examine a set of independent variables and outcomes (i.e., dependent variables). The summary of the dependent variables used in these three studies along with the sources are summarized in Exhibit 4. Hoyle (2019) conducted a quantitative study based on secondary data that included 350 kaizen events across the state of Connecticut. The goal of study was to assess the impact kaizen events success using six independent variables (i.e., department category/type, budget size, number of employees, project focus, unit of analysis, and number of kaizen event conducted) by constructing regression models. The success of kaizen events—as described and measured by Hoyle (2019)—was measured by two dependent variables: percentage of change (or improvement rate) and achieved goal. The percentage of change was defined as the amount of improvement in percentage after the completion of a Kaizen event, whereas the achieve goal was defined whether or not a kaizen event achieved its goal. The following study, i.e., Gityforoze (2018), performed a quantitative study to examine the relationship between three dependent variables (i.e., senior management support, the use of statistical tools, and lean six sigma infrastructure) and organizational culture (i.e., clan, adhocracy, market, and hierarchical) as independent variables. This study was performed using three statistical techniques (i.e., MANOVA, ANOVA, and post-hoc) on a single organization. The third study, i.e., Bakar et al. (2017), also developed a regression model with the goal to examine the impact of LP/LSS tools/techniques (i.e., Kaizen, value stream mapping, and 5S) on organizational performance (i.e., productivity and service delivery). However, this study is not within the scope of this research being developed (i.e., LP/LSS in LGOs); but it could be potential future research efforts to improve the maturity of this research area by examining the impact of tools/techniques on system outcomes.

Table 9 (Exhibit 4, Manuscript #3) Studies Performed Statistical Models in this research area (LP/LSS in LGOs).

Source	Dependent variable	Variable type
Hoyle (2019)	Percent Change	Continuous

	Achieve goal	Binary
Gityforoze (2018)	Senior management support The use of statistical methodology Lean six sigma infrastructure	Ordinal
Bakar et al. (2017)	Organizational productivity Service delivery	Continuous Continuous

While the studies performed within this research area (discussed previously) are useful to understand the variables' relationship and impacts, there is a paucity in terms of the number of quantitatively-designed research studies that developed comprehensive statistical models with a full breadth factor (or variables). Further, it might be difficult to generalize the findings from previous studies as they either focused on a particular geographical region Hoyle (2019) or on a single organization Gityforoze (2018). Thus, this is one of the motivations of this work is to develop a conceptual model that hypothesized a full breadth of factors on system outcome (technical and social system outcomes).

4.5.3 Preliminary conceptual framework (model)

A conceptual framework is defined as "a network, or a plane, of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena" (Jabareen, 2009, p. 51). To develop a conceptual framework (or model), the first step is to identify the endpoint, i.e., outcomes or dependent variables (Earp & Ennett, 1991). Therefore, this research aims to examine the effect of the identified CSFs on system outcomes (technical and social). The social-technical system (STS) reflects the integration of the technical and social requirements for human to perform a system (Fox, 1995). Technical requirements include components, such as equipment, tools, techniques, and process, while the social system includes humans and their relationships (Hadid et al., 2016). However, any improvement initiative should focus on the joint optimization of both technical and social, as they are more likely to have positive interact leading to higher performance (Hadid et al., 2016).

Four dependent variables (see Exhibit 5) were adopted from Keathley-Herring (2016) and divided into two sets. The first set includes variables that are related to technical system outcomes (i.e., improved organizational results, LP/LSS embeddedness, and general success), while the second set includes one variable that is related to social system outcomes (i.e., improved employee results). The improved organizational results targets the perceptions of organization members about the impact of LP/LSS on metric performance. The LP/LSS embeddedness seeks to assesses participants' perceptions of the extent to which LP/LSS is being integrated into work routine, culture, and the deployment across the organizational levels. The general success is used to assess the overall success of LP/LSS in the organization. The social system dependent variable (i.e., improved employee results) assesses employee perceptions about their buy-in, satisfaction, and growth and development. After determining the dependent variables, the following step is to identify the independent variables (i.e., the CFSs). In earlier work (Author, 2022), 47 CSFs were identified and then grouped into six categories. These categorize were organizations (21 factors), workforce (5), communication (4), task design (4), team design (3), and process (10). Each category encompasses a group of factors that fit together based on the literature of change management, organizational behavior, and continuous improvement.

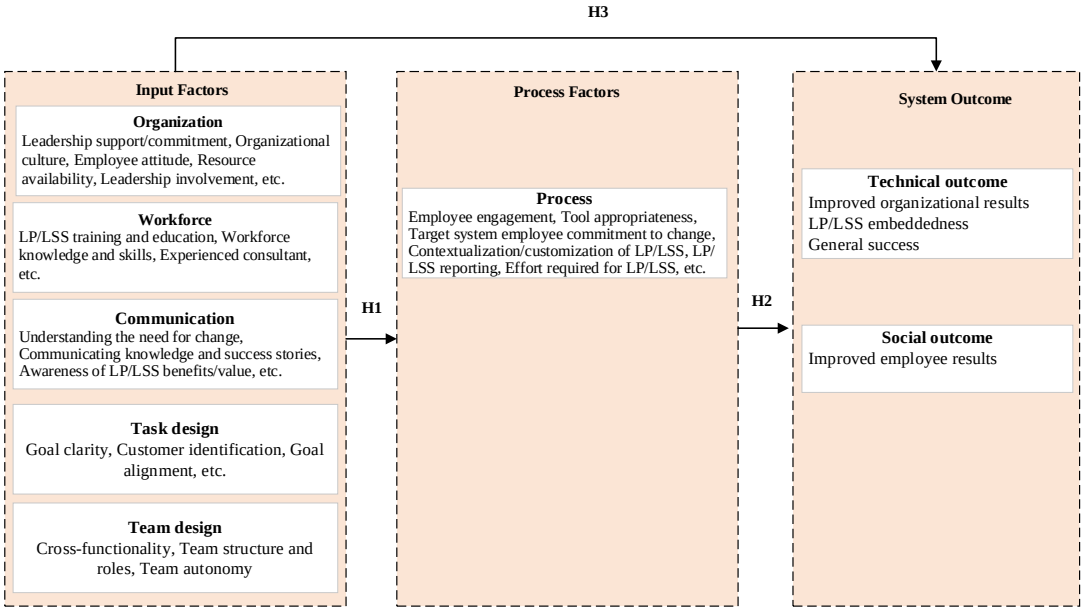
Table 10 (Exhibit 5, Manuscript #3) System Outcome Variables (adopted from Keathley-Herring, 2016).

System outcome	Dependent variable	Operational definition
Technical	Improved organizational results	Benefits gained from LP/LSS, including improvements in values on performance measures, in addition to perceivable improvements in decision-making, management processes, business, and other supporting activities.

	LP/LSS embeddedness	The extent to which LP/LSS is integrated into routine work practices and the culture of the organization.
	General success	The overall development and implementation of LP/LSS was successful in the organization.
Social	Improved employee results	The extent of buy-in and commitment from employees in addition to their satisfaction and growth with LP/LSS.

As described previously, these four dependent variables were adopted from Keathley-Herring (2016), in which a rigorous investigation was performed to examine the impact of a set of CSFs on performance measurement implementation success using a large field study. Their study was adopted for a number of reasons. First, the unit of analysis was at organizational levels, in which it aligns with the scope of this research (i.e., LP/LSS in LGOs) as the interest is to examine CSFs concerning the development and/or implementation of LP/LSS at the organizational level. Second, they targeted organizations that focused on new or re-designed performance measurement systems. That is, the perceptions received from participants were based on their recent experience of redesigning or implementing the performance measurement system. This approach also aligns with the scope of this research (i.e., LP/LSS in LGOs). The researchers will be targeting LGOs that have developed or implemented LP/LSS to gain their most recent experience and determine the existence of the 47 CSFs and the system outcomes. Finally, the adopted dependent variables had been validated empirically, which strengthen the reliability of the constructs as it is highly recommended to use validated instruments as possible (Harpe, 2015).

Figure 18 (Exhibit 6, Manuscript #3) Conceptual Framework for LP/LSS and System Outcomes.



Once the dependent variables (i.e., technical and social system outcomes in Exhibit 5) and the independent variables (i.e., the six categories of the 47 factors from Author, 2022) were defined, the preliminary conceptual framework (or research model) was developed (see Exhibit 6). Due to the high number of factors, only a subset of the factors is shown in the preliminary conceptual framework. The model graphically depicts the relationship between the categories of the CSFs and system outcomes. As discussed previously, the 47 CSFs were grouped into six categories. These six categories were organized into an input-process-output framework, as demonstrated by Liu and Cross (2016). These categories were further mapped onto the type of input and process in the conceptual framework. The input factors include five categories (i.e., *organization*, *workforce*, *communication*, *task design*, and *team design*), and the process factors include one category (i.e., *process*). The output includes both technical and social system outcome factors. In order to achieve the goal of this research and based on the conceptual framework, the following hypotheses were developed:

1. The input factors will be positively related to the process factors.
2. The process factors will be positively related to the system outcomes.
3. The input factors will be positively related to the system outcomes.

This work is a part of on-going research efforts that focus on LP/LSS in LGOs. Therefore, one of the overall goals of this on-going research is to examine the effect of the CSFs on system outcomes through a large field study, which will seek to validate the preliminary conceptual framework and hypotheses. While there is an opportunity to study other characteristics of LP/LSS, such as tools/techniques, this research focuses on CSFs. Empirical research is experimental and evidence-based research conducted to test a specific hypothesis. A number of scholars recommended to conduct empirical field studies that particularly uses surveys (Gordon & Sohal, 2001). In order to conduct the field study and validate the preliminary framework, the researchers aim to target population whose primary experiences focus on the LP/LSS development and implementation in LGO settings. Further, this research aims to study the impact of LP/LSS success at "the organizational level"; thus, one response per organization will be considered.

4.6 Conclusions

The aim of this work was to utilize the SLR to identify empirical publications focused on LP/LSS in LGO settings. Identifying research design methods, analyzing quantitative models, and developing conceptual framework were then performed based on the evidence obtained from the SLR. Based on the evidence from the scientific literature, qualitative research seems to be predominant research methods that were commonly utilized in this research area with few studies performed or construct statistical analysis models. The existing statistical models were also lacking in considering a full breadth of CSFs. Further, the proposed preliminary conceptual framework depicts 47 CSFs—categorized into 6 groups: organization, workforce, communication, task design, team design, and process—with four system outcome variables, improved organizational results, LP/LSS embeddedness, general success, and improved employee results. The conceptual framework is conceptually hypothesized the relationship between the CFSs and system outcomes. However, as argued by Kirillova & Yang (2022), the conceptual research should be performed using an SLR; but, it is incomplete without empirical validation. Therefore, the next step is to test and validate the conceptual model through a large empirical field study. While the analysis performed in earlier work (Author, 2022) identified a comprehensive list of CSFs, narrowing down the number of factors to the most significant ones prior to the large field study could be potentially useful. Thus, an expert study is needed to obtain the experts' opinions on the final set of factors.

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Chapter 5: Manuscript # 4 – Assessment of Critical Success Factors Using Meta-synthesis Evaluation

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5.2 Abstract

A literature review is driven by a variety of purposes, such as assessing the breadth of a field or research area, understanding its theoretical background, or utilizing existing scholarly publications to answer research questions. A methodological approach often utilized to investigate the literature is known as a systematic literature review (SLR). A SLR is a systematic and rigorous research methodology used to capture relevant publications. While the SLR facilitates the process of identifying and characterizing the relevant publications, understanding the content of retrieved publications also requires a structured approach. A robust method used to synthesize publication content is a meta-evaluation. This method consists of meta-analysis and meta-synthesis for quantitative and qualitative information, respectively, retrieved from publications. In many research areas, scholars have interest in identifying critical success factors related to an improvement methodology or approach. However, once the literature is investigated to identify these factors, a broad set is often identified based on frequency of mention in the literature. A meta-synthesis provides a robust approach that can determine the "strength" of these key success factors synthesized from relevant publications, which can provide more complete information about the relative importance of these factors based on more than just frequency of mention. This approach enables the results to be weighted and categorized based on the rigor and quality of studies reflected in publications. The purpose of this work is to apply a meta-synthesis evaluation to findings from two SLRs to develop a more focused set of critical success factors based on more complete information.

Keywords

Meta-evaluation, meta-synthesis, critical success factors, kaizen events, lean production

5.3 Introduction

An introductory stage to any research endeavor is conducting a general literature review to assess the body of knowledge on a field, or research area, and to determine key insights into the research domain. Although a traditional or systematic literature review can provide important details about the emergence, development, and future directions on a particular research area, it can lack in communicating other important aspects related to the rigor and quality of publication findings [1]. A method of evaluation that supports the latter purpose—as it relates to conducting a more in-depth analysis of the publications and its respective findings—is a meta-evaluation. A meta-evaluation is an aggregated assessment of multiple studies to critically evaluate the studies' findings [2]. This type of evaluation provides a structured means to assess the findings and outcomes from preliminary insights. This overall evaluation method is comprised of two sub-approaches to help elucidate essential information and examine studies with criticality in regard to the rigor and quality of the findings within publications. Meta-evaluation is an aggregation of both meta-

analysis (statistical/quantitative) and meta-synthesis (qualitative) approaches [2]. Specifically, a meta-analysis is a comprehensive review of quantitative studies using statistical procedures to provide practical significance on research outcomes or study variables [3]. A meta-synthesis is the systematic review of qualitative studies and is aimed at being interpretive rather than deductive [4, 5]. A key to conducting a constructive and informative meta-analysis is having an adequate quantity of relevant publications with quantitative findings, preferably with homogeneous variables or outcomes to examine the combined effect sizes in order to determine the average effect size of findings, and therefore, confirm the findings' significance [3, 6]. In a similar fashion, a meta-synthesis is typically applied to qualitative studies and helps to achieve a meticulous analysis of study variables, also communicating key aspects pertaining to the significance of those variables [5, 6]. A tenet for empirical research is that the research process and findings ensure objectivity and verifiability of results, which necessitates the importance of confirming these key attributes when making research considerations [6]. A key benefit to the meta-synthesis approach is that the evaluation incorporates a rigor and quality measure on the publications which can be weighted and integrated to increase the defensibility of the studies' findings. Over the years, various approaches to meta-synthesis evaluation—also known as qualitative meta-synthesis—have emerged, including the foundational methods of Noblit and Hare [7] for synthesizing evidence from qualitative studies, reciprocal translational analysis (RTA) synthesis, lines-of-argument (LOA) synthesis, and refutational synthesis [4, 5, 7, 8]. The purpose of this work is to introduce a methodological framework applying a meta-synthesis approach—adapted from previous works and further developed—to evaluate two relevant publication sets [6, 9]. Application of this adapted framework will enable a robust evaluation of the strength of effect of the studies' variables (i.e., success factors in this case), while incorporating a quality appraisal of the studies. The application of this framework will enable researchers to best stratify their study variables and facilitate an efficient down-select process to determine key variables that can be operationalized for use in future work, such as in a research model for an empirical study with statistical hypothesis testing.

5.4 Research Methodology

A comprehensive Systematic Literature Review (SLR) was conducted with the primary purpose of identifying the critical success factors for two respective types of organizational improvement methods in service organizations (*Kaizen events "KEs" in hospitals and Lean production and lean six sigma "LP/LSS" in local government organizations*). An SLR is a rigorous and structured process that evaluates literature on a body of knowledge for a research topic or field [10]. This method of literature review applies a robust procedure to examine publications. Furthermore, this methodology supports the integration of other beneficial rigorous analyses. The initial SLR findings were then used to conduct a prospective meta-synthesis evaluation that would enable more informative insights about the success factors that were extracted.

A meta-synthesis evaluation was applied to two distinct final publication (or paper) sets, which included only empirical studies. Findings in the publications were examined using an integrated synthesis approach to determine the *overall strength of effect* of the study variables (see Figure 1). To determine the overall integrated strength of effect, success factors identified in the final papers were first evaluated for their *strength of effect* on the basis of three criteria. The meta-synthesis evaluation involved the integration of three distinct criteria or aspects that encompasses the frequency of factors, degree of importance, and quality of publications. First, the relative frequency of mention of each factor across all studies was used. This criterion is operationalized as the number of papers that studied each factor (or variable). The second criterion was the degree of importance of each success factor documented in a given paper. This was operationalized as a "large effect*"* based on qualitative evidence indicative of strength of effect of each success factors. Thus, factors that were studied but not found to be having an important effect were not categorized as "large effect" in this approach. The third criterion was the rigor and quality of each publication, assessed by the presence of essential and demonstrable research process criteria, such as aspects related to the research methodology and data collection and data analysis procedures, and outcome criteria related to the research findings. Moreover, after the individual strength of effect ratings were determined for each criterion, they were then combined to determine an *overall integrated strength of effect rating* (see Figure 3). Using this procedure ensured that critical information related to each unique criterion was equitably incorporated into the overall rating, minimizing the possibility of diminishing or losing pertinent information respective to each criterion's strength of effect contribution. Specifically, for the "large effect" criterion, the strength of effect was determined by the degree of importance expressed qualitatively for success factors within a given paper. For example, if a factor was expressed as being important from either a positive or negative orientation (e.g., as an enabler to successful implementation if present or as an obstacle if absent), this factor was assigned as having a "large effect." The rigor and quality of publications was evaluated utilizing assessment

criteria adapted from the Mixed Methods Appraisal Tool (MMAT) [9]. One possible way adopted in the literature to evaluate the quality of a publication is by using the *Journal Impact Factor* (JIF) [6]. However, utilizing this method would enforce a strict limitation on the types of publications that can be used to perform a meta-synthesis evaluation. A high proportion of papers on a particular research topic, for example, Kaizen events (KEs) in hospitals, are captured in conference proceedings, and may be omitted based on the strict publication type restriction incurred when using JIF. Furthermore, this approach may assume that the publication itself may be ascribed to a high degree or low degree of quality purely based on the journal's impact factor even though a more critical examination of the paper itself may determine otherwise. Hence, devising a more inclusive and comprehensive approach to assess the quality of publications can offer a more accurate, enriching, thorough, and representative analysis on this criterion. As a result, the approach used for this work did not restrict the publication type solely to qualitative studies but allowed for the inclusion of both qualitative and quantitative studies. To achieve a more general publication qualification selection, a comprehensive screening tool utilizing a Mixed Methods Appraisal (MMA) for publications was adopted to assess for the quality of publication measure [9]. Four main criteria were selected to provide an equitable contribution in assessing the quality of any publication type in this work. The four criteria include: 1. *Are there clear research questions or objectives?* 2. *Is there a structured methodology for data collection and data analysis?* 3. *Do the collected data allow the researcher(s) to address the research questions/objectives?* 4. *Are there clearly defined findings and are they discussed sufficiently?* The first criterion is an important research process step for any scholarly work, in that it explicitly identifies the focus for the work and purposefully directs the research effort into achieving its outcomes. The next criterion is essential to direct the research in a cohesive and organized manner that will support the data retrieval and data analysis process. Using a systematic way to address a problem would potentially avoid or minimize any oversights that can occur and guide the research effort in a harmonious manner. Next, to achieve quality research work, researchers must ensure the credibility and validity of their research results by utilizing appropriate measures, apparatus, and techniques. Ensuring effective data collection protocols and procedures is essential in being able to obtain quality and accurate data that will appropriately address the research questions and research objectives. Finally, researchers who are contributing to any domain of knowledge should adopt a practice of delivering substantive insights on the research topic to best inform their audience and demonstrate the unique value of their work. The overall meta-synthesis evaluation framework that was developed is shown in Figure 1, and the approach used to determine the overall strength of effect is shown in Figure 2. The individual strength of effect for each criterion could be classified as a "Small (S)" effect, "Medium (M)" effect, or "Large (L)" effect rating based on predefined rating criteria. To determine the overall integrated effect rating based on the three distinct strength of effect criteria, a heat chart (Figure 3) was developed to segment key regions classifying the overall integrated large effect, overall integrated medium effect, and the overall integrated small effect. Specifically, ten unique combinations for integrating the individual effect ratings corresponding to the three assessed criteria were constructed and assigned to an overall integrated effect rating. The three bottom combinations represent the overall integrated small effect, the three top combinations represent the overall integrated large effect, and the four middle combinations represent the overall integrated medium effect.

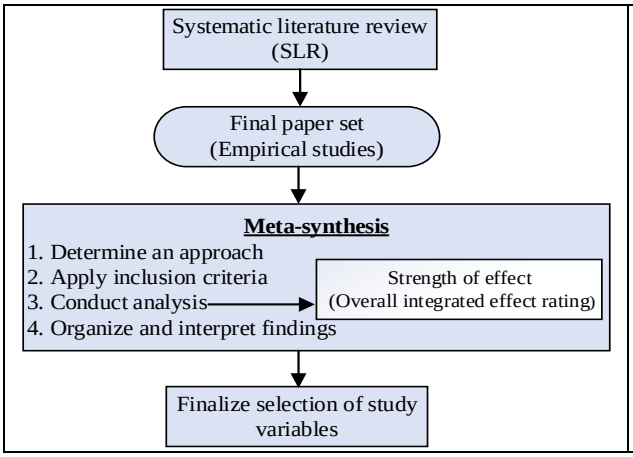

Figure 19 (Figure 1, Manuscript #4) Meta-synthesis Framework

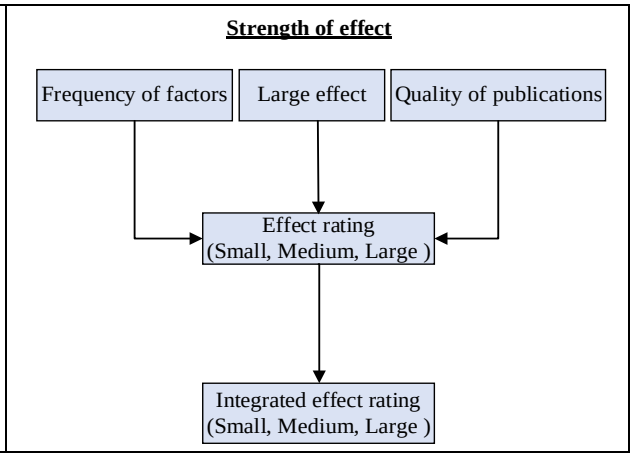

Figure 20 (Figure 2, Manuscript #4) Overall Strength of Effect

Overall Meta-synthesis Integrated Effect Ratings				
	Large Effect	L	L	L
		M	L	L
		S	L	L
	Medium Effect	M	M	L
		M	M	M
		S	M	L
		S	M	M
	Small Effect	S	S	L
		S	S	M
		S	S	S
	Meta-synthesis Individual Effect Ratings			

Figure 21 (Figure 3, Manuscript #4) Integration of Combined Strength of Effect

5.5 Results and Discussion

5.5.1 Case Study: Kaizen events in hospitals

A previous SLR was completed by Harry [11] on the success factors for KEs in hospitals. The approach described here was applied to an extended SLR which resulted in initial raw results of 1,889 papers attained from four databases (ProQuest, Web of Science, Engineering Village, and Scopus). After multiple iterations of screening publications and using defined exclusion criteria to remove unwanted papers, a relevant paper set of 48 papers was finalized for analysis on the research topic. The extended SLR analysis resulted in fifty-four unique success factors that were able to be weighted and ranked based on the meta-synthesis approach applied in this work to evaluate the significance of the success factors identified within the literature. Due to page limitations and for illustrative purposes, only the top five most frequently-occurring factors in conjunction with its respective strength of effect analyses are shown.

Table 11 (Table 1, Manuscript #4) Meta-synthesis Individual Effect Criteria for KEs in hospitals

Factors	**Frequency of Factors**	**Large Effect**	**Quality of Publications**
	Percentage (Effect)	**Importance Score (Effect)**	**Quality Score (Effect)**
Follow-up activities	42% (L)	1.00 (L)	0.94 (L)
General leadership support	35% (L)	0.94 (L)	0.93 (L)
Stakeholder representation	31% (L)	0.93 (L)	0.88 (M)
Organizational culture	29% (M)	1.00 (L)	0.95 (L)
Team commitment to change	29% (M)	1.00 (L)	0.98 (L)

First, for the frequency of factors effect strength criterion, every unique factor from an individual paper was extracted and aggregated to find the total factor occurrence (% of final papers with unique success factor). The cumulative frequencies of all factors were then weighted uniformly and defined as follows: a small effect frequency (2%–15%), a medium effect frequency (16–29%), and a large effect frequency (30%–42%). As observed in Table 1, the most relevant factors based on this analysis for effect strength are *Follow-up activities, General leadership support, and Stakeholder representation*. Next, for the "large effect" criterion, each unique factor from an individual paper was noted for its degree of importance based on qualitative inferences, as noted earlier. A measure for capturing the "large effect" was devised such that a factor indicating a "large effect" was assigned a value of 1, whereas one not identified as having a "large effect" was assigned a value of 0. Each unique factor was then aggregated by finding a cumulative "large effect" or importance score (total frequency of all "large effect" occurrences), and then averaged to ensure a uniform scale. The overall "large effect" scores were then weighted evenly to determine its strength of effect rating and was specified as follows: a small effect importance score (0.50–0.67), a medium effect importance (0.68–0.84), and a large effect importance score (0.85–1.00). Table 1 also indicates that the most relevant factors based on the "large effect" strength of effect analysis are *Follow-up activities, General leadership support, Stakeholder representation, Organizational culture, and Team commitment to change*. Next, the quality of publication criterion

evaluated a publication's quality based on four equally-weighted criteria described earlier (i.e., publication quality ratio was defined as the number of quality criteria evident divided by four). A cumulative quality score (summation of all respective quality ratios for unique factors) was determined, then averaged to ensure a uniform scale. For example, if a unique factor occurred in 20 publications, the cumulative quality score of all 20 publications (sum of 20 ratios) would first be determined, then divided by 20 to find its overall quality score. The overall quality scores were then distributed uniformly to define its strength of effect ratings as: a small effect quality score (0.71–0.80), a medium effect quality score (0.81–0.90), and a large effect quality score (0.91–1.00). From Table 1, the most relevant factors from this analysis are *Follow-up activities, General leadership support, Organizational culture,* and *Team commitment to change.* Finally, the integrated combined strength of effect was determined from all strength of effect analyses by applying the integrated rating classification schema established in Figure 3. From this analysis (Table 2), the most significant factors based on the overall integration strength of effect are *Follow-up activities, General leadership support, Stakeholder representation, Organizational culture, and Team commitment to change.* Overall, this evaluation points to the factors that indicate a strong significance and can be prioritized as potential study variables to be included into an empirical study examining success factors for Kaizen events in hospitals.

Table 12 (Table 2, Manuscript #4) Integration of Meta-synthesis Effect Criteria for KEs in hospitals

Factors	Frequency of Factors	Large Effect	Quality of Publications	Meta-synthesis Integrated Effect
Follow-up activities	L	L	L	L
General leadership support	L	L	L	L
Stakeholder representation	L	L	M	L
Organizational culture	M	L	L	L
Team commitment to change	M	L	L	L

5.5.2 Case Study: Lean production and lean six sigma in local government organizations

A previous SLR was conducted by Alrezq [12] to analyze the literature on success factors for lean production and lean six sigma (LP/LSS) in local government organizations (LGOs). However, Alrezq [12] identified the factors based on the frequency which may hinder characterizing the critical ones for future empirical studies. Therefore, a second SLR with multiple platforms (i.e., ProQuest, Web of Science, Scopus, and Engineering Village) was conducted and used for meta-synthesis to identify the most significant factors. The second SLR yielded a total of 8,454 raw results from four platforms (i.e., ProQuest, Web of Science, Scopus, and Engineering Village). These initial results were examined against exclusion criteria to identify relevant publications to the topic of interest. Thus, a total of 42 publications were identified and used to analyze the literature on success factors. A total of 47 success factors were identified. However, due to space constraints here, the last five years of the final publication set were used to demonstrate this meta-synthesis approach for LP/LSS in LGOs. That is, 20 publications (or 47% of the final paper set) that discussed 43 success factors were examined for this work.

Table 13 (Table 3, Manuscript #4) Meta-synthesis Individual Effect Criteria for LP/LSS in LGOs

Factors	Frequency of Factors	Large Effect	Quality of Publications
	Percentage (Effect)	Importance Score (Effect)	Quality score (Effect)
Leadership support/commitment	65% (L)	0.77 (L)	0.73 (M)
Organizational culture	55% (L)	0.64 (M)	0.75 (M)
Employee attitude	30% (M)	0.67 (L)	0.83 (L)
Workforce knowledge and skills	25% (S)	1.00 (L)	0.75 (M)
Availability of data	25% (S)	0.80 (L)	0.70 (M)

Following the same procedure described in the first application, the frequency of factor effects, large effect, and quality of publication effect were obtained for each factor from the sub-set of publications (i.e., publications within the last five years). Table 3 depicts the three evaluation criteria for meta-synthesis. The weighted uniform range for the frequency of factors effect was rated as small effect frequency (5%–25%), medium effect frequency (26%–45%), and

large effect frequency (46%–65%). *Leadership support/commitment* and *Organizational culture* are the two factors with large effect. The second criterion of meta-synthesis is related to large effect (or degree of importance). This criterion was defined as small effect importance (0–0.33), medium effect importance (0.34–0.66), and large effect importance (0.67–1.00). Thus, based on the largest effect analysis, *Leadership support/commitment, Employee attitude, Workforce knowledge and skills, and Availability of data* were the most relevant factors. The last criterion evaluated the quality of publications and weighted as small effect quality score (0.25–0.50), medium effect quality score (0.51–0.75), and large effect quality score (0.76–1.00). The outcome of the quality of publications criterion indicated that *Employee attitude* has the largest effect.

Table 14 (Table 4, Manuscript #4) Integration of Meta-synthesis Effect Criteria for LP/LSS in LGOs

Factors	Frequency of Factors	Large Effect	Quality of Publications	Meta-synthesis Integrated Effect
Leadership support/commitment	L	L	M	L
Organizational culture	L	M	M	M
Employee attitude	M	L	L	L
Workforce knowledge and skills	S	L	M	M
Availability of data	S	L	M	M

Based on the rating approach described in Figure 3, Table 4 shows the overall integration of the strength of effect analyses. The overall integration indicates that *Leadership support/commitment* and *Employee attitude* are the most significant factors related to LP/LSS in LGOs. While this section utilized a subset of the final publications (i.e., 20 out of 42 publications), these findings may be change as more publications are added to the analysis.

5.6 Conclusions

Developing and applying a meta-synthesis evaluation provided a beneficial way to meticulously examine study variables and justify the case for inclusion of particular variables into future empirical studies. The findings from conducting this analysis demonstrated that the strength or significance of variables can be achieved using a structured method which can help researchers validate and prioritize their study variables in a more defensible way rather than simply based on frequency of mention in a paper set. This proposed approach also allows researchers to synthesize variables' information despite the publication type (qualitative or quantitative) and can be applied to other research settings to help strengthen the validity of variables. One opportunity for future work is to perform a meta-analysis evaluation provided that a sufficient number of quantitative publications exists and that these studies have a high degree of homogeneity among study variables.

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Chapter 6: Manuscript #5 ─ Synthesizing Success Factors for Lean Production and Lean Six Sigma: An Integrated Approach of Meta-synthesis and Expert Assessment

6.1. Manuscript preparation

Chapter 6 (Manuscript #5) has been formatted following the submission guidelines for the *International Journal of Industrial Engineering and Operations Management*, including text format, citation styles, and references. Further refinements to the manuscript may be made prior to submission.

6.2 Structured Abstract

Purpose – This study aims to identify the main critical success factors (CSFs) for Lean Production and Lean Six Sigma (LP/LSS) in Local Government Organizations (LGOs), focusing particularly on the relevance of expert opinions and a previously-published meta-synthesis approach in the decision-making process.

Design/methodology/approach – A structured survey tailored to experts in LP/LSS was conducted. In parallel with the expert survey, a meta-synthesis approach was also integrated to further synthesize the original set of CSFs. The outcomes of the two approaches were analyzed to derive the conclusions.

Findings – Based on the expert survey of 10 participants and a meta-synthesis approach, this study indicated that 29 major CSFs were essential for LP/LSS in LGOs. The experts' evaluations revealed that the set of factors is relatively important with a mean range between 3.5 and 5.6 on a 6-point Likert scale. These factors encompassed areas, such as *Leadership support/commitment, Organizational culture, Resource availability, Experienced consultant, Customer identification, and Defining measures*.

Research limitations/implications – Given the limited number of participants (10 experts), the study may not capture the full range of opinions in this research area. Furthermore, the subjective nature of the responses may also pose limitations.

Originality/value – Addressing a noticeable gap in the literature related to LP/LSS in LGOs, this study is pioneering in its examination of expert opinions on the success factors for this improvement methodology within the context of LGOs.

Keywords: Lean production, lean six sigma, Local government, Public sectors, Expert survey, Factor synthesis, Success factors, Variable reduction

6.3 Introduction

Organizations in the public sector around the world increasingly face the dual challenges of managing limited resources while still striving to provide high-quality services to their constituents. In response, continuous improvement methodologies, such as Lean Production and Lean Six Sigma (LP/LSS), have evolved within the public sector organizations to address various challenges and improve outcomes (Abaidoo and Blankenberger, 2022; Alrezq and Van Aken, 2022; Antony *et al.*, 2019). The literature presents a wide variety of drivers for LP/LSS expansion within the context of public sector organizations, including cost reduction/saving, quality enhancement, governmental priorities, challenges with performance metrics, the emergence of

new leadership, the development of new technology, improving efficiency, and the necessity to expand services in the face of limited resources. (Pedersen and Huniche, 2011; Radnor, 2010, p. 173).

The body of research on this area highlights LP/LSS methodologies as a potentially promising solution for addressing the multifaceted challenges encountered by LGOs. A growing body of research, as evidenced by various case studies (Alosani, 2020; Dey, 2014; Furterer and Elshennawy, 2005; Kregel and Coners, 2018; Suarez Barraza *et al.*, 2009), consistently underscores the suitability of LP/LSS for enhancing the operational efficiency and effectiveness of LGOs. Fletcher (2018), for example, conducted a qualitative study (interviewing 16 public officials) of LSS opportunities across municipalities in the U.S. Because LGOs provide a wide variety of services, Fletcher (2018) discovered that there were many opportunities for using LSS, revolved around streamlining and improving processes, cost-savings, organizational culture, and the quality of goods and services. In a more recent study, Keramida *et al.* (2023) empirically examined the relationship between LP adoption and organization performance with a particular focus on the Greek subservices sector (i.e., citizen's service centers, which are a functional area within LGO contexts). Keramida *et al.* (2023) revealed a statistically significant relationship between LP adoption, operational performance, and citizen and employee satisfaction by reducing the time required to provide a service, response time, and waiting time to receive a service. Similarly, Alosani and Al-Dhaafri (2022) conducted an empirical investigation to study the impact of Kaizen on police performance, concluding that there was a positive association through a culture of innovation. Based on an analysis of the literature, Alrezq and Van Aken (2022) reported 31 unique outcomes of LP/LSS on LGOs grouped into four categories, consisting of organizational focus, process/operation focus, customer focus, and employee focus.

While LP/LSS shows great promise in being able to address many of the common issues encountered in LGOs, various challenges might impede tapping into its full potential and expected outcomes. These challenges, referred to as Critical Success Factors "CSFs" in this study, play a pivotal role in the success or failure of such a methodology. CSFs have been widely researched in various improvement methodologies, such as Six Sigma (Antony and Banuelas, 2002), Lean Production (Kapaj, 2022), Lean Six Sigma (Abu Bakar *et al.*, 2015), and Total Quality Management (Talib and Rahman, 2010). These methods are used in different service sectors, including higher education (Gastelum-Acosta *et al.*, 2023), healthcare (Henrique and Godinho Filho, 2020), finance (Sreedharan *et al.*, 2020), and airport operations (Syltevik *et al.*, 2018). While certain factors may overlap across methodologies in different application types, it is imperative to recognize that the importance of these factors varies significantly among applications, due to the distinctive characteristics inherent to each specific context (Alhuraish *et al.*, 2017).

There is limited research on CSFs for LP/LSS in LGOs. Alrezq and Van Aken (2022) characterized the literature on this research area and outlined different research gaps, emphasizing the need for further in-depth investigation and exploration of the CSFs. Further expanding on this, Alrezq et al. (2023, Manuscript #2) delved into the literature, isolating factors that could potentially influence the success of LP/LSS within LGOs. Their exhaustive analysis cataloged a total of 47 distinct factors. While Alrezq et al.'s findings were grounded in academic literature, there exists a conspicuous dearth of empirical studies or expert surveys on this subject. Notably, a comprehensive investigation into the CSFs for LP/LSS within the LGO context is largely absent, with the notable exception of a work by Keramida *et al.* (2022). Keramida *et al.* (2022) empirically identified eight latent constructs that were essential for LP success within Greek organizations (i.e., communication, training and education, change and project management, organizational

culture, top management commitment/support and leadership, teamwork, employee commitment/involvement and empowerment, and availability of resources). Broadening this lens, several studies have explored CSFs in the public sector or service organizations. Asnan *et al.* (2016) conducted a qualitative study involving interviews in public service sectors and identified seven factors, consisting of employee involvement, knowledge, management commitment, communication, culture, teamwork, and organization readiness. Similarly, another study by Caiado *et al.* (2020) reviewed the existing literature and listed 27 CSFs that were grouped into five dimensions: goals and values, complexity and importance, balance of power, resources and capabilities, and technology and systems. Alrezq and Van Aken (2022) found "public sector organization" to be a broad term that could include a wide variety of organizations (e.g., central government, local government, higher education institutions, and healthcare organizations). For this reason, the present study narrowed its focus to LGOs as the unit of analysis with LP/LSS as the methodology of interest.

While the recent studies in the literature provided informative insights about the CSFs of this methodology, those studies were either focused on a certain region or studied the factors more broadly (as discussed previously, public sector organizations contain a variety of organizational types). Furthermore, the current literature appears to be lacking in terms of soliciting expert opinions about the importance of the CSFs for LP/LSS within LGOs using a comprehensive set of factors. Therefore, the goal of this study is to evaluate the importance of the CSFs based on expert opinions. More specifically, this study adopted a comprehensive list of CSFs that were identified for this research area by Alrezq *et al.* (2023). Their study executed a rigorous systematic literature review (SLR) using four different platforms (ProQuest, Engineering Village, Scopus, and Web of Science) with three groups of different search concepts (i.e., search concepts for LP/LSS, LGOs, and CSFs). A total of 47 CSFs was identified from the literature and are summarized in Table I. The finalized list of factors from Alrezq *et al.* (2023) was then used to develop an expert survey. In a parallel process with the expert survey, the final set of factors was also synthesized using a meta-synthesis approach that was previously published (Harry and Alrezq, 2022). The outcome of the two approaches (i.e., expert survey and meta-synthesis) were then integrated to derive a more concrete and synthesized set of factors.

Table 15 (Table I, Manuscript #5) Critical success factors of LP/LSS in LGOs, adopted from Alrezq et al. (2023)

Leadership support/commitment	External influence for implementation	Tool appropriateness	Workforce knowledge and skills
Organizational culture	Organizational readiness for LP/LSS	Target system employee commitment to change	Experienced consultant
Employee attitude	Leadership style	Contextualization/customization of LP/LSS	External consultant knowledge of LGO processes
Resource availability	Organizational characteristics	LP/LSS reporting	General understanding of LP/LSS philosophy

Leadership involvement	Politics/regulations constraints	Effort required for LP/LSS	Understanding the need for change
Addressing competing priorities	Data quality	Scope of LP/LSS	Communicating knowledge and success stories
Project identification and selection	Supplier relationships	LP/LSS implementation process	Awareness of LP/LSS benefits/value
Availability of data	Organizational experience with LP/LSS	LP/LSS institutionalization	Patience for results
Defining measures	Customer buy-in/engagement	Structured approach to LP/LSS	Goal clarity
Rewards and recognition	Organizational accreditation	Team autonomy	Customer identification
General resistance to change	Employee engagement	LP/LSS training and education	Goal alignment
Target system complexity	Cross-functionality	Team structure and role	

6.4 Research Methodology

The primary objective of this study is to identify the key CSFs for LP/LSS success in the context of LGOs. For clarity, LGOs encompass government organizations or sub-organizations at the state or local levels, excluding federal governments. Thus, representative examples of LGOs include state governments, affiliated state agencies, municipalities, and other government localities. In this study, two approaches (i.e., an expert survey and a meta-synthesis) were used to identify the important factors. The expert survey (further described in the following section) collected the opinions of individuals who had experienced LP/LSS development and/or implementation in LGOs. A meta-synthesis is a systematic review of quantitative and qualitative studies that helps to achieve a meticulous analysis of study variables. This approach was adopted from Harry and Alrezq (2022) and is briefly described in the following sections. Figure 1 shows the two approaches to synthesize the CSFs, followed by the integration. The uniqueness of this study lies in the integration of the two approaches. This integrated method has the potential to reach more insightful conclusions regarding the CSFs. This study seeks to answer the following research question:

R.Q. What are the most important CSFs for LP/LSS in LGOs based on the integration of an expert survey and meta-synthesis?

6.4.1 Expert Survey

An expert survey was developed to evaluate the 47 CSFs based on their importance for LP/LSS in LGOs. About other expert-based methods, such as the Delphi method, an expert was defined by Keeney *et al.* (2011, p. 7) as a "group of 'informed individuals' and as 'specialists' in their field or someone who has knowledge about a specific subject." Furthermore, the inclusion criteria for experts can be assessed according to, for example, their qualifications, number of publications in their area of expertise, and years of experience (Keeney *et al.*, 2011; Shanteau *et al.*, 2002). For this investigation, an expert was defined as an academic, researcher, or practitioner who had experience with LP/LSS in LGO settings. This definition aligns with that of other based-expert methods.

The experts were identified by two main sources. The first set had authored or co-authored two or more publications based on an SLR analysis. The second set of experts was identified through the researchers' professional networks, in addition to expert practitioners who had authored books, magazines, articles, and blog posts. The optimal number of experts to include in a survey is a subject of debate (Shariff, 2015). While some scholars argue for a larger pool of over 100 experts, others contend that a smaller group of 5 to 15 is adequate (Yazdi *et al.*, 2021). The literature presents studies that have used a small set of experts that ranged from 8 to 15 to solicit their opinions to understand certain phenomena (Demirkesen and Bayhan, 2020; Patil and Kant, 2014; Vikas, 2021; Yazdi *et al.*, 2021). In total, 49 experts were identified from different countries, including the U.S., the U.K., Mexico, Canada, Albania, Denmark, Sweden, and Spain.

The structure of the expert survey consisted of four main sections. The first section was related to the CSFs, each of which was assessed by participants based on its importance on a 6-point Likert scale (1 = Not at all important, 2 = Low importance, 3 = Somewhat important, 4 = Moderately important, 5 = Very important, and 6 = Extremely important), supplemented by a definition of each factor. The second section of the expert survey invited participants to identify the most important enablers and barriers to successful LP/LSS in LGOs using open-ended (free-response) questions. The third section asked about participants' background, including current role, improvement methodology experience, years of experience, recency in developing and/or implementing LP/LSS, and geographical location. The fourth section asked participants to suggest other potential participants for future research development (i.e., a larger empirical field study). Furthermore, the scale quality (item per CSF) was developed based on a rigorous literature review and was evaluated and revised multiple times, in addition to following prior studies with a similar approach, such as Gonzalez Aleu (2016) and Keathley-Herring (2016). This process increased the content validity and ensured that each scale item would measure what it was intended to measure. The expert survey template is included in Appendix C.

6.4.2 Meta-Synthesis

A previous study (Harry and Alrezq, 2022) conducted a meta-synthesis to evaluate the strength of the effect of the 47 CSFs based on three criteria. The meta-synthesis assessment process involved three main aspects that included *frequency of factors*, degree of importance (i.e., operationalized as a *large effect*), and *quality of publications*. First, the frequency of mention of each factor across all studies was used. This was measured by the number of papers that reported each factor. The second criterion assessed the importance of each success factor as noted in a given paper. This criterion was measured based on the evidence of the strength of the effect of each factor. The third

criterion focused on the quality of each publication. This criterion assessed the presence of essential and demonstrable research process criteria, such as aspects related to the research methodology (i.e., data collection and data analysis procedures), and outcome criteria related to the research findings. More specifically, the quality of a publication was assessed based on the following four questions for each single publication (Hong *et al.*, 2018): Are there clear research questions or objectives? Is there a structured methodology for data collection and data analysis? Do the collected data allow the researcher(s) to address the research questions/objectives? Are there clearly defined findings and are they discussed sufficiently? Harry and Alrezq (2022) provide a comprehensive description of the meta-synthesis process.

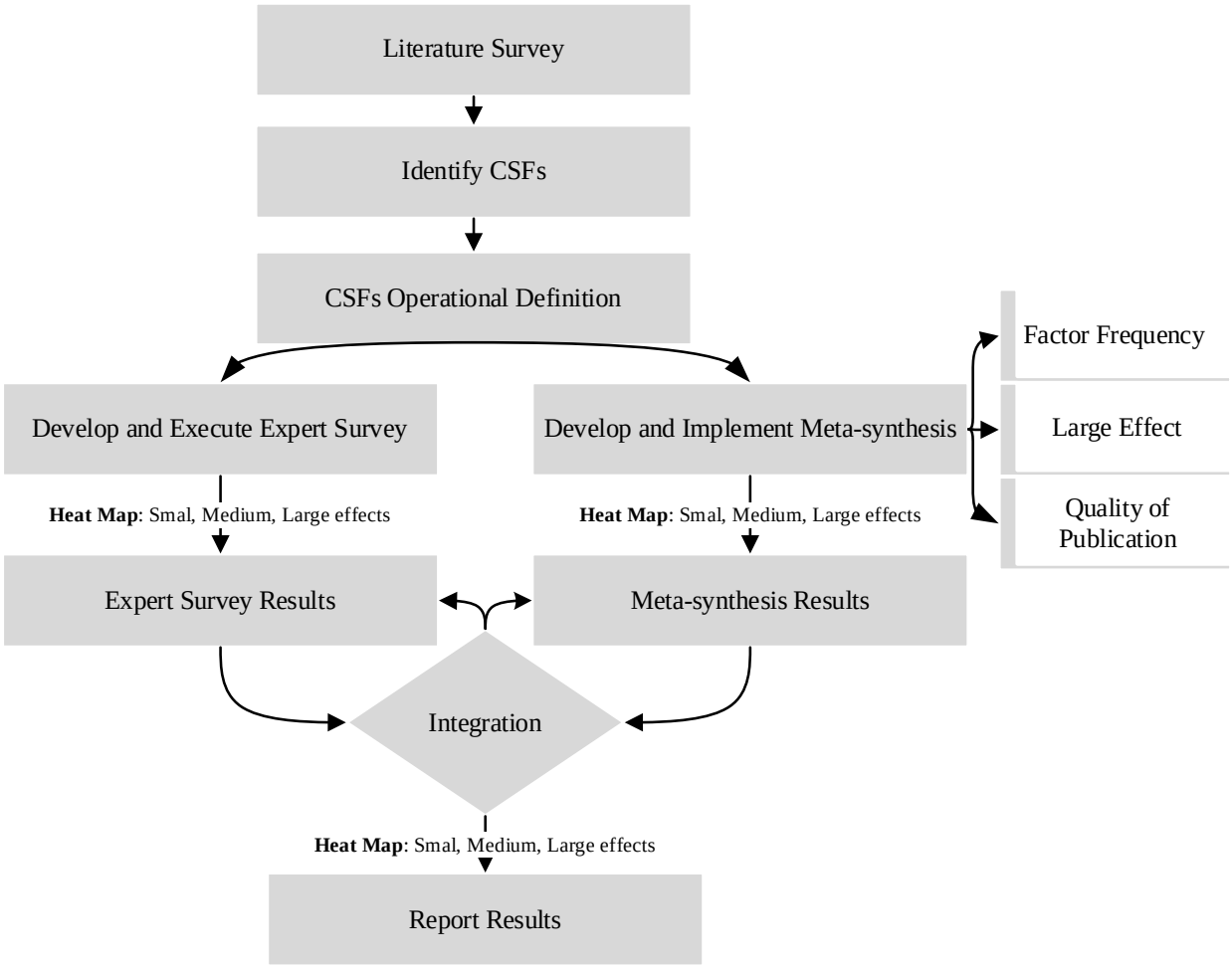

Figure 22 (Figure 1, Manuscript #5) Workflow of factors synthesis through expert assessment and meta-synthesis

6.5 Results and Discussion

An invitation was sent to participants through email describing the goal of the survey with a link to it. The survey was developed using QuestionPro and was open for two months. Out of 45 experts, 10 completed responses were received, with a response rate of 20.4%. Table II depicts the background information of the experts (i.e., 10 participants), of which six respondents were from academics, three were practitioners, and one was a consultant. Furthermore, the results revealed

that the majority of participants had extensive years of experience (six participants reported having more than 15 years of experience) and had recently participated in LP/LSS in the target organizations. Finally, the geographical distribution of the responses included five countries: the U.S., Denmark, Mexico, Sweden, and Albania.

Table 16 (Table II, Manuscript #5) Expert survey demographic

Profile	**Characteristics**	**Responses (N=10 experts)**
Professional practice	Academic/researcher	6
	Practitioner in an LGO	3
	Consultant	1
Experienced improvement methodology	Lean Six Sigma	5
	Lean Production	3
	LP/LSS (integrated approach)	1
	Kaizen	1
Years of experience	More than 10 years	6
	1-5 years	3
	5-10 years	1
Recency in participating in or observing LP/LSS	Less than a year ago	6
	More than five years ago	3
	3-5 years ago	1
Geographical location	The U.S.	6
	Denmark	1
	Mexico	1
	Sweden	1
	Albania	1

As described previously, each participant rated a given CSF based on a 6-point scale. Table III represents the frequency of a given factor from the literature and the mean from the expert survey. It was clear that the participants viewed all the proposed factors as having some level of importance, with the overall mean importance of the entire set of factors ranging from 3.1 to 5.6. These findings agree with the existing evidence in the literature and further validate the SLR process of extracting the CSFs. Further, based on the expert survey analysis, it appeared that *Leadership support/commitment* was the only factor recognized as a top factor in both approaches (i.e., frequency in the literature and expert survey). *Leadership support/commitment* was rated by six experts as an extremely important factor and by four experts as a very important factor (M = 5.6, SD = 0.52). The next highest-rated factor in the expert survey was *Leadership involvement* (M = 5.5, SD = 0.71). While *Leadership involvement* only appeared in nine publications in the literature review, its importance was recognized among experts due to the role that leadership plays in involvement. The importance of *leadership involvement* has been discussed in previous LP/LSS literature, such that organizations adopting this factor tend to be more successful, progress faster, and have more serious people (Laureani and Antony, 2017). Another interesting factor that emerged from the expert survey was *Data quality. Data quality* was among the least frequent factors (appearing only three times) in the literature analysis; however, it received a strong rating of importance in the expert survey (M = 5.0, SD = 0.67). The high rating for this factor might be due to the majority of experts (N = 6 participants) having LSS experience. This improvement

methodology (i.e., LSS) requires sufficient high-quality data to define the baseline for a given problem, as discussed in a case study in an LGO setting (Antony *et al.*, 2017). Further, the expert survey also rated a subset of factors as moderately important or higher. Thus, in total, 33 factors received a score between 3 and 6 on the Likert scale (with a mean ranging between 4.2 and 5.6), while 14 factors were rated as having low importance or lower.

Table 17 (Table III, Manuscript #5) Critical success factors based on the frequency in the literature and expert rating

Category	**Critical Success Factor**	**Frequency in the Literature (N= 44 papers)**	**Mean (SD) (N= 10 experts)**
Organization	Leadership support/commitment	28	5.6 (0.52)
	Leadership involvement	9	5.5 (0.71)
	Employee attitude	14	5.2 (0.63)
	Organizational culture	22	5.1 (0.88)
	Availability of data	6	5.0 (0.82)
	Data quality	3	5.0 (0.67)
	Resource availability	11	4.9 (0.99)
	Defining measures	6	4.9 (0.57)
	Leadership style	3	4.9 (1.52)
	Project identification and selection	7	4.7 (1.06)
	Addressing competing priorities	9	4.5 (0.53)
	Rewards and recognition	5	4.5 (0.71)
	Organizational readiness for LP/LSS	4	4.5 (0.85)
	Organizational characteristics	3	4.4 (1.17)
	General resistance to change	6	4.2 (1.14)
	Customer buy-in/engagement	2	4.1 (1.29)
	Supplier relationships	2	4.0 (1.05)
	Politics/regulations constraints	4	3.9 (1.37)
	External influence for implementation	4	3.6 (1.07)
	Organizational experience with LP/LSS	2	3.5 (1.18)
	Organizational accreditation	1	3.1 (1.20)
Process	Employee engagement	13	5.1 (0.57)
	Target system employee commitment to change	6	5.1 (0.74)
	Tool appropriateness	10	5.0 (0.94)
	Effort required for LP/LSS	5	4.9 (0.74)
	Contextualization/customization of LP/LSS	6	4.8 (1.14)
	Scope of LP/LSS	4	4.6 (0.97)
	LP/LSS implementation process	4	4.6 (0.97)
	LP/LSS institutionalization	5	4.6 (1.43)
	Team autonomy	2	4.5 (1.08)
	Structured approach to LP/LSS	3	4.4 (0.52)
	LP/LSS reporting	6	4.3 (1.06)
Workforce	LP/LSS training and education	13	5.3 (0.48)
	Workforce knowledge and skills	10	5.2 (0.79)

	Experienced consultant	10	5.2 (0.92)
	General understanding of LP/LSS philosophy	2	4.6 (0.97)
	External consultant knowledge of LGO processes	3	4.4 (1.51)
Communication	Patience for results	5	5.3 (0.48)
	Understanding the need for change	8	5.2 (1.14)
	Communicating knowledge and success stories	7	5.0 (0.67)
	Awareness of LP/LSS benefits/value	8	4.7 (1.16)
Task design	Goal alignment	4	5.2 (0.79)
	Goal clarity	9	4.9 (0.74)
	Customer identification	8	4.9 (0.99)
	Target system complexity	4	4.0 (0.94)
Team design	Team structure and roles	2	5.1 (0.74)
	Cross functionality	5	4.6 (0.70)

6.5.1 Integrating the Meta-Synthesis and Expert Survey

This study employed two approaches in parallel to synthesize the final set of CSFs (see Figure 1). The following describes the results from each approach and the results from integrating the two approaches (i.e., overall integration).

To apply this meta-synthesis approach to the CSFs, 47 factors from Alrezq *et al.* (2023) were considered. First, for the frequency of factors effect strength criterion, every unique factor from an individual paper was extracted and aggregated to find the total factor occurrence (the percentage of final papers with a given unique success factor). The cumulative frequencies of all factors were then weighted uniformly and defined as a small effect frequency (2%–22%), a medium effect frequency (23–43%), and a large effect frequency (44%–64%). This criterion (i.e., frequency of factors) identified two relevant factors based on this analysis for effect strength. Next, for the "large effect" criterion, each unique factor from an individual paper was noted for its degree of importance based on qualitative inferences, as explained earlier. A measure for capturing the "large effect" was devised such that a factor indicating a "large effect" was assigned a value of 1, whereas one not identified as having a "large effect" was assigned a value of 0. Each unique factor was then aggregated by finding a cumulative "large effect" or importance score (total frequency of all "large effect" occurrences) and then averaged to ensure a uniform scale. The overall "large effect" scores were then weighted evenly to determine its strength of effect rating and were specified as a small effect importance score (0–0.32), a medium effect importance (033–0.65), and a large effect importance score (0.66–1.00). This criterion resulted in selection of 27 CSFs that were the most relevant factors based on the "large effect" strength of effect analysis and were labeled as a large effect. Next, the quality of publication criterion evaluated a publication's quality based on four equally-weighted criteria described earlier (i.e., publication quality ratio was defined as the number of quality criteria evident divided by four). A cumulative quality score (summation of all respective quality ratios for unique factors) was determined and then averaged to ensure a uniform scale. For example, if a unique factor occurred in 20 publications, the cumulative quality score of all 20 publications (sum of 20 ratios) would first be determined, then divided by 20 to find its overall quality score. The overall quality scores were then distributed uniformly to define its strength of effect ratings as a small effect quality score (0.72–0.80), a medium effect quality score (0.81–0.90), and a large effect quality score (0.91–1.00). Based on the analysis of this criterion, 21 CSFs received a large quality score. The results of each of the three strength effect criteria from the meta-

synthesis approach are summarized in Table V. Finally, the integrated combined strength of effect was determined from all strength of effect analyses by applying the integrated rating classification schema established in Figure 2. From this analysis, Table IV (column labeled "MSE") shows the overall integrated strength of effects as the most significant factors were labeled as "**L**", the following group of significant factors was labeled as "**M**", and the least significant factors were labeled as "**S**".

Overall Meta-synthesis Integrated Effect Ratings	Meta-synthesis Individual Effect Ratings			
Large Effect	L	L	L
	M	L	L
	S	L	L
Medium Effect	M	M	L
	M	M	M
	S	M	L
	S	M	M
Small Effect	S	S	L
	S	S	M
	S	S	S

Figure 23 (Figure 2, Manuscript #5) Integration of combined strength of effect, adopted from Harry and Alrezq (2022)

To further evaluate the factors' strength of effect based on the expert assessment, a similar approach to the meta-synthesis (Harry and Alrezq, 2022) was performed with the expert survey results. The mean and standard deviation were calculated for each factor (see Table III); then, the overall mean scores were distributed uniformly to define the strength of effect ratings as a small effect (3.1–3.8), medium effect (3.9–4.6), and large effect (4.7–5.6). To determine the overall integrated effect rating based on the meta-synthesis and the expert survey, a heat chart (see Figure 3) was developed to segment key regions as an overall integrated large effect, overall integrated medium effect, and overall integrated small effect. Specifically, nine unique combinations for integrating the individual effect ratings corresponding to the two approaches were constructed and assigned to an overall integrated effect rating. The two bottom combinations in Figure 3 represent the overall integrated small effect, the four middle combinations represent the overall integrated medium effect, and the three top combinations represent the overall integrated large effect. The results of the strength of effect for the CSFs based on the expert survey are reported in Table IV (i.e., column labeled "ESE").

Level of effect	**Meta-synthesis**	**Expert survey**
Large	L	L
	M	L
	L	M
Medium	M	M
	S	M
	L	S
	S	L
Small	M	S

	S	S

Figure 24 (Figure 3, Manuscript #5) The overall integration of meta-synthesis and expert rating

Table IV shows the overall integration results for the meta-synthesis evaluation (MSE) and expert survey evaluation (ESE). This integrated approach yielded 29 factors that were determined to have a large effect. That is, each factor that emerged with a large effect in both approaches was considered to have a large effect (i.e., in the overall integration). Similarly, each factor that emerged as a large effect in one approach and as a medium effect in another approach was considered to have a large effect (see Figure 3). These 29 factors accounted for 60% of the total CSFs identified from the literature (see Table I) and came from five categories: organization (11 factors), process (6 factors), communication (3 factors), workforce (4 factors), task design (4 factors), and team design (1 factor).

Some of the CSFs in the final set identified from integrating the two approaches have been reported in recent research as critical for LP/LSS success. While the current literature contains few larger empirical field studies (as described previously in the introduction), Keramida *et al.* (2022) conducted an empirical study for the CSFs of LP adoption with a focus on Greek public sectors (i.e., citizen service centers). In their study, eight factors emerged (i.e., communication, training and education, change and project management, organizational culture, top management commitment/support and leadership, teamwork, employee commitment/involvement and empowerment, and availability of resources.) through exploratory factor analysis and confirmatory factor analysis. However, they concluded that the most important factors were those that were human-related, such as communication, top management commitment and leadership, and organizational culture. Furthermore, in a case study, Nyande *et al.* (2022) reported barriers to Lean implementation in a Driver and Vehicle Licensing Authority in Ghana. Their list of factors included lack of top management support, consulting cost in Lean, strict approval and requirements, lack of knowledge in Lean, and lack of government backing for research and teamwork in Lean. Similarly, Abaidoo and Blankenberger (2022) employed a case study using pattern matching by mapping a lean implementation framework developed by Furterer (2004) to assess how a state agency (i.e., the Department of Health Services) was applying lean principles. Abaidoo and Blankenberger (2022) concluded that the integration of staff and upper management, collaboration, understanding and acceptance from both management and staff, and management involvement were important factors. While there are many factors that overlap with the factors identified in this study, it seems there might be some emerging factors, such as consulting costs in Lean and government backing for research. The emergence of new factors might be due to different reasons. For example, Netland (2016) argued that based on contingency theory, common advice on CSFs might not be universally applicable but rather contingent on specific situations, such as implementation stage, size, and national culture. Moreover, this research area has not fully matured. More specifically, among the research gaps identified by Alrezq and Van Aken (2022), there is still a need to conduct case studies and research in different geographical regions. The resulting contributions of future studies could add more factors that bring more insights and knowledge related to successful implementation within these organizational settings.

Table 18 (Table IV, Manuscript #5) Overall integration of meta-synthesis and expert survey

Critical Success Factor	**Category**	**MSE**	**ESE**	**Overall integration**

Leadership support/commitment [a]	Organization	L	L	L
Organizational culture [a]	Organization	L	L	L
Resource availability [a]	Organization	L	L	L
Experienced consultant [a]	Workforce	L	L	L
Customer identification [a]	Task design	L	L	L
Defining measures [a]	Organization	L	L	L
General resistance to change [a]	Organization	L	M	L
LP/LSS institutionalization [a]	Process	L	M	L
Scope of LP/LSS [a]	Process	L	M	L
Target system complexity [a]	Task design	L	M	L
Leadership style [a]	Organization	L	L	L
Organizational characteristics [a]	Organization	L	M	L
Data quality [a]	Organization	L	L	L
External consultant knowledge of LGO processes [a]	Workforce	L	M	L
Employee attitude [a]	Organization	M	L	L
Employee engagement [a]	Process	M	L	L
LP/LSS training and education [a]	Workforce	M	L	L
Workforce knowledge and skills [a]	Workforce	M	L	L
Tool appropriateness [a]	Process	M	L	L
Goal clarity [a]	Task design	M	L	L
Leadership involvement [a]	Organization	M	L	L
Addressing competing priorities	Organization	M	M	M
Understanding the need for change [a]	Communication	M	L	L
Communicating knowledge and success stories [a]	Communication	M	L	L
Project identification and selection [a]	Organization	M	L	L
Contextualization/customization of LP/LSS [a]	Process	M	L	L
LP/LSS reporting	Process	M	M	M
Patience for results [a]	Communication	M	L	L
Cross-functionality	Team design	M	M	M
Effort required for LP/LSS [a]	Process	M	L	L
Goal alignment [a]	Task design	M	L	L
Organizational readiness for LP/LSS	Organization	M	M	M
Politics/regulations constraints	Organization	M	M	M
Organizational experience with LP/LSS	Organization	M	S	S
Team structure and role [a]	Team design	M	L	L
Awareness of LP/LSS benefits/value	Communication	S	L	M
Availability of data	Organization	S	L	M
Target system employee commitment to change	Process	S	L	M
Rewards and recognition	Organization	S	M	M
External influence for implementation	Organization	S	S	S
LP/LSS implementation process	Process	S	M	M
Structured approach to LP/LSS	Process	S	M	M
Supplier relationships	Organization	S	M	M

General understanding of LP/LSS philosophy	Workforce	S	M	M
Team autonomy	Process	S	M	M
Customer buy-in/engagement	Organization	S	M	M
Organizational accreditation	Organization	S	S	S

Note: [a] Factor emerged as a large effect/strength based on the integration of the meta-synthesis and the expert survey; **MSE**= Meta-synthesis effect; **ESE**= Expert survey effect

6.5.2 Expert Survey Perspectives on CSFs

In addition to having the experts rate the importance of each CSF, the second section of the expert survey invited participants to identify the most important enablers and barriers to successful LP/LSS in LGOs using open-ended (i.e., free response) questions. These questions allowed experts to draw from their vast experience in this area (i.e., LP/LSS in LGOs) and leverage their expertise to provide detailed responses based on their perspectives. Their collective responses revealed that out of the 47 CSFs, 20 factors (about 45% of the total CSFs synthesized from the literature) were distinctly identified as playing a dual role in LP/LSS success. These 20 factors were categorized as both enablers and barriers to the successful implementation of LP/LSS methodologies, as shown in Figure 4. The most frequent factors were: *Leadership Support/commitment*, *Workforce Knowledge* and *Skills*, *Target system Complexity*, and *Organizational culture*. An enabler, in this context, refers to a factor that facilitates or promotes the effective application of LP/LSS principles, leading to improved operational efficiency and quality. On the other hand, when these factors are not appropriately managed or addressed, they can act as barriers, hindering the successful execution of LP/LSS implementation. This duality underscores the importance of a nuanced understanding and strategic management of these factors to harness their potential as catalysts for success while mitigating the risks they pose as obstacles.

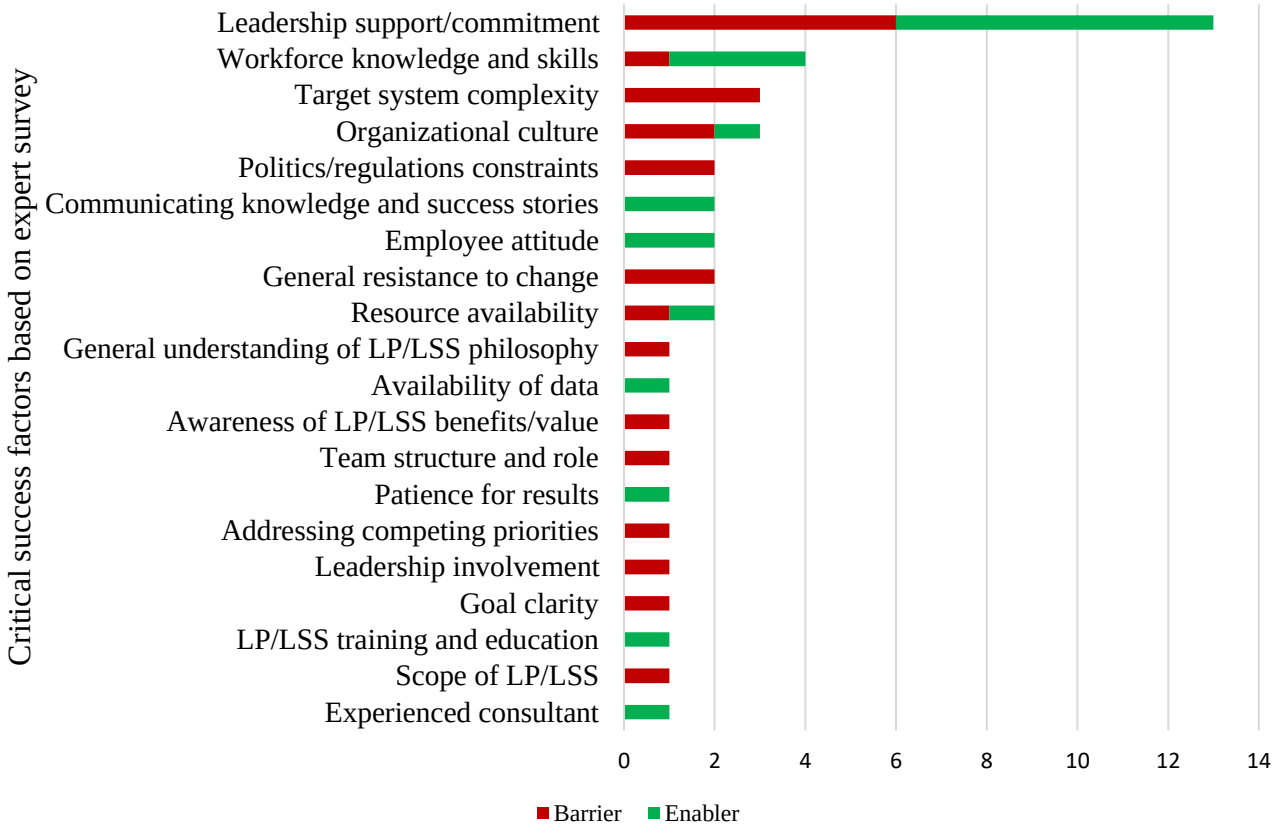

Figure 25 (Figure 4, Manuscript #5) Enablers and barriers reported by expert survey participants

6.6 Conclusions

This study targeted the CSFs associated with the successful development and/or implementation of LP/LSS in LGOs. More specifically, this study adopted a comprehensive set of 47 CSFs that were analyzed by Alrezq *et al.* (2023). In a parallel investigation, two approaches were used to synthesize the factors, including an expert survey and a meta-synthesis. The latter approach was adopted from Harry and Alrezq (2022).

Based on the two rigorous approaches for synthesizing the 47 CSFs, 29 factors emerged as crucial for LP/LSS success. Therefore, to ensure the success and long-term sustainability of LP/LSS within LGOs, all 29 CSFs should be integrated into this improvement program. This set of factors might guide LGOs that are willing to implement LP/LSS based on their needs. It is important to take into consideration these key CSFs identified from this study at the pre-implementation stage. Such an approach would help an organization decide whether or not it has the capabilities and resources to address those CSFs, as these are vital to LP/LSS success and outcome achievement. Furthermore, the use of two approaches in this study to synthesize the CSFs not only enhanced the identification of the most crucial factors uniquely but also added significant value to the results. It is probable that practitioners, particularly those in LGOs, would find the synthesized sets of factors particularly valuable. Furthermore, these identified factors may also prove applicable to other public or service organizations that share similar characteristics.

This study was limited to the adopted set of CSFs. These factors were identified from academic publications. Thus, there might be other factors that are unique to a given system in which LP/LSS is being implemented. Another limitation was related to the number of responses. This study

surveyed 10 experts to analyze the final set of factors. While expert assessment might be another limitation in terms of the potentially subjective rating of each factor, the demographic information indicated that experts had a decent number of years of experience with this improvement methodology.

The result of this study points to several avenues for future work. Conducting a larger empirical field study to examine which of the 29 factors influence system outcomes would be especially useful. Such a study would also help identify factors for a given latent construct, followed by examining the influence on technical and social outcomes. In addition, evaluating the importance of the complete set of factors based on team level could provide useful insights. Improvement teams often interact with this improvement methodology in an action environment as they are the ones who drive the implementation process in a given system or process. Thus, their evaluations can provide more insight based on their experience about which CSFs are more important.

Table 19 (Table V, Manuscript #5) Results of meta-synthesis for each individual criterion

Critical Success Factors		**Frequency of Factors**	**Large Effect**	**Quality of Publications**
		Percentage (Effect)	**Importance Score (Effect)**	**Quality Score (Effect)**
1	Leadership support/commitment	64% (L)	0.79 (L)	0.85 (M)
2	Organizational culture	50% (L)	0.77 (L)	0.82 (M)
3	Employee attitude	32% (M)	0.86 (L)	0.89 (M)
4	Employee engagement	30% (M)	0.62 (M)	0.90 (M)
5	LP/LSS training and education	30% (M)	0.69 (L)	0.88 (M)
6	Resource availability	25% (M)	0.73 (L)	0.93 (L)
7	Workforce knowledge and skills	23% (M)	0.90 (L)	0.78 (S)
8	Experienced consultant	23% (M)	0.78 (L)	1.00 (L)
9	Tool appropriateness	23% (M)	0.60 (M)	0.91 (L)
10	Goal clarity	20% (S)	0.56 (M)	0.86 (M)
11	Leadership involvement	20% (S)	0.78 (M)	0.92 (L)
12	Addressing competing priorities	20% (S)	0.67 (L)	0.89 (M)
13	Customer identification	18% (S)	1.00 (L)	0.91 (L)
14	Understanding the need for change	18% (S)	0.38 (M)	0.97 (L)
15	Awareness of LP/LSS benefits/value	18% (S)	0.88 (L)	0.72 (S)
16	Communicating knowledge and success stories	16% (S)	0.57 (M)	0.93 (L)
17	Project identification and selection	16% (S)	0.57 (M)	0.86 (M)
18	Availability of data	14% (S)	0.83 (L)	0.75 (S)
19	Target system employee commitment to change	14% (S)	0.83 (L)	0.79 (S)
20	Defining measures	14% (S)	0.83 (L)	0.96 (L)
21	Contextualization/customization of LP/LSS	14% (S)	0.33 (M)	0.96 (L)
22	General resistance to change	14% (S)	0.83 (L)	0.92 (L)
23	LP/LSS reporting	14% (S)	0.67 (L)	0.83 (M)
24	Patience for results	11% (S)	0.80 (L)	0.90 (M)
25	Cross-functionality	11% (S)	0.60 (M)	0.95 (L)
26	Rewards and recognition	11% (S)	0.20 (S)	1.00 (L)
27	LP/LSS institutionalization	11% (S)	0.80 (L)	0.91 (L)
28	Effort required for LP/LSS	11% (S)	0.80 (L)	0.80 (M)
29	External influence for implementation	9% (S)	0.00 (S)	0.94 (L)

30	Scope of LP/LSS	9% (S)	0.75 (L)	0.94 (L)
31	Goal alignment	9% (S)	0.75 (L)	0.88 (M)
32	Organizational readiness for LP/LSS	9% (S)	0.75 (L)	0.88 (M)
33	LP/LSS implementation process	9% (S)	0.25 (S)	0.94 (L)
34	Target system complexity	9% (S)	1.00 (L)	0.94 (L)
35	Politics/regulations constraints	9% (S)	0.75 (L)	0.89 (M)
36	Leadership style	7% (S)	0.67 (L)	0.92 (L)
37	Organizational characteristics	7% (S)	0.67 (L)	1.00 (L)
38	Data quality	7% (S)	0.67 (L)	0.92 (L)
39	External consultant knowledge of LGO processes	7% (S)	1.00 (L)	1.00 (L)
40	Structured approach to LP/LSS	7% (S)	0.33 (M)	0.75 (S)
41	Supplier relationships	5% (S)	0.00 (S)	0.75 (S)
42	Organizational experience with LP/LSS	5% (S)	0.50 (M)	0.88 (M)
43	General understanding of LP/LSS philosophy	5% (S)	0.00 (S)	0.75 (S)
44	Team autonomy	5% (S)	0.50 (M)	0.75 (S)
45	Customer buy-in/engagement	5% (S)	0.50 (M)	0.75 (S)
46	Team structure and role	5% (S)	0.50 (M)	1.00 (L)
47	Organizational accreditation	2% (S)	0.00 (S)	0.75 (S)

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Chapter 7: Manuscript #6 – Analysis of Lean Management and Lean Six Sigma in Local Government Organizations Using Partial Least Squares-Structural Equation Model

7.1 Manuscript preparation

Chapter 7 (Manuscript #6) has been formatted following the submission guidelines for the *International Journal of Operations & Production Management*, including text format, citation styles, figure color, and references. Further refinements to the manuscript may be made before submission.

7.2 Structured Abstract

Purpose – This study aims to empirically evaluate and identify the influential factors related to Lean Management and Lean Six Sigma (LM/LSS) implementation success in the context of local government organizations (LGOs).

Design/methodology/approach – A cross-sectional field study targeting LGOs was used to collect data. Exploratory factor analysis (EFA) was employed to identify a representative set of latent variables, followed by conducting a partial least squares-structural equation model (PLS-SEM) model to statistically test the size and significance of CSFs on system outcomes.

Findings – Three endogenous and five exogenous latent variables were identified based on EFA models. With an explanatory power (R^2) ranging between 53% and 71%, the PLS-SEM model revealed that *Improvement Readiness* [$\beta = 0.31, f^2 = 0.16$] and *Change Awareness* [$\beta = 0.22, f^2 = 0.11$] were positively significant on *Transformation Success*. Furthermore, *Sustainable Improvement Infrastructure* [$\beta = 0.46, f^2 = 0.24$] and *Measure-based Improvement* [$\beta = 0.36, f^2 = 0.18$] were each significant and positively influenced *Deployment Success* and *Improvement Project Success*, respectively. Moreover, the factors had small to medium size effects.

Originality/value – This study examined CSFs that were extracted from LGOs' experience with LM/LSS, instead of adopting CSFs from general service sector organizations.

Keywords: Lean management, Lean six sigma, Local government, Public organizations, Partial least squares-structural equation model, PLS-SEM, Success factors

Paper type: Empirical research

7.3 Introduction

The embeddedness of improvement philosophy, practices, and tools/techniques has become an essential strategy for organizations to maintain their competitiveness. Among these strategies and practices are Lean Management and Lean Six Sigma (LM/LSS). LM is an improvement methodology oriented toward the elimination of non-value added activities for systems/processes, while Six Sigma (SS) focuses on reducing variation in processes using statistical tools. The integration of LM and SS (known as Lean Six Sigma and abbreviated as LSS) potentially maximizes the rate of improvement on system outcomes (Gastelum-Acosta et al., 2021).

LM and LSS are key fundamentals of the concept of continuous improvement and have been introduced in nearly all industries (Fenner and Netland, 2023; Fenner et al., 2023). This wide

dissemination of LM/LSS means that LM/LSS has been embraced into systems that are functioning differently from manufacturing (Soliman and Saurin, 2017), for instance, public sector organizations (Psomas et al., 2022), particularly in local government organizations (LGOs), which is the focus on this study. The applications of LM/LSS in LGOs have contributed to improving system-wide performance outcomes, such as financial savings, streamlining processes, and quality of service (Alrezq and Van Aken, 2022).

However, organizations deploying LM/LSS have experienced and reported a spectrum of results, ranging from notable successes to less favorable outcomes (Netland, 2016). Consequently, this diversity of outcomes has contributed to the growth of continuous improvement literature, leading scholars to investigate diverse aspects of LM/LSS, including critical success factors (CSFs). Analyzing CSFs is a key area of focus due to their possibility to increase the success rate (Gastelum-Acosta *et al.*, 2021; Netland, 2016). LGOs are not exceptional in that they also experience challenges in utilizing LM/LSS in their work settings. In fact, the need to investigate the CSFs within the context of LGOs has been identified based on analysis of the scientific literature (Alrezq and Van Aken, 2022). This crucial need has been addressed by identifying and characterizing a comprehensive list of CSFs (Alrezq *et al.*, 2023).

Studying the statistical significance of the CSFs and their relationships to outcomes provides a rigorous and complete understanding of this phenomenon within this organizational context. However, an important characteristic of these CSFs is that they are latent variables (i.e., unobserved variables or constructs that are measured using single or multiple indicators) (Gastelum-Acosta *et al.*, 2021). Furthermore, among the statistical algorithms used to estimate the relationship between latent variables is the partial least squares-structural equation model (PLS-SEM) (Urbach and Ahlemann, 2010). PLS-SEM is a second-generation technique used to explore the relationships between variables (or constructs) when there is limited knowledge (Hair, 2014). PLS-SEM comprises constructs (also known as latent variables) and indicators. The former is a set of variables that are not measurable, while the latter are directly measurable indicators (e.g., items) (Hair, 2017).

PLS-SEM possesses unique characteristics that make it appealing for this study. Firstly, it often exhibits greater statistical power compared to other latent models (e.g., co-variance-based structural equation models), which means it is more efficient in parameter estimation and more likely to detect significant relationships that exist in the population (Hair, 2017). Additionally, PLS-SEM is known for its efficiency, as it reaches the optimal solution after only a few iterations (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). Another key feature of PLS-SEM is that it supports exploring potential relationships without the need for well-established theories (or with a little prior knowledge of structural model relationships) (Hair, 2017). Lastly, PLS-SEM is particularly valuable in exploratory research, where the objective is to discover and develop theories rather than to test and confirm pre-existing ones. It serves as a tool for building models that can later be tested with more confirmatory approaches (e.g., co-variance-based structural equation models) once the theory is more developed (Hair, 2017b, p. 36).

The goal of this study is to design and execute an empirical field study (i.e., using a survey questionnaire) to statistically identify which of the CSFs (see Table 1) have a significant impact on outcomes (further described later). To achieve this goal, an exploratory factor analysis (EFA) was conducted to identify the underlying structure among the list of CSFs, followed by employing PLS-SEM to statistically examine the significance of the relationships between the factors and LGO outcomes.

7.4 Overview of Critical Success Factors and Success Outcomes

The exploration and identification of CSFs associated with LM/LSS in LGOs has been conducted in a thorough and multi-staged manner. The following subsections provide a brief and concise overview of the stages involved in categorizing the CSFs and hypothesizing the relationships based on the developed conceptual model.

7.4.1 Outcome Variables

To understand the most influential factors on outcomes for LM/LSS success, this study employed socio-technical system (STS) theory. STS is a method of viewing an organization as an interconnection of social and technological subsystems, and the relations of the whole organization to the environment (Pasmore *et al.*, 1982). This concept of STS enables the examination of system outcomes of LM/LSS success based on technical and social outcomes as it has been argued that LM/LSS is an integrated socio-technical system (Januszek *et al.*, 2024; Shah and Ward, 2007). The technical system refers to equipment, tools, techniques, and processes, while the social system refers to people and their relationships (Hadid *et al.*, 2016). The STS framework suggests that for optimal outcomes, improvement initiatives should focus on the joint optimization of both technical and social aspects, as they are more likely to have positive interactions leading to higher performance (Hadid *et al.*, 2016; Minshull *et al.*, 2022; Pasmore *et al.*, 1982)

In this study, four outcome variables (consisting of 13 items) were adopted from (Keathley-Herring, 2016; Mushi, 2014) and modified to fit in the context of this study. The outcome variables are divided into two sets. The first set includes variables that are related to technical system outcomes (i.e., *improved organizational results*, *LM/LSS embeddedness*, and *general success*), while the second set contains one variable that is related to social system outcomes (i.e., *improved employee results*). Within the first set, the *improved organizational results* (measured using three items) target the perceptions of organization members about the impact of LM/LSS on performance. The *LM/LSS embeddedness* (three items) seeks to elicit participants' perceptions of the extent to which LM/LSS is being integrated into work routines, culture, and deployment across organizational levels. The *general success* (four items) assesses the overall success of LM/LSS in the organization along with budget and timeline compliance and stakeholder acceptance. Within the second set, the social system variable (i.e., *improved employee results* and measured using three items) assesses employee perceptions about their buy-in, satisfaction, and growth and development.

7.4.2 Critical Success Factors

Initially, Alrezq and Van Aken (2022) surveyed the scientific literature to assess the current status of LM/LSS in the context of LGOs. This exploratory study uncovered that CSFs represented a significant and unexplored area of research. Motivated by this finding, Alrezq et al. (2023) conducted a rigorous systematic literature review to identify and determine the crucial CSFs for the success of LM/LSS in LGO environments. This exhaustive literature review culminated in the identification of a comprehensive list comprising 47 unique CSFs. Building on this groundwork, Harry and Alrezq (2022), along with Alrezq and Van Aken (2023), developed and executed a dual-methodology framework that synergistically combined meta-synthesis with an expert survey. This approach streamlined the initial list of 47 CSFs to a more focused set of 29 distinct factors (see Table 1). These 29 factors were subsequently categorized into six distinct groups, thereby enhancing the clarity and relevance of each factor within the LM/LSS paradigm. The

categorization involved: organization (11 factors), workforce (4 factors), communication (3 factors), task design (4 factors), team design (1 factor), or process (6 factors).

Table 20 (Table 1, Manuscript #7) Synthesized critical success factors

	Category	Variable/item	Code
System outcomes	Technical system	Success Implementation[a]	IMPL_SUCC_1
		Budget Compliance[a]	BUDG_COMP_3
		Task Timeline[a]	TASK_COMP_9
		Stakeholder Acceptance[a]	STAKEH_ACC_10
		Cultural Integration[b]	CULT_INTG_2
		Organizational Deployment[b]	DEPLOY_6
		Activity Integration[b]	ACT_INTG_7
		Organization Improvement[d]	ORG_IMP_4
		Business Improvement[d]	BUSI_IMP_8
		Decision Improvement[d]	DEC_IMP_13
	Social system	Employee Satisfaction[c]	EMPL_SAT_11
		Employee Belief[c]	EMPL_BEL_12
		Employee Skill Enhancement[c]	EMPL_SKI_5
Critical Success Factor	Organization	Leadership support/commitment	LD_SUP_1
		Organizational culture	ORG_CUL_2
		Resource availability	RES_AVL_4
		Employee attitude	EMP_ATT_3
		Project identification and selection	PRJ_SEL_6
		Defining measures	DEF_MEA_7
		General resistance to change	RES_CHG_8
		Leadership involvement	LD_INV_5
		Leadership style	LD_STL_9
		Organizational characteristics	ORG_CHR_10
		Data quality	DAT_QLT_11
	Workforce	LP/LSS training and education	TRA_EDUC_18
		Workforce knowledge and skills	WKF_SKL_19
		External consultant knowledge of LGO processes	EXT_CON_21
		Experienced consultant	EXP_CON_20
	Communication	Understanding the need for change	UND_CNG_22
		Patience for results	PAT_RES_24
		Communicating knowledge and success stories	COM_KNW_23
	Process	Effort required for LP/LSS	EFT_REQ_15
		Contextualization/customization of LP/LSS	CONTX_CUS_14
		LP/LSS institutionalization	INSTIT_17
		Scope of LP/LSS	SCOPE_16
		Employee engagement	EMP_ENG_12

	Tool appropriateness	TOOL_AP_13
Task design	Customer identification	CUS_IDEF_26
	Goal clarity	GOAL_CL_25
	Goal alignment	GOAL_AL_27
	Target system complexity	SYS_COM_28
Team design	Team structure and role	TEAM_ST_29

Note: The list of CSFs was adopted from Alrezq and Van Aken (2023); the number of items is one per critical success factor; **a** refers to items measuring *General Success*; **b** refers to items measuring *LM/LSS Embeddedness;* **c** refers to items measuring *Improved employee results*; **d** refers to items measuring *Improved organization results*

In this study, the input-process-output framework was applied as a theoretical basis to explore the interconnections among the variables, as demonstrated by Liu and Cross (2016). Specifically, the conceptual framework (see Figure 1) visually represents how the six categories of CSFs influence both technical and social system outcomes. These categories are further divided into input and process groups. The input elements include five categories: organization, workforce, communication, task design, and team design. In contrast, the process elements are consolidated into a single category: process. The outcomes of this model are twofold, consisting of both technical and social aspects of the system. Thus, this study aims to validate the operational model (see Figure 1) and examine the following hypothesis:

Hypothesis: All factors have a positive influence on the technical and social system outcomes.

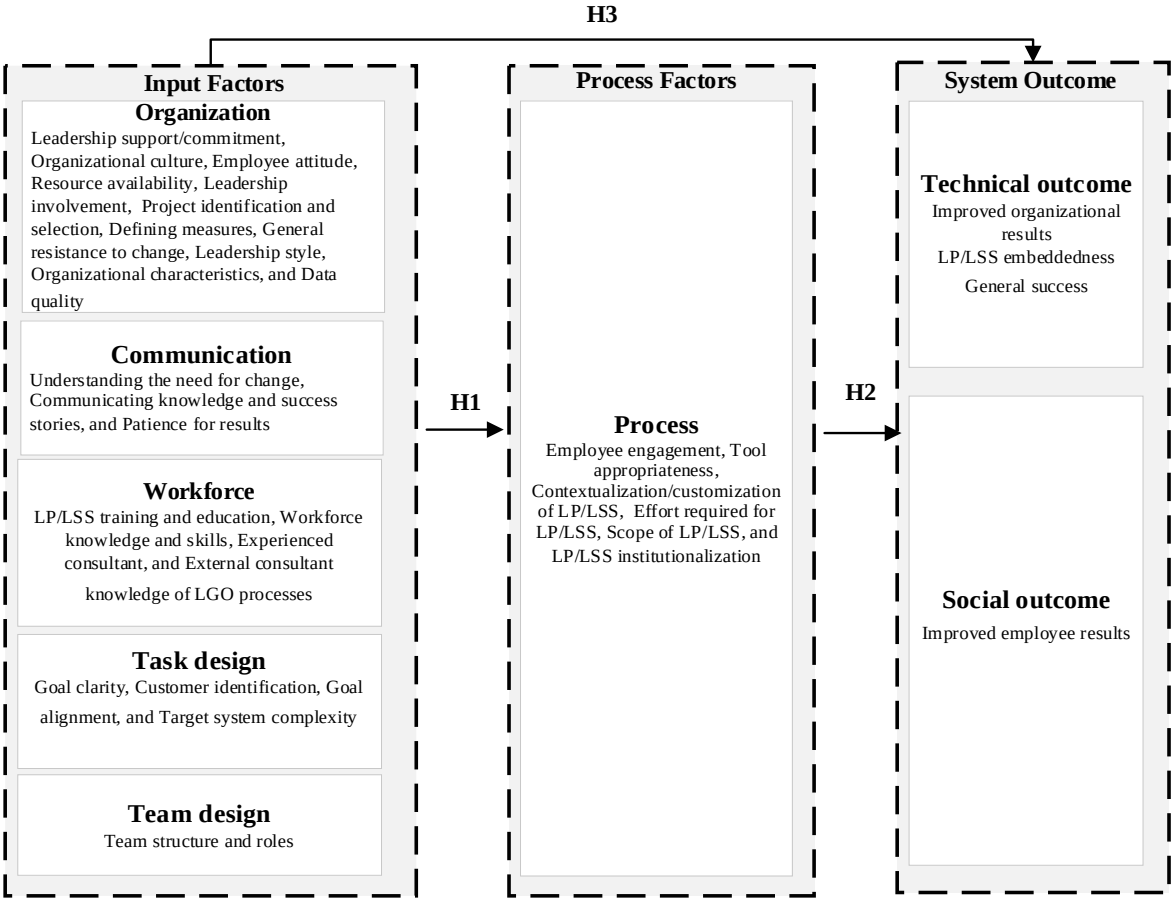

Figure 26 (Figure 1, Manuscript #7) Conceptual model based on the CSFs and system outcomes

7.5 Research Methodology

The primary purpose of this study is to statistically identify the key factors affecting outcomes for the development and/or implementation of LM/LSS within LGOs. To achieve this objective, a large-scale retrospective field study (using an online survey questionnaire) was designed and conducted. The survey's framework was structured around the 29 CSFs and the 13 items representing the independent and dependent variables, respectively (see Table 1). The survey method was chosen due to its robust capability to yield insights applicable to a wide range of populations, its effectiveness in conducting an extensive exploration of numerous variables, and its advantageous combination of user-friendliness and cost-efficiency in data collection (Nikbin *et al.*, 2013). The following section describes the survey design components and statistical techniques used to perform the analysis.

7.5.1 Data collection

The structure of the survey encompassed five main sections: an introduction section, outcome survey items, factor survey items, demographic survey items about the participants and organizations, and a section soliciting suggestions for future respondents. The introduction outlined the study's purpose and clarified key terminologies, such as LM/LSS and CSFs. The next section featured questions targeting the success outcomes of developing and/or implementing LM/LSS, comprising a total of 13 items (i.e., the experienced outcomes post LM/LSS completion). Section three evaluated the impact of each CSF on LM/LSS success through 29 items. The fourth section gathered background information on the organizations where LM/LSS was developed and/or implemented, including details about the participants' experiences and the LM/LSS tools/techniques utilized. The final section sought recommendations from survey participants for other potential respondents who might contribute to the survey. The survey questionnaire is shown in Appendix D.

The ideal number of response options per item and the optimal number of items per question have been subjects of debate in psychometric scale literature (Robinson, 2018). Depending on the variables being studied (e.g., survey limitations/space or respondent characteristics), studies have recommended either a 5-point or 7-point scale (Robinson, 2018); however, other studies found no difference in reliability and validity in a scale with four or more response points (Lee & Paek, 2014). This study used an agreement scale of a 6-point Likert scale (Strongly Disagree, Disagree, Tend to Disagree, Tend to Agree, Agree, Strongly Agree). While various scale types exist (e.g., importance scales in which the factors are ranked based on their importance), an agreement scale was chosen for its suitability in measuring the extent to which a factor was present, aligning with the study's requirement for respondents to evaluate CSFs based on their presence rather than their subjective opinions.

This study focused on examining the effect of CSFs on outcomes experienced by LGOs. Therefore, an organization or a designated sub-unit within an organization (e.g., social services, police, etc.) was identified as the unit of analysis (i.e., the organizational level). Studying phenomena at an organizational level is a widespread approach across various research disciplines, including continuous improvement contexts. Furthermore, this study implemented purposeful sampling for data collection. Purposeful sampling, a non-probability sampling method, entails selecting qualified individuals to investigate a specific phenomenon (Tortorella *et al.*, 2020). Thus, this study invited individuals with relevant experience in developing and/or implementing

LM/LSS within an LGO, encompassing roles such as managers, team leaders/facilitators, team members, or consultants.

7.5.2 Data analysis

The analysis process was performed using the R programming language (Team, 2010) and Rstudio (Allaire, 2012), employing different statistical packages (Ray *et al.*, 2022; Revelle, 2023; Wickham, 2023). Data analysis consisted of three main phases, each including multiple sub-analyses. These three phases were data preprocessing, exploratory factor analysis (EFA), and partial least squares-structural equation model (PLS-SEM).

After the survey concluded, the first phase was related to data preprocessing in which procedures were applied to check for missing values, outliers, and appropriate responses. Within the first phase, the profile of participants, the statistical description of the variables/items, and their correlations were analyzed. The second phase was to perform an EFA analysis. EFA is a technique that belongs to multivariate statistical analyses. EFA aims to identify the minimum number of theoretical constructs (also referred to as dimensions, factors, or latent variables) that efficiently explain the covariation found among a set of measured variables (also termed observed variables, manifest variables, or indicators) (Hair, 2019; Watkins, 2018). There are two commonly-used methods for performing EFA: common factor analysis and principal component analysis (PCA) (Hair, 2019). This study utilized the common factor analysis to reveal the underlying latent structure, primarily based on the common variance in the variables (or measured itemsEFA (or common factor) involves a series of procedures summarized as: assessing data factorability using Kaiser–Meyer–Olikin (KMO) and Bartlett's Test of Sphericity (Garson, 2022; Hair, 2010), determining the potential number of factors using scree plot and parallel analysis (Costello and Osborne, 2005), choosing the appropriate extraction method (e.g., principal axis factoring), selecting an appropriate rotation method (oblique versus orthogonal), assessing loading per item, evaluating cross-loading, communalities, and the percentage of total variance explained (Bikos, 2022; Garson, 2022; Hair, 2010, 2019).

The following phase of analyses focused on developing PLS-SEM to examine the hypothesis of this study (see Figure 1). Due to the unique characteristics of PLS-SEM (described previously in the introduction) and its exploratory nature, PLS-SEM was chosen. PLS-SEM comprises two main models: the measurement model (or the outer model) and the structural model (or the inner model) (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). The measurement model establishes the relationship between the latent variables and their indicators (i.e., measured items), while the structural model illustrates the paths between latent variables (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). Furthermore, PLS-SEM is capable of handling both reflective and formative measurement models. (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). This study adopted a reflective measurement model. In assessing the quality of the reflective measurement model, both reliability and validity were analyzed, as outlined by (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). Reliability is assessed at two levels: the indicator level (using indicator reliability) and the construct level (employing internal consistency reliability, which includes both composite reliability and the reliability coefficient). Indicator reliability determines how well an indicator reflects its intended construct, while internal consistency reliability measures how consistently different indicators capture the same construct. Validity, on the other hand, is verified through convergent validity and discriminant

validity. Convergent validity is assessed using the Average Variance Extracted (AVE). Discriminant validity is tested using the Heterotrait-Monotrait ratio (HTMT), Fornell and Larcker criteria (FLC), and cross-loadings. Convergent validity ascertains how well a construct accounts for the variation in its indicators, whereas discriminant validity gauges how uniquely a construct stands apart from other constructs. After establishing the reliability and validity of the measurement model, the focus shifts to the structural model. This model is then analyzed for collinearity issues, the significance of the paths, its explanatory power (R^2), effect size (f^2), and predictive power ($\text{PLS}_{\text{Predict}}$).

7.6 Results and Discussions

7.6.1 Data Preprocessing

Data collection was carried out between February 2023 and July 2023 using QuestionPro software. Several channels were utilized to distribute the survey including, but not limited to, government-associated organizations, professional societies, social media, and direct contact with government officials. In response, a total of 156 responses were received, yielding less than one percent response rate. Once the data were received and transferred into a centralized file, a data quality assessment (e.g., missing data, straightlining, and data distribution) was conducted (Hair, Hult, Ringle and Sarstedt, 2021). First, missing data at the respondent level (i.e., per case) was investigated. This investigation eliminated 87 respondents (79 respondents did not participate, and eight respondents missed more than 19 items, or 45% of the unanswered items). Furthermore, two respondents were removed as they were not from the targeted organizations (i.e., LGOs). Next, straightlining was screened on the remaining 67 responses. Straightlining occurs when respondents provide uniform answers to a high portion of the survey items (Hair, Hult, Ringle and Sarstedt, 2021). However, a descriptive statistic per respondent was performed and the standard deviation ranged between 0.21 and 1.77, which met the acceptable data quality criteria (lack of presence of zero standard deviation). Finally, the maximum missing data for any item was eight percent; thus, mean imputation was identified as an appropriate approach for handling items with less than 10% missing data (Watkins, 2018).

An evaluation of data quality was conducted to gain insight regarding data distribution. While this study utilizes a non-parametric model (i.e., PLS-SEM), it is crucial to verify that the data is not far from a normal distribution (Hair, Hult, Ringle and Sarstedt, 2021). Extreme non-normal distribution might cause problematic issues with the significance of the parameters (Hair, Hult, Ringle and Sarstedt, 2021). Skewness and kurtosis can be used to assess the normality of the data (see Table 2). Skewness evaluates the symmetry or asymmetry (i.e., shift) of data distribution, whereas kurtosis measures the peakedness or flatness of data distribution (Hair, Hult, Ringle and Sarstedt, 2021). For normally-distributed data, skewness and kurtosis should be between ± 2 and ± 7, respectively (Garson, 2022). Thus, based on the statistical descriptions in Table 2, skewness ranged between -1.46 and -0.33, and kurtosis ranged between -0.97 and 3.33. These findings confirm that the data were normally distributed. Furthermore, a correlation analysis utilizing the Pearson method was conducted, revealing a maximum correlation coefficient of 0.75 (See Appendix E.3).

Table 21 (Table 2, Manuscript #7) Descriptive statistics of the items

Order#	Item	Mean (sd)	Max (min)	Skew	Kurtosis	se	Order#	Item	Mean (sd)	Max (min)	Skew	Kurtosis	se
1	IMPL_SUCC_1	4.66 (1.05)	6 (1)	-0.99	1.31	0.13	22	LD_STL_9	4.07 (1.23)	6 (1)	-0.33	-0.44	0.15
2	BUDG_COMP_2	4.71 (1.19)	6 (1)	-1.29	1.56	0.15	23	ORG_CHR_10	4.15 (0.97)	6 (2)	-0.7	-0.04	0.12
3	TASK_COMP_3	4.12 (1.22)	6 (1)	-0.52	0.2	0.15	24	DAT_QLT_11	4.25 (1.25)	6 (1)	-0.85	0.32	0.15
4	STAKEH_ACC_4	4.52 (1.03)	6 (1)	-0.74	1.12	0.13	25	EMP_ENG_12	4.75 (1.01)	6 (1)	-0.99	1.75	0.12
5	CULT_INTG_5	4.31 (1.31)	6 (1)	-0.86	-0.11	0.16	26	TOOL_AP_13	4.66 (1.02)	6 (1)	-1.46	3.25	0.13
6	DEPLOY_6	3.79 (1.44)	6 (1)	-0.42	-0.97	0.18	27	CONTX_CUS_14	4.61 (0.98)	6 (1)	-1.34	3.33	0.12
7	ACT_INTG_7	4.03 (1.19)	6 (1)	-0.9	0.08	0.15	28	EFT_REQ_15	4.26 (1.11)	6 (1)	-0.98	0.24	0.14
8	EMPL_SKI_8	4.61 (1.03)	6 (1)	-1.24	2.51	0.13	29	SCOPE_16	4.31 (1.05)	6 (1)	-0.72	0.53	0.13
9	EMPL_SAT_9	4.52 (1.13)	6 (1)	-1.16	1.49	0.14	30	INSTIT_17	3.92 (1.37)	6 (1)	-0.59	-0.36	0.17
10	EMPL_BEL_10	4.51 (1.11)	6 (1)	-1.28	1.78	0.14	31	TRA_EDUC_18	4.48 (1.33)	6 (1)	-0.75	0.11	0.16
11	BUSI_IMP_11	4.42 (1.14)	6 (1)	-0.91	0.37	0.14	32	WKF_SKL_19	4.04 (1.17)	6 (1)	-0.58	0.16	0.14
12	ORG_IMP_12	4.71 (1.1)	6 (1)	-1.05	1.05	0.13	33	EXP_CON_20	4.96 (1.24)	6 (1)	-1.2	0.76	0.15
13	DEC_IMP_13	4.12 (1.15)	6 (1)	-0.65	-0.29	0.14	34	EXT_CON_21	4.15 (1.29)	6 (1)	-0.73	0.25	0.16
14	LD_SUP_1	4.45 (1.22)	6 (1)	-0.84	0.49	0.15	35	UND_CNG_22	4.18 (1.29)	6 (1)	-0.63	-0.02	0.16
15	ORG_CUL_2	4.34 (1.25)	6 (1)	-0.84	0.35	0.15	36	COM_KNW_23	4.14 (1.24)	6 (1)	-0.4	-0.21	0.15
16	EMP_ATT_3	4.18 (1.09)	6 (1)	-0.98	1.56	0.13	37	PAT_RES_24	3.71 (1.1)	5 (1)	-0.77	0.1	0.13
17	RES_AVL_4	3.88 (1.3)	6 (1)	-0.48	-0.42	0.16	38	GOAL_CL_25	3.83 (1.19)	6 (1)	-0.48	-0.07	0.15
18	LD_INV_5	4.19 (1.17)	6 (1)	-0.37	-0.27	0.14	39	CUS_IDEF_26	4.55 (1.04)	6 (2)	-0.38	-0.23	0.13
19	PRJ_SEL_6	3.99 (1.16)	6 (1)	-0.6	-0.03	0.14	40	GOAL_AL_27	4.68 (1.1)	6 (1)	-0.75	0.73	0.13
20	DEF_MEA_7	4.06 (1.23)	6 (1)	-0.88	0.32	0.15	41	SYS_COM_28	3.89 (1.22)	6 (1)	-0.49	-0.13	0.15
21	RES_CHG_8	3.48 (1.1)	5 (1)	-0.36	-0.41	0.13	42	TEAM_ST_29	4.46 (1.21)	6 (1)	-0.67	0.37	0.15

7.6.2 Demographic Description

The demographic analysis (see Table 3) of the participants provides insightful results into the background of the respondents, which is crucial for understanding the context in which the survey results should be interpreted.

The majority of the survey respondents were from the U.S., representing a significant 92.1% of the total participants (N= 67). The remaining participants were from Australia, Malaysia, and Turkey, each contributing 1.6%. Based on the predominant responses, the results suggest that the survey findings are primarily reflective of the practices and perceptions within the U.S. context. In addition, the responses have a strong representation from the state level of governments (i.e., 77.8% of responses). This is followed by the city level (12.7%) and the county (9.5%), suggesting that the results are more representative of state-level governmental practices and challenges in relation to LM/LSS. Furthermore, a total of 15 functional areas were reported among participants, with the highest representation coming from social services (27.0%), followed by healthcare (15.9%) and administration services (14.3%). The remaining functional areas (e.g., finance and taxation, transportation, etc.) ranged between 7.9% and 1.6% (a full list of the functional areas is in Appendix E.1). This diversity indicates that the survey captures a wider perspective from different areas within LGO settings. This diversity in results can provide a holistic view of the effectiveness and applicability of LM/LSS across various functions. In terms of organizational size, the largest portion (50.8%) came from organizations with more than 1,000 employees. This is due to the majority of participants being from the state level; however, the results might be more indicative of the experiences and practices in larger organizations, which could have different dynamics and challenges compared to smaller organizations. Regarding the improvement methodologies employed by the participants, Lean Six Sigma was the most prevalent, used by 54.0% of the respondents. This is followed by Lean Production with a general improvement methodology (33.3%) and Lean Production alone (11.1%). In terms of professional experience with LP/LSS, the respondents have significant experience in this area, with 37.1% having 6-10 years of experience, and 21.0% having 11-15 years. This indicates that the survey responses are grounded in the experiences of professionals who have a considerable duration of involvement in their respective areas, lending credibility and depth to the findings. The demographic results of the respondents revealed a predominantly U.S.-based, state-level government perspective, with a strong representation from larger organizations and varied functional areas. The findings are influenced by seasoned professionals experienced in Lean Six Sigma and related methodologies, suggesting that the insights are both contextually and experientially rich and insightful.

Table 22 (Table 3, Manuscript #7) Demographic summary of participants

Variable	Category	Frequency (%)
Country of the Organization	The U.S.	58 (92.1%)
	Australia	1 (1.6%)
	Malaysia	1 (1.6%)
	Turkey	1 (1.6%)
Government Level	State Level	49 (77.8%)
	City Level	8 (12.7%)
	County	6 (9.5%)
	Social Services	17 (27.0%)

Functional Area	Healthcare	10 (15.9%)
	Administration services	9 (14.3%)
Organizational Size	More than 1,000 employees	32 (50.8%)
	Between 251 to 500 employees	9 (14.3%)
	Between 751 to 1,000 employees	7 (11.1%)
	Less than 100 employees	6 (9.5%)
	Between 501 to 750 employees	5 (7.9%)
	Between 101 to 250 employees	4 (6.4%)
Improvement Methodology	Lean Six Sigma	34 (54.0%)
	LM with general improvement methodology	21 (33.3%)
	Lean Production	7 (11.1%)
	Six Sigma	1 (1.6%)
Professional Experience with LM/LSS	Less than a year	1 (1.6%)
	1-5 years	18 (29.0%)
	6-10 years	23 (37.1%)
	11-15 years	13 (21.0%)
	16-20 years	3 (4.8%)
	More than 20 years	4 (6.4%)

Note: The total observations for each demographic variable do not equal N (i.e., 67 observations). This is because some participants skipped questions related to the demographic items.

7.6.3 Exploratory Factor Analysis

EFA was utilized to identify a representative set of latent variables encompassing both dependent and independent variables. EFA, typically applied in the context of large sample sizes, often leads to debate in the literature regarding the optimal sample size (Watkins, 2018). Some early recommendations focused on absolute sample sizes ranging from 50 to 1,000 (De Winter *et al.*, 2009; Garson, 2022; Rouquette and Falissard, 2011), while others recommended a sample-to-item ratio (i.e., N/P ratio) that ranges from 5:1 to 20:1 (Ledesma *et al.*, 2021). However, De Winter *et al.* (2009) advocated for a sample size of $N = 50$ as sufficient for EFA, whereas Thompson (2004) suggested that a ratio of 2:1 could be sufficient for exploratory research settings (as cited in Keathley-Herring, 2016). This minimal ratio was also supported by Costello and Osborne (2005), who discovered that 14.7% of 303 studies used a ratio of 2:1 or less.

This study developed two separate EFA models: Model-1 consisted of 13 items for the dependent variables/items and Model-2 consisted of 29 items for the independent variables/items. Table 4 summarizes the results of EFA for both models.

The first step to performing EFA included the evaluation of the factorability of the data using the Kaiser–Meyer–Olikin (KMO) and Bartlett's Test of Sphericity. The former provides a measure of sample adequacy (MSA), aiding in the assessment of whether the dataset is suitable for yielding meaningful results in factor analysis (ranges between 0 and 1 and should be greater than 0.50), whereas the latter is employed to determine if the correlations among measured variables are sufficient (i.e., $p \leq 0.05$) (Garson, 2022; Hair, 2010). The overall MSA for Model-1 (i.e., the dependent variables) was 0.90 (at the item level, MSA ranged between 0.76 and 0.96 for the 13 items). Similarly, the overall MSA for Model-2 (i.e., the independent variables) was 0.87 (at the item level, MSA ranged between 0.75 and 0.9 for the 29 items). Moreover, the results of Bartlett's

Test of Sphericity for Model-1 and Model-2 were significant at $p \leq 0.05$. These results confirm the adequacy of the sample size to continue performing EFA.

Determining the number of factors is a crucial step in factor analysis. When there are too few factors, it is likely that measured variables that are loaded on a given factor may not form the same dimension. Likewise, in cases with many factors, there is a chance of a factor with a single item or an item cross-loaded on more than one factor (Garson, 2022). Thus, the appropriate approach to determine the number of factors is to use different empirical approaches, such as parallel analysis (Garson, 2022). This study employed two approaches: the scree test and parallel analysis (Costello and Osborne, 2005; Garson, 2022; Stellefson and Hanik, 2008). The results from the scree test and parallel analysis suggested that there should be two to three for Model-1 and four to five factors for Model-2. While there is no universally-accepted method for deciding on the number of factors, it is vital to evaluate multiple solutions, ranging from the greatest to the least number of factors and select the most interpretable solutions (Garson, 2022).

Because the goal of using EFA is to uncover and determine the underlying latent factors based on the measured items (described previously in Table 2), Principal Factor Analysis (PFA) - also known as Principal Axis Factoring (Garson, 2022) - was used as the extraction method. PAF is a least-squares fitting technique employed for dimensionality reduction in data sets. It utilizes the variances and covariances inherent in a set of measured variables (or items) to extract a prespecified number of factors that explain the maximum of common variance in these items (Grieder and Steiner, 2021). Furthermore, oblique rotation (i.e., Promax) was also used for the correlations among the factors (Garson, 2022). Moreover, the evaluation of EFA models should consider several criteria, including factor loading (or variable/item loading), cross-loading, and communalities' cutoff values. Factor loadings, which range between 0 and 1, signify the correlation between items and their associated factors (or latent variables). A higher value indicates a better representation of an item in relation to a construct. This measure reflects the extent to which each item contributes to the factor it is associated with, suggesting that items with higher loadings are more representative of their underlying constructs (Garson, 2022). The literature presents a wide debate regarding the loading cutoff values. Based on a literature survey of the best practices for EFA models, Howard (2016) reported that the largest portion of researchers (based on the number of publications used in their study) choose cutoff values between 0.301 and 0.40. This study used 0.40 as the minimum cutoff value for factor loadings. Moreover, cross-loading refers to an item being loaded on more than one factor. Any item with a cross-loading greater than 75% was a candidate for deletion (Samuels, 2017) as it has been widely practiced (Lotzin, Ketelsen, Krause, *et al.*, 2022; Lotzin, Ketelsen, Zrnic, *et al.*, 2022). Moreover, a variable's communality is the shared variance among the variables as represented by the derived factors (Hair, 2019). Greater communalities' values suggest that a significant proportion of a variable's variance is captured by the factor solution, whereas lower communalities imply that a considerable part of the variable's variance remains unexplained by the factors (Hair, 2019). Communalities with values greater than 0.80 are considered high; however, values between 0.40 and 0.70 are considered acceptable (Costello and Osborne, 2005). MacCallum *et al.* (1999) also recommend evaluating the average communalities for small sample sizes ($N < 100$); an average value above 0.60 is acceptable (Samuels, 2017). Finally, the minimum recommended threshold for cumulative variance explained is 0.60 (Hair, 2019).

The results of EFA for Model-1 and Model-2 are presented in Table 4. In the case of Model-1 (i.e., the dependent variables), three main latent variables emerged from a set of 12 items, with one item (i.e., CULT_INTG_5) excluded due to a high cross-loading. These three latent variables were

labeled as *Transformational Success* (TS; comprised of eight items with loadings ranging between 0.50 and 0.91), *Deployment Success* (DS; consisting of two items with loadings ranging between 0.66 and 0.88), and *Improvement Project Success* (IPS; encompassing two items with loadings ranging between 0.73 and 0.77). Furthermore, most item communalities exceeded the minimum threshold with an overall average communality of 0.69. Finally, the three constructs account for 69% of the variance explained. Likewise, in the context of Model-2 (i.e., the independent variables), five distinct latent variables emerged from a pool of 18 items, leading to the exclusion of 11 items (i.e., ORG_CUL_2, INSTIT_17, SCOPE_16, GOAL_AL_27, TEAM_ST_29, GOAL_CL_25, COM_KNW_23, EXT_CON_21, ORG_CHR_10, RES_CHG_8, and SYS_COM_28) that did not meet the specified criteria above. These five latent variables were identified as *Improvement Readiness* (IR; comprised of six items with loadings ranging between 0.43 and 0.94), *Sustainable Improvement Infrastructure* (SII; consisting of four items with loadings ranging between 0.46 and 0.84), *Supportive Leadership* (SL; with three items with loadings ranging between 0.74 and 0.79), *Measures-based improvement* (MBI; with three items with loadings ranging between 0.63 and 0.88), and *Change Awareness* (CA; encompassing two items with loadings ranging between 0.65 and 0.70). Change Awareness is composed of only two items, diverging from the recommendation in the literature which advises a minimum of three items per factor (Costello and Osborne, 2005). Despite this, the two items demonstrated high loadings and met the minimum threshold for communality, justifying their retention. Additionally, all item communalities exceeded the minimum threshold, with an overall average communality of 0.65. The five constructs collectively account for 65% of the explained variance. Cronbach's Alpha was employed to evaluate the reliability coefficient of the constructs. Ensuring a minimum acceptable value of 0.60, the reliability results for Model-1 demonstrated a range between 0.80 and 0.94, while Model-2 exhibited a range between 0.61 and 0.87 (Hair, 2019).

The results of the EFA models provided insightful outcomes regarding the structure of the conceptual model (see Figure 1). The conceptual model, while theoretically grounded, had not been empirically tested. EFA was instrumental in validating and refining the model's structure. As a result, the model was refined according to the findings from the EFA models. This model's validation provides particularly significant insights given the scarcity of empirical studies concerning CSFs within this research area. Moreover, while the original CSFs were grounded in a global pool of academic research related to LM/LSS in LGOs, the predominant demographic of respondents was from the U.S. Thus, this data-driven insight could be more representative of the current domain's state in the U.S. This regional specificity offers a refined contrast to the broader literature and presents a model that is both up-to-date and contextually relevant for practitioners within the U.S.

Table 23 (Table 4, Manuscript #7) Results of exploratory factor analysis

Variable	Code	New Code	KMO	Loading	Communality	Cronbach's Alpha	SS Loading	Cumulative Variance
Transformational success (TS)[Model 1]	EMPL_SAT_9	TS1	0.90	0.91	0.77	0.94	5.2	0.43
	ORG_IMP_12	TS2		0.89	0.80			
	STAKEH_ACC_4	TS3		0.84	0.69			
	EMPL_SKI_8	TS4		0.80	0.67			
	DEC_IMP_13	TS5		0.77	0.69			

	BUSI_IMP_11	TS6		0.75	0.67			
	IMPL_SUCC_1	TS7		0.65	0.70			
	EMPL_BEL_10	TS8		0.50	0.38			
Deployment success (DS)[Model 1]	DEPLOY_6	DS1		0.88	0.70	0.80	1.59	0.57
	ACT_INTG_7	DS2		0.66	0.74			
Improvement project success (IPS)[Model 1]	BUDG_COMP_2	IPS1		0.77	0.65	0.82	1.45	0.69
	TASK_COMP_3	IPS2		0.73	0.77			
Improvement Readiness (IR)[Model 2]	TOOL_AP_13	IR1	0.87	0.94	0.85	0.87	3.41	0.19
	CONTX_CUS_14	IR2		0.93	0.77			
	EFT_REQ_15	IR3		0.71	0.59			
	EMP_ENG_12	IR4		0.68	0.68			
	EXP_CON_20	IR5		0.48	0.41			
	CUS_IDEF_26	IR6		0.43	0.42			
Sustainable Improvement Infrastructure (SII)[Model 2]	TRA_EDUC_18	SII1		0.84	0.76	0.84	2.37	0.32
	PAT_RES_24	SII2		0.82	0.72			
	WKF_SKL_19	SII3		0.63	0.56			
	RES_AVL_4	SII4		0.46	0.44			
Supportive Leadership (SL)[Model 2]	LD_STL_9	SL1		0.79	0.82	0.89	2.33	0.45
	LD_INV_5	SL2		0.78	0.79			
	LD_SUP_1	SL3		0.74	0.64			
Measures-based improvement (MBI)[Model 2]	DAT_QLT_11	MBI1		0.88	0.67	0.86	2.19	0.57
	DEF_MEA_7	MBI2		0.77	0.84			
	PRJ_SEL_6	MBI3		0.63	0.70			
Change Awareness (CA)[Model 2]	EMP_ATT_3	CA1		0.70	0.72	0.61	1.47	0.65
	UND_CNG_22	CA2		0.65	0.40			

Note: Model-1 refers to the analysis of dependent latent variables, while Model-2 addresses the analysis of independent latent variables, New codes were used with PLS-SEM.

7.6.4 PLS-SEM Model

The development and analysis of PLS-SEM consists of three stages that involve model specification, measurement model evaluation, and structural model analysis (Hair *et al.*, 2014). The PLS-SEM development process and analysis followed the recommendations from Hair, Hult, Ringle, Sarstedt, *et al.* (2021). The SEMinR package in R (Allaire, 2012) was used to develop and run the model (Ray *et al.*, 2021).

Model specification includes specifying inner and outer models. The inner model is about identifying the relationship between latent variables, the exogenous (i.e., independent variables) and the endogenous (i.e., dependent variables). This study has five exogenous and three endogenous constructs. The outer model specifies the relationship between latent variables and their corresponding items and determines the mode of the PLS-SEM (i.e., formative or reflective). The inner and outer model was developed based on the results from EFA (see Table 4) and a

reflective mode was chosen for this study (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). The following sections describe the remaining analysis of PLS-SEM (measurement and structural models).

7.6.4.1 Measurement Model

At this step, the model has been specified and run. The output of the model was used to assess the quality of the reflective measurement model before conducting the structural model. Before evaluating the metrics, it is advisable to first check the algorithm's convergence. Ideally, convergence should occur in fewer than 300 iterations (Hair *et al.*, 2021). In this case, the algorithm successfully converged in just six iterations. Following the procedures by (Hair *et al.*, 2021), four criteria were used to assess the quality of the reflective measurement model: (1) indicator's reliability, (2) internal consistency reliability, (3) convergent validity, and (4) discriminant validity. The indicator's reliability measures how much an indicator's variance is explained by the construct. The recommended loading threshold is 0.708, which accounts for 0.50 of the variance explained, demonstrating sufficient item reliability (Sarstedt *et al.*, 2022). The internal consistency reliability ensures that indicators are relevant and associated with each other for a given construct. The internal consistency reliability is evaluated using composite reliability (ρ_C), Cronbach's alpha (α), and reliability coefficient (ρ_A). The values of composite reliability (ρ_C) should range between 0.60 and 0.95, while Cronbach's alpha (α) should exceed 0.60. The reliability coefficient (ρ_A) should be between composite reliability (upper bound) and Cronbach's alpha (lower bound) (Sarstedt *et al.*, 2022). The following criterion is convergent validity, which is the extent to which a construct converges in its indicators by explaining the items' variance (Sarstedt *et al.*, 2022). Convergent validity is assessed by Average variance extracted (AVE) with a minimum acceptable value of 0.50. Finally, discriminant validity is concerned with constructs that are distinct from each other. It is assessed using Fornell and Larcker, the heterotrait-monotrait ratio (HTMT), and HTMT bootstrapping. Fornell and Larcker propose that the squared AVE of a construct must exceed its highest correlation squared with any other construct. The value of HTMT should not exceed 0.85 (for conceptually distinct constructs) or less than 0.95 (for conceptually similar constructs). HTMT bootstrapping allows for constructing confidence intervals for the HTMT to test the null hypothesis (H0: HTMT ≥ 1) against the alternative hypothesis (H1: HTMT < 1). The HTMT bootstrapping enables the creation of confidence intervals for the HTMT to evaluate the null hypothesis (H0: HTMT ≥ 1) versus the alternative hypothesis (H1: HTMT < 1). If the confidence interval includes the value one (meaning H0 is valid), it suggests that discriminant validity is not present (Henseler *et al.*, 2015).

Table 24 (Table 5, Manuscript #7) Results of reliability analysis and convergent validity

Latent Variable	Code	Indicator's Reliability (0.708)	(α >0.50)	ρ_C (0.50-0.95)	AVE (> 0.50)	$\alpha \leq \rho_A \leq \rho_C$
TS	TS1	0.90	0.94	0.95	0.69	0.94
	TS2	0.89				
	TS3	0.83				
	TS4	0.84				
	TS5	0.83				
	TS6	0.83				

	TS7	0.85				
	TS8	0.68				
DS	DS1	0.90	0.80	0.91	0.84	0.83
	DS2	0.93				
IPS	IPS1	0.92	0.82	0.92	0.85	0.82
	IPS2	0.92				
IR	IR1	0.88	0.88	0.91	0.62	0.88
	IR2	0.85				
	IR3	0.82				
	IR4	0.77				
	IR5	0.70				
	IR6	0.70				
SII	SII1	0.84	0.84	0.89	0.68	0.85
	SII2	0.81				
	SII3	0.86				
	SII4	0.77				
SL	SL1	0.91	0.89	0.93	0.82	0.89
	SL2	0.90				
	SL3	0.89				
MBI	MBI1	0.83	0.86	0.91	0.78	0.89
	MBI2	0.93				
	MBI3	0.89				
CA	CA1	0.92	0.61	0.83	0.71	0.71
	CA2	0.76				

Table 5 presents the indicator's reliability, internal consistency reliability, and convergent validity, whereas Table 6 shows the results of discriminant validity. Based on the output, the overall results of the measurement model are within the acceptable range. Therefore, the reliability and validity of the measurement model are established. However, one item (i.e., TS8) was below the recommended minimum value. Hair *et al.* (2021) suggested that an indicator loading between 0.40 and 0.708 could be a candidate for deletion only if removing that indicator leads to an increase in the internal consistency reliability or convergent validity. Thus, this suggestion was tested, and no such improvement emerged; therefore, this item was retained.

Table 25 (Table 6, Manuscript #7) Discriminant validity based on Fornell–Larcker criteria, the heterotrait-monotrait ratio (HTMT)

Constructs	IR (HTMT)	SII (HTMT)	SL (HTMT)	MBI (HTMT)	CA (HTMT)	TS (HTMT)	DS (HTMT)	IPS (HTMT)	HTMT 95% bootstrap CI does not include 1
IR	0.79 (—)	—	—	—	—	—	—	—	Yes
SII	0.58 (**0.68**)	**0.82** (—)	—	—	—	—	—	—	Yes
SL	0.64 (**0.73**)	0.60 (**0.69**)	**0.90** (—)	—	—	—	—	—	Yes
MBI	0.57 (**0.66**)	0.53 (**0.61**)	0.68 (**0.76**)	**0.88** (—)	—	—	—	—	Yes
CA	0.51 (**0.64**)	0.49 (**0.66**)	0.54 (**0.70**)	0.50 (**0.61**)	**0.84** (—)	—	—	—	Yes
TS	0.73 (**0.80**)	0.64 (**0.72**)	0.72 (**0.79**)	0.65 (**0.72**)	0.64 (**0.79**)	**0.83** (—)	—	—	Yes
DS	0.44 (**0.51**)	0.67 (**0.79**)	0.59 (**0.69**)	0.53 (**0.60**)	0.51 (**0.70**)	0.66 (**0.75**)	**0.91** (—)	—	Yes
IPS	0.65 (**0.76**)	0.51 (**0.61**)	0.70 (**0.82**)	0.71 (**0.84**)	0.54 (**0.73**)	0.66 (**0.76**)	0.55 (**0.67**)	0.92 (—)	Yes

Note: diagonal values represent Fornell–Larcker criteria, which is a square root of a construct's AVE and should be greater than the other values under it; Values between parentheses represent the values of HTMT and should be less than 0.85

7.6.4.1 Structural Model Evaluation

Once the measurement model was established and confirmed, the structural model was next evaluated. The analysis of the structural model included examining (1) the potential for collinearity issues, (2) evaluating the size and significance of paths, (3) assessing the explanatory power or coefficient of determination (i.e., R^2), and (4) investigating out-of-sample predictive power using $PLS_{Predict}$ (Hair *et al.*, 2021).

Table 26 (Table7, Manuscript #7) PLS-SEM results

Paths	β	T Stat.	95% bootstrap CI	Significant at 5%?	VIF	f^2	R^2 (Adj R^2)
IR ➔ TS*	0.31	2.57	[0.10, 0.57]	Yes	2.02	0.16	0.71
SII ➔ TS	0.15	1.62	[-0.02, 0.35]	No	1.82	0.04	(0.68)
SL ➔ TS	0.22	1.92	[-0.02, 0.44]	No	2.49	0.06	
MBI ➔ TS	0.14	1.13	[-0.12, 0.35]	No	2.05	0.03	
CA ➔ TS*	0.22	2.02	[0, 0.43]	Yes	1.58	0.11	
IR ➔ DS	-0.12	-1.02	[-0.33, 0.13]	No	2.02	0.01	0.53
SII ➔ DS*	0.46	3.74	[0.24, 0.71]	Yes	1.82	0.24	(0.50)
SL ➔ DS	0.22	1.24	[-0.14, 0.56]	No	2.49	0.04	
MBI ➔ DS	0.12	0.86	[-0.15, 0.39]	No	2.05	0.01	
CA ➔ DS	0.18	1.23	[-0.14, 0.42]	No	1.58	0.04	
IR ➔ IPS	0.24	1.75	[-0.02, 0.51]	No	2.02	0.08	0.64
SII ➔ IPS	-0.03	-0.26	[-0.23, 0.25]	No	1.82	0.00	(0.61)
SL ➔ IPS	0.26	1.87	[-0.02, 0.53]	No	2.49	0.08	
MBI ➔ IPS*	0.36	3.26	[0.12, 0.56]	Yes	2.05	0.18	
CA ➔ IPS	0.11	0.76	[-0.19, 0.37]	No	1.58	0.02	

Note: The asterisk (*) donates significant paths, R^2 demonstrates explanatory power, f^2 indicates the effect size (with values of 0.02, 0.15, and 0.35 representing small, medium, and large effects, respectively), Test the significance of paths at 95% CI (Significance level = 5% and the critical value is 1.96)

Table 7 summarizes the results of the structural model. First, the collinearity was evaluated by examining the values of the variance inflation factor (VIF) for each predictor construct. VIF values below 5.0 reveal that there is no concern about collinearity issues. The value of VIF of the structural model ranged between 1.58 and 2.49, indicating an acceptable range (Hair *et al.*, 2021).

Next, the model's explanatory power (i.e., R^2) was evaluated for the three endogenous constructs (i.e., TS, DS, and IPS). The R^2 represents the squared correlation between the actual and predicted values, known as in-sample predictive power (Hair, Hult, Ringle and Sarstedt, 2021). While the determination of the value of R^2 is dependent on the research context, the literature presents 0.75, 0.50, or 0.25 for endogenous latent variables as strong, moderate, or weak (Hair, Hult, Ringle and Sarstedt, 2021). The R^2 of TS, IPS, and DS were 0.71, 0.64, and 0.53, respectively, indicating a moderate to strong in-sample predictive power. In addition to R^2, the effect size (f^2) can also be used to assess the changes in R^2 when a given exogenous construct is removed from the model. It helps determine the significant influence of the excluded construct on the endogenous constructs. Following the guideline of Chen (1988) for assessing f^2 (i.e., 0.02, 0.15, and 0.35, respectively, representing small, medium, and large effects), the results (see Table 7) revealed that the overall effects were moderate to small. More specifically, IR and CA (f^2 = 0.16 and 0.11, respectively) had a medium size effect on TS. Furthermore, SII on DS (f^2= 0.24) also had a medium size effect, and MBI on IPS (f^2 = 0.18) had a medium size effect. The remaining exogenous constructs had small size effects ($f^2 < 0.02$) to no effect.

Third, to assess the significance of the structural model relationship, the bootstrap method with 10,000 subsamples was used as recommended by recent literature (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021; Magno *et al.*, 2022). Because PLS-SEM is a non-parametric method, a bootstrap is needed to estimate standard error and confidence intervals (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). Bootstrapping is a technique that involves repeatedly drawing subsamples from the original dataset (with replacement) to estimate models for each drawn subsample. This method is employed for calculating the standard errors of coefficients, enabling the evaluation of their statistical significance without depending on the assumptions of data distribution (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). To test the significance and relevance of the path coefficient, a significance level of 5% ($\alpha < 0.05$, two-tailed at 95% confidence intervals) was established. This setting means that a significant path coefficient at 5% , if the value zero does not fall into the 95% confidence interval and the t-test is greater than 1.96 (Hair, Hult, Ringle and Sarstedt, 2021). Based on the results from the structural paths, the antecedent *Improvement Readiness* (IR) *(*$\beta = 0.31, t = 2.57, CI[0.10, 0.57]$) and *Change Awareness* (CA) ($\beta = 0.22, t = 2.02, CI[0, 0.43]$) were significant and had a positive influence on *Transformation Success* (TS). For the outcome *Deployment Success* (DS), *Sustainable Improvement Infrastructure* (SII) ($\beta = 0.46, t = 3.74, CI[0.24, 0.71]$) was the only significant exogenous variable and had the highest positive impact among all significant predictor constructs. Furthermore, *Measurement-Based Improvement* (MBI) ($\beta = 0.36, t = 3.26, CI[0.12, 0.56]$) was significant and positively influenced *Improvement Project Success* (IPS). The total paths in the model (see Figure 2) were 15 different paths and only four were significant. Other non-significant paths that had a negative impact were *IR* on *DS* ($\beta = 0. -0.12, t = -1.02, CI[-0.33, 0.13]$) and *SII* on *IPS* ($\beta = -0.03, t = -0.26, CI[-0.23, 0.25]$). Figure 2 represents the architecture of the structural model along with path coefficients and the 95% confidence intervals.

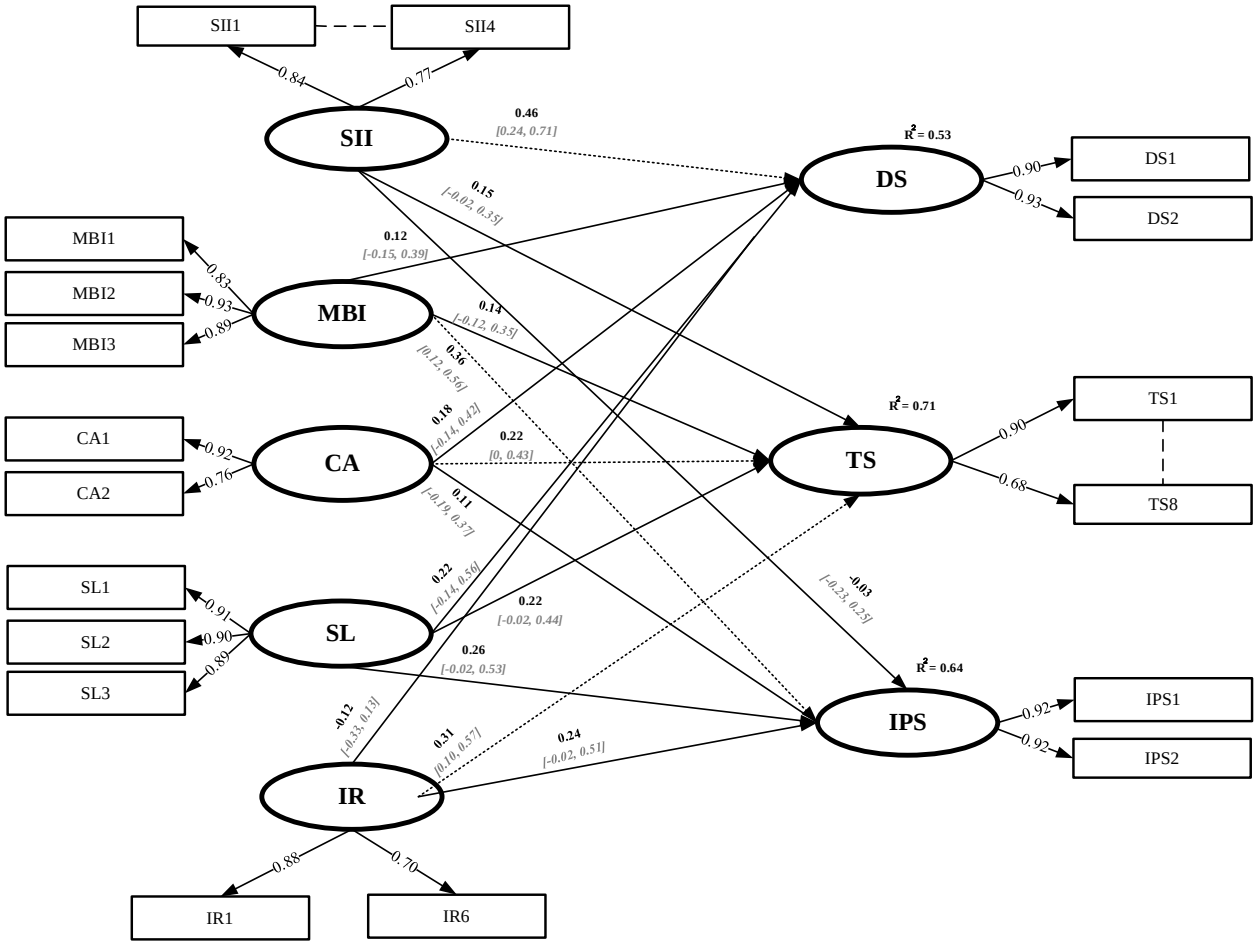

Figure 27 (Figure 2, Manuscript #7) Structural model architecture. *Italic* and Gray values represent the 95% confidence intervals. Dash lines represents the significant coefficient paths

The model's predictive power (or out-of-sample predictive power) is the ability of the model to predict new cases (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). This approach was introduced by Shmueli et al. (2016) through $PLS_{Predict}$. More specifically, the $PLS_{Predict}$ is a holdout-sample-based procedure (i.e., k-fold cross-validation) that generates case-level predictions on an item or a construct level to facilitate the assessment of a PLS path model's predictive power (Hair, Hult, Ringle, Sarstedt, *et al.*, 2021). To evaluate $PLS_{Predict}$, root mean square error (RMSE) or mean absolute error (MAE) are the metrics used by comparing each indicator's RMSE or MAE values with a naïve linear regression model benchmark. Based on the results (see Table 8), the out-of-sample predictive error has lower values compared to the naïve LM model benchmark for all the indicators, which concludes that the model has a high predictive power.

Table 27 (Table 8, Manuscript #7) $PLS_{Predict}$ results

	PLS		**LM**	
	RMSE	**AME**	**RMSE**	**MAE**

TS1	0.74	0.60	0.78	0.65
TS2	0.76	0.62	0.91	0.73
TS3	0.82	0.69	0.92	0.71
TS4	0.77	0.61	1.08	0.84
TS5	0.87	0.71	1.10	0.85
TS6	0.95	0.73	1.15	0.87
TS7	0.77	0.60	1.08	0.82
TS8	0.94	0.71	1.19	0.87
DS1	1.25	1.00	1.53	1.22
DS2	0.91	0.70	1.09	0.86
IPS1	0.92	0.72	1.30	1.04
IPS2	0.92	0.71	1.18	0.91

7.7 Discussion

This study aimed to empirically examine the CSFs for LM/LSS success in LGOs. The PLS-SEM model was employed in this investigation due to its powerful algorithm in exploratory research settings (described in detail in the introduction) (Hair, Hult, Ringle and Sarstedt, 2021). In addition, PLS-SEM can handle small sample sizes (see, for example, R. *et al.*(2020)'s utilizations of 65 responses).

The profile of respondents was mostly from the U.S. (92.1%) and was representative of larger organizations (over 1,000 employees). The responses came from diverse functional areas with more than 15 functional areas represented in responses, adding a rich perspective to the investigation. This could suggest the applicability of this improvement methodology across a variety of working areas and environments. Furthermore, one of the survey questions focused on asking respondents about LM/LSS tools and techniques used. The results revealed that tools such as Brainstorming, Process Flow Chart, and Project Charter were more frequently utilized than tools like Statistical Process Control and Quality Function Deployment, which are among the least used (see Appendix E.2).

At the CSF level (see Table 2), the findings represented interesting results regarding the CSFs (CSFs numbered from 14 to 42). The mean values were observed to be predominantly in the upper half of the scale, with a range from 3.48 to 4.96 implying a generally positive agreement on observing these CSFs for LM/LSS. The findings revealed that *Experienced consultant* (EXP_CON_20) received the highest mean values (i.e., 4.96), suggesting that experienced consultants could be a crucial aspect in supporting the development and/or implementation process. The following most highly rated were *Employee engagement* (EMP_ENG_12; having a mean value of 4.75), *Tool appropriateness* (TOOL_AP_13: having a mean value of 4.66), and *Contextualization/customization of LM/LSS* (CONTX_CUS_14; having a mean value of 4.61). The standard deviation of the CSFs ranged between 0.97 and 1.37, indicating a moderate level of response variability. This could suggest that while most answers were positive, people's opinions still varied within this sample. This degree of variation in responses is essential for a comprehensive understanding of the different opinions among respondents, showing that despite a generally positive trend, there is a wide range of individual perspectives.

This study developed a conceptual model that hypothesized the relationship among the CSFs and outcome variables. To empirically validate the model, 29 CSFs were tested and then decomposed into 5 latent variables through EFA models. These latent variables were *Improvement*

Readiness, Sustainable Improvement Infrastructure, *Supportive Leadership*, *Measures-Based Improvement*, and *Change Awareness*. These five latent factors serve as core critical areas that public officials and policymakers should consider for embracing LM/LSS into LGO settings. *Sustainable Improvement Infrastructure* describes an organizational environment where LM/LSS can thrive. This construct suggests a foundation that supports continuous improvement, not just through tools and techniques, but also through education, skill-based and resource-oriented. This critical area is not just about immediate improvements but also about creating conditions where these improvements can be maintained and built upon over time. *Change Awareness* is not just about being informed of the changes; it also relates to cultivating a supportive attitude and understanding in target system areas. This awareness is fundamental to overcoming resistance to change and ensuring the smooth implementation and sustainability of LM/LSS initiatives. *Improvement Readiness* encompasses the foundational elements that prepare an organization for successful LM/LSS implementation. These elements collectively create an environment conducive to continuous improvement, where tools are not only used correctly but are also tailored to the organization's specific needs, backed by adequate resources, employee engagement, and expert guidance. *Supportive Leadership* implies a leadership paradigm that is integral to the successful adoption and implementation of LM/LSS. Leaders in this framework are not just figureheads but active participants and champions of LM/LSS, fostering an environment where these methodologies can thrive. Finally, *Measures-Based Improvement* captures the essence of utilizing high-quality data, strategically choosing impactful projects, and monitoring progress through defined metrics. It underscores the integration of data-driven decision-making with strategic project management, which are both vital in LM/LSS.

Literature in this area has not extensively focused on studying CSFs, both empirically or conceptually. However, among the few existing studies, Keramida et al. (2022) identified eight latent variables associated with Lean success in Greek public sector organizations, including communication, training and education, change and project management, organizational culture, top management commitment/support and leadership, teamwork, employee commitment/involvement and empowerment, and availability resources. Furthermore, the PLS-SEM was conducted to investigate the influence of the five latent variables on outcomes. The results revealed that *Improvement Readiness* and *Change Awareness* were positively significant on *Transformational success*. Likewise, *Sustainable Improvement Infrastructure* and *Measures-based improvement* were each significant and influenced *Deployment success* and *Improvement project success*, respectively. Given the important role that supportive leadership plays in the context of LM/LSS, it is interesting that it has not emerged as a significant factor. Zulkeflee et al. (2023) also found that leadership had no impact on LM implementation; however, they claimed that the lack of leadership knowledge and a lack of empirical research in developing countries could be a contributing factor. Yet, in the context of this study, the absence of a leadership component might be relevant to the sample size (further discussed later).

7.8 Conclusions

Driven by the scientific gap in the literature and the lack of international attention, this study focused on statistically investigating the CFSs associated with LM/LSS success in the context of LGOs. In this study, a total of 29 CSFs were variables of interest, along with 13 items that

measured technical and social system outcomes. To examine these variables, a cross-sectional field study using a survey instrument was designed and disseminated across LGOs. A total of 156 responses was received; however, just 67 represented usable responses. The majority of the responses were received from the U.S. (approximately 90%) and about 68% of the participants had more than 5 years of professional experience.

EFA models were developed to identify a representative set of latent variables, followed by employing the PLS-SEM model to statistically test the significant latent variables on outcomes. The main outcomes are that there are five major areas (i.e., IR, SII, SL, MBI, and CA) that need to be carefully considered when it comes to LM/LSS development and/or implementation in LGOs. However, four of these latent variables were statistically significantly related to outcomes. That is, *Improvement Readiness* and *Change Awareness* were positively significant on *Transformational success*, whereas *Sustainable Improvement Infrastructure* and *Measures-based improvement* each were significant and had a positive impact on *Deployment success* and *Improvement project success*, respectively. Moreover, the uniqueness of this study is that the studied CSFs were extracted from the literature based on LGOs' experience with LM/LSS, instead of adopting CSFs from other general service sectors. The findings of this study could serve as a reference/guideline for researchers, practitioners, and policymakers to take into account critical components that potentially increase the likelihood of success in implementing LM/LSS in LGOs. Furthermore, the success of LM/LSS might not be restricted to the latent/construct level. In other words, the 29 CSFs can be crucial and supportive guidelines to LGOs for LM/LSS deployment.

This study has a number of limitations. First, the sample size is relatively small, and a high proportion of participants were from the U.S.; thus, the findings of this study might not be generalizable to other countries. However, this limitation opens an opportunity for future research. This study could be replicated in other geographical regions to identify more insights regarding how CSFs are perceived in other geographical contexts. Furthermore, incorporating new hypothetical relationships (i.e., control variables) could provide rich and interesting findings. Finally, it could be highly beneficial to conduct a system dynamic model-based case study to examine the CSFs and their interactions for LM/LSS success rate.

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Chapter 8: Conclusions

To maintain competitiveness, organizations must continuously seek efficient and adaptable strategies to cope with the challenges brought on by globalization and rising customer demands. With this aim, LGOs have adopted Lean Production and Lean Six Sigma (LP/LSS) within their organizations. LP/LSS helps LGOs be more flexible, effective, and efficient, capable of thriving amidst both external and internal pressures. However, difficulties in achieving the expected outcomes of LP/LSS are a major concern, and there has been a lack of rigorous investigation in the current literature on LP/LSS in LGOs. This study sought to address this gap through sequential investigations of the CSFs associated with LP/LSS success. This chapter presents the overall conclusions of the research, including a summary of the findings, limitations, implications, and recommendations for future work.

Research Summary

This section discusses the research's development based on the research roadmap summarized in Chapter 1 (see Figure 1), which included three main phases: research framing, variable reduction, and operational model. Figure 28 visually summarizes the findings of the study.

The first phase investigated the current status of LP/LSS within the context of LGOs (Manuscript #1) and surveyed the literature for the CSFs associated with the success of this improvement methodology (Manuscript #2). Adopting an SLR, the assessment of this research area (Manuscript #1) was investigated using different dimensions (i.e., research questions) that covered the major outcomes/benefits of using LP/LSS in LGOs, research design, evaluation of publications, and prominent authors. Gaps in the literature were also identified. This analysis reported research avenues across 11 themes. Among these themes, investigating CSFs emerged as a potential area for empirical analysis. A subsequent analysis (Manuscript #2), motivated by the identified scientific research gaps, focused on the CSFs crucial for LP/LSS success in LGOs. This

extensive review of 8,454 raw records identified 44 relevant publications, which were then thoroughly analyzed to identify 47 distinct CSFs. These factors were defined for clarity and categorized into six groups: organization, communication, workforce, task design, team design, and process.

The second phase involved condensing the comprehensive set of CSFs specified in Manuscript #2. For this purpose, a meta-synthesis approach was implemented (Manuscript #4), combining qualitative and quantitative approaches to ensure a thorough examination of the factors. The evaluation procedure using the meta-synthesis for the 47 CSFs was based on three criteria: frequency of variables (or factors), degree of importance (operationalized as a large effect), and quality of publications. The total effect rating for every CSF was established by applying these three criteria. This analysis clustered the set of CSFs into 14 factors with a large effect, 21 with a medium effect, and 12 with a small effect. The meta-synthesis findings were integrated with the expert survey (Manuscript #5), which was designed and distributed to scholars and practitioners. After the survey, the data were analyzed to compute the overall mean scores for each factor. Next, the results were distributed uniformly to define the strength of effect ratings for each factor as a small effect, medium effect, or large effect. To classify the overall integrated effect for the CSFs based on the meta-synthesis and the expert survey, a heat chart (see Figure 21) was developed to classify key regions as an overall integrated large effect, overall integrated medium effect, or overall integrated small effect. This rigorous analysis showed that 29 CSFs had a large effect. As a result, these 29 CSFs were candidates for the empirical investigation.

The third phase involved developing the conceptual model and identifying outcome variables. Once the final set of CSFs was synthesized and identified, a conceptual framework that hypothesized the relationships among factors and system outcomes was developed (Manuscript

#3). The model contained five categories, each including a relevant number of factors. The outcome variables reflected variables that measured technical and social outcomes. The technical system outcomes encompassed three variables (*improved organizational results, LM/LSS embeddedness*, and *general success*), while one variable was related to social system outcomes (*improved employee results*).

The last manuscript (Manuscript #6) empirically evaluated the statistical significance of the CSFs in LGO outcomes. To this end, a survey with four main sections was developed. The survey's structure included items measuring the outcomes of implementing LP/LSS, items measuring the presence and effect of the CSFs during the development and/or implementation phases of LP/LSS, items gathering detailed background information about the participants, and a section that asked participants for referrals to further enrich the study's data pool. Once the survey was concluded and the initial screening of the responses had been conducted, a total of 67 responses were deemed valid for further analysis.

Table 28. Summary of the statistical significance paths

Latent variables	**Outcome variables**		
	Transformation success	Deployment success	Improvement project success
Improvement readiness	Positive		
Sustainable improvement infrastructure		Positive	
Supportive leadership			
Measures-based improvement			Positive
Change awareness	Positive		

Two EFA models were developed to test the underlying latent variables for the CSFs (i.e., independent variables) and system outcomes (i.e., dependent variables). The EFA models identified five latent variables as the independent variables and three latent variables as the dependent variables as summarized in Table 28. The independent variables included *improvement*

readiness (IR), sustainable improvement infrastructure (SII), supportive leadership (SL), measures-based improvement (MBI), and change awareness (CA), whereas the dependent variables were transformation success (TS), deployment success (DS), and improvement project success (IPS). To examine the significance of the independent variables, a PLS-SEM model was employed. The findings showed that *improvement readiness (IR)* and *change awareness (CA)* had a significant positive influence on *transformation success (TS)*. *Sustainable improvement infrastructure (SII)* and *measures-based improvement (MBI)* were significant positive predictors of *deployment success (DS)* and *improvement project success (IPS)*, respectively. These results provide valuable insights and could serve as a comprehensive guide for researchers, practitioners, and policymakers. This study aims to assist LGOs' stakeholders in making informed decisions by identifying and highlighting key factors crucial to implementing LP/LSS successfully. A clear understanding of these factors could facilitate more effective planning, execution, and evaluation of lean practices, ultimately contributing to improved outcomes in LGOs and other organizational contexts.

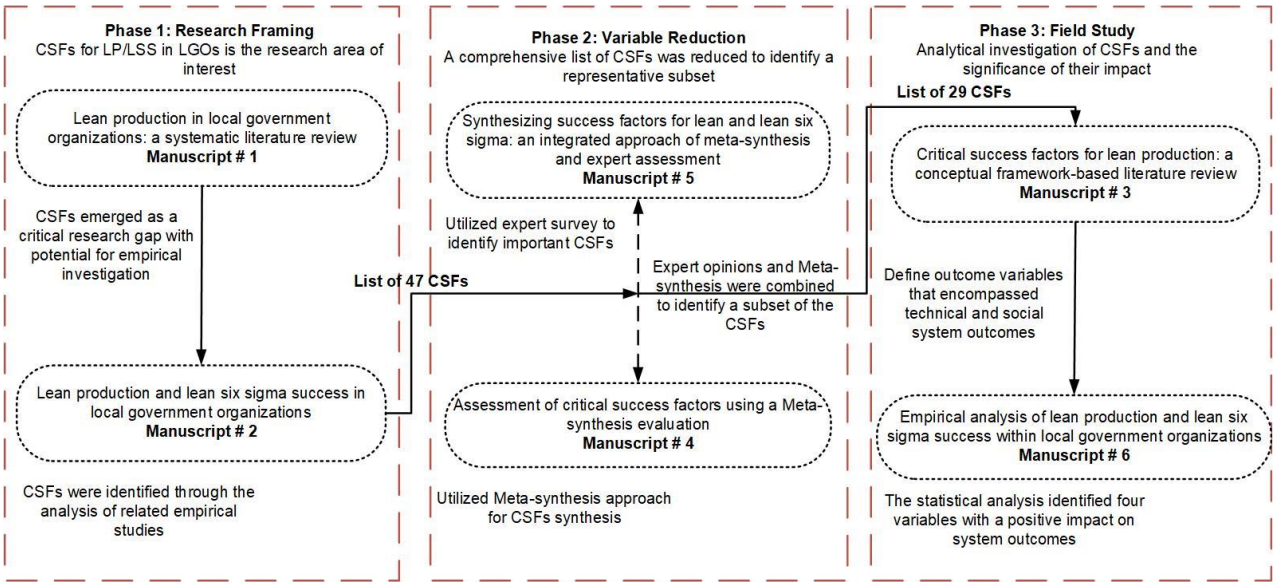

Figure 28. Summary of research findings

Contributions

This study contributes to advancing the research area on CSFs associated with LP/LSS in LGOs. Its characterization of the current status of LP/LSS in LGOs could be used as a reference to understand this research area and build upon the findings. The study also identified a comprehensive list of factors derived from publications documenting enablers and barriers related to LP/LSS experience. This effort makes these factors unique as they are derived from relevant publications and do not adopt CSFs experienced in other service organizations. Furthermore, these factors were developed and operationalized to make them easier to understand, especially for practical applications. Another contribution is the development of an integrated approach (i.e., meta-synthesis and expert survey). In the current literature, many studies have utilized only one approach (e.g., expert surveys or fuzzy logic) to highlight key factors, while this research offers a meta-synthesis approach that can be integrated with an expert survey for more rigorous results. Finally, there is a dearth of empirical research examining the CSFs in the context of LGOs. This study contributes to the overall understanding of such factors in both research and practice.

Implications

This research highlights that the readiness of an organization for improvement, employee buy-in, and understanding of the need for change are crucial for achieving transformational success. In practice, practitioners need to prioritize activities, ensuring that tools and methods are well-suited to their specific needs and that employees are engaged from the beginning. It could also be beneficial to conduct readiness assessments before launching LP/LSS initiatives. This might help to identify gaps related to, for example, tools, techniques, and employee engagement levels. Practitioners should also work to create a culture that is positively responsive to change, emphasizing clear communication, and the benefits of LP/LSS initiatives. Implementing change management programs that include clear and regular communication, education, and engagement

activities could support spreading the awareness of LP/LSS. The results also revealed that a robust supporting system, such as training and education and resources, is needed for deploying this type of improvement methodology. More specifically, establishing a solid foundation that supports continuous learning and improvement is essential for the widespread deployment of LP/LSS. Thus, this suggests that practitioners should invest in training programs to build the necessary knowledge and skills across the organization and ensure that both financial and non-financial resources are available to support LP/LSS activities over the long term. The findings of this research also identified the significance of using accurate and reliable data for supporting LP/LSS initiatives. Establishing robust data collection and analysis processes helps to guide project identification and monitor performance. Thus, incorporating a data management strategy might assist to ensure the quality and reliability of data used and provides data-driven insights to maximize impact and resource efficiency. The synthesis of success factors for LP/LSS within LGOs, as revealed through this systematic research effort, provides a comprehensive blueprint for practitioners looking to utilize the full potential of this improvement methodology. By understanding and addressing the identified factors, practitioners can enhance their implementation success to achieve significant improvements in both social and technical system outcomes. As LP/LSS continues to evolve, it is also important that practitioners remain adaptable, leveraging insights from ongoing research and practice to refine and enhance their approaches to achieving organizational excellence.

Limitations of this Research

The SLR represents a method for aggregating and analyzing research findings, offering valuable insights that can inform policy, practice, and future research directions. However, it faces several limitations that should be taken into account. One of its main limitations is related to the platforms employed. While this study mitigated this limitation by executing the search terms in multiple

platforms, there could be other relevant publications that were not indexed in any of the platforms selected for this study.

A second limitation of this study was the number of items used to measure each of the 29 factors. Psychometric literature recommends a minimum of three items per construct (Robinson, 2018). Increasing the number of items helps capture the concepts of multidimensional variables. While using multi-item scales is common in research, some experts have started to question this approach, as participants often find them repetitive and too much work, which can lead to fewer people completing the survey (Robinson, 2018). To solve this problem, in some cases, a single item has been shown to be as good as a multi-item scale (Robinson, 2018). This study used a single item to measure each of the CSFs. This approach was preferred given the final set of 29 factors identified by the meta-synthesis and expert survey. If, on average three items were utilized to measure each factor, this would have resulted in 87 survey items. The overall length of such a survey, expected response time, and possible decrease in response rate led to the use of one item per factor.

The next limitation of this study is related to the sample size. While different strategies were used to maximize the number of responses, many circumstances hindered reaching a larger sample size. However, this study utilized statistical techniques for achieving reliable results, including EFA and PLS-SEM. EFA is suitable for identifying the underlying structure of data from a small sample size. Furthermore, PLS-SEM was employed to assess the significance of the factors, given this technique's flexibility with small samples, particularly when the models comprise many constructs and their items (Hair, 2017). Because the majority of responses were from the U.S., the outcomes of the study could be more relevant to LGOs located within that country.

Future Work

One of the main contributions of this research is the identification of research gaps in the literature related to LP/LSS in LGOs. Alrezq & Van Aken (2022) (Manuscript #1) identified 11 themes in this regard: research design/methodology, LM/LSS impact/benefits, treatment/additional variables, organizational strategic approach, tools/techniques of LM/LSS, critical success factors, case studies, LM/LSS with other management/change management approaches, functional units, additional organizational types, and geographical context. These themes could guide researchers to focus on critical areas to advance this research area. This study focused on one of the identified themes (i.e., CSFs), leaving it to future research to address the other themes.

Future research could draw data from a larger sample size, addressing one of this study's limitations. This would help to employ other statistical techniques, such as regression models or path models, to examine the impact of the 29 CSFs on the system outcome. Moreover, increasing the sample size could also help examine the effect of contingency on the CSFs for LP/LSS implementation in LGO settings. Contingency theory argues that there is no one-size-fits-all approach to organizations or managing a process; rather, the optimal approach depends on the specific circumstances (Netland, 2016). This is supported by Donaldson (2001), in which various approaches for implementation were dependent on a given system's context (as cited in Netland, 2016). Translating contingency theory to this research context, a larger sample size would permit evaluating the CSFs contingent on certain conditions, such as the maturity level of LP/LSS in an LGO, functional units (e.g., social, police, etc.), or scope of geographical region (e.g., state vs. city). Such comparisons could reveal meaningful insights into which factors are more crucial in certain conditions.

To maximize the response rate, a single-item survey was used to evaluate the 29 CSFs. However, future studies could assign more than one item to each factor, particularly the factors

found to be significant in this study. Moreover, this research identified and evaluated a comprehensive list of factors, opening up opportunities for future research to focus on specific factors. For example, leadership support/commitment was among the most frequent factors; thus, further investigation of leadership components (e.g., style, skills, or knowledge) could offer insights and guidance for leaders in LGOs.

Finally, the data were collected from only one respondent per organization based on their past experience. This view of a single individual might not reflect a broader view of other individuals who were engaged in the implementation process. Thus, future work could include collecting data from more than one individual at the same organization. While the interest is at the system level (i.e., a unit of analysis), data could be gathered and then aggregated, presenting a unique implementation system or organization. Furthermore, the data reflected the perceptions of participants at a single point in time. More specifically, data were collected by soliciting participant perceptions about their past experience related to LP/LSS development and/or implementation. While the survey explicitly recommended participants use the latest experience (i.e., implementation event), the gap between actual implementation and data collection might introduce less consistency across organizations. Thus, future research could address this.

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Appendix A: Final Set of Publications Analyzed in Chapter 2 (Manuscript #1)

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Appendix B: Final Set of Publications Analyzed in Chapter 3 (Manuscript #2)

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Zefaj, E. (2019). *Measuring Municipal Readiness to Apply Lean Six Sigma* [Doctoral dissertation]. University of New York.

Appendix C: Expert Survey for Critical Success Factors for LP/LSS in LGOs.

Academic invitation email letter

Email Subject: Invitation to Participate in Expert Survey on Lean Production and Lean Six Sigma in Local Government Organizations, Virginia Tech Study. IRB Protocol Number: 22-352

Dear (*insert name*),

Based on your scholarly publications on Lean Production or Lean Six Sigma (LP/LSS) in Local Government Organizations (LGOs), we invite you to participate in an Expert Survey on critical success factors affecting LP/LSS success in this organizational setting. In other works, these critical success factors may also be called barriers, obstacles, or enablers, etc. We are inviting a group of prominent experts—who are at least 18 years old and English speakers—for their feedback on a set of critical success factors we have identified from a systematic literature review, and you were identified as an expert due to your published work in this research area.

We are interested in this research area because these critical success factors play a significant role in successful implementation for achieving outcomes (e.g., lead time, process time, customer satisfactions, financial savings, etc.). Based on a rigorous Systematic Literature Review, we have identified a comprehensive list of potential success factors that appeared in published studies. In this Expert Survey, we ask you to rate the importance of these potential success factors in terms of their impact on LP/LSS success and outcomes in LGO settings.

The responses to this Expert Survey will be strictly confidential, but a summary of the results of the survey can be provided upon request. The results from this survey will be used to refine the set of potential success factors and to develop a survey instrument for a larger empirical field study in this research area (LP/LSS in LGOs). Your participation is voluntary, and we hope that you will accept participating in this Expert Survey. If you are aware of any individuals who have experience with LP/LSS in LGOs, we encourage you to share this invitation with them.

Following this Expert Survey, we will conduct a larger empirical field study of LP/LSS in LGOs. If you are aware of any LGOs that may be interested in participating in the larger field study, we welcome your suggestions by providing their contact information at the end of this survey. The survey should take up to 10-15 minutes to complete. To begin the Expert Survey, please go to the link below.

Thank you in advance for your participation and assistance with this research.
https://virginiatech.questionpro.com/t/AU4AgZs9YM

Sincerely,
Mohammed Alrezq
Ph.D. Candidate
Grado Department of Industrial and Systems Engineering
Virginia Tech
Alrezq@vt.edu

Dr. Eileen M. Van Aken
Professor and Department Head
Grado Department of Industrial and Systems Engineering

Virginia Tech
evanaken@vt.edu

Practitioner invitation email

Email Subject: Invitation to Participate in Expert Survey on Lean Production and Lean Six Sigma in Local Government Organizations, Virginia Tech Study. IRB Protocol Number: 22-352

Dear (*insert name*)

Based on your experience with Lean Production or Lean Six Sigma (LP/LSS) in Local Government Organizations (LGOs), we invite you to participate in an Expert Survey on critical success factors affecting LP/LSS success in this organizational setting. In other works, these critical success factors may also be called barriers, obstacles, or enablers, etc. We are inviting a group of prominent practitioner experts—who are at least 18 years old and English speakers—for their feedback on a set of critical success factors we have identified from a systematic literature review. You were identified as an expert due to your current or previous position in an LGO, which was identified through professional networks.

We are interested in this research area because these critical success factors play a significant role in successful implementation for achieving outcomes (e.g., lead time, process time, customer satisfactions, financial savings, etc.). Based on a rigorous Systematic Literature Review, we have identified a comprehensive list of potential success factors that appeared in published studies. In this Expert Survey, we ask you to rate the importance of these potential success factors in terms of their impacts on LP/LSS success and outcomes in LGO settings.

The responses to this Expert Survey will be strictly confidential, but a summary of the results of the survey can be provided upon request. The results of this survey will be used to refine the set of potential success factors and to develop a survey instrument for a larger empirical field study in this research area (LP/LSS in LGOs). Your participation is voluntary, and we hope that you will accept participating in this Expert Survey. If you are aware of any individuals who have experience with LP/LSS in LGOs, we encourage you to share this invitation with them.

Following this Expert Survey, we are conducting a larger empirical field study of LP/LSS in LGOs. If you are aware of other LGOs that may be interested in participating in the larger field study, we welcome your suggestions by providing their contact information at the end of this survey. The survey should take up to 10-15 minutes to complete.

To begin the Expert Survey, please go to the link below.
Thank you in advance for your participation and assistance with this research.

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Sincerely,
Mohammed Alrezq
Ph.D. Candidate
Grado Department of Industrial and Systems Engineering
Virginia Tech
Alrezq@vt.edu

Dr. Eileen M. Van Aken
Professor and Department Head
Grado Department of Industrial and Systems Engineering

Virginia Tech
evanaken@vt.edu

Academic reminder email

Email Subject: Invitation to Participate in Expert Survey on Lean Production and Lean Six Sigma in Local Government Organizations, Virginia Tech Study. IRB Protocol Number: 22-352

Dear (*insert name*)

This is a friendly reminder email to invite you to participate in an expert survey to evaluate the critical success factors related to Lean Production and Lean Six Sigma (LP/LSS) success in local government organizations (LGOs). We are inviting a group of prominent experts—who are at least 18 years old and English speakers—for their feedback on a set of critical success factors we have identified from a systematic literature review. **The objective of this survey to rate the importance of these potential success factors in terms of their impact on LP/LSS success and outcomes in LGO settings.** The survey should take up to 10-15 minutes to complete, and the results of the survey will be used to develop a larger empirical field study.

The responses to this Expert Survey will be strictly confidential, but a summary of the results of the survey can be provided upon request. If you are unable to participate, please let us know at your earliest convenience so that we may contact other experts. If you are aware of any experts that may be interested in participating in this expert study, we welcome your suggestions by providing their contact information (name and email address).

Thank you in advance for your participation and assistance with this research.
https://virginiatech.questionpro.com/t/AU4AgZs9YM

Sincerely,
Mohammed Alrezq
Ph.D. Candidate
Grado Department of Industrial and Systems Engineering
Virginia Tech
Alrezq@vt.edu

Dr. Eileen M. Van Aken
Professor and Department Head
Grado Department of Industrial and Systems Engineering
Virginia Tech
evanaken@vt.edu

Practitioner reminder email

Email Subject: Invitation to Participate in Expert Survey on Lean Production and Lean Six Sigma in Local Government Organizations, Virginia Tech Study. IRB Protocol Number: 22-352

Dear (*insert name*)

This is a friendly reminder email to invite you to participate in an expert survey to evaluate the critical success factors related to Lean Production and Lean Six Sigma (LP/LSS) in local government organizations (LGOs). We are inviting a group of prominent practitioner experts—who are at least 18 years old and English speakers—for their feedback on a set of critical success factors we have identified from a systematic literature review. **The objective of this survey to rate the importance of these potential success factors in terms of their impact on LP/LSS success and outcomes in LGO settings.** The survey should take up to 10-15 minutes to complete and the results of the survey will be used to develop a larger empirical field study.

The responses to this Expert Survey will be strictly confidential, but a summary of the results of the survey can be provided upon request. If you are unable to participate, please let us know at your earliest convenience so that we may contact other experts. If you are aware of any experts that may be interested in participating in this expert study, we welcome your suggestions by providing their contact information (name and email address).

Thank you in advance for your participation and assistance with this research.
https://virginiatech.questionpro.com/t/AU4AgZs9YM

Sincerely,
Mohammed Alrezq
Ph.D. Candidate
Grado Department of Industrial and Systems Engineering
Virginia Tech
Alrezq@vt.edu

Dr. Eileen M. Van Aken
Professor and Department Head
Grado Department of Industrial and Systems Engineering
Virginia Tech
evanaken@vt.edu

Expert Survey of Lean Production and Lean Six Sigma in Local Government Organizations

Introduction

You have been invited to participate in this Expert Survey because of your expertise with Lean Production and Lean Six Sigma (LP/LSS) in Local Government Organizations (LGOs). Based on a rigorous Systematic Literature Review, we have identified a potential set of critical success factors (in other works, these critical factors may also be referred to as barriers, enablers, obstacles, challenges, etc.) that influence LP/LSS success and outcome achievement. In this Expert Survey, we would like to obtain your feedback on how important you think each of these potential factors are based on your prior research and/or experience.

Definition of Key Terms

- **Lean Production (LP)—**an improvement methodology that follows a set of principles (or philosophy) and uses tools/techniques (e.g., value stream mapping, 5S, 5Whys, etc.) for maximizing customer value and minimizing waste**.**
- **Lean Six Sigma (LSS)—**a combination of practices and tools from LP and Six Sigma for better maximizing benefits and better achieving desired goals.
- **Lean Production and Lean Six Sigma (LP/LSS)—**in this research, lean production and lean six sigma are the improvement methodologies of interest due to the increased dissemination in LGOs. Thus, for simplicity, the abbreviation "LP/LSS" is used to refer to the overall improvement methodology of interest in this research.
- **Critical Success Factors—**all barriers, enablers, obstacles, or any variables that influence LP/LSS success and performance outcomes.
- **Development—**the initial stage that includes identifying the project/initiative's boundary, defining the problem(s), clarifying the expected outcome(s), selecting team members, allocating resources, etc. **Implementation—**actual execution of LP/LSS tools/techniques - to put LP/LSS into practice.
- **Organization—**the overall organization, or sub-unit within the organization, in which LP/LSS is developed and/or implemented**.**
- **Local Government Organizations (LGOs)**—a local authorized organization that serves a particular geographical region (i.e., state governments, city governments, county/village, and other municipalities).

It is very important to note that, in this Expert Survey, we are interested in the factors you consider important for LP/LSS success within LGOs**. More specifically, we are interested in evaluating the importance of factors that impact the development and/or implementation of LP/LSS methods, tools, and techniques.** Your participation in this survey is voluntary and will be strictly confidential. The survey will take about 10-15 minutes to complete. You may decline to answer any question(s) you choose, but it is highly encouraged to respond to them all. You may also discontinue responding to the survey at any time. If you have questions about the survey, please contact Mohammed Alrezq (Alrezq@vt.edu). If you have questions about your rights as a research participant, please contact Virginia Tech Institutional Review Board (IRB) Human Research Protections Program (HRPP) Administrator at irb@vt.edu.

Division of Scholarly Integrity and Research Compliance
Institutional Review Board
North End Center, Suite 4120 (MC 0497)
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732
irb@vt.edu
http://www.research.vt.edu/sirc/hrpp

MEMORANDUM

DATE: June 16, 2022

TO: Eileen Van Aken, Mohammed Shjea Al rezq

FROM: Virginia Tech Institutional Review Board (FWA00000572)

PROTOCOL TITLE: Evidence-based expert assessment of critical success factor for lean production in local government organizations

IRB NUMBER: **22-352**

Effective June 16, 2022, the Virginia Tech Human Research Protection Program (HRPP) determined that this protocol meets the criteria for exemption from IRB review under 45 CFR 46.104(d) category (ies) 2(ii).

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit an amendment to the HRPP for a determination.

This exempt determination does not apply to any collaborating institution(s). The Virginia Tech HRPP and IRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

https://secure.research.vt.edu/external/irb/responsibilities.htm

(Please review responsibilities before beginning your research.)

PROTOCOL INFORMATION:

Determined As:	**Exempt, under 45 CFR 46.104(d) category(ies) 2(ii)**
Protocol Determination Date:	**June 16, 2022**

ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol, and which of the listed proposals, if any, have been compared to this protocol, if required.

SPECIAL INSTRUCTIONS:

***Please note: The HRPP office has stopped stamping documents for Exempt protocols. It is your responsibility to maintain these documents and make current versions available on request.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this protocol is to cover any other grant proposals, please contact the HRPP office (irb@vt.edu) immediately.

Critical Success Factors

Section 1:
A potential list of critical success factors related to LP/LSS success in LGOs was identified through a systematic literature review. For each critical success factor, we have provided an operational definition and 6-point importance scale. Please respond to the questions to rate how important you believe each factor is for LP/LSS development and/or implementation.

1. **Leadership support/commitment**: Extent to which Leaders demonstrate commitment and buy-in for LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

2. **Organizational culture**: Extent to which the organizational culture is open and supportive of LP/LSS philosophy and principles.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

3. **Employee attitude**: Extent to which employees buy-in and accept LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

4. **Resource availability**: The amount of financial and non-financial resources allocated to support LP/LSS, including money, people, equipment, etc.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

5. **Leadership involvement**: Extent to which leaders are involved throughout the development and implementation of LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

6. **Addressing competing priorities**: Extent to which solutions are developed for other priorities that may compete with LP/LSS for resources and attention.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

7. **Project identification and selection**: Identification, prioritization, and selection of specific LP/LSS initiatives/projects having the most benefit to the organization.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

8. **Availability of data**: Extent to which data needed to analyze and understand the targeted processes/systems are available.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

9. **Defining measures**: Extent to which relevant performance measures that track and monitor the progress of improvement are defined and implemented.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

10. **Rewards and recognition**: Extent to which recognition and rewards are provided to organizational members who contribute to LP/LSS goals and success.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

11. **General resistance to change**: Extent to which there is a lack of resistance to changes made as a result of LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

12. **External influence for implementation**: Extent to which the organization is influenced to implement LP/LSS due to external factors, such as government requirements or other external pressures.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

13. **Organizational readiness for LP/LSS**: Extent to which the organization has the pre-conditions to be ready for LP/LSS, including a clear vision for LP/LSS and effective communication.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

14. **Leadership style**: Extent to which leaders' style and approach are aligned with LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

15. **Organizational characteristics**: Extent to which planning activities address the key organizational characteristics for successful LP/LSS, such as size and the unit of analysis.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

16. **Politics/regulations constraints**: Extent to which any external regulations and requirements are aligned with LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

17. **Data quality**: Accuracy, validity, and reliability of the data used by the organization to support LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

18. **Supplier relationships**: Extent to which supplier relationships relevant to processes being targeted for improvement are established.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

19. **Organizational experience with LP/LSS**: Level of previous organizational experience with LP/LSS such as through prior projects/initiatives.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

20. **Customer buy-in/engagement**: Extent to which customers and other stakeholders buy-in to LP/LSS and are appropriately engaged in LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

21. **Organizational accreditation**: Extent to which recognition and experience gained from accreditation activities support LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

22. **Employee engagement**: Extent to which employees from areas targeted are involved and engaged in LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

23. **Tool appropriateness**: Extent to which the LP/LSS tools and techniques used for analysis and problem solving are appropriate.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

24. **Target system employee commitment to change**: Extent to which employees in areas targeted for LP/LSS commit to changes made to processes.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

25. **Contextualization/customization of LP/LSS**: Extent to which LP/LSS tools and techniques are customized and adapted to fit and align with the organizational context.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

26. **LP/LSS reporting**: Extent to which stakeholders receive reporting on progress and activities of LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

27. **Effort required for LP/LSS**: Extent to which the amount of time and effort devoted to LP/LSS development and implementation is appropriate and feasible.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

28. **Scope of LP/LSS**: Extent to which the scope of LP/LSS development and implementation within the organization is appropriate and feasible.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

29. **LP/LSS implementation process**: Extent to which execution of LP/LSS follows a gradual and flexible process, with pilot testing, staged implementation, etc.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

30. **LP/LSS institutionalization**: Extent to which LP/LSS is deployed throughout the organization, including various organizational levels and units.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

31. **Structured approach to LP/LSS**: Extent to which a structured approach is used to develop and implement LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

32. **Team autonomy**: The level of decision-making authority and autonomy given to employees working on LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

33. **LP/LSS training and education**: Investing in and providing the education/training required to develop the workforce knowledge/skills needed to support LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

34. **Workforce knowledge and skills**: Extent to which people in the organization had adequate knowledge, skills, and competencies to support LP/LSS.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

35. **Experienced consultant**: Availability of an experienced professional (within or from outside the organization) with sufficient knowledge of LP/LSS to support facilitation, coaching, and implementation.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

36. **External consultant knowledge of LGO processes**: Extent to which any external consultant used is familiar with processes and context of LGOs to translate and adapt concepts and tools/techniques.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

37. **General understanding of LP/LSS philosophy**: Extent to which people in the organization have a clear understanding of the principles and concepts associated with LP/LSS philosophy.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

38. **Understanding the need for change**: Extent to which a clear and compelling need for change is communicated throughout the organization.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

39. **Communicating knowledge and success stories**: Extent to which LP/LSS best practices and success stories are shared across the organization.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

40. **Awareness of LP/LSS benefits/value**: Extent to which the value and benefits associated with LP/LSS are clearly understood by those across the organization.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

41. **Patience for results**: Extent to which people in the organization have the necessary patience for improvements in results to be realized.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

42. **Goal clarity**: Extent to which the goals and aims of LP/LSS are clear and understood across the organization.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

43. **Customer identification**: Extent to which customers of processes targeted for improvement are clearly identified.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

44. **Goal alignment**: Extent to which LP/LSS is aligned with organizational goals and priorities.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

45. **Target system complexity**: Extent to which the workflow, interconnections, and interdependencies in processes targeted for improvement are routine and not complex.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

46. **Cross-functionality**: Extent to which teams used to develop and implement LP/LSS include individuals from cross functional areas.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

47. **Team structure and roles**: Extent to which teams used to develop and implement LP/LSS have clearly defined roles and responsibilities.

Not at all important	Low importance	Somewhat important	Moderately important	Very important	Extremely important

Section 2:
Based on your experience with LP/LSS development and/or implementation in LGOs, please respond to the following open-ended questions.

Q1. In your view and based on your experience, what are the most significant barriers or obstacles that affect LP/LSS success in LGOs?

Q2. In your view and based on your experience, what are the most significant enablers that affect LP/LSS success in LGOs?

Section 3: Background Information
We would like to know more about your experience; thus, please response to the following questions.

1. How would you classify your experience with LP/LSS?
   a. Academic/Researcher
   b. Practitioner in an LGO
   c. Consultant
   d. Other:
2. In which improvement methodology do you have the most experience?
   a. Lean Production
   b. Lean Six Sigma
   c. LP/LSS (integrated approach)
   d. Other:
3. How many years of experience do you have with LP/LSS implementation?
   a. Less than a year
   b. 1-5 years
   c. 5-10 years
   d. More than 10
4. When was the last time that you participated in or observed the implementation of LP/LSS in an LGO?
   a. Never
   b. Less than a year ago

c. 1-2 years ago
d. 3-5 years ago
e. More than five years ago

5. Where is your current geographical location?
   a. The U.S.
   b. The U.K.
   c. Germany
   d. Denmark
   e. Spain
   f. Mexico
   g. Other:

Section 4

Following the completion of this expert survey, we will be conducting a larger empirical field study for LP/LSS in LGOs. If you know any LGOs that might be interested in participating in this study, please complete the following:

Contact name
Contact email

The research team appreciate your time and response to this expert survey

Appendix D: Empirical Survey for Critical Success Factors for LP/LSS in LGOs.

Invitation email letter

Email Subject: Invitation to Participate in a Survey on Lean Production and Lean Six Sigma in Local Government Organizations, Virginia Tech Study
IRB Protocol Number: **22-875**

Based on a comprehensive systematic literature review, we identified a potential set of critical success factors "CSFs" (e.g., barriers, enablers, obstacles, etc.) related to Lean Production and Lean Six Sigma (LP/LSS) success in local government organizations (LGOs). The purpose of this study is to identify which of the CSFs are most strongly related to LP/LSS success in these organizational settings.

Based on your experience with LP or LSS, we invite you to share with us your experience through participating in this survey study. We are seeking a broad sample of LGOs that have developed and/or implemented LP or LSS; thus, only one participant per organization (or a sub-unit within the organization) is needed for this study. We encourage you to share this e-mail invitation with others (i.e., academic/researchers and practitioners) who have experience in LP or LSS in LGOs.

More detailed information about the survey structure, instruction, and other key definitions are included in the survey link below. Participating in this survey is voluntary and should take approximately 20 minutes to complete.
Thank you in advance for your participation and assistance with this research.
Insert Survey link

Sincerely,
Mohammed Alrezq
Ph.D. Candidate
Grado Department of Industrial and Systems Engineering
Virginia Tech
Alrezq@vt.edu

Dr. Eileen M. Van Aken
Professor and Department Head
Grado Department of Industrial and Systems Engineering
Virginia Tech
evanaken@vt.edu

Invitation email letter— Reminder

Email Subject: Invitation to Participate in a Survey on Lean Production and Lean Six Sigma in Local Government Organizations, Virginia Tech Study
IRB Protocol Number: 22-875

This is a friendly reminder email to invite you to participate in a large-scale survey study to investigate the critical success factors "CSFs" (e.g., barriers, enablers, obstacles, etc.) related to Lean Production and Lean Six Sigma (LP/LSS) success in local government organizations (LGOs). The purpose of this study is to identify the CSFs most strongly related to LP/LSS success in these organizational settings.

We are seeking a broad sample of LGOs that have developed and/or implemented LP or LSS; thus, for this survey study, we are only seeking one participant per organization (or a sub-unit within the organization). Please read the following to complete the survey:

- If you have already completed this survey study, please ignore this reminder invitation.
- If you have forwarded the original survey invitation to someone in your network, please forward this reminder to ensure that they also receive this reminder email.
- If you would like to extend this invitation to someone in your network, please forward this reminder invitation to the person who should complete the survey.

Thank you in advance for your participation and assistance with this research.
Insert Survey link

Sincerely,
Mohammed Alrezq
Ph.D. Candidate
Grado Department of Industrial and Systems Engineering
Virginia Tech
Alrezq@vt.edu

Dr. Eileen M. Van Aken
Professor and Department Head
Grado Department of Industrial and Systems Engineering
Virginia Tech
evanaken@vt.edu

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irb@vt.edu
http://www.research.vt.edu/sirc/hrpp

MEMORANDUM

DATE: October 5, 2022

TO: Eileen Van Aken, Mohammed Shjea Al rezq

FROM: Virginia Tech Institutional Review Board (FWA00000572)

PROTOCOL TITLE: Lean Production and Lean Six Sigma Success in Local Government Organizations: An Empirical Research

IRB NUMBER: **22-875**

Effective October 5, 2022, the Virginia Tech Human Research Protection Program (HRPP) determined that this protocol meets the criteria for exemption from IRB review under 45 CFR 46.104(d) category (ies) 2(ii).

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit an amendment to the HRPP for a determination.

This exempt determination does not apply to any collaborating institution(s). The Virginia Tech HRPP and IRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

https://secure.research.vt.edu/external/irb/responsibilities.htm

(Please review responsibilities before beginning your research).

PROTOCOL INFORMATION:

Determined As: **Exempt, under 45 CFR 46.104(d) category(ies) 2(ii)**
Protocol Determination Date: **October 5, 2022**

ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol, and which of the listed proposals, if any, have been compared to this protocol, if required.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this protocol is to cover any other grant proposals, please contact the HRPP office (irb@vt.edu) immediately.

Lean Production and Lean Six Sigma Success in Local Government Organizations: An Empirical Research

You have been invited to participate in this survey because of your experience or expertise with Lean Production (LP) or Lean Six Sigma (LSS) in Local Government Organizations (LGOs). In this survey study, LP and LSS are the improvement methodologies of interest; thus, for simplicity, the abbreviation "LP/LSS" is used to refer to the overall improvement methodology. The purpose of this study is to determine the critical success factors (CSFs) that are most strongly related to LP/LSS success in LGO settings. Before proceeding with the survey, please review the following information.

Definition of Key Terms

- **Lean Production (LP)—**an improvement methodology that follows a set of principles (or philosophy) and uses tools/techniques (e.g., value stream mapping, 5S, 5Whys, kaizen events, etc.) for maximizing customer value and minimizing waste**.**
- **Lean Six Sigma (LSS)—**a combination of practices and tools from LP and Six Sigma for better maximizing benefits and better achieving desired goals.
- **Critical Success Factors (CSFs)—** barriers, enablers, obstacles, or any factors that may influence LP/LSS success and performance outcomes.

Who should complete the survey?

We only need one person from each participating organization (or sub-unit within the organization) to complete the survey. **We also encourage you to share this survey invitation with individuals involved in implementing LP/LSS in other parts of your organization if it was managed as a separate initiative**. Survey respondents must meet the criteria below:

1. Be at least 18 years old and a native or fluent English speaker; and
2. Have experience related to the development and/or implementation of LP/LSS within an LGO
3. Served as a manager, team leader/facilitator, team member or consultant related to a LP/LSS initiative within the organization.

If you do not meet these above criteria, please exit the survey now.

Which LP/LSS initiative should I consider in answering the survey questions?

If you have supervised, led/facilitated, or collaborated in more than one initiative that has been completed, please **consider only the most recently-completed LP/LSS** initiative that was developed and/or implemented when you answer the survey questions.

Information Sheet for Participation in a Research Study

Principal Investigator: Eileen Van Aken, Ph.D.
Co-investigator: Mohammed Alrezq
IRB#: **22-875**
Title of Study: Lean Production and Lean Six Sigma Success in Local Government Organizations: An Empirical Research

You are invited to participate in a survey. This form includes information about the survey and contact information if you have any questions.

I am a PhD student in Industrial and Systems Engineering at Virginia Tech, and I am conducting this research as a part of my dissertation work.

- WHAT SHOULD I KNOW?

If you decide to participate in this survey study, you will complete **four main sections** in this survey. **The first section** includes background questions related to the organization in which LP/LSS was developed and/or implemented, participants experiences, and LP/LSS tools/techniques used. **The second section** includes questions related to the success outcomes of developing and/or implementing LP/LSS (i.e., the experienced outcomes once LP/LSS is completed). **The third section** is related to the Critical Success Factors (CSFs) in which each factor will be assessed based on its impact on LP/LSS success. **The fourth section** includes suggestions from the survey participants for other potential participants who might be willing to fill out this survey. The survey should take approximately 20 minutes.

We do not anticipate any risks from completing this survey.

You can choose whether to be in this survey study or not. If you volunteer to be in this survey study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

- CONFIDENTIALITY

We will do our best to protect the confidentiality of the information we gather from you, but we cannot guarantee 100% confidentiality.

Any data collected during this survey study will be kept confidential by the researchers. Any identifiers obtained will be kept strictly confidential and not included in any publication work as a result of the research study. The obtained data will be downloaded and stored on a secured and password protected Google Drive which is administered and managed by Virginia Tech. Any identifiers will be separated from the data and then be coded. The survey results will be stored for three years after the study has been completed and then destroyed.

- WHO CAN I TALK TO?

If you have any questions or concerns about this survey study, please feel free to contact the co-investigator at Alrezq@vt.edu or 443-214-6729**.** You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact the Virginia Tech HRPP Office at 540-231-3732 (irb@vt.edu).

Please print out a copy of this information sheet for your records.

If you would like to participate in this survey, click "Begin the survey" to begin or "No thanks" to exit.

Section 1: Participants Experience and Background

The purpose of this section is to learn about the organization in which LP/LSS was developed and/or implemented and your experience with LP/LSS. **Please keep in mind the most recent experience with LP/LSS project/initiative**.

Characteristics of the organization

1. In what country is the organization located (Please select a location in which LP/LSS was developed and/or implemented)?

The U.S.	Denmark
The U.K.	Spain
Germany	Mexico
Other (please specify):	

2. Which of the following best describes **the governmental level of the organization**? The governmental level represents the territory in which the organization controls.

□ State level	□ Village
□ City level	□ Town
□ County	□ Other (please specify):

3. Which of the following best describes **the functionality of the targeted area** in which LP/LSS has been developed and/or implemented (i.e., unit of analysis)?

□ Social service	□ Court
□ Policing force	□ Housing
□ Transportation	□ Waste and recycling
□ Finance and taxation	□ Administration services
□ School and education	□ Healthcare
□ Other (please specify):	

Note: Open text for other unit of analysis will be applied.

4. What is the approximate **population size** (i.e., **inhabitants**) that the organization serves? Please provide a specific number.

5. Which of the following best describes **the size of the targeted area for improvement**? The **target area for improvement** refers to the system (or process) in which LP/LSS was developed and/or implemented. Please consider the size of the targeted area for improvement in terms of the number of employees.

□ Less than 50 employees	□ Between 51 and 100 employees
□ Between 101 and 150 employees	□ Between 151 and 200 employees
□ More than 200 employees	

6. Which of the following best describes the **institutionalization level of LP/LSS**? The institutionalization level refers to whether LP/LSS was developed and implemented within a single, multiple, or all sub-units (i.e., department, division, etc.) of the organization.

□ Within a single sub-unit of the organization	□ Across all sub-units of the organization
□ Within multiple sub-units of the organization	□ Other (Please specify):

7. Which of the following best describes **the overall size of the organization** in which LP/LSS has been developed and/or implemented?

Less than 100 employees	Between 101 to 250 employees
Between 251 to 500 employees	Between 501 to 750 employees
Between 751 to 1,000 employees	More than 1,000 employees

Characteristics of LP/LSS

8. Which of the following best describes the **main focus of the improvement methodology** used for this initiative? The main focus of the improvement methodology refers to whether this project/initiative used only LP tools/techniques, a combination of LP and Six Sigma (known as Lean Six Sigma "LSS"), or LP with other general improvement methodologies.
   - Lean Production
   - Lean Production with other general improvement methodology
   - Lean Six Sigma
   - Other (please specify):

9. Which of the following LP/LSS improvement tools were used during the LP/LSS project/initiative? There are unique tools to LP (such as Value stream Mapping, 5S, and 5Whys), unique tools to Six Sigma (such as cause and effect diagram, Statistical Process Control, and Spaghetti Diagram), a combination of LP and SS, and general improvement tools (such as Process Flow Chart, Project Charter, and brainstorming):
   - Value Stream Mapping
   - Visual Management
   - 5S
   - 5Whys
   - Process Flow Chart
   - Kaizen Event
   - Visual Management
   - Cause and Effect Diagram/Analysis
   - Check Sheet Kanban
   - Critical to Quality
   - Mistake Proofing
   - One-Piece Flow
   - Quality Function Deployment
   - Project Charter
   - Gemba (i.e., go and see)
   - Benchmarking
   - Cycle Time Analysis
   - A3
   - Policy Deployment
   - Spaghetti Diagram
   - Statistical Process Control
   - Brainstorming
   - Lead Time Analysis
   - Process Time Analysis
   - Single-Minute Exchange of Dies
   - Other (Please specify):

Note: multiple options will be allowed and open text for additional tools applied.

10. How would you best describe the type of LP/LSS you were involved in? This refers to whether LP/LSS project/initiative was **implemented** (i.e., the need was identified, and solutions were developed and then implemented within LP/LSS project/initiative), or **not implemented** (i.e., the need was identified, and solutions were developed; but were **NOT YET** implemented within LP/LSS project/initiative but rather will be at a later time)
    - Implementation
    - Non-implementation

Characteristics of LP/LSS development and/implementation

11. Where is your current geographical location?
    - The U.S.
    - The U.K.
    - Germany
    - Spain
    - Mexico
    - Other:

- Denmark

12. How would you classify your experience with LP/LSS?
    - Academic/Researcher
    - Consultant
    - Practitioner in an LGO
    - Other:

13. In which improvement methodology do you have the most experience?
    - Lean Production
    - LP/LSS (Lean Production and Lean Six Sigma)
    - Lean Six Sigma
    - Other (please specify):

14. How many years of experience do you have with LP/LSS implementation?
    - Less than a year
    - 1-5 years
    - 6-10 years
    - 11-15 years
    - 16-20 years
    - More than 20 years

15. Were you a member of the team that led the development and/or implementation of LP/LSS?
    - Yes
    - No

16. Which of the following best describes your role (or roles) in LP/LSS development and/or implementation process?
    - Top-level leader/ manager in the organization
    - Member of the team that guided LP/LSS development and/or implementation
    - Consultant within the department or from other departments/units within the organization
    - External consultant (i.e., external consultant to the organization, such as consulting firm, researcher, etc.)
    - Process owner (e.g., an employee belongs to the area targeted for improvement)
    - Other (please specify):

17. How long ago was this LP/LSS completed? (Please select the one that best describes how long ago this LP/LSS was completed)
    - Less than 6 months ago
    - Between 6 and 12 months ago
    - Between 12 and 18 months ago
    - Between 18 and 24 months ago
    - More than 24 months ago

18. How long has the organization been working on LP/LSS project/initiative? This refers to the organization's experience with LP/LSS in number of years
    - Less than 1 year of experience
    - Between 1 and 2 years of experience
    - Between 3 and 4 years of experience
    - Between 5 and 6 years of experience
    - More than 6 years of experience

19. How many people directly participated in this LP/LSS as team members, including yourself? (Please provide a specific number)?

Section 2: LP/LSS outcomes

In this section, we are interested in your perception about the primary goal(s) of LP/LSS project/initiative; that is, the outcomes experienced once the implementation process was complete. **As noted earlier, please use the most recently completed LP/LSS project/initiative to respond to these questions.**

1. Organizational performance improved after implementing LP/LSS
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

2. Decision making and other management processes improved after LP/LSS implementation
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

3. Business and supporting activities were improved after LP/LSS implementation
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

4. LP/LSS activities were integrated into routine business practices and procedures.
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

5. Using LP/LSS became an important part of the culture in the organization
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

6. LP/LSS was deployed throughout the organization
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

7. Employees believed that using LP/LSS was important for the organization
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

8. Employees were satisfied with LP/LSS.
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

9. Employees knowledge, skills and abilities improved after LP/LSS implementation
   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

10. The implementation of LP/LSS was successful
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

11. The allocated tasks with LP/LSS were completed within the estimated time of completion
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

12. LP/LSS was completed within the estimated budget
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

13. The results of LP/LSS were acceptable to all stakeholders
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

Section 3: Critical Success Factors related to LP/LSS success

In this section, we are interested in your experiences during and immediately following the development and/or implementation process of LP/LSS. Based on your most recent experience with LP/LSS, please indicate the extent to which each of the following critical success factors (CSFs) affect/impact LP/LSS success. CSFs refer to all barriers, enablers, obstacles, or any factors that influence LP/LSS success and performance outcomes. **Please use the most recently completed LP/LSS project/initiative**.

To what extent do you agree with the following statements?

1. **Leadership support/commitment**: Extent to which Leaders demonstrate commitment and buy-in for LP/LSS.

   *Leaders **demonstrated** commitment and buy-in for LP/LSS.*

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

2. **Organizational culture**: Extent to which the organizational culture is open and supportive of LP/LSS philosophy and principles.

   *The organizational culture **was** open and supportive of LP/LSS philosophy and principles.*

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

3. **Employee attitude**: Extent to which employees buy-in and accept LP/LSS.

   *Employees **had** buy-in and acceptance for LP/LSS.*

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

4. **Resource availability**: The amount of financial and non-financial resources allocated to support LP/LSS, including money, people, equipment, etc.

   The right amount of financial and non-financial resources was allocated to support LP/LSS, including money, people, equipment, etc.

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

5. **Leadership involvement**: Extent to which leaders are involved throughout the development and implementation of LP/LSS.

   Leaders were involved throughout the development and implementation of LP/LSS.

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

6. **Project identification and selection**: Identification, prioritization, and selection of specific LP/LSS initiatives/projects having the most benefit to the organization.

   *LP/LSS initiatives/projects **were** identified, prioritized, and selected based on the most benefit to the organization.*

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

7. **Defining measures**: Extent to which relevant performance measures that track and monitor the progress of improvement are defined and implemented.

Relevant performance measures that track and monitor the progress of improvement were defined and implemented.

Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

8. **General resistance to change**: Extent to which there is a lack of resistance to changes made as a result of LP/LSS.

   *There **was** a lack of resistance to changes made as a result of LP/LSS.*

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

9. **Leadership style**: Extent to which leaders' style and approach are aligned with LP/LSS.

   Leaders' style and approach were aligned with LP/LSS.

   Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

10. **Organizational characteristics**: Extent to which planning activities address the key organizational characteristics for successful LP/LSS, such as size and the unit of analysis.

    Planning activities addressed the key organizational characteristics for successful LP/LSS, such as size and the unit of analysis.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

To what extent do you agree with the following statements?

11. **Data quality**: Accuracy, validity, and reliability of the data used by the organization to support LP/LSS.

    There was accurate, valid, and reliable data used by the organization to support LP/LSS.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

12. **Employee engagement**: Extent to which employees from areas targeted are involved and engaged in LP/LSS.

    Employees from areas targeted were involved and engaged in LP/LSS.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

13. **Tool appropriateness**: Extent to which the LP/LSS tools and techniques used for analysis and problem solving are appropriate.

    LP/LSS tools and techniques used for analysis and problem solving were appropriate.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

14. **Contextualization/customization of LP/LSS**: Extent to which LP/LSS tools and techniques are customized and adapted to fit and align with the organizational context.

LP/LSS tools and techniques were customized and adapted to fit and align with the organizational context.

Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

15. **Effort required for LP/LSS**: Extent to which the amount of time and effort devoted to LP/LSS development and implementation is appropriate and feasible.

    The amount of time and effort devoted to LP/LSS development and implementation was appropriate and feasible.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

16. **Scope of LP/LSS**: Extent to which the scope of LP/LSS development and implementation within the organization is appropriate and feasible.

    The scope of LP/LSS development and implementation within the organization was appropriate and feasible.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

17. **LP/LSS institutionalization**: Extent to which LP/LSS is deployed throughout the organization, including various organizational levels and units.

    LP/LSS was deployed throughout the organization, including various organizational levels and units.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

18. **LP/LSS training and education**: Investing in and providing the education/training required to develop the workforce knowledge/skills needed to support LP/LSS.

    The organization invested in providing training/education needed to develop the knowledge/skills needed to support LP/LSS.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

19. **Workforce knowledge and skills**: Extent to which people in the organization had adequate knowledge, skills, and competencies to support LP/LSS.

    People in the organization had adequate knowledge, skills, and competencies to support LP/LSS.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

20. **Experienced consultant**: Availability of an experienced professional (within or from outside the organization) with sufficient knowledge of LP/LSS to support facilitation, coaching, and implementation.

    An experienced professional (within or from outside the organization) with sufficient knowledge of LP/LSS was available to support facilitation, coaching, and implementation.

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

To what extent do you agree with the following statements?

21. **External consultant knowledge of LGO processes**: Extent to which any external consultant used is familiar with processes and context of LGOs to translate and adapt concepts and tools/techniques.

    Any external consultant used was familiar with processes and context of LGOs to translate and adapt concepts and tools/techniques of LP/LSS.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

22. **Understanding the need for change**: Extent to which a clear and compelling need for change is communicated throughout the organization.

    A clear and compelling need for change was communicated throughout the organization.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

23. **Communicating knowledge and success stories**: Extent to which LP/LSS best practices and success stories are shared across the organization.

    LP/LSS best practices and success stories were shared across the organization.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

To what extent do you agree with the following statements?

24. **Patience for results**: Extent to which people in the organization have the necessary patience for improvements in results to be realized.

    People in the organization had the necessary patience for improvements in results to be realized.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

25. **Goal clarity**: Extent to which the goals and aims of LP/LSS are clear and understood across the organization.

    The goals and aims of LP/LSS were clear and understood across the organization.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

26. **Customer identification**: Extent to which customers of processes targeted for improvement are clearly identified.

    Customers of processes targeted for improvement were clearly identified.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

27. **Goal alignment**: Extent to which LP/LSS is aligned with organizational goals and priorities.

    LP/LSS was aligned with organizational goals and priorities.
    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

28. **Target system complexity**: Extent to which the workflow, interconnections, and interdependencies in processes targeted for improvement are routine and not complex.

    *The workflow, interconnections, and interdependencies in processes targeted for improvement **were** routine and not complex.*

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

29. **Team structure and roles**: Extent to which teams used to develop and implement LP/LSS have clearly defined roles and responsibilities.

    *Teams used to develop and implement LP/LSS **had** clearly defined roles and responsibilities.*

    Strongly disagree Disagree Tend to disagree Tend to agree Agree Strongly agree

Section 4

If you know someone (i.e., academic/researchers or practitioners) that might be interested in participating in this study, please complete the following:

Contact name

Contact email

The research team appreciates your time and response to this survey

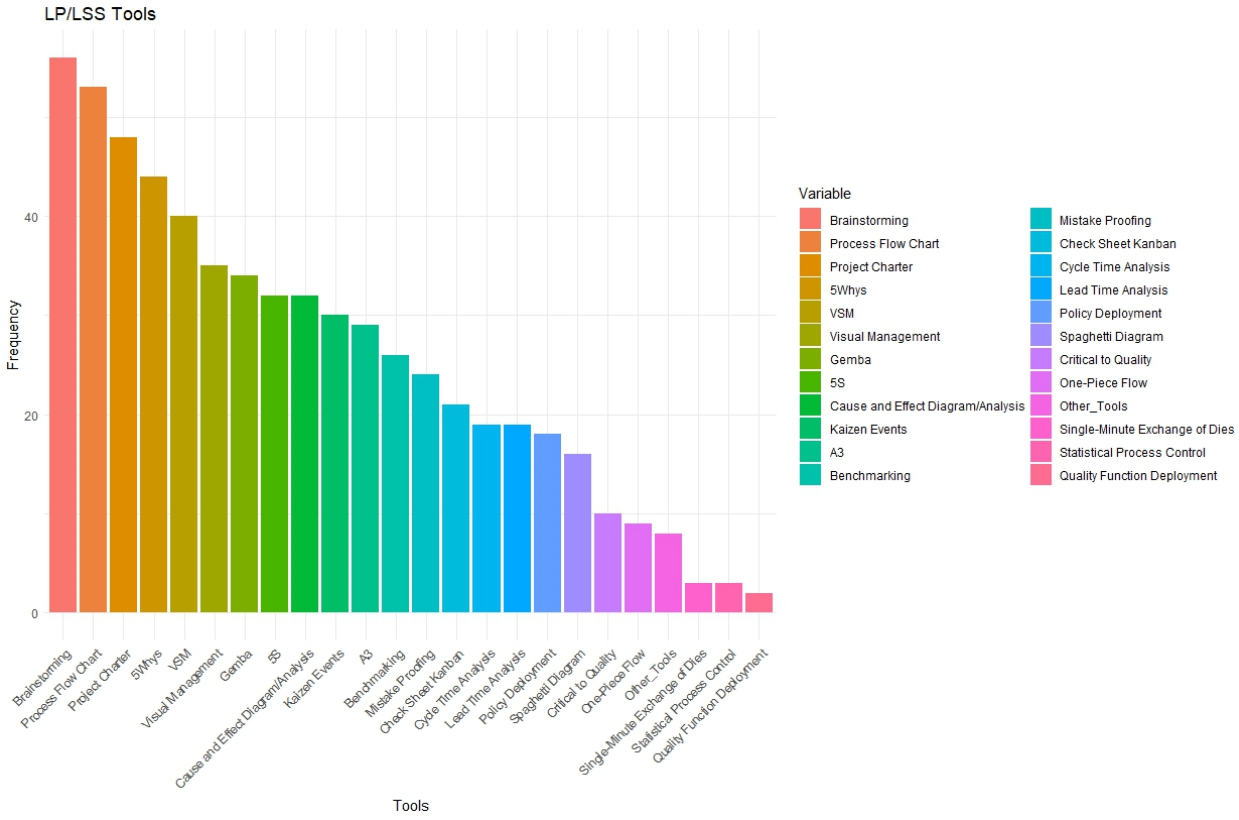
Appendix E: Empirical Survey Data Results.

Appendix E.1: Demographic description of the participants

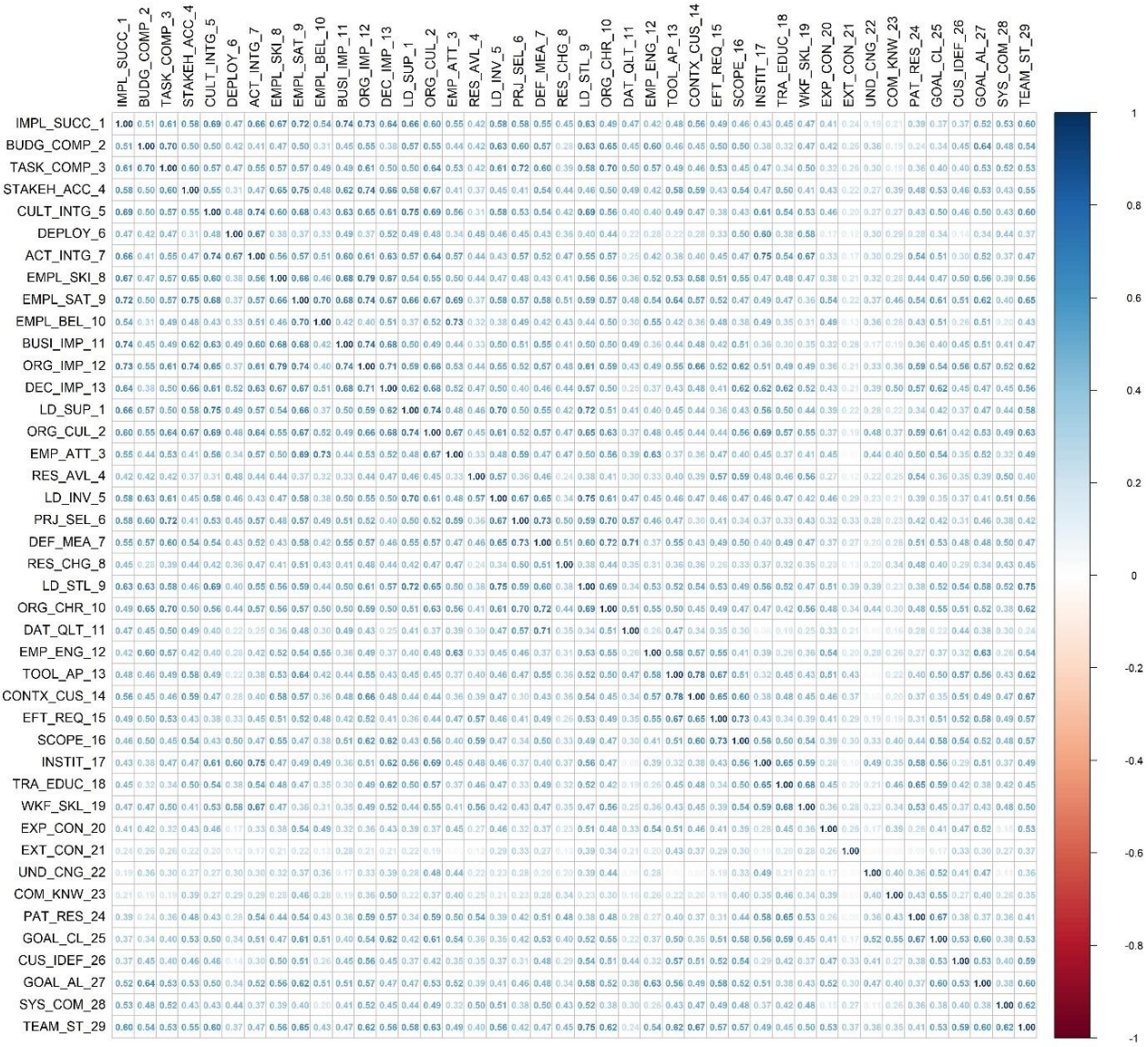
Variable	Category	Frequency (%)
Organization Country	USA	58 (92.06%)
	Australia	1 (1.59%)
	Malaysia	1 (1.59%)
	Turkey	1 (1.59%)
Government Level	State level	49 (77.78%)
	City level	8 (12.70%)
	County	6 (9.52%)
Functional Area	Social Services	17 (26.98%)
	Healthcare	10 (15.87%)
	Administration services	9 (14.29%)
	Finance and taxation	5 (7.94%)
	All/Multiple Functional Area	4 (6.35%)
	Transportation	4 (6.35%)
	Environmental Protection	3 (4.76%)
	School and education	3 (4.76%)
	Court	1 (1.59%)
	Facility Maintenance	1 (1.59%)
	Government regulated Services	1 (1.59%)
	Health and Human Services-enterprise wide	1 (1.59%)
	Legal/Public Records	1 (1.59%)
	Public Works services	1 (1.59%)
	Regulatory	1 (1.59%)
	Workers Compensation	1 (1.59%)
Institutionalization Level	Within multiple sub-units of the organization	30 (47.62%)
	Across all sub-units of the organization	25 (39.68%)
	Within a single sub-unit of the organization	8 (12.70%)
Organizational Size	More than 1,000 employees	32 (50.79%)
	Between 251 to 500 employees	9 (14.29%)
	Between 751 to 1,000 employees	7 (11.11%)
	Less than 100 employees	6 (9.52%)
	Between 501 to 750 employees	5 (7.94%)
	Between 101 to 250 employees	4 (6.35%)
Improvement Methodology	Lean Six Sigma	34 (53.97%)
	Lean Production with other general improvement methodology	21 (33.33%)
	Lean Production	7 (11.11%)
	Six Sigma	1 (1.59%)
IMPL_PCT	0-20%	9 (14.29%)
	21%-40%	9 (14.29%)
	41%-60%	20 (31.75%)
	61%-80%	16 (25.40%)

	81%-100%	9 (14.29%)
EXP_YRS	Less than a year	1 (1.61%)
	1-5 years	18 (29.03%)
	6-10 years	23 (37.10%)
	11-15 years	13 (20.97%)
	16-20 years	3 (4.84%)
	More than 20 years	4 (6.45%)
COMP_AGO	Less than 6 months ago	11 (18.03%)
	Between 6 and 12 months ago	14 (22.95%)
	Between 12 and 18 months ago	10 (16.39%)
	More than 24 months ago	26 (42.62%)
ORG_EXP	Less than 1 year	8 (13.33%)
	Between 1 and 2 years	10 (16.67%)
	Between 3 and 4 years	11 (18.33%)
	Between 5 and 6 years	5 (8.33%)
	More than 6 years	26 (43.33%)
Experience Role	Practitioner in an LGO	52 (85.25%)
	Consultant	5 (8.20%)
	Academic/Researcher	3 (4.92%)
Role Type	Member of the team that guided LP/LSS development and/or implementation	23 (37.10%)
	Top-level leader/ manager in the organization	17 (27.42%)
	Consultant within the department or from other departments/units within the organization	15 (24.19%)
	External consultant	4 (6.45%)
	Process owner	3 (4.84%)

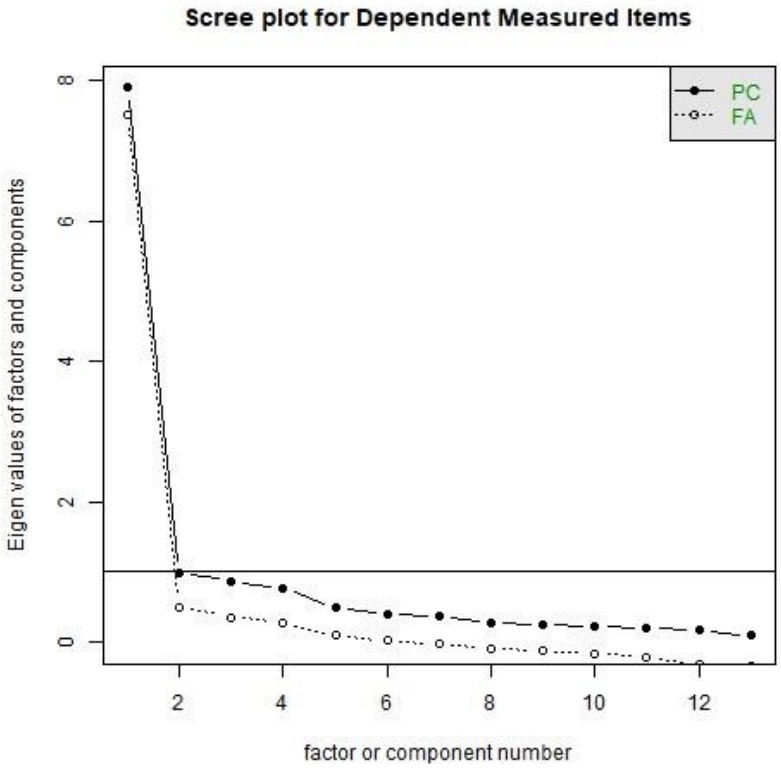
Appendix E.2: Frequence of LM/LSS Tools used in LGOs

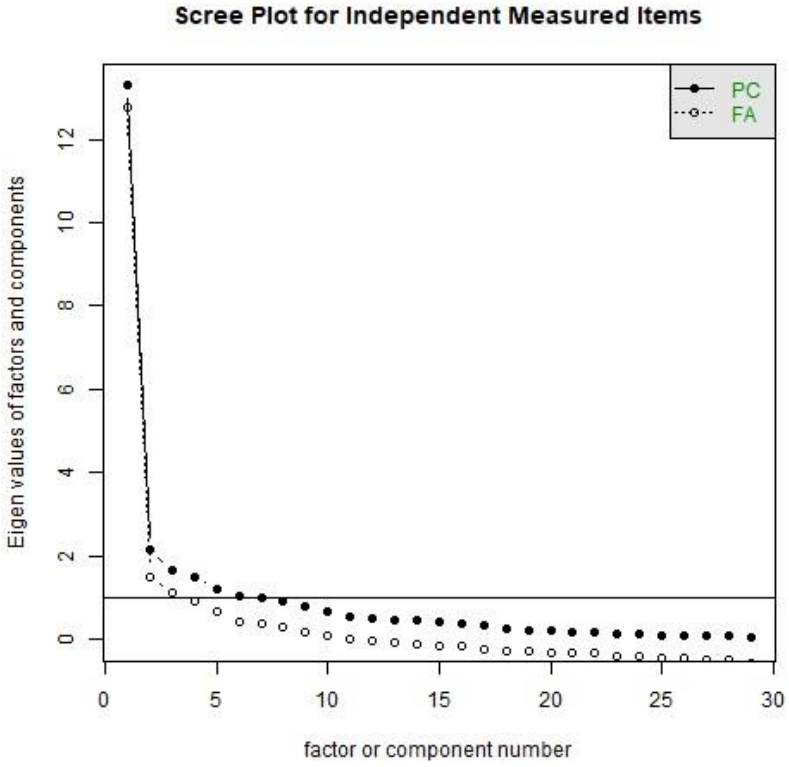


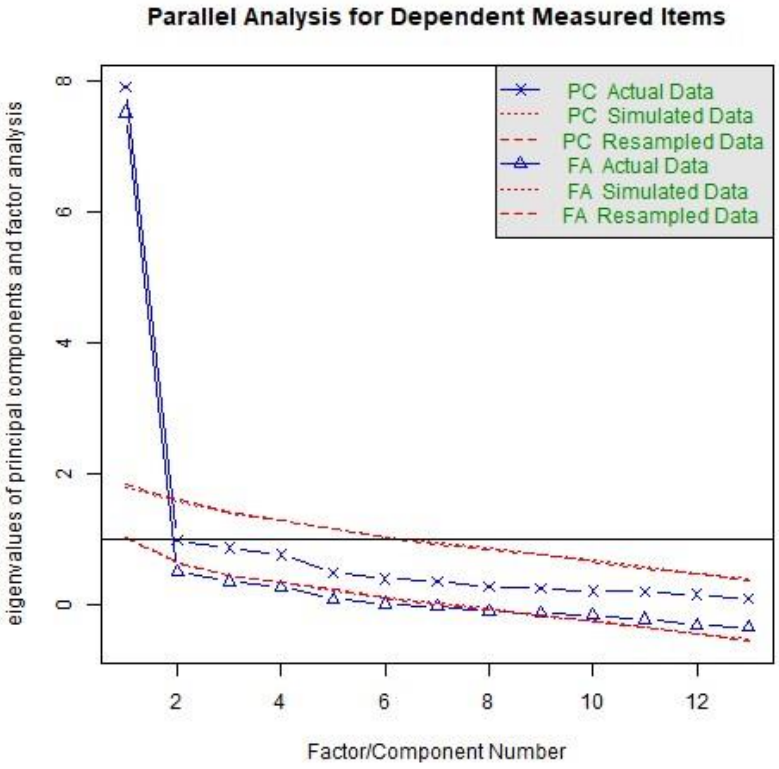
Appendix E.3: Items correlation matrix

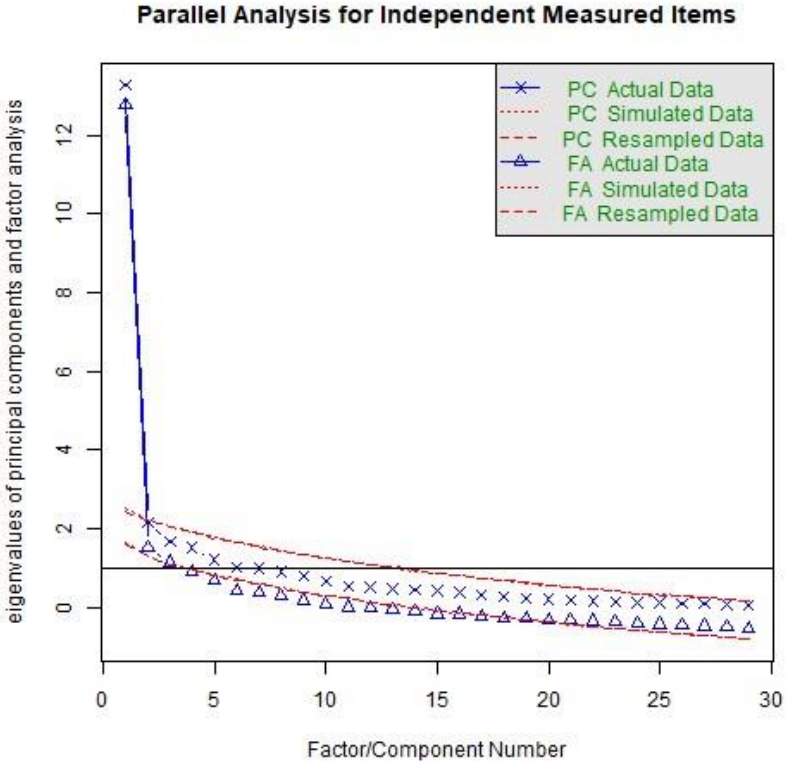


Appendix E.4: Determining number of factors





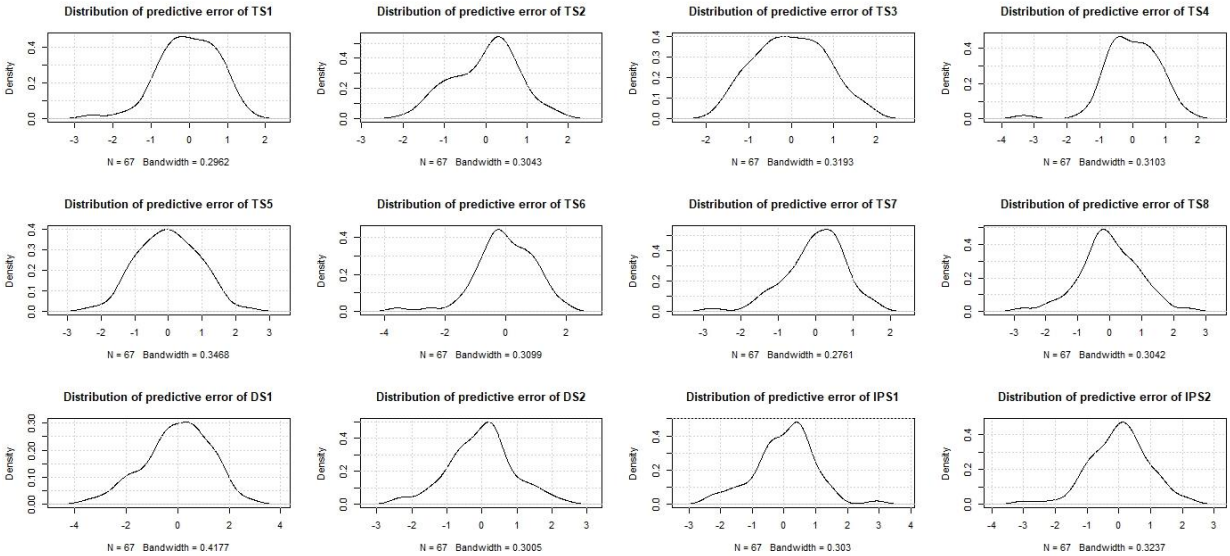

Parallel Analysis for Dependent Measured Items
PC Actual Data
PC Simulated Data
PC Resampled Data
FA Actual Data
FA Simulated Data
FA Resampled Data
eigenvalues of principal components and factor analysis
Factor/Component Number


Parallel Analysis for Independent Measured Items
PC Actual Data
PC Simulated Data
PC Resampled Data
FA Actual Data
FA Simulated Data
FA Resampled Data
eigenvalues of principal components and factor analysis
Factor/Component Number

Appendix E.5: Exploratory factor analysis model for the dependent variables

Measured items	Factor 1	Factor 2	Factor 3	Communality	Cronbach's Alpha
	Transformational Success	Deployment success	Improvement project success		
EMPL_SAT_9	**0.91**	-0.09	0.03	0.77	0.94
ORG_IMP_12	**0.89**	-0.11	0.10	0.80	
STAKEH_ACC_4	**0.84**	-0.23	0.17	0.69	
EMPL_SKI_8	**0.80**	-0.02	0.04	0.67	
DEC_IMP_13	**0.77**	0.22	-0.17	0.69	
BUSI_IMP_11	**0.75**	0.16	-0.08	0.67	
IMPL_SUCC_1	**0.65**	0.18	0.07	0.70	
EMPL_BEL_10	**0.50**	0.12	0.04	0.38	
DEPLOY_6	-0.17	**0.88**	0.12	0.70	0.82
ACT_INTG_7	0.28	**0.66**	-0.02	0.74	
BUDG_COMP_2	0.02	0.05	**0.77**	0.65	0.80
TASK_COMP_3	0.11	0.11	**0.73**	0.77	
SS Loading	5.20	1.59	1.45		
Cumulative Variance	0.43	0.57	0.69		
Factor Correlations	1				
	0.66	1			
	0.65	0.51	1		

Appendix E.6: Exploratory factor analysis model for the independent variables

Measured items	**Factor 1** Improvement Readiness	**Factor 2** Sustainable Improvement Infrastructure	**Factor 3** Supportive Leadership	**Factor 4** Measures-based improvement	**Factor 5** Change Awareness	**Communality**	Cronbach's Alpha
TOOL_AP_13	**0.94**	0.06	-0.10	0.18	-0.24	0.85	0.87
CONTX_CUS_14	**0.93**	0.13	0.03	-0.11	-0.22	0.77	
EFT_REQ_15	**0.71**	0.03	-0.05	0.08	0.05	0.59	
EMP_ENG_12	**0.68**	-0.25	0.05	-0.09	0.42	0.68	
EXP_CON_20	**0.48**	-0.01	0.18	-0.06	0.11	0.41	
CUS_IDEF_26	**0.43**	0.18	-0.01	0.08	0.08	0.42	
TRA_EDUC_18	0.06	**0.84**	0.20	-0.20	-0.08	0.76	0.84
PAT_RES_24	-0.07	**0.82**	-0.29	0.13	0.28	0.72	
WKF_SKL_19	0.10	**0.63**	0.07	-0.04	0.05	0.56	
RES_AVL_4	0.11	**0.46**	0.11	0.08	0	0.44	
LD_STL_9	0.15	-0.03	**0.79**	-0.07	0.11	0.82	0.89
LD_INV_5	-0.05	0	**0.78**	0.24	-0.04	0.79	
LD_SUP_1	-0.03	0.07	**0.74**	0.06	-0.01	0.64	
DAT_QLT_11	0.11	-0.11	-0.04	**0.88**	-0.12	0.67	0.86
DEF_MEA_7	-0.03	0.18	0.15	**0.77**	-0.08	0.84	
PRJ_SEL_6	-0.11	-0.06	0.23	**0.63**	0.24	0.70	
EMP_ATT_3	0.15	0.01	-0.07	0.17	**0.70**	0.72	0.61
UND_CNG_22	-0.17	0.15	0.06	-0.13	**0.65**	0.40	
SS Loading	3.41	2.37	2.33	2.19	1.47		
Cumulative Variance	0.19	0.32	0.45	0.57	0.65		
Factor correlations	1 0.56 0.65 0.57 0.50	 1 0.60 0.52 0.45	 1 0.60 0.57	 1 0.46	 1		

Appendix E.5: PLS-SEM predict power: out-sample predictive power