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Indrė Liutkevičienė

Developing Digitally Supported Process Improvement Capabilities in Small and Medium Enterprises

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This dissertation was prepared in 2013-2020 and 2026 at the ISM University of Management and Economics under the right of Doctoral studies granted to ISM University of Management and Economics, UAB (together with Aarhus University [Denmark], BI Norwegian Business School and Tartu University [Estonia]).

The dissertation is defended on an external basis.

Supervisor: Assoc. Prof. Niels Gorm Maly Rytter (University of Southern Denmark, DK, Social Sciences, Management – S 003).

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I dedicate this work to the teachers of my first school, the former Viešvėnai Secondary School in Telšiai District, whose dedication inspired a lifelong appreciation of learning.

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KEY TERM DEFINITIONS

Enterprise resource planning (ERP) – commercial software packages that enable "the integration of all information flowing through a company – financial, human resources, supply chain, and customer information" (Davenport, 1998, p.121).

Information technology (IT) – refers to the collection of computer systems, software applications, communication networks, and related technological resources used to acquire, process, store, and disseminate information across organisations (Uwizeyemungu & Raymond, 2011; Karimi et al., 2007).

Lean philosophy – built on the concept of eliminating waste and employing five principles: Value, Value Stream, Flow, Pull, and Perfection (Womack and Jones, 2003).

Six Sigma – "a business improvement approach that seeks to find and eliminate the causes of defects or mistakes in business processes by focusing on process outputs which are critical in the eyes of customers" (Antony et al., 2017, p.1704).

Lean Six Sigma concept (LSS) is an integrated process improvement methodology that combines Lean principles for eliminating waste and improving flow with Six Sigma methods for reducing process variation and defects, thereby improving quality, efficiency, and customer value (Arnheiter & Maleyeff, 2005; Salah et al., 2010; Antony et al., 2017).

Process / operational excellence – process improvement projects that are typically focused on eliminating waste and variation for a particular business process in scope, and ultimately developing visible and measurable process performance improvements, such as cost reductions, decreased defects, and improved delivery time, etc. (Rytter, 2012)

Process improvement capability – an organisation's continuous improvement capabilities are "an evolving process that requires the accumulation and integration of new behaviours over time (Hansen and Møller, 2016, p.198). Additionally, encompassing "the maturing of continuous improvement behaviour that leads to a maturing of performance impact, from local to organizational level, and from operational to strategic" (Bessant and Francis, 1999, p.1107).

Digitally supported process improvement capability – an organisation's ability to systematically improve its business processes by combining structured improvement methodologies, such as Lean Six Sigma, with digital technologies, such as ERP systems, which provide data integration, process visibility, and technological

support for the execution and control of improvement initiatives (Liutkevičienė et al., 2026).

Performance measurement – “an early warning detection system indicating what has happened; diagnose reasons for the current situation (often requiring an explosion of aggregate process management into greater detail); and indicate what remedial action should be undertaken” (Bond,1999, p.1321).

INTRODUCTION

The relevance of the research, research problem and the research gap

Small and Medium size Enterprises (SMEs) support the development of industries, boost self-employment, and ensure sustainable growth of the economy (Bhat et al., 2021). As SMEs grow, they face organisational and leadership challenges that must be overcome to maintain competitiveness and further growth, as described by Greiner (1998). The analysis of SME growth remains crucial in the context of contemporary economics and research (Garcia-Martinez et al., 2023). A challenge to SMEs' growth journey occurs when a focus on product or service innovation needs to be complemented by the delegation of decision-making powers, and development of staff, autonomy and capabilities for process standardisation and improvement. An additional challenge for scaling SMEs is the increased need for adopting the latest digital technologies, including Artificial Intelligence (AI), to support key business functions and processes going forward (Shahin et al., 2024; Saghiri et al., 2025). During the last few decades, SMEs have used two dominant approaches for building such capabilities: adopting and implementing either Enterprise Resource Planning (ERP) and digitalisation (Terra et al., 2023; Abd Rahman et al., 2021; Sun et al., 2015) or Lean Six Sigma management systems (Bhat et al., 2021).

When considered independently, ERP systems and the Lean Six Sigma management framework represent two distinct approaches to organisational improvement. ERP systems (Davenport, 1998) digitalise the information flow across functions and offer a range of functionalities, supporting daily business processes by offering an infrastructure for process improvement (Masini and Wassenhove, 2009). Thus, "the value of ERP does not reside in the technological assets, but in the ability to develop repeatable patterns of value-creating actions using those assets" (Masini and Wassenhove, 2009, p.275). In contrast, Lean Six Sigma has been conceptualised in multiple ways within the literature (Stentoft and Freytag, 2013). Lean thinking is grounded in five core principles of identifying value, mapping value streams, creating flow, establishing pull, and pursuing continuous improvement (Womack and Jones, 2003). Six Sigma is a structured business improvement approach aimed at identifying and eliminating the causes of defects and process variation by focusing on outputs that are critical to customers (Antony et al., 2017). Together, Lean and Six Sigma form an integrated process management approach that enables continuous improvement

in the performance of an organisation's core business processes (Salah et al., 2010).

However, SMEs struggle when implementing just one of these approaches on its own (Powell, Alfnes, et al., 2013). Empirical studies have demonstrated a higher likelihood of achieving not only short-term benefits but also long-term operations and service excellence for companies that are able to combine and integrate these two complementary initiatives (Busto Parra et al., 2021; Erkayman, 2019; Powell, Riezebos, et al., 2013; Powell, Alfnes, et al., 2013). Consequently, it can be argued that digitally supported process improvement capability can be better enabled by combining ERP and Lean Six Sigma, as Lean Six Sigma provides a systematic improvement approach, and ERP can provide digital support for process improvement. Therefore, digitally supported process improvement capability can be defined as an organisational capability that develops continuous and systematic process improvement through the integration of Lean Six Sigma's structured improvement logic with ERP-enabled digital support for data availability, process standardisation, and performance monitoring.

While there are many tools and guidelines for the implementation of ERP and Lean Six Sigma, most lack a theoretical foundation such as a description of the underlying explanatory organisational mechanisms, or a generic framework for developing digitally supported business process improvement capability by combining ERP and Lean Six Sigma implementation. Therefore, managers struggle with implementation because they do not know which elements of a tool or technology are crucial and why, nor how to go about implementing them (Kumar et al., 2024). With the recent increase in opportunities for digitalisation and automation, through the use of AI and generative AI (GAI) solutions, there is a clear need for in-depth research that proposes and evaluates a generic framework, together with investigating the organisational mechanisms impacting the adoption of digital process improvement capabilities. An in-depth study of Lean Six Sigma and ERP implementation could provide this through the consequent theoretical contribution of the framework and specific mechanisms of aligned efforts, as well as their impact on the short-term and long-term development of competitiveness, particularly in the context of how they enable SMEs in their growth and competitiveness creation journey. Such research can establish a foundation for creating a set of robust recommendations that SME managers can utilise to improve operations or service excellence.

The research problem could be defined in the way that ERP and Lean Six Sigma

are widely used approaches to promote operational excellence. Nevertheless, the research on their interactions when implemented in combination, leveraging the advantages of both IT processes and industrial operations, is limited. Thus, there is a business need for further knowledge regarding how this category of companies can benefit from integrating Lean Six Sigma initiatives in addition to their ERP implementations with the purpose of achieving ongoing improvements of service speed, quality, and delivery performance etc. for their customers, while maintaining flexibility and keeping their costs low (Gijo et al., 2019; Obwegeser et al., 2019).

The purpose of this study is to create an understanding of how the combination of ERP and Lean Six Sigma can be used to transform SMEs into organisations that are more process-oriented with improved process performance. The generic framework for implementing ERP and Lean Six Sigma in combination should be composed in order to develop digitally supported continuous improvement capability, and additionally, the mechanisms supporting such an implementation should be identified to help improve the productivity, quality, and competitive advantage of the companies.

Research questions, aim, and objectives

Building on the discussion of ERP and Lean Six Sigma integration, this chapter outlines the aim, research questions and objectives that frame the study's investigation into digitally supported process improvement capabilities in SMEs. Accordingly, the study is guided by the following research aim:

Propose and evaluate a generic framework for developing digitally supported business process improvement capabilities by combining ERP and Lean Six Sigma implementation and identifying the key organisational mechanisms that support the adoption of the capabilities.

The purpose of this work can be itemised in two research sub questions:

- *How can a generic framework be designed and evaluated that combines ERP systems and Lean Six Sigma principles to support the development of digitally supported business process improvement capabilities?*
- *What are the key organisational mechanisms that enable the adoption of digitally supported process improvement capabilities?*

The research includes the following objectives:

1. Establishing from the literature how ERP implementation and the

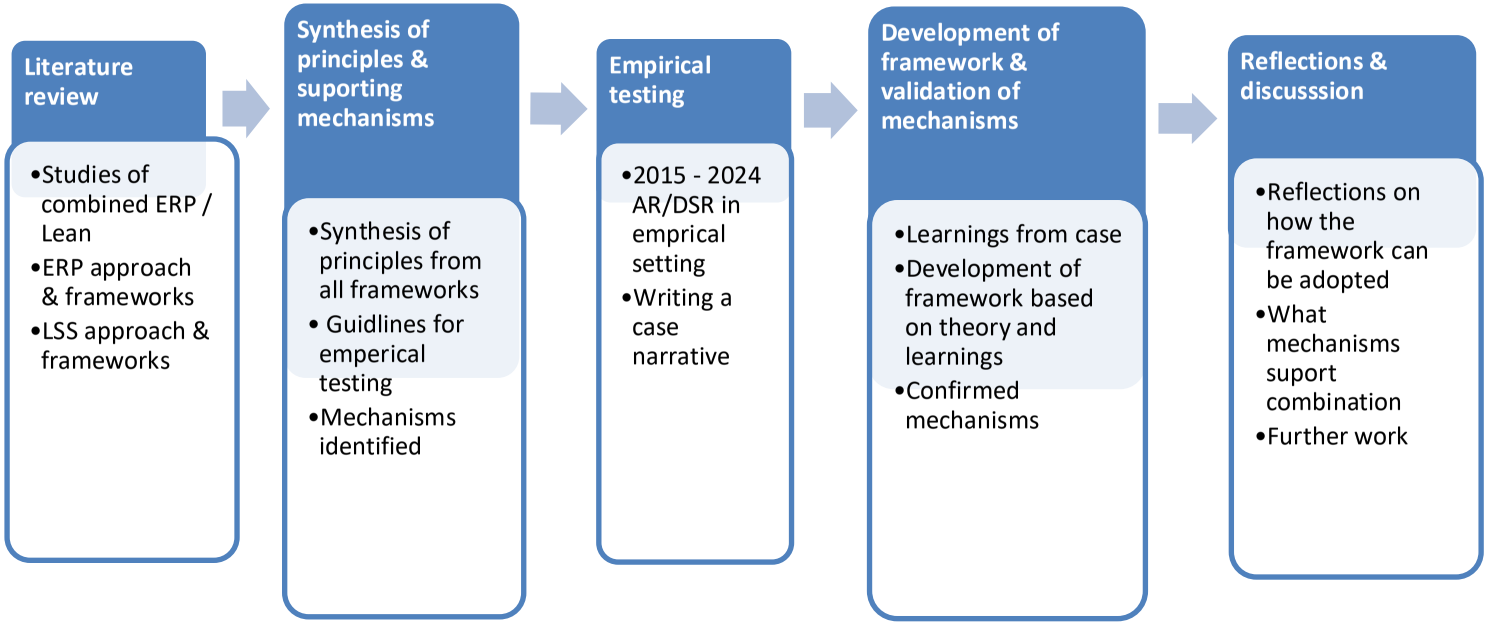
deployment of Lean Six Sigma management approaches are valuable for digitally supported business process improvement and its capabilities.

2. To develop a theoretical framework with steps for achieving digitally supported continuous improvement capabilities while integrating ERP and the Lean Six Sigma approach, as well as identifying possible organisational mechanisms supportive of such an approach during its implementation.
3. To define process improvement and digitally supported continuous improvement capabilities measures for the evaluation of a combined ERP and Lean Six Sigma approach implementation success.
4. To validate and test the framework and organisational mechanisms on a selected case study company through the actions researched in combination with design science research.
5. To develop recommendations for the companies concerning how to implement ERP and Lean Six Sigma management approaches in a combined manner for achieving digitally supported process improvement capabilities and to reap greater benefits from these investments.

Research methodology

The study design consists of a review of the existing research literature on Lean Six Sigma and ERP implementation, a development synthesis of principles for a new framework and the mechanisms supporting it, empirical testing of the new theory in a service operations context via action research in combination with design science research, development of the framework, validations of the mechanisms, and reflection upon the study, as shown in Figure 1.

Figure 1. The study design



Source: created by author

The research questions mentioned above are explored via a case study of an integrated ERP - Lean Six Sigma business transformation intervention in an SME, which persisted over nine years. The principles and elements for the framework were derived from the extant literature and subsequently applied as input for a solution incubation, using Design Science Research (DSR; Van Aken et al., 2016) in the case study. Measures of productivity, quality and an improvement capability maturity model were used to evaluate the framework. Additionally, Design Science Research with the CIMO framework, Action Research (Coughlan and Coghlan, 2009) and longitudinal, participative case study research were a source of inspiration for the framework development in this study. The study results and learnings gleaned enabled solution refinement and the development of a generic framework for digital supported process improvement capabilities and the mechanisms supporting this integrated approach. Qualitative and quantitative data is used to identify mechanisms concerning how ERP-Lean can improve SME processes-orientation, measured in terms of productivity, quality, and process improvement capability.

Chosen qualitative methods refer to a qualitative analysis of the study and its results. The nature of the expression in which the main emphasis is made is based on theoretical sociology and the philosophy of logic, with the justification process including the categories of historical comparison, individual observation, questioning, intuition, official and personal documents, utilising experience, journalistic and artistic statements, conclusions, and recommendations (Chosen and Symon, 2024). Narrower sense qualitative methods are special methods and ways of research, social phenomena, processes, and systems of qualitative traits characteristics (Myers, 2013). It is important in this type of research that the researcher maintains control over the research process, as well as maintaining distance regarding the evidence gathered, together with the analysis and conclusions derived from the study.

Results and contributions of the research

The research provides a tested framework for ERP - Lean Six Sigma implementation together with supporting mechanisms, validated in SME service operations, demonstrating how the latter can be deployed to raise productivity, deliver quality improvements, and increase continuous improvement capability

considerably.

Furthermore, scientific knowledge was yielded, i.e., an empirically tested framework for the implementation of ERP and Lean Six Sigma, with four supporting mechanisms for the digitally supported process improvement capabilities being identified. In assessing the success of the implementation, a number of metrics was used to investigate its impact on service operations and improvement capability.

Regarding the managerial implications, the findings provide practical guidance for the implementation of the ERP and Lean Six Sigma approaches in combination. The created framework is generic and should be applicable for organisations in other industries and for larger enterprises if properly incorporated into their existing practices and systems. The framework and its four supporting mechanisms can address the need for organisations today to digitalise, improve their processes and create a competitive advantage while developing their digitally supported continuous improvement capability by combining ERP and Lean Six Sigma.

Limitations of the dissertation and directions for future studies

The dissertation contributes to both theory and offers practical advice to businesses on how to implement Lean Six Sigma and ERP in combination to reach digitally supported business process capabilities. However, questions can perhaps be raised regarding the following limitations:

- It is not known if case observations / results are transferable to companies of different segments, sizes, or in other countries.
- Action research and DSR requires considerable time and effort and is less “controllable” as a research strategy than other methods. It is a challenge to accomplish this in alignment with the overall research schedule.
- A question mark remains as to whether the researcher managed to keep sufficient control over the research process while maintaining enough distance from the gathered case evidence and conclusions of the study.

It would be worthwhile to conduct at least several other case studies to confirm or confront the results. Low sample qualitative research is not generalisable to a larger population. However, the research includes rich contextual details, which improves the transferability of the research findings to other contexts. Future research should investigate the extent to which these findings apply to a wider range of contexts, for example, to companies that have more extensive experience using

Lean and ERP. Furthermore, the study shows that future research could investigate the time lapsing and its impact on the implementation effect, and to what extent sustainable implementation could be accelerated. Future research could investigate how the combination of Lean, ERP, and other digital components impact the capacity for building continuous improvement capability and competitive advantage.

Structure of dissertation

The dissertation is structured as follows. In Chapter 1, the literature and existing theory is presented and reflected upon in order to show the current status, evolution trends of the past, and recommendations for future directions. In Chapter 2, the research design and analysis methods that were employed in this study are described. The research findings are presented in Chapter 3, which is followed by a discussion of the findings in Chapter 4. The final chapter summarises and concludes the research study findings and sets out some potential implications of this study for management theory and practice.

PUBLICATIONS AND CONFERENCE PRESENTATIONS BASED ON THE DOCTORAL RESEARCH[1]

Peer-reviewed publications:

1. Liutkevičienė, I., Rytter, N. G. M., & Hansen, D. (2022). Leveraging capabilities for digitally supported process improvement: a framework for combining Lean and ERP. *Business Process Management Journal, 28*(3), *765-783*. DOI:10.1108/BPMJ-05-2021-0296
2. Liutkevičienė, I., Hansen, D., Rytter, N. (2026). Organisational mechanisms for building digital process improvement capabilities to foster SME competitiveness and growth. Production Planning & Control, 1–17. DOI:10.1080/09537287.2025.2605310

Presentations of research at conferences:

1. Liutkevičienė, I. (2017). A combined ERP and Lean approach for continuous business process improvement. *The 16th EurOMA Doctoral Seminar.* Edinburgh, Scotland.
2. Liutkevičienė, I. (2015). A combined Lean - Six Sigma and ERP implementation approach. *The 14th EurOMA Doctoral Seminar.* Neuchâtel, Switzerland.
3. Liutkevičienė, I., Rytter, N. (2014). A combined Lean-Six Sigma and ERP approach towards Operations and Service Excellence. *21st EurOMA Conference.* Palermo, Italy.

[1] Material from these publications and conference presentations has been incorporated into this dissertation.

THE ERP AND LEAN SIX SIGMA THEORETICAL INTERSECTION FOR DIGITAL SUPPORTED PROCESS IMPROVEMENT CAPABILITIES

This chapter is dedicated to reviewing the extant work on ERP and Lean Six Sigma, and how they can be combined for continuous improvement. This section consists of five sub-chapters, which discuss the existing literature. First, the methodology for the literature review is presented. Then ERP and Lean Six Sigma definitions are set out, together with how their combination was achieved. The review of existing implementation frameworks is accomplished in respect of ERP, Lean Six Sigma, as well as using them in combination. Recommendations for the new framework are presented. The mechanisms of the combined ERP and Lean Six Sigma approach are reviewed in the existing literature, together with the measurement of continuous improvement capability where possible.

1.1. Systematic approach of the literature analysis

The development of this doctoral research is grounded in a systematic review of the relevant scientific literature. The literature review was conducted in two main stages: prior to the initiation of the empirical work and in parallel with the empirical research process. The initial stage served to establish the theoretical foundation, refine the research gap and problem, and inform the research design. The subsequent, iterative review ensured continuous alignment with the evolving academic discourse and supported the interpretation of empirical findings.

During the first stage, a systematic search and analysis of the literature relevant to Lean Six Sigma and ERP were carried out across a range of academic journals. The criteria for selecting journal articles for the review were as follows next. First, the article had to have been published in a peer-reviewed journal. Secondly, only articles with ‘ERP’ or ‘Enterprise Resource Planning’ and ‘Lean’ or ‘Six Sigma’ mentioned in their abstracts were included. Furthermore, articles with “IT” (information technology) referred to in their abstracts were also included to incorporate the fact that IT in the current business environment often comprises ERP (Maguire, 2016). Following these criteria, every effort was made to gather all the available journal articles. Even so, it is possible that some existing articles were not covered by this review.

While analysing literature, it was observable that Lean and ERP were very extensively analysed separately. Table 1 shows the numbers of articles found in academic journals on different databases from the beginning of the year 2000 to the

end of 2014. The search was achieved using the TAYLOR AND FRANCIS, EMERALD, EBSCO and SCIENCE DIRECT databases.

The volume of research on ERP and Lean Six Sigma as isolated topics was enormous in comparison to the small number of research studies featuring a combined approach. Thus, showing that there is a need to examine the possibilities offered by combination, while it is generally known that both approaches seek to improve the processes of organisations.

Table 1. ERP and Lean topics in different databases

Name of database	ERP in abstract	Lean in abstract	ERP and Lean abstract
SCIENCE DIRECT	6,444	9,885	4
EBSCO	22,547	44,094	16
EMERALD	379	1,013	4
TAYLOR AND FRANCIS	2,611	4,717	2

Source: created by author

A systematic literature search of studies combining ERP and Lean Six Sigma was carried out. The number of articles was very significantly lower than for the independent approaches search. All articles with ‘ERP’ or ‘Enterprise Resource Planning’ and ‘Lean’ or ‘Six Sigma’ in the abstract were included. As is shown in table above, the databases search yielded just 26 papers. Some articles with ‘information technology’ instead of ERP in their abstracts were also considered relevant and included. A list of the journals is presented in Table 2 giving the results of the combined approach search. These articles were selected for review and are discussed in this dissertation, along with some books and relevant conference proceedings papers.

The selected articles were read before they formed the basis of a systematic comparison of Lean Six Sigma and ERP implementation approaches and their similarities and differences, reported practical implementation outcomes, and suggested factors regarding implementation success / failure.

During the second stage of the literature review, additional relevant studies were systematically searched for and reviewed through multiple iterative cycles conducted over the course of the nine-year longitudinal research period. This iterative approach reflected the evolving nature of the empirical investigation and ensured that the study

remained theoretically grounded throughout its duration. While two peer-reviewed journal articles reporting interim findings from the study were published during this period, the literature review process itself was continuous rather than episodic.

Table 2. ERP and Lean Six Sigma combined approach from various journals

Name of journal	**ERP and Lean / Six Sigma in abstract**
Global Journal of Flexible Systems Management	2
International Journal of Advanced Manufacturing Technology	1
International Journal of Lean Six Sigma	1
Operations Management	1
Computers in Industry	3
Journal of Manufacturing Systems	1
International Journal of Information Management	1
Industrial Engineer	1
Industry Week	1
Information Technology & People	1
International Journal of Production Economics	1
International Journal of Operations & Production Management	4
Benchmarking: An International Journal	2
International Journal of Production Research	3
Journal of Manufacturing Technology Management	1
Enterprise Information Systems: Concepts, Methodologies, Tools and Applications	1
Journal of Enterprise Information Management	1
TOTAL:	26

Source: created by author

As empirical work progressed and papers were being written and submitted for publication about the research, the relevant academic literature was continuously monitored, re-examined, and expanded to capture emerging theoretical developments and empirical insights. This ongoing engagement with the literature enabled the revisiting of initial assumptions and responses to new conceptual debates relevant to digitally supported process improvement capabilities, ERP systems, and Lean Six Sigma implementations.

Within this stage of the review, academic articles published between 2014 and 2025 were systematically consulted, critically read, and selectively incorporated into the study. These sources were used not only to enrich the analysis and interpretation of the longitudinal case findings, but also to refine, substantiate, and strengthen the

theoretical contribution of the research. In particular, the extended literature review supported the novel generic framework and organisational mechanisms for implementing Lean Six Sigma and ERP in SMEs to improve their business process excellence.

By adopting this iterative and reflexive literature review strategy, the research maintained a strong alignment between empirical insights and theoretical development, thereby enhancing the depth, robustness, and relevance of the study's contributions over time.

1.2. ERP and Lean Six Sigma

This section will investigate the literature on ERP, Lean Six Sigma and existing studies that combine them to facilitate producing an overview of the suggested synergies and contradictions between the two approaches.

1.2.1. ERP systems

The purpose of this section is to review the relevant information associated with ERP systems, their definition history, application, and importance.

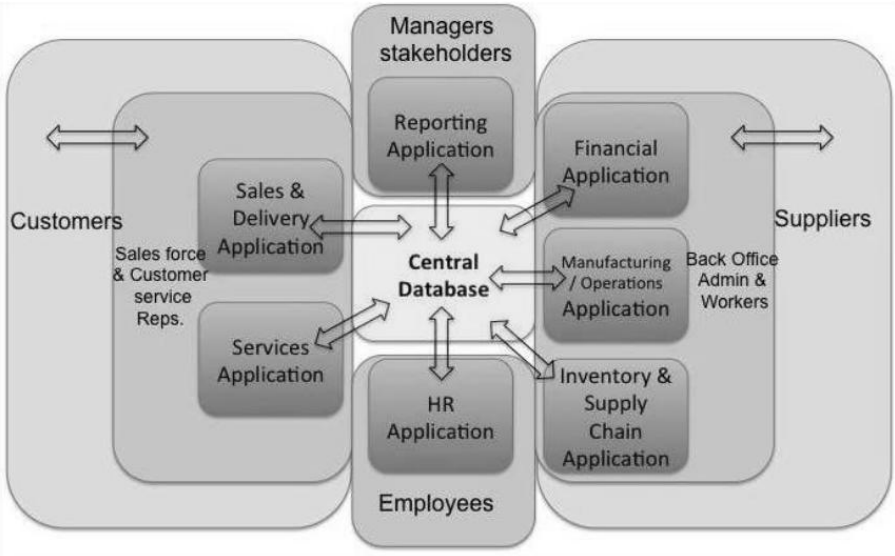
ERP definition

Enterprise resource planning (ERP) systems are commercial software solutions intended to integrate all information flows within an organisation, including financial, human resource, supply chain, and customer-related data (Davenport, 1998). They provide a unified information infrastructure for managing the complexities of contemporary business operations and addressing the challenges associated with operating in global markets (Hill and Hill, 2012). ERP systems integrate the data and processes of an organisation into a single system (Ghosh and Skibniewski, 2010 An ERP system is a business management system, made up of an integrated set of comprehensive software, which can be used to manage and integrate all of an organisation's business functions through a rationalised data architecture, one marked by core process integration and shared product or customer databases (Kraemmergaard and Schlichter, 2010). ERP systems are software packages built from a number of modules, covering areas such as human resources, sales, finance and production, which integrate data across the organisation through the business processes embedded in them (Jacobs and Weston, 2007). In doing so they bring an

organisation's data and processes together into a single system, and their reach extends across the whole organisation (Ghosh and Skibniewski, 2010). ERP systems are built on a common data and process architecture that supports comprehensive end-to-end business operations. These applications automate and facilitate a wide range of administrative and operational processes across industries, encompassing core business functions, customer-oriented activities, administrative tasks, and enterprise asset management. Utilised by organisations of all sizes, ERP systems are regarded as indispensable in large enterprises while also experiencing growing adoption among emerging small businesses. The complexity of the global economy, together with what modern consumers expect, has made it essential for businesses to streamline their processes and to manage and optimise their data. ERP typically provides the foundation for doing so (Essex et al., 2024). Typical ERP components, as defined by Davenport (1998), are presented in Figure 2.

Certain modules are regarded as core to almost every kind of business, and these are the first to be deployed (Essex et al., 2024).

Figure 2. General ERP components



Source: Davenport (1998)

The finance module streamlines core financial activities, including accounting, invoicing, financial analysis, forecasting, and reporting. It is frequently the primary driver behind an organisation’s transition from standalone accounting applications to

an ERP system. As business operations become more complex, the need for an integrated platform capable of managing financial transactions and accounting across multiple business units or product lines becomes increasingly evident (Essex et al., 2024).

Human resources (HR), often referred to as human capital management (HCM), represents another key business function that organisations seek to enhance through ERP systems. Core HCM capabilities typically include employee record management, benefits administration, and payroll processing, while additional talent management features, such as recruitment and performance management, are commonly incorporated.

Other ERP modules that are widely implemented across organisations include order management, sales management (CRM), and purchasing (procurement) (Essex et al., 2024).

Organisations operating in manufacturing or distribution commonly implement a supply chain management (SCM) module to monitor inventory levels and coordinate warehousing and transportation activities throughout the supply chain. Where operational requirements are more sophisticated, they may also deploy a warehouse management system (WMS) and a transportation management system (TMS), potentially sourced from different software providers, to support these logistics functions more effectively (Essex et al., 2024).

As Essex et al. (2024) note, an ERP system usually spans several major functional areas, and which areas these are varies with the kind of business the system is meant to serve.

Companies implement an ERP system to improve competitiveness and operational performance (Holsapple et al., 2005). They expect their processes and performance to improve together with the ERP system implementation. Where competitive and regulatory pressure to adopt ERP systems is strong enough, firms are more inclined to draw on their internal capabilities to make implementation succeed (Schniederjans and Yadav, 2013). ERP deployments are complex and some organisations struggle to define the business benefits.

The benefits delivered by ERP systems can be grouped into four key areas: enabling business innovation, improving business process efficiency, supporting process standardisation, and reducing IT-related costs (Schniederjans and Kim, 2003). Organisations tend to concentrate on the latter two areas because they are

more straightforward to measure and quantify. Nevertheless, the greatest organisational impact is often achieved through innovation and process efficiency improvements, represented by the first two areas (Schniederjans and Yadav, 2013).

Evolution of ERP systems

Computerised business applications originated in the accounting and finance domain during the 1960s, operating on mainframe computer systems. These early solutions offered greater speed and accuracy than manual methods; however, they were costly, provided only limited functionality, and remained relatively slow by modern standards (Essex et al., 2024). Before long these applications gave rise to dedicated, standalone solutions of their own, such as sales order processing and manufacturing requirements planning (Jacobs and Weston, 2007). The progression beyond MRP during the late 1970s and early 1980s was largely motivated by the need to achieve greater integration across the functional silos that characterised organisations at that time. It could be argued that software developers recognised the potential of data integration at a very early stage, well before the movement towards flatter organisational structures emerged (Jacobs and Weston, 2007). In the early 1960s the manufacturing industry developed Material Requirements Planning (MRP) to help manage materials by quantifying them according to requirements, serving purely as a tool for organisation and scheduling (Wallace and Kremzar, 2002). “The mid-1970s saw the birth of major software companies that would later become key ERP vendors” (Jacobs and Weston, 2007, p.358).

The term Manufacturing Resource Planning II (MRP II) was introduced to distinguish the enhanced capabilities of the next generation of systems. At the same time, the competitive priorities of manufacturing shifted during the 1980s towards quality improvement, influenced by the emergence of quality pioneers such as Deming, Juran, Crosby, Ishikawa, and others. Manufacturing strategies increasingly focused on tighter process control, world-class manufacturing practices, and the reduction of overhead costs. To support these objectives, continuously evolving MRP II systems incorporated features such as closed-loop scheduling, improved shop-floor reporting, integration with due-date scheduling and procurement activities, and more comprehensive cost-reporting capabilities (Jacobs and Weston, 2007). As a second-generation system, MRP II offered extended functionality, including distribution management, shop-floor control, project management, finance, and

human resources modules (Wallace and Kremzar, 2002).

Enterprise Resource Planning (ERP) grew out of MRP-II and reached beyond the usual bounds of manufacturing to take in all stakeholders, with customers and suppliers receiving particular attention (Wallace and Kremzar, 2002). It brings together every functionally active area of a business, from materials and capacity planning, scheduling and shop floor control to profitability, customer satisfaction and supplier relationships, so that almost nothing in an organisation's operations falls outside its scope (Wallace and Kremzar, 2002).

Technological progress accelerated during the 1990s, and ERP systems emerged as one of the main areas of development, allowing companies to integrate processes across functional areas. The choice of software and hardware solutions widened considerably in this period, driven in large part by the Y2K problem, which pushed both organisations and the leading software vendors towards system upgrades. Many suppliers have entered and left the ERP market since then. SAP, Oracle and Microsoft still hold the dominant positions today, with Infor, Epicor and Sage forming a second tier. The next phase of ERP development has centred on product convergence and the move to cloud computing, which in turn has opened the way for artificial intelligence applications (Jacobs and Weston, 2007).

By the early 2000s the spread of the Internet had turned ERP into a web-based solution. This change created a need for smooth integration between ERP platforms and other business applications, among them project management systems and a range of operational software. ERP systems went on to become the backbone of many e-business initiatives, helping to raise customer satisfaction and improve operational performance. Their further development has been marked by the addition of ever more sophisticated technical capabilities through integration with complementary applications (Essex et al., 2024). As ERP solutions gained acceptance, companies in a wide range of industries, along with government institutions, started to adopt them and to draw benefit from what they offered. ERP also made it easier to implement e-commerce and business-to-business (B2B) platforms, speeding up access to digital business processes. ERP thus grew out of its original role as a back-office application and became a front-office platform through its links with customer-facing systems.

The latest generation of ERP software is defined by the growing use of cloud solutions delivered remotely under the Software-as-a-Service (SaaS) model. This

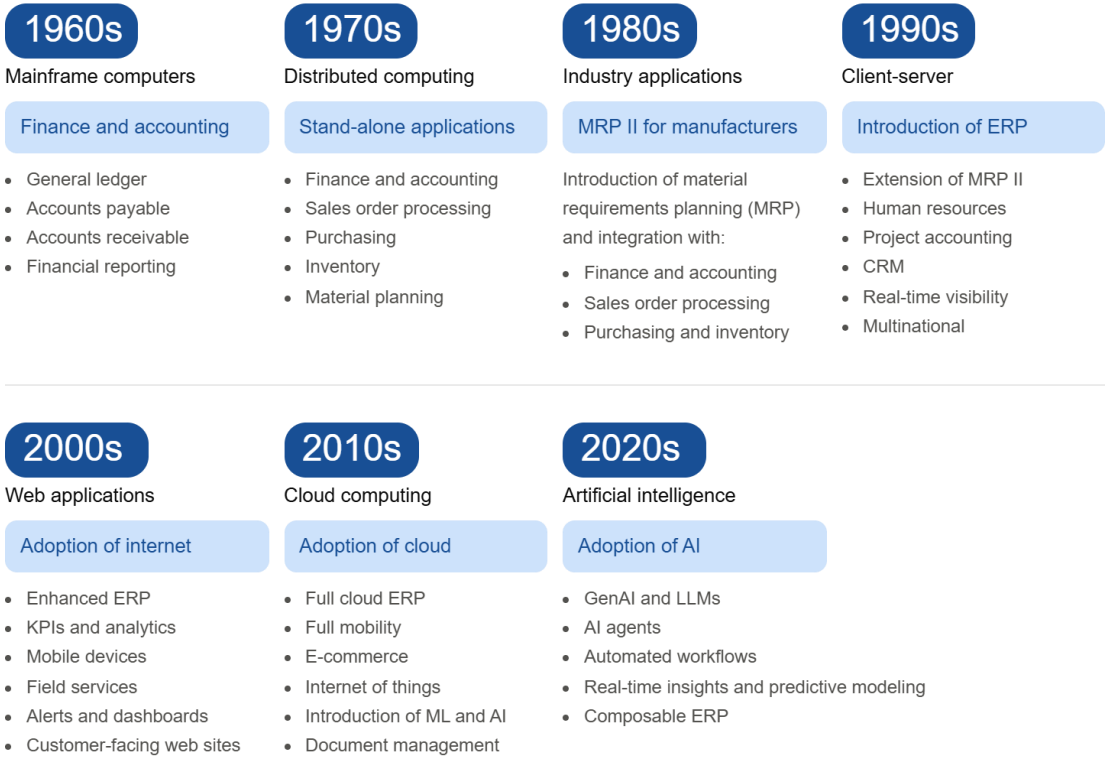
way of deploying ERP has been made possible by advances in internet technologies, which allow entire software suites to be supplied and maintained remotely, without the end user having to invest in the hardware and infrastructure once needed to run large ERP systems on site. Barriers to adoption have fallen sharply as a result, placing ERP within reach of a far wider range of businesses and doing much to explain its growing use among mid-sized organisations. The graphical overview of ERP systems evolution is presented in Figure 3.

A couple of the literature reviews carried out on ERP provided the necessary literature validation (Kraemmergaard and Schlichter, 2010; Moon, 2007). Moon (2007) suggested a classification of the topics: the ERP software; implementation of ERP; optimisation of ERP; ERP for supply chain management; management through ERP; and case studies on ERP.

The ERP research areas are presented in Table 3, adopting the approach of Kraemmergaard and Schlichter (2010). Table 3 outlines ERP research as a broad and multi-dimensional field covering not only implementation, but also post-implementation optimisation, organisational impact, technological architecture, supply chain integration, education, market development, and methodological approaches to studying ERP. This classification shows that ERP research has moved beyond the technical introduction of systems towards an understanding of how ERP affects management practices, organisational change, process standardization, and value creation.

A particularly important stream concerns the optimisation of ERP, where the focus is on how organisations can use ERP more effectively after implementation to maximise benefits such as competitiveness, good financial performance, and improved user outcomes. The table also highlights that ERP is studied both as a technological tool, including modules, architecture, and integration, and as an organisational phenomenon that shapes culture, best practices, and managerial decision-making.

Figure 3. The history of ERP



Source: *What is ERP?* sap.com

Table 3. ERP research areas

Implementation	ERP system introduction into organisations: this category covers studies of ERP selection, the separate stages of implementation and the difficulties attached to each of them, critical success factors, the alignment of business processes during implementation, and the diffusion of ERP inside the organisation.
Optimisation of ERP	More effective use of ERP systems within organisations: this category brings together research on post-implementation issues, system usefulness, competitive advantage gained through ERP, ERP users, and the financial benefits of ERP and ERP II in an organisational setting.
Management and ERP issues	The effect of ERP implementation on management and organisations: here belong studies of the managerial side of implementation, the organisational impact of ERP, organisational change, ERP and best practice, cultural questions in ERP use, and work seeking to understand ERP as a phenomenon.
The ERP tool	The nature of ERP systems, modules and applications: this category consists of studies of system architecture, system languages and integration standards, customisation, ERP extensions and add-ons, and ERP II systems as organisational tools.
ERP and supply chain management	The application of ERP systems within groups of companies: this category covers the use of ERP systems alongside other information technologies and systems, together with studies of what ERP contributes to co-operation and integration across supply chains.
Studying ERP	Approaches to studying ERP systems: this group includes papers asking how ERP systems may or should be researched, drawing on a variety of theoretical and analytical frameworks.
ERP and education	ERP education and training in university curricula: this category gathers studies on the design of ERP courses, the fitting of ERP systems into existing study programmes, and the lessons learnt from such attempts.
The ERP market and industry	The development of the ERP market over time: this category takes in studies of market requirements, vendors' market shares, and the wider spread of ERP systems across particular industries and regions.

Source: Kraemmergaard and Schlichter (2010)

Overall, the table suggests that ERP systems should be understood not merely as software applications, but as socio-technical platforms that influence business processes, organisational capabilities, and wider industry development.

ERP systems in service contexts

The expansion of the service sector across the 27 member states of the European Union has prompted questions regarding the adequacy of current understanding of innovation activities in service-oriented economies, particularly given that innovation is widely recognised as a key driver of competitiveness in advanced economies (Ruivo et al., 2017). In service firms, IT investment makes up on average about 35 per cent of total investment, against 19 to 22 per cent in manufacturing firms. The same difference shows up in a firm's IT intensity, measured as IT investment per employee, which confirms that service firms use IT more intensively than manufacturers do (Uwizeyemungu and Raymond, 2011). Service sector organisations invest twice as much in IT per employee in comparison to manufacturing sector organisations (Uwizeyemungu and Raymond, 2011). ERP is a major element of IT in the current business environment (Maguire, 2016), therefore, the analysis of ERP systems in a service context is important.

Industries differ significantly in their operating environments and business characteristics, and therefore the factors influencing ERP utilisation and value realisation are also likely to vary across sectors. Consequently, systematic differences are expected in both the use of ERP systems and the value derived from them between organisations operating in manufacturing and service industries (Ruivo et al., 2017). The concept of a service generally refers to an activity or performance, often accompanied by a product that is intangible and cannot be defined using the same dimensions as manufactured goods (Botta-Genoulaz and Millet, 2006). A key distinction between these sectors lies in the relative importance of information and customer service within service organisations, compared with the predominance of physical goods in manufacturing, in relation to the value generated by operational processes (Ruivo et al., 2017). As a result, it is essential for ERP vendors and managers to recognise that each industry possesses distinct requirements, necessitating different implementation approaches and system functionalities based on established best practices (Botta-Genoulaz and Millet, 2006).

Uwizeyemungu and Raymond (2011) argue that ERP adoption reveals significant differences between service and manufacturing organisations at the software module level. For instance, service firms rarely implement production planning modules, as the concept of material requirements planning is generally not

applicable in service environments (Uwizeyemungu and Raymond, 2011). By contrast, they make more extensive use of human resource and workforce management modules than manufacturing organisations. In terms of ERP functionality, Botta-Genoulaz and Millet (2006) suggest that the service sector derives substantial benefits from logistics-related modules, including project management and after-sales service applications, although the degree of integration remains less comprehensive than that observed in manufacturing environments.

The findings of Ruivo et al. (2017) indicate that ERP use in both service and manufacturing firms acts as a strategic resource, supporting collaboration inside and outside the organisation while also holding data for business analysis. As ERP adoption matures, users tend to rate successful system use less highly, while collaboration grows in importance, letting firms open up new ways of using information to improve business processes and drawing on operational data for reporting, decision-making and resource planning (Ruivo et al., 2020). Ruivo et al. (2017) show more precisely that once system use is weighed against other organisational system factors, it has no direct effect on IT value creation. What ERP systems set out to do is improve transaction processing by standardising business processes and integrating operational activities and data, which keeps internal information consistent and uniform (Ruivo et al., 2020).

There is evidence that service organisations make growing use of the analytical side of ERP to build new resources and competences as market conditions shift, and so strengthen their competitive position (Ruivo et al., 2020). Ruivo et al. (2017) argue that these analytical capabilities matter even more in service firms than in manufacturing. That is not to say manufacturers ignore what analytics contribute to business decisions. Service organisations are simply more information-intensive by nature and therefore need more analytical processing and wider circulation of information than manufacturers do (Uwizeyemungu and Raymond, 2011). Because ERP systems allow firms to cut costs and work more efficiently by integrating business processes and sharing common resources across the enterprise, they have become a basic mechanism for process optimisation in both manufacturing and service networks (Jones et al., 2006). Firm size also represents an important determinant of ERP value creation within the service sector (Ruivo et al., 2017). ERP implementation is widely recognised as a complex, costly, and time-intensive undertaking (Ruivo et al., 2020). Larger organisations generally possess greater

financial and organisational resources, enabling them to absorb the risks associated with such investments. Consequently, they are more likely to adopt and utilise ERP systems, understand their capabilities, and successfully leverage their benefits to generate organisational value (Ruivo et al., 2017).

From the perspective of small and medium-sized enterprises (SMEs), service-based SMEs have the potential to become major drivers of economic growth in countries undergoing industrial restructuring and a transition towards knowledge-intensive industries. Accordingly, there is considerable interest in understanding the extent of IT adoption and utilisation within service SMEs, as well as identifying the factors that influence both adoption and effective use (Uwizeyemungu and Raymond, 2011).

When evaluating opportunities for IT adoption, service SMEs should actively consult their customers, as customers are often directly involved in the service delivery process and are therefore exposed to the technologies being implemented, such as automated teller machines (ATMs) in the banking sector (Uwizeyemungu and Raymond, 2011). *This is where Lean Six Sigma philosophy with a customer orientation perspective can help.* A further peculiarity of the service SME context is that IT adoption and assimilation in these firms ought to arise from an alignment between two things: on one side, the strategic orientation and competencies that define their organisational context, and on the other, particular elements of their technological and environmental contexts (Uwizeyemungu and Raymond, 2011). This aligns with the study of Ghazaleh et al. (2019) on the sustainability of post ERP in a service industry that introduces outcomes concerning how an aligning strategy towards ERP can enable firms to better serve their business uses' needs.

IT / ERP is necessary but not sufficient

In Necessary but not Sufficient, Goldratt et al. (2017) arrives at the following conclusion: For organisations operating in today's technology-driven environment, success depends on more than simply providing advanced technological solutions. They must demonstrate how such technologies create tangible value for their clients and contribute directly to financial performance, as the ultimate measure of business success lies in the value delivered to shareholders. Furthermore, once technological innovations have removed operational constraints, organisations must also address the cognitive and managerial limitations that may hinder progress. Existing business

rules and assumptions often need to be reconsidered, as emerging technologies are eliminating many of the restrictions upon which they were originally based.

Goldratt et al. (2017) emphasise that although technology is essential, it is not sufficient on its own to meet the information requirements of organisations, achieve rapid results in a bottom-line-oriented economy, or establish a platform for sustained future performance. Consequently, the combination of information technology with managerial approaches such as Lean Six Sigma and similar methodologies provides an effective means of enabling organisations to rethink established ways of working and focus on alternative forms of measurable business value.

Companies anticipate that processes and performance will improve as the ERP system is implemented (Sun et al., 2015). Organisations generally expect ERP systems not only to resolve challenges associated with business process integration but also to facilitate the seamless flow of information across functional areas and enhance the efficiency and coordination of organisational processes. (Bharathi and Parikh, 2012). In many cases expectations are too high when evaluated against the degree to which this can actually happen.

Information technology is not the solution for all problems, rather is an instrument, and like all other instruments, it can be used profitably, but if it is used with a lack of wisdom, it can be dangerous (Boero, 2011). The outcomes of ERP implementation failure are typically visible “in an implementation being delayed, going over budget, requirements for additional funding, potential loss of authorisation security, data confidentiality, authentication safety, server downtime, or ultimately, system failure” (Schniederjans and Yadav, 2013, p.368). Overall, a failure entails wasting large amounts of a firm’s money or destroying its competitive advantage; ultimately leading to the system’s or sometimes even an organisation’s demise. It is thus essential that care is taken to obviate inexpedient managerial approaches when implementing ERP.

1.2.2. Lean Six Sigma philosophy

As discussed above, ERP and other solutions are necessary for companies in today’s business environment, but more is needed. Therefore, I suggest that companies should combine EPR and other IT solutions together with managerial solutions. Lean Six Sigma is one such option. This chapter will present the Lean Six Sigma philosophy and its development history. Firstly, a review of Lean and Six

Sigma is presented separately, showing how the concept of Lean Six Sigma emerged.

Lean definition and its historical development

The origins of Lean are usually traced back as far as fifteenth-century Venice, although it was Henry Ford who first embedded the concept within a manufacturing system (Hessing, 2020). An important precursor came in 1799, when Eli Whitney developed the principle of interchangeable parts. Ford built on this in 1913, refining the flow of production through experimentation with the interchangeability and movement of components, and thereby achieving a far greater degree of standardisation in work processes. Nevertheless, the Ford production system was constrained by its limited variety and its focus on a single product specification. Following the Second World War, Toyota drew inspiration from Ford's production flow principles and developed the Toyota Production System (TPS) (Ohno, 2019). This approach shifted attention from the utilisation of individual machines to the optimisation of workflow across the entire production process. The Toyota Production System set out mainly to cut production costs, raise product quality and lift throughput, so that the company could respond more readily to shifting customer demands (Ohno, 2019). Two of its defining features were machinery sized to match actual production volumes and machines able to regulate themselves. Quality improved as a result, equipment was arranged to follow the process flow, and quick changeover methods were worked out, which made it possible to produce several different components in fairly small batches while still passing requirements clearly from one stage of the process to the next. Despite the considerable difficulties caused by the 1973 oil crisis, Toyota demonstrated exceptional performance. This success prompted the Massachusetts Institute of Technology (MIT) to initiate the International Motor Vehicle Program (IMVP) in order to investigate the challenges confronting the automotive industry at the time and to analyse the Lean production system (Ohno, 2019). The concept of Lean manufacturing emerged within the automotive sector during the late 1980s through the work of a research team led by Jim Womack. However, Lean gained worldwide recognition following the publication of *The Machine That Changed the World* by Womack, Jones, and Roos (2008) in 1990. Lean has subsequently been widely adopted because of its effectiveness as a management approach for enhancing organisational efficiency and performance

(Womack et al., 2008). Over time, both academics and practitioners have further refined the Lean concept by incorporating effective practices derived from the Toyota Production System (Vashishth et al., 2019) and progressively extending its application to a variety of sectors.

Even though there are many ways to define Lean (Womack and Jones, 2003; Modig and Åhlström, 2012), it is undeniably an effective process management approach that enables a continuous improvement of organisational core business processes. Improvement projects are typically focused on eliminating waste and creating variation in scope for a particular business process, and ultimately developing visible and measurable process performance improvements, such as cost reductions, decreased defects, and improved delivery time, etc (Rytter, 2012).

Today, organisations across all industries that are exposed to global competition and rapid technological change face similar pressures to transform their operations in ways that better align with evolving environmental demands. In Western economies, globalisation has placed substantial competitive pressure on traditional mass-production models. In *Lean Thinking*, Womack and Jones (2003) expanded the Lean philosophy beyond the automotive sector, broadening its applicability to other industries. The Lean philosophy is founded on the elimination of waste and is structured around five core principles: Value, Value Stream, Flow, Pull, and Perfection (Womack and Jones, 2003). This five-step thought process for guiding the implementation of Lean techniques is presented in Figure 4 below.

Figure 4. Five Lean principles

Source: Lean Enterprise Institute. (www.lean.org)

Identify Value

The fundamental starting point of Lean thinking is the concept of value. According to Womack and Jones (2003), value can only be determined by the end customer and becomes meaningful only when it is expressed in relation to a specific product or service, delivered at the right time, at the appropriate price, and in a manner that satisfies customer requirements. Value is therefore defined by the customer's need for a particular product or service. Considerations such as delivery lead time, price, and any additional requirements or expectations all contribute to the customer's perception of value. In essence, value represents what customers are willing to pay for. Consequently, organisations must strive to identify both the explicit and latent needs of their customers. Customers are not always able to clearly express their requirements, particularly in the case of innovative products or emerging technologies (Liker, 2004). Various qualitative and quantitative techniques, including interviews, surveys, demographic analysis, and web analytics, can assist organisations in identifying and understanding what customers consider valuable. Through the application of these approaches, firms can determine customer preferences, desired methods of product or service delivery, and acceptable price levels. Traditional organisations often seek customers for their products through mass marketing activities. In contrast, Lean production adopts a customer-centred perspective, whereby products and services are designed and developed to align closely with customer requirements (Powell, 2011).

Map the value stream

A value stream encompasses all activities necessary to move a product from initial concept to customer delivery (Liker, 2004). It includes every problem-solving activity involved in concept development, detailed design, engineering, and production launch; the information-related activities extending from order processing and scheduling to delivery; and the physical transformation of raw materials into a finished product received by the customer (Womack and Jones, 2003). Once value has been defined, the next step is to map the "value stream", meaning every step and process that takes a particular product from raw materials through to delivery to the customer. Value-stream mapping is a straightforward exercise, though often a revealing one, that sets out all the actions carrying any product or service through a given process. The process in question may sit in procurement, design, administration, production, HR, delivery or customer service. The point is to draw a

map on a single page showing how materials and the product move through the process. What you are looking for is every step that creates no value, so that you can then work out how to remove it, taking the customer's understanding of value as the reference point and picking out the activities that genuinely feed into it (Womack and Jones, 2003). Anything that adds nothing for the end customer counts as waste. Waste falls into two groups: non-value adding but necessary, and non-value adding and unnecessary (Liker, 2004). The second is pure waste and should go; the first should be cut back as far as possible. Removing or trimming unnecessary steps makes it possible to give customers precisely what they want and to bring down the cost of producing the product or service at the same time (Womack and Jones, 2003). Ultimately, mapping the value stream also results in a better understanding of the entire business operation.

Create Flow

With value defined precisely, the value stream for a given product family mapped in full by the lean enterprise, and the plainly wasteful steps taken out, the next stage of lean thinking can begin: making the remaining, value-creating steps flow (Womack and Jones, 2003). Following removal of all waste from the value stream, the next task is to make sure the remaining steps run smoothly, without interruption or delay. This can be approached in several ways: breaking steps down, rearranging the sequence of production steps, levelling the workload, setting up cross-functional departments, and training staff to be multi-skilled and adaptable (Liker, 2004). The Lean Enterprise Institute advises that the value-creating steps should be arranged in tight sequence, so that the product or service flows smoothly towards the customer, this can call for breaking down entrenched ways of thinking and making the effort to work across departments, which is often among the hardest challenges a lean programme has to overcome.

Establish Pull

“Pull in the simplest terms means that no one upstream should produce a good or service until the customer downstream asks for it” (Womack and Jones, 2003, p. 67). Better flow shortens the time to market, or time to the customer, often by a wide margin. Delivering products as they are needed becomes far more practical, which is the basis of just-in-time manufacturing and delivery (Crawford, 2016). The customer, in effect, pulls the product from the supplier as required. Nothing then has to be built ahead of demand, and no materials sit in stock as costly inventory needing

management, so both the manufacturer or provider and the customer save money (Crawford, 2016). A pull-based system aims to hold inventory and work in progress to a minimum while keeping the materials and information needed for work to flow without hindrance. Put differently, it allows just-in-time delivery, with products made when they are wanted and in the exact quantities wanted. Such systems always take their shape from what the end customer needs. Working backwards along the value stream through the production system makes it possible to ensure that what is produced will meet those needs (Crawford, 2016).

Seek Perfection

When organisations manage to specify value accurately, map the whole value stream, make the value-creating steps flow without interruption and let customers pull value from the business, the effect is unexpected: perfection stops looking like an unrealistic ambition (Womack and Jones, 2003). The fifth step, the pursuit of perfection, makes lean thinking and continuous process improvement part of the organisational culture (Womack and Jones, 2003). Every employee should work towards perfection in delivering products built around customer needs, and the company itself should be a learning organisation, one that keeps finding ways to get a little better day by day (Liker, 2004). As the gains accumulate, it is worth remembering that lean is not a static system: it takes constant effort and vigilance to perfect, and every employee has to be involved in putting it into practice (Liker, 2004).

The five lean principles offer a framework for building an organisation that is both efficient and effective (Liker, 2004). Lean lets managers find where their organisation is inefficient and deliver better value to customers, and its principles encourage better flow in work processes alongside a culture of continuous improvement (Womack et al., 2008).

At its core, the lean production system is about eliminating waste along the whole value chain and improving without let-up (Womack and Jones, 2003). In manufacturing, waste takes in over- and under-production, excessive movement of materials and people, unnecessary processes, and defects, along with any process that does not add value to the product directly (Womack et al., 2008).

Anything that does not add value to the product must be removed. The Lean approach distinguishes seven types of waste (Ohno, 2019): first is transportation (moving goods adds no value in itself, yet shifting them from one stage of the process to the next cannot be avoided, so the process should be arranged in a way that

removes the holding area); second is inventory (components that sit idle instead of being processed and to which no value is being added); the third type of waste is unnecessary motion, whether of people or of equipment; the fourth is overproduction (making more parts or products than is actually needed counts as waste); the fifth is extra processing (doing more work than the required level of value demands); the sixth category is waiting, or lost time (which may mean waiting for an upstream process to deliver or for a machine to finish its cycle); the final category is defects, where the emphasis falls on the time lost in detecting them and putting them right.

Six Sigma definition and theoretical development

"Six Sigma was developed at Motorola by an Engineer Bill Smith in the middle of 1980s, as a business improvement approach that seeks to find and eliminate causes of defects or mistakes in business processes by focusing on process outputs which are critical in the eyes of customers" (Antony et al., 2017, p.1074). Its principles can be applied to shift the process average, to build products and processes that are robust, and to cut the excessive variation that leads to poor quality. Six Sigma rests on a statistical problem-solving methodology, which supplies the data on which solutions are based and produces marked improvements to the bottom line (Antony et al., 2017).

Crucially, Six Sigma gave Motorola an overall roadmap, a problem-solving process known as MAIC, standing for measure, analyse, improve and control. MAIC linked the individual tools and drew them together, so that employees could be trained in a single approach general enough to suit a wide range of problems, which spared them reinventing the wheel with each new project (Antony et al., 2017). Six Sigma also had clear management backing, with a supporting infrastructure behind it: line items in budgets, resources, project-selection systems and the like (Antony et al., 2017).

"Motorola achieved tangible results, and other organisations began to take notice, CEO Jack Welch loudly proclaimed that General Electric (GE) was jumping into the Six Sigma game in late 1995 that the initiative moved from the back pages of the business section to the front page of the newspapers" (Antony et al., 2017, p. 1075). Some projects had stalled because it was unclear what problem was actually being tackled, and how it fitted the wider objectives, so GE added a Define step at the front of the MAIC process, producing what we now call DMAIC (Hoerl, 2001).

Define turned out to be the decisive step, the one that frequently settled whether a project succeeded over the long run. Careful problem definition is, more broadly, something researchers in problem solving have long recognised as necessary (Kadry, 2018).

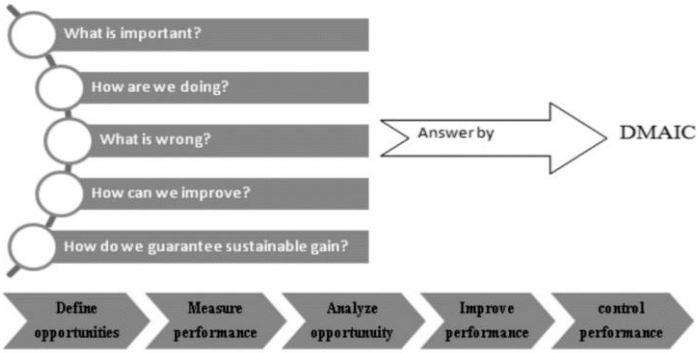
Andersson et al. (2006) describe Six Sigma in terms of documenting manufacturing management processes and monitoring deviations. Sigma is the Greek letter used as a statistical unit for the standard deviation of a population (Andersson et al., 2006). Six Sigma therefore refers to six standard deviations, just as Three Sigma refers to three. Standard deviation is the measure of statistical dispersion used most often in probability and statistics, showing how widely the values in a dataset are spread (Kadry, 2018). “It is the square root of the variance, or the root mean square deviation from the average, and is defined this way precisely so as to give a measure of dispersion. If defects are assumed to follow a standard normal distribution, this corresponds to roughly two quality failures for every billion parts manufactured, though in applying the methodology the figure used is 3.4 per million” (Kadry, 2018, p.3). Once this information is available, the next aim of Six Sigma is to design processes that remove such deviations (Andersson et al., 2006). An organisation working to Six Sigma succeeds through the predictability of its results, and measurement and data analysis are central to that. “The challenge of the methodology, then, is to apply a set of quality and management tools through a systematic process, improving the key operational and business processes so that Six Sigma performance is reached on the relevant process indicators and metrics” (Kadry, 2018, p.4). Controlling variation at every step of the work process is what Six Sigma rests on. This consists of five steps known as DMAIC (Hoerl, 2001):

- Define (setting out the goals and the processes concerned);
- Measure (assessing product capability, process capability and risk);
- Analyse (establishing what causes what);
- Improve (changing the process so that it performs better);
- Control (putting procedures in place that keep variation within acceptable limits and hold product quality consistent).

Over the past decades the DMAIC problem-solving methodology, together with the tools and training that support it, has developed into a set of powerful, robust and widely adopted practices, worked out specifically to help teams reach root-cause problem-solving more efficiently (Kadry, 2018). A graphical overview of DMAIC

processes is presented in Figure 5 below.

Figure 5. DMAIC processes.



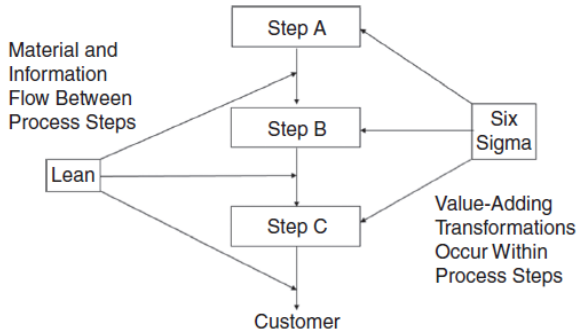
Source: Kadry (2018).

The processes and tools DMAIC supplies are necessary but not sufficient: they do nothing in themselves to secure organisational acceptance and adoption of the solutions a team develops (Kadry, 2018).

Lean Six Sigma concept

Jayaraman et al. (2012) states that Lean and Six Sigma are two of the most effective business-improvement programs or techniques available. Both Six Sigma and Lean had produced tremendous results, but had limitations, some type of integration of the two became appealing, as well as making intuitive sense (Antony et al., 2017). The limitations, though, run in opposite directions. Lean does not cope well with complex problems that call for intensive data analysis and advanced statistical methods, whereas practitioners of Six Sigma found that by no means every problem warranted months of data collection before it could be solved (Antony et al., 2017). Lean principles could be applied broadly with little data and bring immediate benefit, leaving Six Sigma for those problems that genuinely demanded close analysis. What matters in bringing the two together is neither the nature of the response variable, whether quality, waste or time, nor the particular tools to be used, since neither approach invented its tools but rather combined existing ones in novel ways, so neither holds any claim over them (Antony et al., 2017). A process view of Lean Six Sigma by Antony et al. (2017) is presented in Figure 6.

Figure 6. Process view of Lean Six Sigma

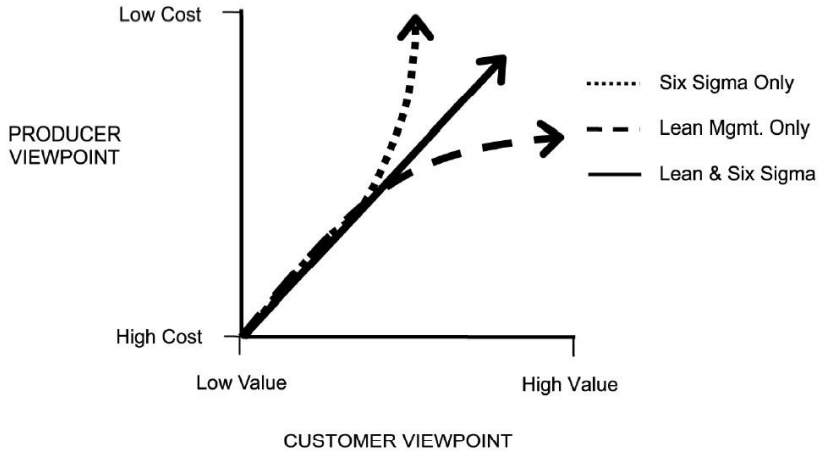


Source: Antony et al. (2017)

Combined, they amount to a process management approach that puts continuous improvement of performance at the centre of a company's business processes (Salah et al., 2010). Managers and staff are trained in Lean Six Sigma methods, improvement projects are selected carefully, usually around waste and variation within a defined process, and are structured through a model such as DMAIC or PDCA, drawing on a standard toolbox of SIPOC diagrams, process maps, value stream maps, the seven wastes, Ishikawa diagrams, descriptive and inferential statistics, Kanban and flow thinking, with the aim of solutions that can be implemented and that yield visible, measurable gains in cost, defects and delivery time (Rytter, 2012).

Lean Six Sigma relies on the strengths of both Lean management and Six Sigma (Arnheiter and Maleyeff, 2005). An LSS organisation, on the account given by Arnheiter and Maleyeff (2005), draws three things from lean management. It works to an overriding philosophy of maximising the value-added content of everything it does, it keeps its incentive systems under review so that they push towards optimising the whole rather than the parts, and it judges every management decision by what that decision does to the customer. From Six Sigma it takes another three. Decisions rest on data, so that changes follow from scientific study rather than ad hoc inquiry; methods are chosen for their capacity to reduce variation in quality characteristics; and education and training are organised as a structured programme across the whole company (Arnheiter and Maleyeff, 2005). Arnheiter and Maleyeff (2005) depicted the nature of the Lean Six Sigma improvements using a graphical overview, which appears in Figure 7.

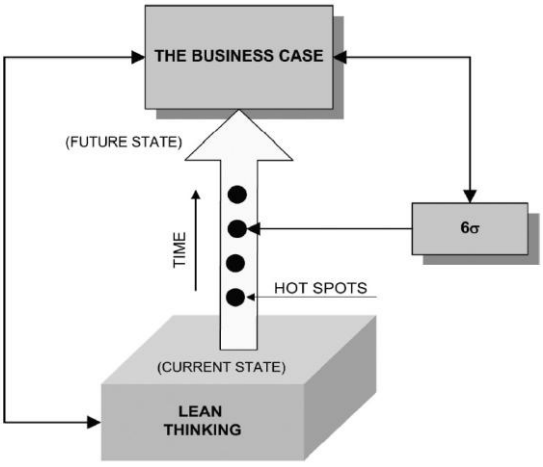
Figure 7. The nature of improvements that may occur when practicing Lean Six Sigma



Source: Arnheiter and Maleyeff (2005)

Lean and Six Sigma integration is discussed by Pepper and Spedding (2009), who say that this combination creates a consistent management tool for business process improvement. The integration of Lean and Six Sigma into a single, coherent tool for business process improvement is set out in Figure 8 below.

Figure 8. The nature of improvements that may occur when practicing Lean Six Sigma

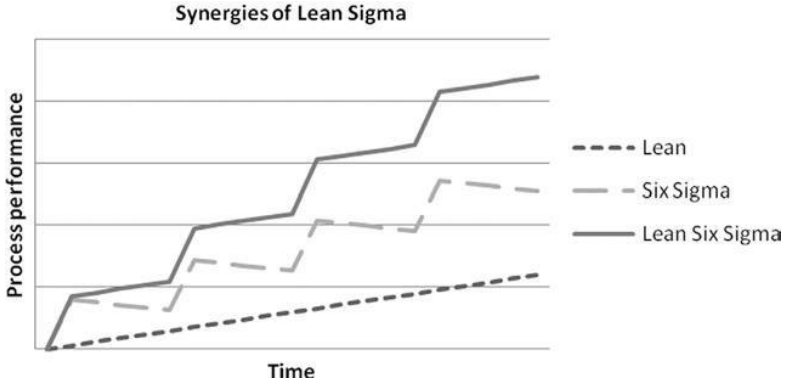


Source: Pepper and Spedding (2009)

The framework rests on lean philosophy, which sets the strategic direction and the base from which improvement proceeds, and which orientates the general dynamics of the system by giving a reading of how operations currently stand (Pepper and Spedding, 2009). Working from that base, lean thinking picks out the areas where improvement matters most, the hot spots. Six Sigma then supplies a focused, project-based methodology for tackling them and moving the system towards the future state it is meant to reach (Pepper and Spedding, 2009).

Assarlind et al. (2013) offer a mental model of the synergies between lean and Six Sigma, showing how the two connect by suggesting that a lean initiative can offset a decline in Six Sigma results (Pepper and Spedding, 2009). This gives rise to a spectrum of views, from running lean and Six Sigma in parallel at one end to a fully integrated system at the other. The concepts can be brought together in various ways, too, whether by mixing or transferring tools, ideas and philosophies (Assarlind et al., 2013). Figure 9 shows how Assarlind et al. (2013) pictured the Lean Six Sigma method impacting upon process performance.

Figure 9. Mental model of Lean and Six Sigma synergies



Source: Assarlind et al. (2013)

Each of the two methods has its own strengths, and many firms adopt one or the other. Applied together, however, they form a considerably more effective approach, allowing a company to deliver high-quality products quickly and without the trade-offs between cost, speed and quality that either method alone tends to impose (Assarlind et al.,2013).

Sunder M et al. (2018) suggest that although there are papers on Lean Six Sigma enabling business excellence capability, future research should focus on Lean

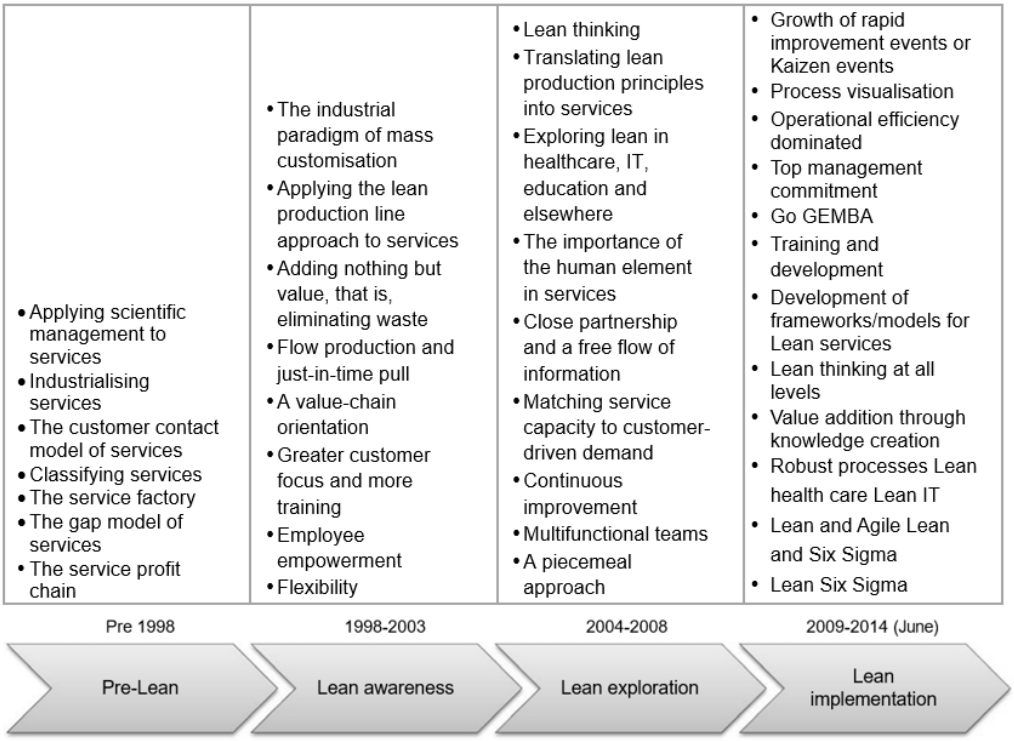
Six Sigma for creating dynamic capability in organisations.

Lean Six Sigma in the services sector

Lean and Six Sigma originated in manufacturing, but their significant potential for the service sector has also come to be recognised (Sunder M et al., 2018). In service organisations, lean is a methodology for cutting waste, particularly wasted time, and making the process more efficient (Sunder M et al., 2018). It calls for looking at the process from the client's point of view, so that waste and inefficiency can be removed (Ohno, 2019). Six Sigma, by contrast, concentrates on refining the process and reducing its variability, so as to produce the same result at least 99.9997 per cent of the time (Antony et al., 2017). The philosophy behind lean principles does not change as one move from manufacturing to services, but the tools and practices of Lean Six Sigma have to be adapted to fit service industries (Sunder M et al., 2018). Within a service organisation it can be applied across sales, marketing, credit, collections, customer service, back office, front office, operations and product development. Anywhere a business system exists, Lean Six Sigma can be brought to bear (Sunder M et al., 2018). Such systems are typically made up of people, processes, resources, strategy, customers and products, and the organisation itself, its value streams, its process management system and its workplace management system all count as examples (Gupta et al., 2016). Of these components, two are indispensable if a system is to be open to Lean Six Sigma at all: people and processes. Services bring a particular difficulty, in that waste is intangible and therefore hard to spot, and the customer takes part in producing the service (Gupta et al., 2016). A further obstacle is that service organisations are often simply unaware of what Lean Six Sigma could do for them. The literature reviewed by Gupta et al. (2016) nonetheless shows that applying it in services has produced positive results. A graphical overview of Lean service concept development is presented in Figure 10, adopted from Gupta et al. (2016).

The industrialisation of services began with attention to quality, to understanding service processes, to balancing supply and demand, to the gap model of service quality, to failure demand, and to customer satisfaction alongside employee loyalty (Gupta et al., 2016).

Figure 10. Evolution of Lean services



Source: Gupta et al. (2016)

Service firms struggling with quality, globalisation and the arrival of IT turned to manufacturing for methodologies that might solve their problems. Gupta et al. (2016) found in their overview that lean could not simply be carried across from manufacturing. Virtual service factories are harder to manage, since customers interact with the process, staff resist unfamiliar practices, and turnover runs higher, so the lean approach has to be shaped to the setting. Production and consumption happen at once, and the customer takes part in producing the service, which makes such tailoring unavoidable.

Antony et al. (2017) report that beyond the gains to the bottom line, the most striking benefits of Lean Six Sigma for service organisations are greater customer satisfaction, higher employee morale, better cross-functional teamwork, more consistent service levels, and wider familiarity with problem-solving tools and techniques.

Gupta et al. (2016) note nevertheless that authors broadly agree lean thinking,

properly applied, brings services both cost efficiency and higher productivity. Sunder M (2013) argues that Lean Six Sigma project managers should not fix on improving a single project metric but should hold an end-to-end view of the process and understand it from every angle.

Lean Six Sigma spread through service firms mainly via healthcare and IT, with further work in education, finance and the public sector. It can be applied either through rapid improvement events or as a full implementation, and most organisations have chosen the former (Gupta et al., 2016). Womack and Jones (2003) put full implementation at three to five years. Improvement events serve to introduce lean thinking, and once enthusiasm has built the organisation should move to full implementation if lean is to be genuinely adopted (Gupta et al., 2016).

Lean also works to cut costs and manage risk in service firms, alongside improving customer and employee satisfaction (Sunder M et al., 2018). Empirical research on Lean Six Sigma in services remains at an early stage, and it needs to move from descriptive contributions towards operational definitions of Lean Six Sigma practices, as the more mature literature on lean manufacturing has already done (Malmbrandt and Åhlström, 2013). That would make the extent of adoption measurable, and in turn open up questions such as what conditions favour lean adoption in services, what problems and pitfalls attend it, and how far lean practices can be transferred between service settings.

Malmbrandt and Åhlström (2013, p.1152) state that the importance of defining of Lean service is now greater than ever, as Lean service is increasingly being seen as a philosophy rather than as a set of tools and techniques.

1.2.3. Comparison of ERP and Lean Six Sigma approaches and analysis of the current research state

The literature on ERP and Lean Six Sigma highlights the opportunities for integration. ERP emphasises business process integration across and within all functions (Davenport, 1998; Ghosh and Skibniewski, 2010), whereas Lean Six Sigma emphasises waste elimination, process flow, and value creation (Womack and Jones, 2003; Jacobs and Weston, 2007). Both approaches place similar emphasis on business process improvement and performance efficiency, which should make it possible to combine them. However, studies of Lean-Six Sigma implementations

show that expectations are not always fulfilled. The implementation results tend to decay over time due to a range of causes; one of them being, e.g., that an appropriate IT or ERP infrastructure is missing. Ultimately, process improvements are not sustained and continued if sufficient process automation is not enabled or if the data driven decision support offered through the real time measurements in place is not sufficiently implemented (Done et al., 2011).

Studies on LSS and ERP implementation outcomes thus confirm that none of the approaches are sufficiently powerful on their own; companies are often forced to look into and deploy more than one approach if they are to reap the full benefit from their initial efforts with either LSS or ERP.

A comparison of Lean Six Sigma and ERP approaches has been produced, emphasising their differences and similarities by specifying how they deal with a number of features / aspects. Table 4 below displays an overview of these.

Table 4. LSS and ERP approaches, their similarities and differences

Approach	**Lean**	**Six Sigma**	**ERP**
Main References	Womack and Jones (2003) Liker and Morgan (2011) Kumar et al. (2013) Modig and Åhlström (2012) Ohno (2019)	Hoerl (2001) Arnheiter and Maleyeff (2005) Andersson et al. (2006) Antony et al. (2017) Kadry (2018)	Davenport (1998) Jacobs and Weston (2007) Hendricks et al. (2007) Silveira et al. (2013) Marchand and Peppard (2013)
Definition	LEAN methodology is proven to help organisations achieve on time delivery of the right quality. It focuses on enabling people to see the product or services and the whole value stream from the perspective of the customer. Lean is used to eliminate waste, variation and work imbalance by deploying five lean principles.	SIX SIGMA methodology is a well-disciplined and structured approach used to enhance process performance and achieve a high level of quality and low level of variability. The main idea is DMAIC (define, measure, analyse, improve, control).	ERP is an enterprise-wide information system that integrates and controls all the business processes in the entire organisation.
Origin	Production Planning and Control	Quality Management	Computer Integrated Manufacturing, MRP, MRP-II
Emphasis	Business with standard and Lean provision and consumption processes	Culture for continuous improvement of business processes	Emphasis on business process integration across and within all functions
Aims	Waste elimination, create **process** flow and value	**Process** capability / stability and reduction of variation	For integration and optimisation of the **processes** and transactions in a corporation

Approach	Lean	Six Sigma	ERP
Main process and business solution elements	Modular product design Process standardisation Group or Line layouts Flow Line balancing CODP positioning Pull – Kanban Heijunka Levelling SMED Jidoka PokaYoke Visual Management Lean Leadership Hoshin Kanri	Process stability Process standardisation Clear roles and responsibilities Process Measures Quality circles Belt resources	Master Data Management and Quality Business Process Standardisation Standard ERP software tailored to business needs Integration of IT applications IT infrastructure Data warehouse and performance reporting tools User training and super users
Improvement objectives	Customer value and internal efficiencies	Customer satisfaction	Organisational efficiency and performance
Typical measures	Lead time vs value added time Inventory levels Cost profiling First pass yield Delivery time	Product Quality Defects per million opportunities Process capability index Customer satisfaction	Employee satisfaction Lead time Inventory levels

Source: Created by author

The above overview shows that both approaches have a similar emphasis, which is for business process improvement and performance efficiency. That indicates a potential for developing an integrated Lean Six Sigma and ERP approach. This allows the assumption that absorption in each and the possibilities for combining them could lead to positive results which, thus, also formed the basis for attempting to develop and propose the integrated Lean Six Sigma and ERP implementation.

The existing research on combining ERP and Lean Six Sigma

From the above chapters referring to the existing research, it is notable that businesses across industries have, over the last decades, implemented either ERP (enterprise resource planning) or related IT (information technology) systems and/or Lean Six Sigma management approaches in their attempts to develop process excellence and increase their competitiveness (Ghobakhloo and Fathi, 2019; Maguire, 2016; Powell, Riezebos, et al., 2013). Organisations are aware that one way to enhance their competitive position is to become more process oriented through operational excellence (Nadarajah and Kadir, 2016). For SMEs that are growing, process orientation can be one way of tackling their pressing challenges,

such as the crises of delegation and coordination (Greiner, 1998). As a means of improving their processes, businesses across industries are implementing either ERP (Sun et al., 2015) or Lean Six Sigma management systems (Nadarajah and Kadir, 2016).

The scholarship suggests that ERP and Lean Six Sigma are complementary (Powell, 2013). 19 articles were identified, ranging from case studies to theoretical papers. As discussed in the literature review methodology, most of the papers were analysed before 2019 and papers that were published later were then added when working on this thesis. The 19 papers are discussed in detail and presented in Table 5 below.

Table 5. Papers on combined Lean Six Sigma and ERP approaches

Authors	**Topic**	**Research approach**	**Industry Focus**	**Main findings**
Ward and Zhou (2006)	IT and Lean integration on Lead - Time Performance	Survey (1,757 completed surveys)	US manufacturing companies	"Lean/JIT practices and IT integration is reducing customer lead Time" (p.195).
Cagliano et al. (2006)	The linkage between supply chain integration and manufacturing improvement programs	Based on the European sample of IMSS III (425 Companies)	European manufacturing companies	There is a link between "integration of information flows and integration of physical flows – and the adoption of Lean production" (p.295). "The introduction of ERP systems is not related to any supply chain integration dimension" (p.295).
Pope (2008)	IT and lean	Overview of practices in use	US manufacturing companies	"Instead of focusing on the differences between IT and Lean, should be looked at the potential in making both work together" (p.39).
Nauhria et al. (2009)	A Holistic Approach of ERP-enabled Lean Six Sigma	Literature review and theory building	Manufacturing	"A holistic approach to competitive manufacturing by integrating ERP, Lean manufacturing and six sigma initiatives has been suggested" (p.41).
Riezebos et al. (2009)	Lean Production and information technology: Connection or contradiction	Literature review	Manufacturing	"Practices converge into hybrid production systems, in a way that is consistent with the principles with Lean Production" (p.237).
Hong et al. (2010)	Integration of supply chain IT and Lean practices for MC (mass customisation)	Survey	Manufacturing more than 100 employees	"ERP use is not positively related to MC performance when using Lean practices" (p.584).

Authors	Topic	Research approach	Industry Focus	Main findings
Halgeri et al. (2010)	ERP Supporting Lean Manufacturing in SMEs	Literature review and theory building	Manufacturing SMEs	"Lean manufacturing has been successfully integrated with ERP software as a best-of-breed approach useful to many SMEs" (p.72).
Powell and Strandhagen (2011)	Lean production vs ERP systems: an ICT paradox	Literature review and theory building	Manufacturing	There is "a synergistic impact to be gained as a result of combining and synchronising the two" (p.35).
Bortolotti and Romano (2012)	'Lean first, then automate': a framework for process improvement in pure service companies.	Case study	Automating processes in pure service-providing companies	Automation of a process that is not streamlined can generate problems that can slow down the flow and increase errors. A process should first be mapped to highlight waste. Only when the new process is streamlined, can it be automated. In doing so, the new process will automate only value-added activities (p.521).
Pritchard (2013)	Data Analytics make Companies Lean	Overview of practice in use	Manufacturing	There has to be a balance between IT and Lean (p.24).
Powell (2013)	Review of Lean and ERP literature	Literature overview and theory building	Manufacturing	"In combining lean production principles with contemporary ERP systems, integrated throughout the supply chain with the support of the internet and other information technologies, it is possible to move closer to a new paradigm: ERP-enabled lean" (p.1504).
Powell, Alfnes, et al. (2013)	ERP-based Lean implementation process	Action research with one company	Manufacturing SME in Norway	"The ERP implementation process can be considered as a catalyst for the implementation of lean production in an enterprise" (p.334).
Powell, Riezebos, et al. (2013)	ERP support for pull production	Multiple case study (4 cases)	Manufacturing SMEs in Netherlands	"Identified five maturity levels of ERP support for pull production: initial, planned, validated, controlled, and optimising" (p.406).
Stojkic et al. (2014)	Lean Tools and CRM Software Solutions	Literature review and theory building	General	Linking organisational tools, such as Lean tools and software CRM solutions, is a necessity (p.47).
Iris and Cebeci (2014)	Relationship between ERP utilisation and Lean manufacturing maturity	Survey	Manufacturing SME in Turkey	"Effective usage of specific ERP modules can contribute toward applying Lean principles and vice versa" (p.261).
Chiarini and Vagnoni (2017)	Strategies for modern operations management	Survey with eight questions	120 large European manufacturing companies	"The integration of ERP strategies with Lean and agile systems and customised products / processes to be difficult" (p.1065).

Authors	Topic	Research approach	Industry Focus	Main findings
Sartal and Vázquez (2017)	Implementing IT and Operational Excellence: Planning, emergence and randomness in the survival of adaptive manufacturing systems	Case study over a period of 11 years (2003–2014)	In one of the world's largest canning factories	IT features influence specific routines: data reliability for problem-solving, real-time info for flow, and knowledge integration for conflict. The timing and order of Lean-IT implementation are crucial for effective transformation and capability building (p.14).
Vincent et al. (2019)	Critical success factors for Lean implementation in IT outsourcing relationships	A multiple case study	Six IT outsourcing relationships investigated by means of 36 semi-structured interviews	"In total, 16 CSFs for Lean implementation in IT outsourcing relationships are identified and described" (p.715).
Ghobakhloo and Fathi (2019)	The enabling role of Lean-digitised manufacturing	An in-depth five year case study	Manufacturing firm	"Transition requires the organisational integration of many IT-based modern technologies and the digitisation of entire value chains. The development of Lean-digitised manufacturing system is a viable business strategy for corporate survivability in the Industry 4.0 setting" (p.1).
Erkayman (2019)	Transition to a JIT production system through ERP implementation: a case from the automotive industry	Action research	Automotive industry	"The implementation of ERP applications for transition to a JIT production system provides useful and purposive results when implemented correctly. ERP applications can serve as an important tool and facilitator for the transition to JIT production system" p.5473).
Shamsi and Aftab (2018)	Exploring LSS implementation barriers in Information Technology industry	Literature review and survey	256 usable questionnaires with a response rate of 64 per cent	"The challenges of "part-time involvement in Lean Six Sigma projects", "time consuming", "staff turnover in middle of project", "difficulty in data collection" and "difficulty in identifying project scope" emerged as the most critical barriers in the context of the IT industry" (p.523).
Gijo et al. (2019)	Application of LSS in IT support services	Case study	IT services depart. of a large electrical equipment manufacturing company	"This study has resulted in reducing the turn-around-time of all core processes in the organisation. The indirect financial savings estimated as a result of this overall impact" (p.417).

Authors	Topic	Research approach	Industry Focus	Main findings
Obwegeser et al. (2019)	Continual Process Improvement for ITIL Service Operations: A Lean Perspective	Case study (based on a design science research (DSR) approach)	Sigle case study	Using a DSR approach, the authors "developed a five–step process improvement framework for ITIL (Information Technology Infrastructure Library) service operations, based on the use of the Lean toolset. The proposed framework offers a structured approach for process improvement in practice, and a basis for more systematic research" (p.141).

Source: Created by author

Ward and Zhou (2006) analysed the impact of IT integration and Lean/just-in-time practices on lead-time performance for manufacturing companies. This study highlights the relative contribution of Lean/JIT practices and IT integration in reducing customer lead-time. Pope (2008) identifies a significant business potential for the manufacturing sector in combining the two approaches. Nauhria et al. (2009) introduce the concept of "ERP-enabled Lean" to achieve Lean and competitive manufacturing via accurate data and predictable processes (well implemented ERP), facilitating the identification and elimination of waste, and reducing the variability of core processes (Lean). Riezebos et al. (2009) identify "connections" and "contradictions" in Lean production and information technology, while Hong et al. (2010)'s benchmark study of product and service-focused manufacturers reveals how the integration of supply chain IT and Lean practices are a requirement to succeed with mass customisation. Halgeri et al. (2010) reported how Lean manufacturing, when well-integrated with several ERP software solutions, can be the best approach, and useful for many manufacturers, including SMEs. Powell and Strandhagen (2011) explained how synergies between Lean production and ERP systems can handle the ICT paradox. The authors claim that the benefits of Lean and ERP systems are almost identical, and that these include reduced cost, reduced inventory, and increased productivity, but also that set targets are more easily achieved by combining and synchronising implementation efforts. Lean will increase the processing speed, capacity, and visibility of contemporary ERP systems, which allows for closer coordination between shop floor activities and the supply chain, and additionally, ERP will enable continuous elimination of waste within Lean production (Powell and Strandhagen, 2011). Pritchard (2013) claims that business applications

and data analytics can make companies more Lean, i.e., more effective and better at continuous improvement, as access to data from ERP and business intelligence (BI) applications enables companies to further fine-tune their processes. In line with these studies, Unver (2012) investigates how an ISA-95-based manufacturing intelligence system can support Lean initiatives and identifies how contextualisation of low-level shop floor data with ERP level data can generate KPIs in a dynamic way. Such KPIs are considered critical to the implementation of a range of Lean performance measures for core business processes such as value-added/non-value-added time, work in process, process throughput, manufacturing lead time, set-up time, and labour productivity, etc. These observations are very much in line with the previous conclusions of Done et al. (2011) regarding the importance of real time measurements and incentives for sustaining process improvement or Lean implementations in UK SMEs.

Powell (2013) carried out a literature review regarding ERP systems and Lean production, presenting a set of pertinent factors and useful insights on the role and implications of ERP systems in Lean production. In the research of Powell, Alfnes, et al. (2013), the existing methodologies for Lean production and for ERP systems are brought together in a concurrent, single best practice approach, which the authors term an "ERP based Lean implementation process". Their findings suggest that the ERP implementation process may be regarded as a catalyst for introducing Lean production in an enterprise. Powell, Riezebos, et al. (2013) suggest that the use of an appropriate ERP system may indeed have a catalytic effect on the introduction of pull systems and other Lean production practices. Iris and Cebeci (2014)’s survey of manufacturing SMEs in Turkey shows how the effective use of ERP modules can contribute to applying Lean principles and vice versa. Finally, Stojkic et al. (2014) identify a need for linking organisational tools, such as Lean with CRM software implementations, along with providing a set of recommendations concerning how companies can acquire insight into the costs, duration, and progress of their CRM implementation project, while also improving their administrative business processes via Lean and the multidisciplinary skills of both individuals and teams.

Chiarini and Vagnoni (2017) surveyed 120 large European manufacturing companies and reported the integration of ERP strategies with Lean, agile systems, and customised products/processes to be difficult. Shamsi and Aftab (2018) examined the barriers to Lean Six Sigma implementation in the Information

Technology industry through a literature review combined with a survey. Their findings show that "part-time involvement in Lean Six Sigma projects", "staff turnover in middle of project", "difficulty in data collection" and "difficulty in identifying project scope" emerged as the most critical barriers in an IT context. Vincent et al. (2019) studied critical success factors for Lean implementation in IT outsourcing relationships and found management, leadership, measuring operational performance, utilisation of Lean tools/techniques, communication about the goals, internal Lean experience, measuring continuous improvement, and compatibility of the organisational culture to be of importance. Ghobakhloo and Fathi (2019) described the enabling role of Lean-digitised manufacturing. They completed an in-depth five-year long case study of a manufacturing firm, tracing its journey from failure through to the implementation of enterprise resource planning to its successful integration of the IT-based technology trends of Industry 4.0. A Lean-digitised manufacturing system is a viable business strategy for corporate survivability in the Industry 4.0 setting. This transition requires organisational integration of many IT-based modern technologies and the digitisation of entire value chains. Gijo et al. (2019) discussed the application of LSS in IT support services via a case study in the IT services department of a large electrical equipment manufacturing company in India. They concluded that the LSS DMAIC methodology could reduce the complaint resolution time and the corresponding standard deviation. This study had also resulted in a reduced turn-around-time for all core processes in the organisation.

The review of existing research on the interaction of the ERP and Lean Six Sigma approaches and their implementation has, thus, revealed a strong consensus regarding the benefits of combining the application of Lean Six Sigma and ERP improvement efforts, rather than applying them in isolation. The majority of the contributions regarding Lean pointed towards considering ERP technologies and methods as a vehicle for making companies more Lean and Kaizen-driven, though, in a few papers, it is also claimed that the Lean Six Sigma approach is essential for successful ERP implementations. The increasing volume of research investigating how ERP (and IT) implementations become a prerequisite for long-term Lean Six Sigma and competitive manufacturing or service operations unsurprisingly take into account the widespread efforts in the industry over the last decade to digitalise manufacturing and service operations, not only via ERP but also through industry 4.0 etc. From the above literature review, however, it becomes obvious that articles on

the subject are primarily based on theory, and that few empirical studies of ERP and Lean Six Sigma implementations in combination have been done, despite the widespread deployment of both approaches among industrial companies. Upon closer inspection of the empirical research, it turns out that several papers have applied survey methods, for example, Ward and Zhou (2006) who studied data gathered from US manufacturing companies, and Cagliano et al. (2006), who studied European manufacturing company data from 2001. Only a few studies, however, provide a more in-depth or longitudinal study of ERP and Lean Six Sigma implementations in practice using case study methods and action research etc., as conducted, for example, by Powell, Riezebos, et al. (2013).

However, many companies, particularly service companies in the digital economy today, are in a situation where their operations and business processes are supported by IT (Kobus et al., 2018) or ERP, but where these companies have not yet succeeded in developing their capability for continuous improvement and Kaizen to the full extent (Gupta et al., 2016). Several studies confirm that it becomes increasingly relevant for service companies to improve service operations if they wish to maintain a competitive advantage (Vashishth et al., 2019).

1.2.4. Digitally supported process improvement capability through ERP and Lean Six Sigma

As the literature analysis reveals, many organisations use ERP and Lean Six Sigma initiatives in isolation, even though their scopes, deployed methods, and tools overlap considerably, and despite both ultimately aiming to generate tangible improvements for the same business performance targets: customer satisfaction cost levels, delivery dependability, quality, lead times, and inventories etc. (Bell, 2014). The discussed empirical studies have demonstrated a higher likelihood of achieving operations and service excellence for companies who combine, align, and integrate the two complementary initiatives compared to businesses developing and running them independently (Erkayman, 2019; Ghobakhloo and Fathi, 2019; Chiarini and Vagnoni, 2017; Powell, Riezebos, et al., 2013; Powell, Alfnes, et al., 2013).

The extant literature on combining ERP and Lean Six Sigma interventions dates back a decade, focuses on the introduction of ERP, and was conducted largely in manufacturing settings. The possible research gap is therefore discussed further.

The research gap defined before the start of empirical research

A review of the existing literature reveals a need for further in-depth investigation into the combined implementation of Lean Six Sigma and ERP systems within service-oriented organisations. While prior studies have examined ERP and LSS largely as separate improvement initiatives, or have focused predominantly on manufacturing contexts, limited attention has been given to their aligned or integrated implementation in service companies. Moreover, empirical evidence remains fragmented regarding how combined ERP – Lean Six Sigma initiatives influence both short-term performance improvements and the long-term development of organisational competitiveness, especially in service-focused SMEs.

Further research is needed to address this gap, explicate how ERP and Lean Six Sigma can be effectively combined, and delineate which organisational mechanisms support their successful implementation in service environments. Such research can provide a robust foundation for the development of a practical and structured implementation framework, outlining the key phases, activities, and managerial actions required to build ERP – Lean Six Sigma integration. The outcomes of this research have the potential to identify the supportive organisational mechanisms and actionable recommendations that service-based SMEs can leverage in their pursuit of operational and service excellence.

As the longitudinal investigation unfolded over nine years, the research gap and aims were iteratively refined to reflect emergent findings from other research, as well as shifting technological and organisational contexts.

Refinement of the research gap through the longitudinal study

Over the nine-year longitudinal study, the research gap progressively shifted. At the outset, the empirical focus of the study was: how can service-based SMEs integrate ERP and Lean Six Sigma to improve performance and competitiveness. The initial gap was therefore positioned at the intersection of two well-established streams - ERP implementation and structured process improvement - with limited evidence regarding how these initiatives can be aligned or integrated in service contexts, where processes are often less standardised, more people-intensive, and harder to observe than in manufacturing (Sunder M et al., 2018).

As the study progressed, the business environment and research around it changed. It became increasingly clear that the ERP – Lean Six Sigma combination

was best understood as one pathway through which firms could build a broader and more enduring competence: the ability to improve processes using digital technologies. Over the last 10-15 years, digitalisation and automation have become central to how service work is designed, executed, measured, and continuously improved (Saghiri, et al. 2025). This changing context reframed the research gap: rather than treating ERP as a stand-alone system and Lean Six Sigma as a stand-alone methodology, a new question emerged: How could SMEs develop and sustain an improvement capability that is digitally supported, and enabled by integrated data, workflow automation and analytics, etc. In this sense, the focus moved from an integrated implementation to a capability formation, capturing how digital tools and process improvement logic co-evolve over time inside an organisation (Wang and Zhang, 2025).

This evolution also reflected a broader shift in the environment: as new technologies continuously emerge, for example, AI-enabled features embedded in business platforms, and organisations face repeated waves of required change that cannot be addressed through one-off projects alone (Chiarini and Kumar 2021). Accordingly, the research aim expanded to explain digitally supported process improvement capability as a dynamic organisational competence, one that allows firms to continually reconfigure processes as technologies evolve, while maintaining operational discipline, service quality, and strategic alignment.

While performing the longitudinal study and observing the newly published articles it is argued that digitally supported process improvement capability can be achieved by integrating ERP systems with Lean Six Sigma because each addresses complementary dimensions of improvement (Wang and Zhang, 2025). ERP systems provide standardised, integrated, and real-time data across processes, creating transparency and enabling consistent execution, while LSS offers structured methodologies and analytical tools to identify waste, reduce variation, and improve process performance. When combined, ERP supplies reliable digital process data that strengthens Lean Six Sigma problem identification, measurement, and control phases (Unver, 2013; Powell, 2013). At the same time, Lean Six Sigma guides how ERP functionalities are configured, used, and continuously improved rather than treated as static IT solutions (Blijleven et al., 2019). Together, this integration embeds continuous improvement into digitally enabled processes, resulting in a sustainable, organisation-wide process improvement capability.

While SMEs resilience and growth are critical to economic vitality (Bhat et al., 2021), it is necessary to investigate how to support the transformation of SMEs into more process-oriented organisations, together with enhancing process performance. In that context, particular emphasis is placed on the development of a generic ERP – Lean Six Sigma implementation framework aimed at building digitally supported continuous improvement capability, as well as identifying the organisational mechanisms that enable such implementation to improve productivity, quality, and competitive advantage in SMEs.

To address the research gap outlined above, the next two chapters elaborate upon the study's theoretical and explanatory foundations. Chapter 1.3 develops the theoretical basis for combining ERP and Lean Six Sigma implementation, whereas Chapter 1.4 examines the organisational mechanisms that enable and sustain the application of this integrated ERP – Lean Six Sigma approach in SMEs.

1.3. Theoretical development of combined ERP and Lean Six Sigma implementation

Powell and Strandhagen (2011) claim that the benefits associated with Lean Six Sigma and ERP systems are almost identical (reduced cost and inventory, plus increased productivity), but also that set targets are more easily achieved by combining and synchronising the two implementation efforts. Based on a review of the existing literature, a clear need for in-depth research concerning Lean Six Sigma and ERP combined implementation has emerged. Thus, the existing frameworks of ERP and Lean Six Sigma implementation are analysed in this chapter. Additionally, the implementation frameworks are reviewed as separate approaches.

1.3.1. Existing framework for combined ERP and Lean Six Sigma implementation

Reviewing the literature, just one integrated framework for an ERP-based Lean Six Sigma implementation process (Powell, Alfnes, et al., 2013) was found. It describes in detail the situation when a company is in a position to select and implement a new ERP system. The framework provides a clear step-by-step guide to combining ERP and Lean Six Sigma including establishing a strategic vision, trainings, ERP software selection and Lean Six Sigma tools' introduction. They divide the implementation into three main situations and phases: I – basic Lean Six Sigma

and ERP, II – advanced ERP-enabled Lean Six Sigma Production, III – continuous improvement. The framework was tested in a production case company. The Powell, Alfnes, et al. (2013) framework is suitable for companies that choose and implement ERP, using it in combination with Lean Six Sigma efforts. This was the case for many businesses a decade or two ago. Today, however, many more companies have run ERP systems for several years and are struggling to improve both process and client value in addition to their IT infrastructure and applications using Lean Six Sigma tools.

A clear need emerged for further in-depth studies of Lean Six Sigma and ERP implementations that extend the tools to a service context. “Unlike the manufacturing context, where LSS requires a reduction of automation and digitisation, in the pure service context, automation and digitisation is desirable” (Bortolotti and P. Romano, 2012, p.520) – it can be argued that whenever possible, ERP should be used as an automation and digitisation tool, enabling Lean Six Sigma to avoid multiple IT solutions in the company since these are difficult integrations to support. The ERP ability to enable Lean Six Sigma in service contexts should be investigated further.

In reality, only one framework featuring a combined ERP and Lean Six Sigma implementation approach was identified. For the purpose of this research, I expanded the parameters to investigate the benefits of individual ERP and Lean Six Sigma implementation methodologies.

1.3.2. Lean Six Sigma adaptation and transformation frameworks

By 1996, Womack and Jones (2003) had proposed five principles for implementing Lean.

Notable implementation frameworks are derived from the context of production: A step-by-step approach to Lean manufacturing implementation is offered by Hobbs (2004), built around seven consecutive elements which appear to map onto the five Lean principles. Bicheno and Holweg (2009) present a hierarchical Lean transformation framework.

Additionally, one may add two more methodologies, less orientated towards the production sector, which suggest that improvement should happen in loops.
Malmbrandt and Åhlström (2013) discuss Lean service principles by searching for commonalities in definitions. Kumar et al. (2013) claimed that the most valuable lesson from designing and executing the Lean initiative at a telecommunications company was the fact that it is possible to simultaneously achieve customer service

excellence and improve financial results.

Nightingale and Mize (2002) describe the Transition to Lean Roadmap, which was developed to help organisations transform themselves into Lean enterprises. The model consists of three interdependent "cycles". The first is the Entry / Reentry Cycle, covering the actions tied to the decision to adopt the Lean paradigm. This cycle is closely connected to the enterprise strategic planning cycle. The second, the Long-Term Cycle, is where the environment and the conditions needed for a successful transformation are created. Once the action steps in this cycle are completed, the organisation is ready to move into detailed planning and implementation. The third is the Short-Term Cycle, in which the detailed implementation is planned, carried out and monitored. This cycle runs at a fast clock speed, with continuing phases of action, monitoring and corrective action. The Long-Term Cycle is revisited periodically in order to make use of the lessons learned during implementation and to take account of changes in the dynamic external environment.

The framework sets out the overall "flow" of action steps required to initiate, sustain and continuously refine an enterprise transformation grounded in Lean principles and practices (Nightingale and Mize, 2002).

1.3.3. ERP implementation frameworks

In the world of ERP, the term implementation is often used to describe a well-defined project, covering the steps from choosing a system and its configuration through to training its users, and eventually the ‘‘go-live’’ phase (Powell, Alfnes, et al., 2013). Several researchers have developed process models simulating ERP implementation. The implementation processes examined in this study are Vilpola (2008), with the discussed model being based on previous models of ERP implementation, Berchet and Habchi’s (2005) five-stage model, Pellerin and Hadaya’s (2008) four-phase model, Rajagopal’s (2002) six-stage model, and Wallace and Kremzar’s (2002) ‘‘ERP Proven Path’’ methodology for ERP implementation. These models all represent a linear process with the steps following one after another, though most of them emphasise continuous improvement at the completion (Berchet and Habchi, 2005; Pellerin and Hadaya, 2008; Rajagopal, 2002; Wallace and Kremzar, 2002).

Two of the models represent a cycle better suited for continuous process improvement: Harwood’s (2003) ERP implementation cycle and Parr and Shanks

(2000) implementation phases with the project phase shown with a cycle. Harwood's (2003) ERP implementation cycle is very general and outlines only the main steps, such as improvement, need, vendor selection, implementation, go live, and review. The ERP implementation phases of Parr and Shanks (2000) comprise a project-based model; this means that companies have to plan a separate project for each ERP implementation-based enhancement.

1.3.4. Overview of Lean Six Sigma and ERP implementation steps

Table 6 highlights the different steps proposed in Lean Six Sigma and ERP implementation frameworks. Blue represents the combined framework steps, while white represents ERP framework steps, and grey constitute Lean Six Sigma framework steps. The steps highlighted in purple are used in both the ERP and Lean Six Sigma frameworks.

The overlapping steps from ERP and Lean Six Sigma are continuous improvement, ongoing trainings, process definition, performance goals, and strategic vision, as well as initial trainings.

Most of them represent linear approach steps, with the exception of Nightingale and Mize (2002) and Kumar et al. (2013). While the continuous improvement associated with implementing EPR and Lean Six Sigma tools is not discussed in detail in most of the frameworks, it is necessary for the analysis of additionally available continuous improvement project frameworks and steps.

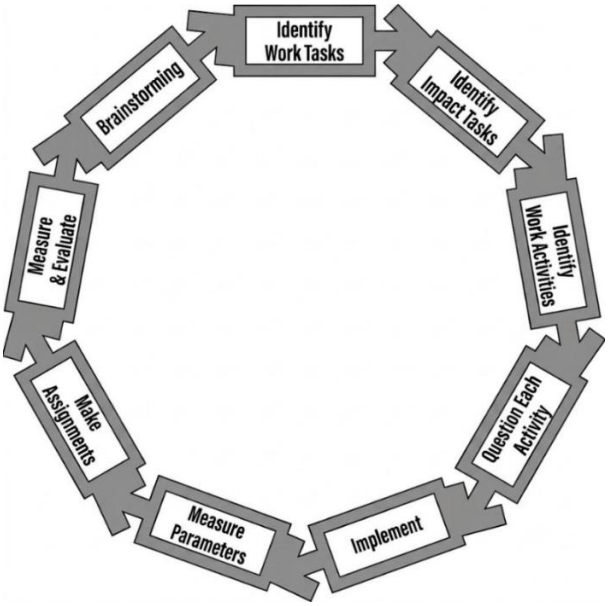
Table 6. Steps of the Lean Six Sigma and ERP implementation frameworks

	Powell, Alfnes, et al. (2013)	Bortolotti and Romano (2012)	Vilpola (2008)	Pellerin and Hadaya (2008)	Berchet and Habchi (2005)	Wallace and Kremzar (2002)	Rajagopal (2002)	Kumar et al. (2013)	Malmbrandt and Åhlström (2013)	Bicheno and Holweg (2009)	Hobbs (2004)	Nightingale and Mize (2002)	Womack and Jones (2003)
Investment and cost–benefit analysis	■				■	■	■						
Define system requirements	■	■	■	■	■	■	■						
Software and vendor selection	■		■		■	■	■						
Business process reengineering	■		■	■			■						
Data cleanup and conversion	■					■							
Software configuration	■	■	■	■		■							
Software installation	■		■		■	■							
Software customisation	■	■	■			■	■						
System integration	■	■				■							
ERP system project Go-live	■	■	■	■	■	■							
Establish strategic goals and vision	■			■	■	■	■			■	■	■	■
Initial education	■		■		■	■				■		■	■
Define performance goals	■	■	■	■		■		■		■		■	■
Define processes	■	■	■	■	■	■	■	■	■	■	■	■	■
Ongoing training / learning	■	■	■	■	■	■			■	■		■	■
Continuous improvement	■	■		■	■	■		■	■	■	■	■	■
Organisational setup for change	■											■	■
Define and establish teams	■	■						■		■	■	■	■
Implement basic foundations of Lean Six Sigma	■									■		■	
Understand customer needs		■						■	■	■	■		
Define products	■									■	■		■
Establish zero defect mentality	■								■	■			■
Vertical information systems	■									■		■	■
Identify flow and challenges in it	■	■						■	■	■	■	■	
Standardise work								■	■				
Lean accounting	■									■			■
Pull system	■							■	■	■	■		
Measure / control		■						■	■	■		■	

Source: Liutkevičienė et al. (2022)

As Harrison et al. (1997) demonstrated, continuous improvement processes are an ongoing cycle of activities, while business processes are not static but rather dynamic in nature (Nadarajah and Kadir, 2016). A graphical overview of Harrison's continuous improvement activities is presented in Figure 11.

Figure 11. Continuous Improvement Process



Source: Harrison et al. (1997)

Operational inefficiencies can be eliminated continuously on a project-by-project basis by taking each project through the define-measure-analyse-improve-control (DMAIC) phases (Lokkerbol et al., 2012). Kumar et al. (2013) used DMAIC when executing the Lean Six Sigma improvement initiatives and achieved customer service excellence as well as better financial results. Sunder M (2016) discusses DMAIC usage when adapting Lean and Six Sigma tools in banking and financial service companies.

There are two ways in which ERP can be helpful in continuous improvement projects. Firstly, ERP can maintain and automate standardised work while ensuring that work is done in an exact sequence and format (Ghobakhloo and Hong, 2014). Secondly, ERP systems deliver process and performance data to Lean improvement projects and create a so-called "data-driven decision-making culture" in companies (Pritchard, 2013; Halgeri et al., 2011; Nauhria et al., 2009).

1.3.5. Theoretical grounding for a combined ERP and Lean Six Sigma implementation framework

Based on the analysis and comparison of the relevant frameworks for isolated and integrated implementation of Lean Six Sigma and ERP systems presented above, a synthesis of principles is proposed. The aim is to offer a framework for companies that intend to improve operations performance using ERP and Lean Six Sigma and are in the early phases of deploying the two approaches. The synthesised principles for this combined ERP - Lean Six Sigma framework are:

A) **The preparation phase** is important in a framework, as most of the existing contributions highlight the need for developing a transformation programme with a realistic pace for implementation activities which the main stakeholders can commit to. Ownership / responsibility for these efforts must also be allocated to designated individuals and initial training must be planned and executed. The preparation also includes clarifying the starting point in terms of ERP usage and Lean Six Sigma adaptation maturity.

B) **A method for managing and executing improvement projects** is equally important for a framework, and these should preferably be based on DMAIC or a similar continuous improvement approach that can be applied on a project-by-project basis. Such a method / sequence of standardised steps will, of course, need to be applicable to a broad set of smaller / bigger improvement cycles with specific targets and should be tailored to the individual company's needs and resources (Lokkerbol et al., 2012). A project will usually be broken down into the following steps:

- ***Define the current situation and issues***. (Harrison et al., 1997; Nightingale and Mize, 2002; Lokkerbol et al., 2012; Kumar et al., 2013; Nadarajah and Kadir, 2016; Sunder M, 2016).
- ***Brainstorm new ideas*** (Harrison et al., 1997) *and analyse* the possible solutions (Kumar et al., 2013).
- ***Identify and plan*** the tasks for the particular project (Kumar et al., 2013; Harrison et al., 1997; Nightingale and Mize, 2002).
- ***Implement improvement*** (Kumar et al., 2013; Harrison et al., 1997; Nightingale and Mize, 2002).
- ***Measure and monitor the improvements*** (Nightingale and Mize,

2002).

- ***Control and adjust*** (Nightingale and Mize, 2002; Lokkerbol et al., 2012; Kumar et al., 2013; Nadarajah and Kadir, 2016; Sunder M, 2016).

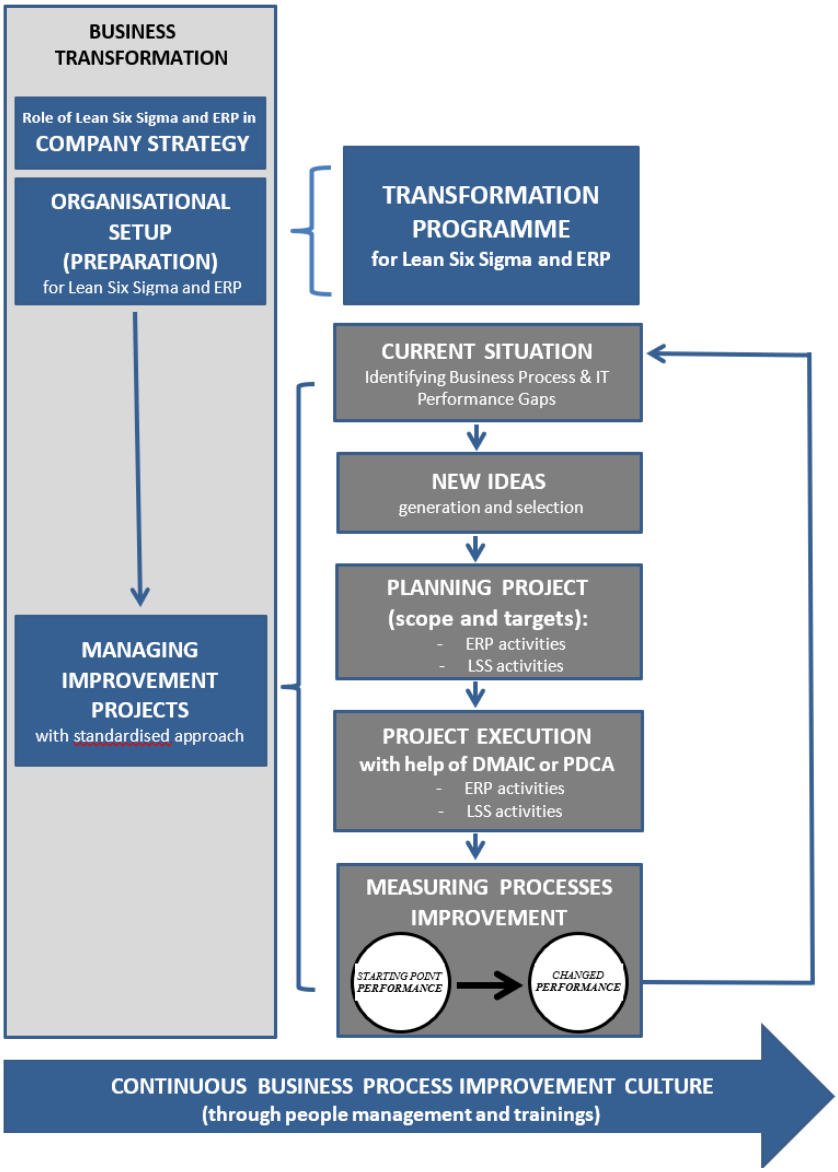
C) **Emphasis on cycles of continuous process improvement** must be included in the steps above as is seen, for instance, with the DMAIC framework.

D) **Evaluation metrics and procedures** should be part of the framework, as a set of business and process performance metrics based on productivity (costs), quality, time and customer satisfaction appears in several of the existing recommended frameworks. For example, Bessant and Francis (1999) with their capability / maturity framework, and Delgado et al., (2014).

There are two ways ERP can be helpful in continuous improvement projects. Firstly, ERP can maintain and automate standardised work, while ensuring that work is done in an exact sequence and format (Ghobakhloo and Hong, 2014). Secondly, ERP systems deliver process and performance data to Lean Six Sigma improvement projects and create a so-called “data-driven decision-making culture” in companies (Pritchard, 2013; Halgeri et al., 2011; Nauhria et al., 2009).

The framework and its steps were developed, and the results are presented later in this section based on a five-year in-depth design science case study that was conducted from 2015 through to 2019. Thus, the framework based on the literature review was constructed in 2014 and presented at the EurOMA 2014 conference. This proposed combined framework of ERP and Lean Six Sigma, focusing on business transformation and improvement project challenges, is presented in Figure 12.

Figure 12. The ERP and LSS framework constructed based on literature review



Source: Created by author

A description of the framework appears below:

- *Step 1: Role of Lean Six Sigma and ERP in COMPANY STRATEGY*. Several researchers, e.g., Hadaya (2008), have stressed that companies implementing LSS or ERP must clearly delineate how these initiatives will contribute to meeting company targets and provide capabilities, conferring

competitiveness for the company in its industry.

- *Step 2: ORGANISATIONAL SETUP (PREPARATION) for Lean Six Sigma and ERP.* A lot of attention is given to the preparation aspect, as mentioned in the Kumar et al. (2013) and Pellerin and Hadaya (2008) frameworks. Responsible people should be identified. A programme for transformation should be created with business processes, along with an ERP strategy being established. A realistic pace for the implementation activities and plan for transformation must be developed, and commitment must be developed by the main stakeholders. The best practices of other companies must be understood.
- *Step 3: MANAGING IMPROVEMENT PROJECTS with a standardised approach.* The actual implementation is the most important part of the transformation process. It is essential that there is a group of people (the transformation team) that manages all ongoing projects and ensures that all project implementations are standardised, with a set of techniques and tools being applied and handled in the same manner, and projects prioritised according to the overall situation in the company. Teams and resources should be arranged for each project, and the targets must be set. Each project must have the same flow:
  - Analysis of current situation, baseline performance, and identification of root causes
  - New ideas and solutions and “paper” validation or analysis of their cost / benefits
  - Planning particular projects
  - Particular project execution / implementation
  - Development of measurements and monitoring of the improvements

  After one particular project is completed, it should be returned for evaluation of the particular situation and the generation of new ideas for the next improvement project, and thereby the cycle should continue.
- *Step 4: IMPROVEMENT CULTURE for Business Process and ERP / IT.* The necessity of creating continuous improvement is mentioned in all three reviewed frameworks of Kumar et al. (2011), and Hadaya (2008). It must be achieved through human resource management and trainings. In the short

term, LSS tools and basic ERP functionality will be required for this. Project manager coaching and training is important. Typically, external consultants or experts are needed to train the trainer within the company, who then becomes the LSS or ERP super user, etc. However, in the long-term leadership coaching must also be delivered, so that middle and top managers develop capabilities for supporting Kaizen activities. Utilising TWI and similar Lean Six Sigma leadership training principles is essential.

To summarise, this section provides the theoretical foundation for developing an integrated ERP – Lean Six Sigma implementation framework aimed at building digitally supported process improvement capability. It demonstrates that ERP and Lean Six Sigma should be understood as complementary approaches, where ERP enables data integration, process, and standardisation, while Lean Six Sigma provides a structured methodology for waste reduction, variation control, and continuous improvement. On this basis, the proposed framework addresses the managerial dimensions of implementation, including process alignment, performance measurement, employee involvement, and organisational learning. To strengthen its relevance and applicability, the framework was later empirically tested to both validate and enhance its theoretical design. The empirical evidence supporting this validation is presented in subsequent chapters of the dissertation.

1.4. Identified mechanisms supporting a combined ERP and Lean Six Sigma approach

Another area where the ERP and Lean Six Sigma combination must be analysed is the organisational mechanisms that can support a combined ERP and Lean Six Sigma approach, leading to digitally supported process improvement capabilities. Therefore, a detailed review of the existing ERP and Lean Six Sigma research has been completed to clarify which set of specific factors is required for companies, particularly SMEs, to accomplish aligned or integrated implementation. Thus, the possible factors, along with their interplay while supporting ERP and Lean Six Sigma approaches, are overviewed in the chapter below, and are derived from the literature.

Overview of LSS and ERP factors based on the existing literature

Based on the literature review, ten factors were identified determining how ERP

and Lean in combination can support building capabilities for process improvement, competitiveness and growth, which are summarised in Table 7 below. The type of paper is indicated, with the letter E referring to empirical papers and the letter T delineating theoretical papers. The symbol ● indicates that the factor was identified in that particular paper, and the symbol ϒ indicates that the factor supports ERP, Lean, or both.

The first factor, highlighted by the existing research, explains that Lean tools and activities can support the elimination of waste activities in ERP projects. Both Ghobakhloo and Fathi (2019) and Powell, Alfnes, et al. (2013) state that Lean practices can be used to simplify and improve data capture and preparation processes for ERP systems. Accordingly, the second factor identified indicates that applying Lean can eliminate waste data in ERP. Powell, Alfnes, et al. (2013) call for Lean practices as a clear strategy to improve data integrity and eliminate the collection of unnecessary data.

The third factor is improving ERP functionality caused by Lean deployment. Companies incorporate Lean best practices into their ERP systems. This includes a variety of new modules, toolsets, and functionalities created in existing software (Blijleven et al., 2019). The fourth factor is the ability, with the help of ERP, to create routines of standardised work. As part of Lean projects, standards are set for routine work, and ERP can maintain this while also ensuring that work is done in an exact sequence and format (Sartal and Vázquez, 2017).

The fifth factor explains how ERP can support flow and enable Lean efforts. ERP systems can provide data that allows for the identification of flow constraints and bottlenecks and thereby support the creation of more flow and demand-driven manufacturing (Powell, Riezebos, et al., 2013). “The automation of information flow is fundamental for pure service companies, where the information is the core of the service, without any physical good” (Bortolotti and Romano, 2012, p. 520).

The sixth factor identifies how ERP systems can enable pull production (Erkayman, 2019). Pull production systems, used for forecasting, inventory and capacity management, require accurate data to function correctly, which is provided by an ERP solution (Powell, Riezebos, et al., 2013). Factor seven explains how ERP systems deliver process and performance data to Lean improvement projects and create something labelled as data-driven decision-making (Maguire, 2016; Ghobakhloo and Fathi, 2019).

Table 7. Factors obtained from the literature to support ERP and Lean Six Sigma

FACTORS	*Support for LEAN SIX SIGMA*	*Support for ERP*	Ward and Zhou (2006)	Masson and Jacobson (2007)	Nauhria et al. (2009)	Riezebos et al. (2009)	Riezebos and Klingenberg (2009)	Hong et al. (2010)	Halgeri et al. (2010)	Powell and Strandhagen (2011)	Powell, Alfnes, et al. (2013)	Bortolotti and Romano (2012)	Powell (2013)	Powell, Riezebos, et al. (2013)	Unver (2013)	Ghobakhloo and Hong (2014)	Stojkic et al. (2014)	Iris and Cebeci (2014)	Bell (2014)	Maguire (2016)	Sartal and Vázquez (2017)	Blijleven et al. (2019)	Ghobakhloo and Fathi (2019)	Erkayman (2019)
Type of paper (T/E)			E	T	T	T	T	E	T	T	E	E	T	T	E	E	T	E	T	E	E	E	E	E
Elimination of waste activities in ERP and simplified processes		V	●	●	●				●		●	●				●			●	●		●	●	
Elimination of waste data in ERP and data integrity		V			●				●		●	●								●	●		●	●
Improvement of ERP functionality		V		●			●		●									●				●		
Standardised work	V			●	●	●	●		●	●	●	●				●	●		●	●	●		●	
Support for FLOW	V			●	●			●	●	●		●			●	●			●	●	●		●	
Support for PULL	V			●		●	●	●	●	●	●		●	●				●		●				●
Data for improvement (KPIs from ERP)	V		●	●	●	●	●	●	●	●	●		●	●	●	●	●		●	●	●	●	●	●
Employee involvement	V	V									●	●		●		●			●	●		●	●	●
Management support	V	V									●		●	●							●	●	●	●
Strategic vision	V	V									●	●										●	●	

Source: Liutkevičienė et al. (2026)

Factors eight and nine concern employee involvement and management support, which is considered critical when improving ERP usage and deploying Lean practices. A Lean culture encourages staff and management to be more interested in the new efficient work processes and tools offered by ERP solutions. IT lead projects that do not capture the business and human dimensions of processes at an early stage are likely to fail (Powell, Alfnes, et al., 2013; Erkayman, 2019).

A set of additional factors for aligned ERP and Lean implementations could be more strategic in nature. Powell, Alfnes, et al. (2013) state that both ERP and Lean approaches should be commenced by deciding on the strategic vision and values of a company. Pre-existing strategic and organisational readiness for process standardisation and improvement in the company are prerequisites for both Lean and ERP success (Ghobakhloo and Fathi, 2019).

Interaction of the factors

The factors obtained from the literature review can be represented in graphical overview, showing the interaction and support for the Lean Six Sigma and ERP approaches. A graphical overview is given in Figure 13, showing both approaches, and the arrows represent to what approach the factor provides the support.

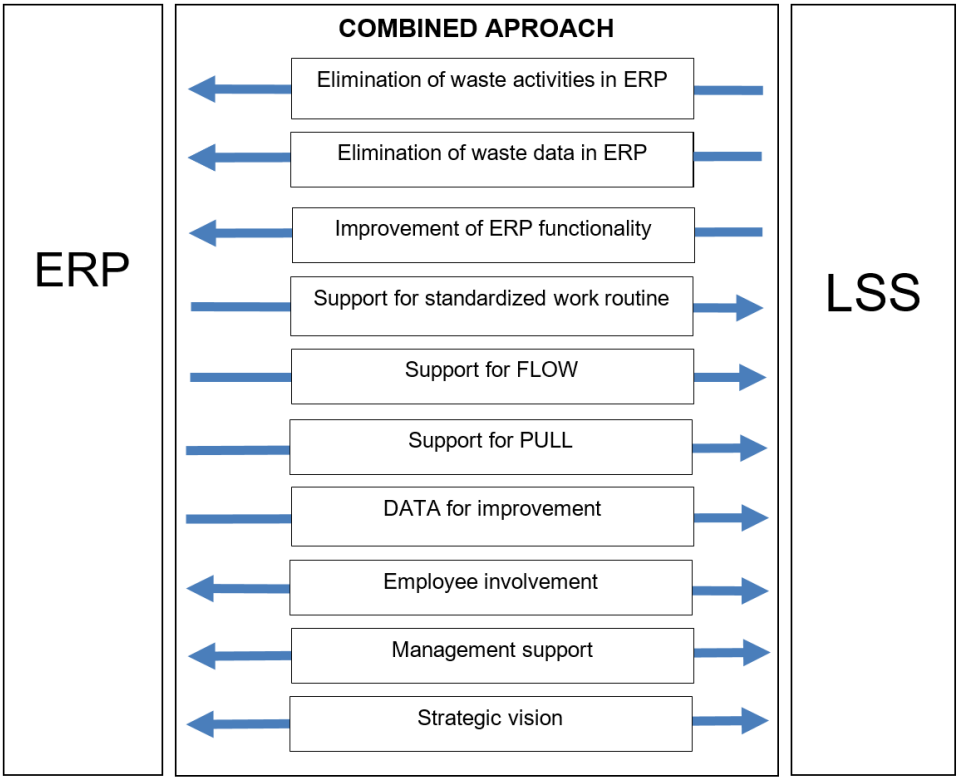
Elimination of waste activities in ERP - Lean Six Sigma supports ERP by identifying and removing non-value-adding activities embedded in digitally executed processes. This leads to leaner ERP-supported workflows and improves the effectiveness of ERP as a process execution platform.

Elimination of waste data in ERP - Lean Six Sigma principles help reduce redundant, unused, or excessive data captured and processed within ERP systems. As a result, ERP data structures become more aligned with process needs and better support fact-based improvement.

Improvement of ERP functionality - Lean Six Sigma guides the purposeful configuration and use of ERP functionalities based on process performance requirements. This ensures that ERP capabilities evolve in line with continuous improvement objectives rather than technical considerations alone.

Support for standardised work routine - ERP supports Lean Six Sigma by embedding standardised workflows and procedures into daily operations. This standardisation creates process stability, which is essential for effective LSS analysis and control.

Figure 13. Interaction of factors of aligned ERP and Lean Six Sigma approaches



Source: Created by author

Support for FLOW - ERP enables Lean flow by integrating end-to-end processes and reducing information silos across organisational functions. Real-time data availability and automated handovers help to minimise delays and interruptions in process execution.

Support for PULL - ERP systems operationalise Lean pull principles by supporting demand-driven planning and execution mechanisms. This allows pull logic to be sustained digitally across complex and interdependent processes.

DATA for improvement - ERP provides accurate and timely process data that forms the empirical foundation for Lean Six Sigma analysis. This data enables measurement, root-cause analysis, and performance monitoring within structured LSS improvement cycles.

Employee involvement - Lean Six Sigma promotes employee participation in

problem identification and improvement, while ERP provides transparency regarding process performance. Together, they enable employees to engage in data-driven and system-supported improvement activities.

Management support - ERP strengthens management support by increasing visibility and control over organisational processes. Lean Six Sigma translates this visibility into structured governance and decision-making for continuous improvement initiatives.

Strategic vision - Strategic vision aligns ERP and Lean Six Sigma by defining long-term improvement and digitalisation goals. ERP operationalises the strategy, while LSS ensures that strategic objectives are pursued through continuous, measurable improvement.

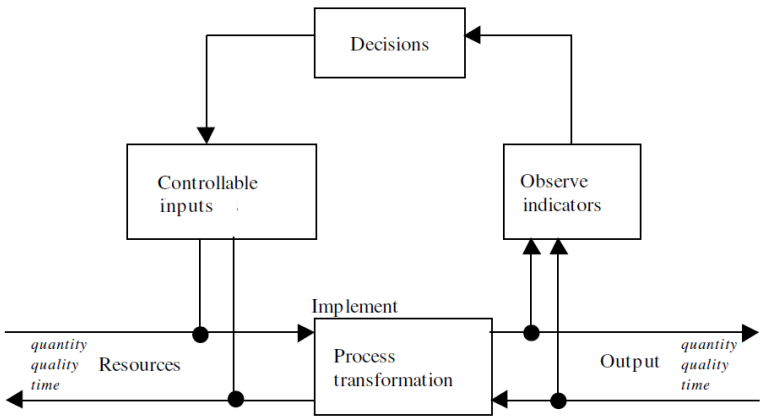
The factors identified above provide an informative list of the important ways that ERP and Lean Six Sigma initiatives can be combined and obtain results together. However, the factors do not sufficiently propose concrete Lean and ERP actions designed to impact intervention outcomes, and nor do they provide explanatory theoretical mechanisms for how ERP and Lean Six Sigma can transform an organisation together. Therefore, the factors were empirically investigated using a more substantiated framework. This was intended to devise more concrete actions and provide a deeper theoretical understanding of the transformative organisational mechanisms by which SMEs can successfully adopt digitally supported process improvement capabilities. This investigation was accomplished via the context–intervention–mechanism–outcome (CIMO) framework (Van Aken, 2004), which is introduced in the methodology section, with the results of empirical testing being presented subsequently in the dissertation.

1.5. Theoretical justification of the continuous digital improvement maturity when implementing ERP and Lean Six Sigma in combination

In previous chapters, I have discussed the potential of creating digitally supported process improvement capability by combining ERP and Lean Six Sigma. It is, though, critical to evaluate whether such a combination can provide any kind of measurable result for organisations. It is taken as given that any well-engineered business process is one in which measures of process performance have been established, and in which process performance is steered in the desired direction by using those measures to control the process (Powell et al., 2001). The ability to

measure the impact of the implemented changes is crucial for business process improvement (Harrison et al., 1997). “It is widely accepted that any well-designed organisational process includes a control mechanism through which it can be decided which aspects of the performance of the process are to be measured and how these measurements are to be used to change the level of resources utilised in the process” (Powell et al., 2001, p.63). It is required that process performance is measured and the information is related back to the current situation for the purposes of the next improvement cycle (Nadarajah and Kadir, 2016). Figure 14 below, based on Powell et al. (2001), shows, a business process and uses of resources can transform inputs into outputs for a customer.

Figure 14. A process measure and transformation model



Source: Powell et al., (2001)

The management of process improvement and its measurement consist of three activities: observation of the situation and particular indicators, assessment of the situation and decision-making, and designing the controllable inputs for the next improvement step. In other words, firstly, indicators should be specified for the processes: process measurements that reflect the efficiency and effectiveness of the process (Powell et al., 2001). Next, an assessment must be undertaken of the indicators observed and “health of the process, that is, to make decisions as to the appropriate value of controllable inputs based on the values of indicators and their goals for the process” (Powell et al., 2001, p.65). Finally, a decision should be made

concerning which controllable inputs will be used to influence process performance (Powell et al., 2001). Measurements make continuous improvement possible at each stage of implementation when underperformance is detected (Sun et al. 2015). The success of the continuous improvement process hinges on the ability to measure and objectively evaluate the impact of the implemented changes (Harrison et al., 1997).

Jääskeläinen and Laihonen (2013) point out that measuring service outcomes carries particular challenges, among them at least the following:

- how to identify a common set of measurable attributes across different types of customers;
- how to establish which factors on the customer side are actually affected;
- how to separate the outcome produced by a given service activity (for example, consultancy) from other factors influencing customers at the same time (for example, an economic recession); and
- how to handle the time lag between a given service activity and the point at which the outcomes materialise.

In an ideal world, a performance measurement system would provide an early warning system showing what has taken place, diagnose the reasons behind the current situation (which often calls for aggregate process management to be broken down into far greater detail), and point to the remedial action that should be taken (Bond, 1999). Service performance is a highly customer-specific phenomenon (Jääskeläinen and Laihonen, 2013). Customer-oriented performance measurement is readily associated with customer satisfaction surveys, although a broader approach to developing measurement is worth considering. A customer may, for instance, take on a role in setting the measurement criteria for service outcomes. With this in mind, customer-target-oriented measurement emerges as a possible way of measuring customer value in a tailored manner (Jääskeläinen and Laihonen, 2013).

Phusavat et al. (2009) discuss four significant roadblocks to implementing performance measurement in an organisation, relating to staff empowerment, budgeting, external knowledge and the link with software use. On empowerment of staff, the authors agree that the sustainability and effectiveness of performance measurement depend on how executives view the people working for them. On budgeting practices, Phusavat et al. (2009) note that the impact of performance measurement can be greatly diminished unless the budgeting process itself

undergoes a drastic change. As for external knowledge, drawing on knowledge from outside sources helps to build staff confidence in the usefulness of performance measurement. On the link with software use, the authors point to many well-known cases in which the selection of unsuitable software has rendered performance measurement futile. Accounting control software, for example, effectively prevents cross-project collaboration within an organisation, particularly where project delays and the customer satisfaction index are among the key performance areas to be measured. “The rigid control imposed by software of this kind has a negative effect on the deployment of performance measurement. Despite excellent financial control and accuracy, where the resources devoted to a single project can be accounted for, such companies do not achieve high performance” (Phusavat et al., 2009, p.659).

Taticchi et al. (2012) proposed that the first step is to define "what" information should be analysed, together with "how" it should be processed and "how" it could be integrated so as to generate valuable information for managerial action. Once the processes have been identified, they are assessed by the performance system that will subsequently be used to report the results achieved. This system concentrates on measuring company processes and other parameters (key performance indicators, KPIs) that matter to the business. A sound performance measurement system, in particular, should not stop at a list of KPIs, but should also establish the relations between them and the degree to which each affects the business. Delgado et al. (2014) argue that measurement is the first step leading to control and, in due course, to improvement. Otherwise, if something cannot be measured it cannot be understood, if it cannot be understood it cannot be controlled, and if it cannot be controlled it cannot be improved (Harrington et al., 1999).

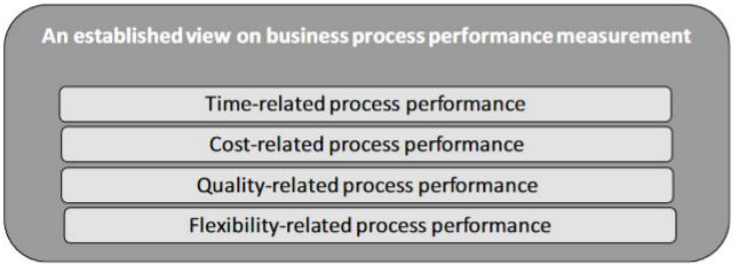
To evaluate whether the Lean Six Sigma and ERP intervention actually enables process-orientation and increased competitiveness for a company, a discussion of how process measurement and improvement capability is going to be evaluated in this work is presented in the following two subchapters. Firstly, a set of business and process performance metrics are discussed, which can benchmark the case evidence. Then, Lean Six Sigma and EPR capability, or the maturity framework, with which improvement capability is going to be evaluated in this work, will be described.

1.5.1. Measuring process performance

When it comes to evaluating the tangible improvements created, companies will

typically have a range of KPIs and a more or less developed performance measurement and reporting system to provide updated numbers for these metrics to inform decision-making, which can compare results to targets set and decide on actions (Tan et al., 2004). Bond (1999) identifies key performance factors: quality; delivery reliability; customer satisfaction; cost; safety; and morale. Internal business processes measurements, according to Van Looy and Shafagatova (2016), are flexibility; productivity; quality; process time; and cost. Dumas et al. (2013) posit that time; cost; quality; and flexibility are the typical performance perspectives of business process performance measurements, as shown in Figure 15 below.

Figure 15. An overview of the process performance perspective



Source: Dumas et al. (2013).

Each of the four dimensions is discussed briefly below, along with the ways in which it is typically translated into specific performance measures.

Time: This is often the first performance dimension when analysing processes (Dumas et al., 2013). Cycle time is one of the most commonly used process performance measures, referring to the time required to handle a single case from beginning to end. Process performance can be improved by reducing the average or longest cycle time. Another important objective is achieving compliance with cycle time targets established with customers. Furthermore, attention may be directed to cycle time variability, a key concern in quality improvement approaches such as Six Sigma. A more detailed evaluation of time-related performance can be achieved by distinguishing between the main components of cycle time:

• Processing time (also called service time): refers to the period during which process resources, including personnel and information systems, are actively engaged in executing tasks associated with a case (Dumas et al., 2013).

• Waiting time: represents periods of inactivity within the process. These delays

may result from resource shortages, creating queueing time, or from dependencies on other processes, activities, or external parties whose input is required before work can continue (Dumas et al., 2013).

Cost: Another performance dimension that commonly comes into play when a business process is analysed and redesigned is financial in nature (Dumas et al., 2013). The emphasis could equally well be placed on turnover, yield or revenue, given that an increase in yield may have the same effect on an organisation's profit as a reduction in cost. Cost can be viewed from several perspectives. Dumas et al. (2013) draw a distinction between fixed and variable costs:

- Fixed costs are overheads that remain largely unaffected by the intensity of processing. They arise most commonly from the use of infrastructure and the maintenance of software systems.
- Variable costs move in step with some measurable quantity, such as the volume of sales, the number of goods purchased, or the number of staff recruited.

Closely related to productivity is the notion of operational cost, which can be linked directly to the outputs of a business process. Labour cost usually accounts for a substantial share of it, that is, the cost of the human resources engaged in producing a good or delivering a service (Dumas et al., 2013).

Quality: The quality of a business process can be viewed from at least two different angles (Dumas et al., 2013): from the client’s side and from the perspective of the process participant. Dumas et al. (2013) frame this as the distinction between external quality and internal quality.

External quality, in the account given by Dumas et al. (2013), is measured through the client's satisfaction with either the product or the process. Product satisfaction reflects the extent to which the delivered output meets the client's specifications or expectations, with service level agreements setting out what those expectations are. Process satisfaction concerns how the work is carried out and turns particularly on the quality and timeliness of the information clients receive about progress whilst execution is under way. The authors identify two common measures: churn rate, which captures the proportion of interactions customers abandon before completion and matters most in online settings, and net promoter score, which records on a ten-point scale how willing customers would be to recommend the

product or service.

Internal quality, by contrast, is concerned with the perspective of those taking part in the process. The issues that arise here include the degree of control participants feel over their work, the level of variation they encounter, and whether the work itself is experienced as challenging (Dumas et al., 2013).

Flexibility: The performance criterion least often noted when the effect of process redesign is measured is the flexibility of a business process (Dumas et al., 2013). Flexibility can be defined in general terms as the ability to respond to change. Such changes may affect various parts of the business process, for instance, following Dumas et al. (2013):

- the ability of resources to carry out different tasks within a business process setting;
- the ability of a business process as a whole to cope with various cases and with changing workloads;
- the ability of management to alter the structure and the allocation rules;
- the organisation's ability to alter the structure and responsiveness of the business process so as to accommodate the wishes of the market and of business partners.

Another way of approaching flexibility as a performance dimension is to draw a distinction between runtime and build-time flexibility (Dumas et al., 2013). Runtime flexibility concerns the scope for dealing with changes and variations while a particular business process is being executed. Build-time flexibility concerns the scope for altering the structure of the business process itself. Setting the flexibility of a business process apart from the other dimensions is becoming increasingly important (Dumas et al., 2013).

Delgado et al. (2014) approach the same question from a different direction. They gather the concepts used for process measurement and arrange them in two groups. The first covers measures that apply to business processes in general, the second those that apply to processes delivered through services.

Among the general measures, throughput time records the whole period from the initiation of a case to its completion, while capacity expresses how many cases the process can handle per unit of time and points to where the bottlenecks lie. Resources refer to the tangible assets required to carry out the activities, and cost to the human resources consumed in producing a good or delivering a service. Path

execution distinguishes cases that complete successfully from those that do not, for example a card payment that is authorised against one that is rejected. Quality is treated in two senses, externally as the satisfaction of the user with the product or the process, and internally as the conditions under which people work within it. Flexibility describes how far the process can react to change, whether in the resources performing the tasks, in the volume of work or in the structure of the process itself (Delgado et al., 2014).

Four of the general measures come close to the vocabulary of Lean. Rework denotes a loop in the process where criteria decide whether a job may continue. Value-adding activities are those the process needs in order to meet what the customer expects, and non-value-adding activities are those that do not contribute to that outcome. Defects and errors are the faults in the process or the product that led to repair, rework and waste (Delgado et al., 2014).

The service-oriented measures address the behaviour of the systems through which the process runs. Response time is the interval within which a response to an event is guaranteed, throughput the number of responses completed within a given interval, and capacity the highest throughput that can be reached without breaching the agreed response time. Availability concerns whether the service is ready for use and reliability whether it keeps working overtime. Confidentiality and integrity concern the data, the first keeping it out of reach of unauthorised users and the second protecting it from unauthorised change (Delgado et al., 2014).

Two features of this classification matter for the present study. Capacity and throughput appear in both groups with different meanings, which is a reminder that the same term can be defined at the level of the process or at the level of the system that supports it, and that the two should not be mixed when indicators are set. The classification also brings the operational and the technical measures into one frame, which suits a study of processes that are executed in an ERP system and improved through Lean Six Sigma, since evidence of improvement has to be visible on both sides.

Typical business process metrics or KPIs recommended for a study of ERP and / or Lean Six Sigma implementations include the following measurement categories, which I will also emphasise in this study: productivity (costs), quality, time, and customer satisfaction orientation (Delgado et al., 2014). I have used definitions of the four KPI categories which were applied in the company and have not developed

additional metrics to track any implementation benefits. The specific metrics for the case were: cost-based productivity (revenue in EUR versus number of employees); the customer recommendation rate; support tickets per customer; the percentage of tickets solved during one day; and the time length of project implementation.

It is important to ensure that performance measures are aligned with organisational objectives (Lucianetti et al., 2019). For example, if the organisation is pursuing a low-cost strategy, then an adequate and relevant number of performance measures should be specified in order to attain information that can be used to steer organisational actions towards a low-cost strategy (Lucianetti et al., 2019).

1.5.2. Measuring improvement capability

Regarding company maturity, with respect to process orientation or Kaizen practices and culture, previous research has already produced a set of capability / maturity frameworks. I propose applying the widely disseminated Bessant and Francis (1999) model, as it provides a detailed outline of the different maturity levels that were previously operationalised (Hansen and Møller, 2016).

The maturity model by Bessant and Francis (1999) operates on six levels. The first is the absence of any continuous improvement activity, marked by problem-solving that happens at random. The second is the trying out of ideas, where the effects remain local to those immediately involved with the continuous improvement, or stem from short-term inputs such as a training intervention. The third is structured and systematic continuous improvement, marked by structured efforts such as an idea management or recognition system, by formal attempts to create and sustain continuous improvement through a formal problem-solving process, and by the use of participation, with training in continuous improvement tools broadened out and time set aside for the work. The fourth is strategic continuous improvement, which brings in all of the above together with the formal deployment of strategic goals and the measurement of continuous improvement against those goals. The fifth is autonomous innovation, which adds broad responsibility devolved to problem-solving units, generating high levels of experimentation and both incremental and discontinuous innovation. The sixth is the learning organisation, where everyone is actively involved in continuous improvement and treats it as the dominant way of life.

Table 8 shows each maturity level in the continuous improvement capability model of Bessant and Francis (1999), describing performance and practices.

Table 8. Summary of continuous improvement capability maturity levels

Level	Performance	Practice
0 = No continuous improvement activity	No impact arising from continuous improvement.	Unstructured problem-solving carried out mainly by specialists. Activity occurs in occasional bursts, separated by periods of inactivity and non-participation. Benefits are short-term, with no strategic impact.
1 = Trying out the ideas	Effects that are minimal and purely local.	Improvement arises from learning-curve effects tied to a new product or process, or from a short-term input such as training, and tails off once these are exhausted. Effects are short-lived and highly localised.
2 = Structured and systematic continuous improvement	Some improvement in morale and motivation.	Formal, sustained improvement supported by a defined problem-solving process, participation, CI training, structured idea management and recognition. Runs parallel to operations, with ad hoc cross-functional work.
3 = Strategic continuous improvement	Effects at local level, with continuous improvement activity that can be measured (the number of participants or the number of ideas)	All of the above, together with the formal deployment of strategic goals. Continuous improvement monitored and measured against those goals. In-line system.
4 = Autonomous innovation	Measurable effects on performance but confined to individual projects.	As above, but with the problem-solving unit itself taking responsibility for mechanisms and timing, which brings high levels of experimentation.
5 = The learning organisation	Little or no impact on the bottom line.	Continuous improvement is the dominant way of working, with learning captured and shared automatically, everyone actively involved in innovation, and both incremental and radical change pursued.

Source: Bessant and Francis (1999)

Bessant and Francis (1999) argue that continuous improvement capability matures through an evolutionary process, one requiring new behaviours to be

accumulated and integrated over time. As these behaviours mature, their performance impact broadens accordingly, shifting from the local to the organisational level and from the operational to the strategic (Bessant et al., 2001).

The Bessant and Francis (1999) maturity model for continuous improvement capabilities was used in this research as a sensitising concept to investigate whether the cases developed continuous improvement capabilities. It was chosen for the details and the examples it offers at each level.

RESEARCH DESIGN

There is a vast volume of research analysing ERP and Lean Six Sigma in isolation, while the combined approach of ERP and Lean Six Sigma is not researched enough in organisations. Therefore, in this research, the aim is to **propose and evaluate a generic framework for a combined ERP and Lean Six Sigma implementation for developing continuous improvement capability, together with identifying mechanisms that can enable process-orientation in SMEs, while implementing the integrated framework.** A longitudinal case study is employed, which was feasible and practical for capturing a combined Lean Six Sigma and ERP implementation to achieve the research aim. Design Science Research (DSR; Van Aken et al., 2016) and Action Research (Coughlan and Coghlan, 2009) and their longitudinal, participative case study research were a source of inspiration for combining ERP and Lean Six Sigma, as outlined in this study.

Therefore, the research began with a pre-research interview with the continuous improvement consultant. Whilst I managed a company at that time, which was engaged in ERP implementation, it was crucial for me gather as much knowledge as possible regarding continuous improvement practices to commence intervention in the company that could build continuous improvement capability based on ERP and Lean Six Sigma combined approach. The initial methodology that was applied to conducting and analysing this pre-research interview is presented in this chapter, and later in the chapter, I present both methodologies and describe how they were used when conducting the intervention and design of the case study.

2.1 Pre-research interview with field expert

This sub-chapter explains how the consultant was selected, how the interview was conducted, as well as the analytic strategy, together with describing how the data analysis was conducted, what difficulties were encountered, and providing a short.

There was the interview conducted with one of the known improvement consultants. The main criteria were the involvement and benevolence of the interviewee, with the likelihood of being able to communicate openly also being important. The interview took place in April 2014, before continuous improvement initiatives were commenced in the company.

The rationale for the chosen analytic strategy

For the analysis of interview data, the method of template analysis was used, based on Cassell and Symon (2004). This method was chosen because it is flexible and allows the researcher to meet their own requirements. The term template analysis refers to a particular way of thematically analysing qualitative data (Cassell and Symon, 2004). It is suitable for any kind of textual data, which can be interview transcripts, diary entries, text from electronic interviews, answers to open questions in written questionnaires and others. The flexibility of the method is very important for a researcher at the starting point of his / her work, offering possibilities to change and adapt the template during the process at the most suitable moment. The process commences with a coding template, but that is open to subsequent changes.

Conducting the data analysis

Template analysis was used to develop a coding template summarising the themes identified as important within the dataset and arranging them hierarchically (Cassell and Symon, 2004). The analysis began with a set of a priori codes representing themes expected to be relevant, treated as provisional and open to revision or removal where they proved unsuited to the data.

The data were first read through and any segment bearing on the research was marked. Segments matching existing themes were coded accordingly; those that did not prompted the definition of new themes (Cassell and Symon, 2004). These were arranged into an initial template once a subset of the data had been coded, after which the template was applied to the dataset as a whole and modified in the light of a careful reading of each transcript. Once a final version had been settled and all transcripts coded, it formed the basis on which the dataset was interpreted and the findings established.

Difficulties encountered

One of the difficulties in analysing this interview that should be mentioned concerns translation. As part of the interview was in, that segment had to be translated into English because the research and resulting presentation will be in English. The largest challenge was to an exact written description of the speaker's thoughts, as the translation of words can influence the research outcome. Part of the interview was held in English, but that seemed to be difficult for the interviewee. There

were a lot of mistakes in the spoken text, making it challenging to present the transcript of the interview in a proper and correct way. The researcher was aware that the correction of errors had the potential to alter the meaning of ideas expressed in the interview.

Another point to mention is that the interview, as well as its transcript and analysis, took far more time than originally expected. The process contained sudden changes and issues that did not go as planned. However, a researcher has to be open-minded and ready to deal with unexpected things, such as it is not always possible to keep to the planned sequence of questions, and in some cases the interviewer gives an answer that does not relate to the question that was asked. Asking clear and simple questions, controlling the interview flow, and obtaining answers that are pertinent to the question asked was sometimes challenging.

Analysing the data required special analytical, interpretive, and observation skills. To understand the relations and draw the outcome out of text data requires experience. It is difficult to do high-quality work in a first attempt, and this process, as well as the data gathering, has been a learning experience for me.

Reflection on conducting qualitative research

My experience is that conducting qualitative research can be difficult at times. It can be difficult to plan and complete on time, and experience and practice are needed to understand the links and patterns when analysing the data and drawing conclusions. The possibility of various different interpretations could be challenging for the researcher in the early phase.

The interview process was less controlled than expected. Questions had been prepared but formulating them in a way that the interviewer could understand them was not always easy. In some instances, questions had to be repeated or rephrased.

The English / Lithuanian language translation also made the process more complex. Initially, the interviewee offered to do the interview in English, but when that became, the language was changed to Lithuanian. Thus, the translation issue arose; additionally, the non-English answers contained a lot of mistakes that had to be dealt with during the transcription process.

The analysis of data has shown the diversity and wide scope of information that can be derived from one interview. During this study it became necessary to think in new ways that supported open-mindedness, while being prepared for unexpected

issues to appear.

Despite the challenges when conducting the interview, the usefulness of qualitative research is clear. Management and business contexts offer different lookouts, which pave the way for different perceptions as to what is happening within a company, and its customer relationships. Qualitative approaches, such as case study research or deep interview analysis, entail efforts to address complexity while accepting that the object of study can be confusing and / or ambiguous, which can add further variables and categories to a context. This kind of research is less rigorous than traditional quantitative approaches but can provide greater relevance.

In conclusion, although qualitative research is carried out in both business settings and academic institutions, quantitative work continues to be regarded as more scientific and therefore superior, notwithstanding its limited capacity to accommodate complexity. It could be argued that when addressing the complex reality of management issues, a qualitative methodology supported by modern natural sciences is superior to a quantitative methodology emanating from traditional natural sciences (Cassell and Symon, 2004).

2.2 Research Setting

This section of work is dedicated to describing the research setting: methods used for empirical testing, the way the case was selected, the research process model, the data collection, the data analysis, and the role of researcher.

2.2.1 Methods used for empirical testing

The empirical testing phase was based on the Action Research and Design Science Research (DSR) methodologies. Both methodological approaches are discussed in the following sections.

Action research design

Due to the qualitative nature of this investigation and the type of research question, the research methodology selected was action research, which can also be compared to longitudinal, participative case study research (Coughlan and Coghlan, 2002). Action Research (Coughlan and Coghlan, 2002) and longitudinal, participative case study research were a source of inspiration for the framework combining ERP and Lean Six Sigma, as outlined in this thesis.

Action research helped for this study because it accommodates the two requirements the research design imposed: sustained engagement over time, and the combination of intervention with inquiry. Reason and Bradbury (2007) define action research as a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview. Its defining feature is the pursuit of change and the production of knowledge as a single undertaking rather than as separate activities, a point the authors capture in observing that action without reflection is blind, whilst theory without action remains inert.

Coghlan (2011) offers a compatible account, describing action research as an emergent process of inquiry in which applied behavioural science knowledge is integrated with existing organisational knowledge and brought to bear on real organisational problems. It works simultaneously towards change within the organisation, the development of self-help competencies among its members, and the advancement of scientific knowledge (Coghlan, 2011). This threefold orientation made the approach well suited to a study conducted over an extended period, in which successive interventions were both the means of bringing about improvement and the source of the evidence on which the analysis rests.

Action research was used in the study to determine the roles of the researchers conducting the study and the intervention in the company (Brydon-Miller, 2009). I held a managerial role in the company while also being the primary data collector. This dual role meant that the researcher managed the project and the study simultaneously; a dual position that requires clear research roles and structure (Coughlan and Coghlan, 2009).

Action research is built on a program theory concerning the effects of certain changes (Coughlan and Coghlan, 2009). In this research, I analysed the real scenario prevailing in a service company engaged in applying Lean Six Sigma initiatives and improving ERP usage. To do so, a research strategy was designed to collect information from the actual company environment. This action research required the skills to implement Lean Six Sigma tools and facilitate the industry to work on productivity and improvements. As a researcher, I measured the outcomes for further analysis and provided a discussion in later segments of this dissertation.

Attention was also given to the role of each person involved in the research project, since this bears directly on the validity of the study. My position inside the

company gave me access to the data and allowed me to carry out the interventions, analyse them and describe the outcomes, while the two consulting researchers, who were co-authors of the publications produced from this work, took an active and challenging role. Their scrutiny helped to reduce the natural biases arising from my own involvement in the company.

Design Science Research (DSR)

The research methodology was inspired by Design Science Research (DSR; Van Aken et al., 2016), which aims to develop knowledge that can guide action in future situations. By utilising the Context-Intervention-Mechanism-Outcome framework (CIMO) (Aken, 2004; Denyer et al., 2008), the study sought to identify explanatory mechanisms for implementing integrated ERP and Lean Six Sigma by studying the real-life intervention in its full context, and utilising the rich data derived from various sources to identify mechanisms that can be analysed for future use. DSR was selected due to the conceptual, qualitative, and application-oriented nature of the research questions.

DSR aims to discover knowledge that can be used to predict action, in this case the development of an empirically tested framework. Based on principles identified in the literature, the DSR strategy was used in a company setting for developing practical knowledge grounded in a participatory worldview (Reason and Bradbury, 2007). Through an emergent inquiry process that combined the applied behavioural science knowledge from scholarship with existing organisational knowledge, the process led to organisational problem solving through the implementation of ERP and Lean Six Sigma and the development of continuous improvement capability among the members. It also yielded scientific knowledge, i.e., an empirically tested framework for the implementation of ERP and Lean Six Sigma. In order to assess the success of the implementation, a number of metrics were used to investigate the impact on service operations and improvement capability.

Similar to a case-based action research approach, the DSR strategy investigates an intervention in a company setting and requires a participatory process concerned with developing practical knowing grounded in a participatory worldview (Reason and Bradbury, 2007). Coghlan (2011) adds that when working with an emergent inquiry process in which applied behavioural science knowledge is integrated with existing organisational knowledge and applied to solve real organisational problems, the

process will bring about organisational change, both via developing self-help competencies in organisational members and by adding to scientific knowledge.

The findings of this dissertation derive from the outcomes of an intervention. The intervention was designed in collaboration with the case company, and data pertaining to it were gathered both prior to and following its implementation. The analysis was guided by the Context, Intervention, Mechanisms and Outcomes (CIMO) model, proposed by Van Aken and colleagues (2016) for research in operations management. Grounded in a design science approach, CIMO permits systematic comparison of variation in context and in intervention practices, thereby enabling identification of the mechanisms that increase the likelihood of a successful intervention (Van Aken et al., 2016). The research process focuses on bringing about change while also contributing to new knowledge. By using a systematic and pragmatic analytical model of the CIMO framework, drawing on the approach used by Hamja et al. (2022), general findings were developed. This study developed knowledge about the possibilities to create continuous improvement while combining ERP and Lean Six Sigma.

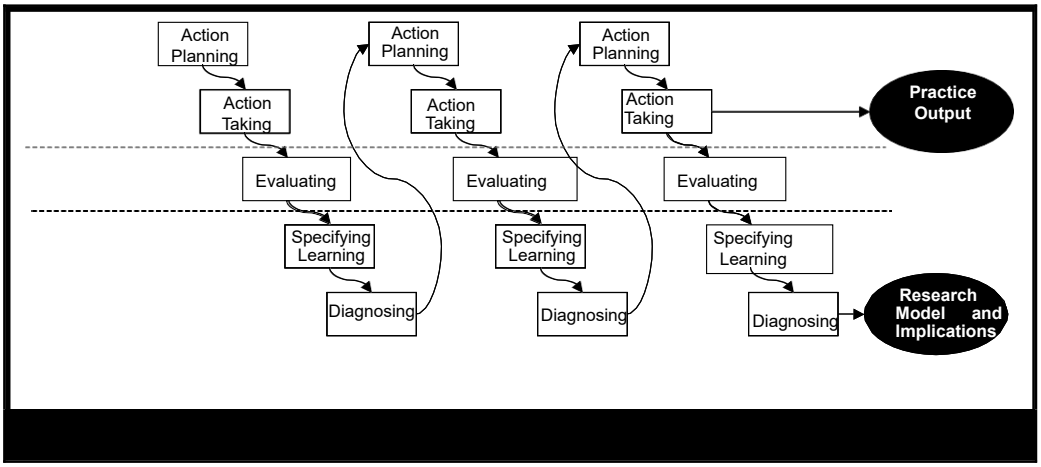
2.2.2 The case selection and the research process

Myers (2013) argues that collaboration and engagement of a case company is crucial. Having a researcher who also holds a management role in the case company gave access, high levels of collaboration, and engagement. The selected case company was a small IT company based in Lithuania with responsibility for sales, implementation, and support in the local marketing of a software solution that was initially created in Estonia. The scoping of the problem was done in 2015 and based on the results of a customer satisfaction survey that showed a need for more effective processes in the company. This led to the formulation of the intervention study for the period of 2014 - 2019. The company had a clear incentive (Myers, 2013) to complete the research project to develop its competitive edge.

The research process model is shown in Figure 16, adopted from Coghlan and Brannick (2009).

The evolving research process identified how each stage of the research process built on data generated in the previous stage. Within each stage there are five sequential activities – action planning leading to action taking, followed by a period of evaluating, specifying learning, and diagnosing issues for the next stage.

Figure 16. Research process model



Source: Coghlan and Brannick (2009)

Each improvement project is taken through the three or four action research cycles. This means that process improvement is planned, necessary actions are taken, the result of the action is evaluated, learning derived from it is specified, and diagnoses are accomplished, upon which the next action planning is based. “In working within the realm of practical knowing, where knowing is always incomplete and where reflexive attentiveness to unfolding contextual dynamics is central to both understanding and action, action research’s emphasis on cycles of action and reflection is paramount” (Coghlan, 2011, p.61).

This type of process improvement is at the base of the PDCA cycle used in LSS. This stands for Plan, Do, Check, and Act, and it goes together very naturally with the action research model. Throughout all these cycles, data was gathered and discussed with my PhD supervisor in terms of the research, as well as with the Lean Six Sigma consultant in terms of improvement capability creation.

After four completed annual improvement cycles, together with research cycles, the description of the research was completed for the publications, and consultations took place with the two other researchers involved.

The role of the researcher is discussed further in the next chapter.

2.2.3 The role of the researcher

The researcher role is important in all research. My position as a researcher raised a question that had to be settled before anything else: who was I in relation to the setting and the people working within it? Action researchers face this in a form that other researchers largely do not, since the relationship to the site and its participants is itself part of the method rather than a preliminary to it (Herr and Anderson, 2005). The difficulty is compounded by the fact that an action researcher may stand inside or outside the setting and may be pursuing collaborative relationships with those taking part, which makes the implications of that positioning far from self-evident (Herr and Anderson, 2005).

Nor are the categories themselves stable. Thomson and Gunter (2011) show that insider and outsider status is layered and mobile, shifting as a study proceeds rather than holding fixed throughout. This matters practically as well as conceptually: clarity about where the researcher stands underpins any assessment of validity or trustworthiness and bears directly on the ethics of the work (Herr and Anderson, 2005). Academic research has gone further than traditional evaluation studies in working out how insiders can properly be brought into the research process, whereas commissioned work of the latter kind is more often organised around solving a specified problem or appraising a particular programme (Herr and Anderson, 2005).

The position described here is that of the practitioner researcher, where the person conducting the study and the person engaged in the practice are the same (Coghlan and Brannick, 2009). Working this way offers two things at once: it deepens reflection on one's own practice, with problem-solving and professional development as the aim, and it produces knowledge of that practice from within. Establishing where one stands is rarely straightforward, but it is not a preliminary that can be set aside (Herr and Anderson, 2005)

While positioning my role in the research, I relied on the discussion of Herr and Anderson (2005) regarding the continuum and implications of positionality. Their continuum sets out six positions, running from the researcher who studies their own practice, through several forms of collaboration between insiders and outsiders, to the outsider who studies insiders. Every position on the continuum contributes to the knowledge base and to improved or critiqued practice. The difference between them does not lie in whether research is produced, but in what else the work is able to change (Herr and Anderson, 2005).

At the insider end, the research also serves self and professional transformation, because the person carrying out the study is the person whose practice is under examination. The collaborative positions in the middle, whether insiders working together, insiders working with outsiders, or reciprocal insider and outsider teams, extend this effect to professional and organisational transformation, since the findings are worked through by people who stand in different relationships to the setting. At the outsider end, where outsiders collaborate with insiders or study them, the contribution shifts towards organisational development and transformation. The researcher still influences the organisation, but no longer their own practice within it (Herr and Anderson, 2005).

Using the Herr and Anderson (2005) classification, I was an insider. I was the researcher and the practitioner one and the same. I conducted the research while holding a managing role in the company under study, which gave me direct access to its processes, to the people who carry them out and to the reasoning behind the decisions taken about them. Familiarity of this kind shortens the distance to the data, but it also makes it harder to notice what has become ordinary through daily exposure. Nevertheless, I wanted the research to make a contribution to my own setting and clients, to empower myself professionally and personally, and to deliver organisational change in my managed company. While completing the change, it was important to me to create meaning from the practice. I felt as though I am also a practitioner engaged in “learn to learn” about my practice, and thereby becoming a better practitioner. In a sense, I was a practitioner learning and developing to be a researcher and providing case study data on how my organisation evolved. It was important to me to be an insider, who generates important knowledge to be shared among practitioners. I also wanted to build a knowledge base that can inform the research community about the actions and beliefs of practitioners — a knowledge base that is otherwise unavailable as noted by Herr and Anderson (2005).

Therefore, I was in changing positions through the years of research from being an insider, in collaboration with other insiders, and an insider in collaboration with outsiders. While initiating the change in the organisation, I involved my team throughout the process. This was aimed not only at using collaborative approaches to the inquiry, but also re-culturing the organisation.

As an insider in collaboration with outsiders, there were a couple of important perspectives. Firstly, an external consultant was involved who helped with

transformation of the organisation, providing trainings for the team. Another perspective was that the researchers from Denmark were consulted concerning the methodology.

I needed to play an active role in conducting the intervention in the company. Consulting researchers were concerned with ensuring the quality of the data collection and analysis. This dual role meant that I both managed the transformation project in the organisation and studied it at the same time, which requires clear research roles and structure, as discussed by Coughlan and Coghlan (2009). This role is increasingly common in the context of managers participating in academic programmes (Coughlan and Coghlan, 2002). As noted by Nosek (2007), an insider action researcher can provide sensitive data to which outsider action researchers may not have access, and they are capable of systematically evaluating organisational interventions. Doing research in and on one's own organisation means that a member of the organisation is undertaking an explicit research role in addition to the normal functional role that they hold in the organisation (Nosek, 2007). I had to balance my organisational role, which continued, with the additional demands of an inquiry and research role. I also needed to be aware of how my role influenced my view of the world, as well as how I am perceived by others, and to be able to make choices as to when to step into and out of each of the multiple roles I held.

Carrying out action research demands a more disciplined cycle of work than everyday practice tends to require situations must be diagnosed, action planned and taken, and the results evaluated, each with a rigour that ordinary organisational routine seldom imposes (Coghlan and Holian, 2007). There are many issues I had to consider while embarking on research within my own organisation. Questions also arose about maintaining sufficient distance from the setting, achieving anything approaching objectivity requires that personal assumptions and interpretations be examined rather than taken as given (Coghlan and Holian, 2007). There is the matter of using appropriate frameworks for viewing, understanding, summarising and conveying meaningful descriptions of the data that has been gathered (Greenwood and Brydon-Miller, 2006). Reporting raises its own questions, from how the study should be written up and fed back to how it might be disseminated beyond the organisation. The most sensitive question, however, concerns interpretations or findings the organisation would rather not see published, and how these are to be managed (Coghlan and Brannick, 2009).

Undertaking action research within one's own system can be seen to involve managing the interlocking challenges (Coghlan and Brannick, 2009). As an insider action researcher, I needed to build on my closeness with the setting, which was easy to do as a manager of the company, while, at the same time, creating distance from it in order to see things critically and enable change to happen. This is referred to as preunderstanding (Coghlan and Brannick, 2009). Holding dual roles, as a company manager and an action researcher, can create ambiguities which may involve role confusion, role conflict, and role overload, as noted by Coghlan and Brannick (2009). I also had to manage organisational politics with responsibility for the success and quality of the action research. Coghlan and Brannick (2009) point out that these challenges are not static ones. Action research is a dynamic and iterative process in which the situation itself changes as a result of deliberate action. Preunderstanding, role duality and organisational politics all shift, whether as the consequence of deliberate action or as the unintended consequence of actions taken (Coghlan and Brannick, 2009).

Coghlan and Brannick (2009) remind that an attempt to drive radical change from within exposes the researcher to considerable difficulty and personal risk. Meeting these demands calls for self-reflection alongside a willingness to be vulnerable, together with realistic expectations, tolerance, humility, generosity, self-containment and a capacity to keep learning. As the manager, I was a supporter of the people in the organisation, and as an insider change agent, I was a saboteur of the organisation's rituals and a questioner of some of its beliefs. The account offered by Coghlan and Brannick (2009), which presents insider action research as taxing yet invigorating, and as advancing the researcher's learning alongside the development of the organisation, accords with my own experience of conducting this study.

2.2.4 The data collection

In order to investigate the intervention, rich methods of data collection were used. Coughlan and Coghlan (2002) identify two types of data. Data of the first kind, commonly termed hard, derives from sources such as financial accounts and reports (Coughlan and Coghlan, 2009). The second kind, described as soft, comes from observation, discussion and interviewing. The label reflects the perceptual character of such material and the interpretive difficulty this creates, since establishing a valid

reading of it is rarely straightforward (Coughlan and Coghlan, 2009). The author confirms that both sources of data were used regarding the case company: financial and all other reports where intensively monitored, mainly via ERP and observation, and discussions with team members were also carried out.

In action research it is common for data generation to be derived via active involvement in the day-to-day organisational processes. “Not only is data generated through participation in and observation of teams at work, problems being solved, decisions being made, and so on, but also through the interventions which are formed to advance the project” (Coughlan and Coghlan, 2009, p.231). The observations and interventions in the case company were made in formal settings - meetings and interviews that were held regularly: each year, quarter, week, or every day, such as stand-up meetings, as well as in informal settings, such as over coffee, lunch, and other recreational settings. Both formal and informal observation settings are supported by Coughlan and Coghlan (2002).

“In action research, directly observable behaviour is an important source of data for the researcher” (Coughlan and Coghlan, 2009, p.231). Observations of the dynamics at work, for example, communication patterns, behaviour, routines, norms, elements of culture, problem-solving, and decision-making provide the basis for the inquiry into underlying assumptions and their effects on the work and life in the organisation (Coughlan and Coghlan, 2002). Thus, as an action, the author was dealing with directly observable phenomena in the organisation.

Insider action research rarely has a clean starting point, as Herr and Anderson (2005) observe, since the researcher has typically been engaged in the problem for some time already as a practitioner within the organisation. Moving from practice to explicit inquiry therefore meant fitting the methodological approach around material that had already accumulated, rather than beginning from an empty position. Not everything drawn on here was generated after the research was formally under way.

The first question at that point was what already existed that might bear on the study. Two sources proved relevant: local knowledge produced within the organisation itself, and larger datasets documenting trends that had a bearing on the questions being asked. Material of this kind is available to be drawn upon rather than created, a distinction Herr and Anderson (2005) treat as characteristic of insider work. The second question was: what data are possible through the daily routines of work, things that I did as part of my work role? Since the research role was in addition to

my duties as manager of the organisation, as the insider action researcher I had to look at the tasks being accomplished in the organisation, the routines that were carried out, that could become part of data gathering, if formally brought to that level of systematisation (Herr and Anderson, 2005). For example, I video recorded the improvement sessions delivered with an external consultant. As time for research is always somewhat limited, I suspect there is the possibility that I wanted to see where it was possible to build on the requirements of my manager role, utilising factors that could be used simultaneously as part of the data, as recommended by Herr and Anderson (2005).

The research database is extensive, comprising some quantitative material but consisting principally of qualitative sources. These include correspondence kept as a form of journal, case studies, audio and video recordings, transcripts of meetings and interviews, minutes, surveys, reports, policy and procedure documents, publications in print and electronic form, photographs, validation responses and meeting summaries, along with other materials appropriate to the research (Herr and Anderson, 2005).

In order to investigate the intervention, several methods of data collection and a variety of data sources were used (Coughlan and Coghlan, 2009), including:

- Videos and pictures from each improvement session
- Documents, drawings, and posters produced during improvement sessions and discussions
- Summaries of weekly meetings
- Protocoled quarterly meetings with partners
- Recorded interviews with employees and summaries of employee meetings
- A3 forms used for process improvement projects
- Notes with reflections made after meetings or workdays with interesting outcomes
- Performance data gathered from the ERP system
- Pictures and other case evidence data from the authors

Some pictures are presented in Appendix 1, together with a case narrative, and other case data evidence is available upon request.

The review and description of data commenced in early 2019. Visiting and revisiting the data has been essential, while, as stated by Herr and Anderson (2005), it is difficult for the action researcher to grasp everything at once and data may need

to be revisited in the light of new experiences. I re-read all the material and reviewed the videos repeatedly and reflected on my narrative. In this way, the gathered data was systematised with a view to making it available for analysis. The data analysis process is described in the following section.

2.2.5 Data analysis and theory building

Coghlan (2011) states that the action researcher works from the epistemological assumption that the purpose of academic research and discourse is not just to describe, understand, and explain the world, but also to change it. Therefore, the change in the case company was initiated in 2014 and continued until present day now, with reporting in the dissertation then being accomplished (2020-2026). As noted by Herr and Anderson (2005), data analysis begins immediately and guides further data gathering and decision-making. As the insider researcher there was a tension in that decisions for action must sometimes be made before I had reached a thorough understanding of the data. As the manager of the company with responsibility not only for the results of the intervention and research but for the results in the company overall, it was especially challenging. The realities and timelines of the practice setting sometimes collided with my desire as a researcher for more time to reflect and create meaning. The capacity to freeze-frame the whole endeavour while further analysis was pursued was not a luxury available to me in my concurrent roles as action researcher and manager.

As noted by Herr and Anderson (2005), there are multiple layers to the data analysis process: the initial meaning making, including some decisions regarding directions for interventions or actions; and then a revisiting of the data for a more thorough, holistic understanding. Therefore, I saw my data analysis as having two different stages. Firstly, the intervention cycles together with action research cycles that were completed from 2015 to 2023, and then the revisiting the data stage from 2019 to 2024, when articles on the case study were written for scientific papers and the dissertation was completed.

Engaging as an action researcher in the action research cycles of diagnosing, planning, action, taking action, and evaluating action after each intervention in the case organisation from 2015 to 2023, I endeavoured to both understand and shape on the process. I was also engaging in my own experiential learning, reflecting, interpreting, and taking actions as a manager in the organisation. Learning in action

is grounded in the inquiry-reflection process (Coughlan and Coghlan, 2002). I reflected upon the process of interventions by stepping back from the ongoing intervention process, with a view to planning further action. As noted by Coghlan (2011), and as I observed, there is a critical link between the concrete experience, the interpretation, and taking new action. This was key to my own learning development, as it enabled me to develop an ability to uncover and make explicit to me the aspects I planned, discovered, and achieved in practice. Coughlan and Coghlan (2002) also argue that reflection must be brought into the open so that it goes beyond their privately held, taken-for-granted assumptions and helps the researcher to see how their knowledge is constructed. In action research, reflection is the activity that integrates action and research.

The collected data were used to write a case narrative in nine chronological parts, starting with the background and situation of the case company before the improvement initiatives. This was followed by descriptions of the interventions conducted from 2015 to 2022. The case narrative concluded with an epilogue and formation of results by the year 2023:

- Background situation of case company before improvement initiatives (2014)
- Setting the strategy, creating awareness for Lean and building the first Kaizen capabilities (2015)
- Applying a standard and digitally supported Lean process for customers' ERP implementations (2016)
- Improving customer support / service processes and performance (2017)
- Understanding and improving the customer journey while using ERP (2018)
- Redesigning of the client-facing integration process independently through continuous improvement (2019)
- Maintaining a process improvement culture during COVID-19 restrictions (2020–2021)
- Renewing customer orientation and improving the software implementation process for customers through intervention (2022)
- Epilogue and outcome (2023)

The criteria and tools for analysis need to be talked through and ultimately directly linked to the purpose of the research and the aim of the interventions (Coughlan and Coghlan, 2002).

As a starting phase of DSR, solution incubation is about understanding the

problem and developing the first solution design, which is detailed enough to be implemented while possibly being incomplete (Chaudhuri et al., 2021). The principles and elements for the framework were derived from the extant literature and subsequently applied as input for solution incubation. As a second phase of DSR, solution refinement includes refining the initial solution design through iterations and verification of what works and what does not. and thus, this includes design improvements, implementation, and evaluation (Chaudhuri et al., 2021). The study results and learnings gleaned enabled solution refinement and the development of a generic framework for implementing Lean Six Sigma and ERP in combination. To move beyond problem-solving, the next phase of DSR is to evaluate the artifact that has been developed from a theoretical standpoint, placing the focus on building a substantive theory that is context dependent and developed for a narrowly defined context and empirical application (Chaudhuri et al., 2021). Therefore, the combined framework of ERP and Lean Six Sigma implementation was discussed during this work.

2.3 Research quality assurance

Karlsson (2009) discusses the concept of research quality in operations management as possessing four particular requirements: construct validity, internal validity, external validity, and reliability. Guba and Lincoln (1994) suggest that the ultimate objective for quality research in operations management is “trustworthiness”. Yin (2009) also discussed the quality of research design in terms of the same four tests, specifically for case studies. Thus, this section discusses the quality of the overall research design in more detail and uses the original four validity tests common for qualitative research based on Yin (2009) to evaluate the “trustworthiness” of the results.

Construct validity

Yin (2009) suggests that the construct validity test is a particularly demanding one in case study research. Following Yin's (2009) recommendation, multiple sources of evidence were used in this research project because every source has its own advantages and its own limitations (Yin, 2009). This study uses documentation, interviews and direct observation. These three were chosen because the weaknesses of one are largely covered by the strengths of the others, so as to

encourage convergent lines of inquiry. Direct observation, for instance, was applied in order to confirm the results of the interviews, and documentation was likewise drawn on to confirm results where this was necessary. Triangulation of the kind Yin (2009) advocates ensures that any would-be anecdotal evidence raised at the interview stage is confirmed and witnessed, which strengthens the quality of the research results. Each of the three sources contributes something the other two cannot. Documents are stable and were not produced for the purposes of this study. They can be consulted as many times as needed, they record exact details such as dates, names and figures, and they cover a long period, many events and several settings. Their limitations are mainly practical. Relevant documents can be hard to locate, the surviving set is rarely complete, and what was written down reflects the intentions of whoever produced it. Access is sometimes refused as well (Yin, 2009).

Interviews make it possible to address the topics of the case directly and to obtain explanations of why events developed as they did. What is gained in focus can be lost in accuracy. Imprecise questions bias the answers, respondents do not always remember events correctly, and an interviewee may say what the interviewer appears to expect (Yin, 2009).

Direct observation covers events at the moment they occur and keeps the context of the case visible. It is demanding in terms of time, and a single researcher can observe only a small part of what happens, since broader coverage would require a team of observers. Behaviour may also change when people know they are being watched (Yin, 2009).

Triangulation allows realisation of the strengths and reduces the impact of the weaknesses associated with each type. A statement made in an interview can be checked against a document and against what is seen in the workplace, and a document can be read in the light of what the people who work with it say about it. Construct validity in this study rests on that convergence rather than on any single source (Yin, 2009). Additionally, the chain of evidence that was established through the use of a case study protocol supported construct validity. Draft reports of the case study were prepared as soon as possible after the fieldwork had been completed and were then reviewed, which also helped to strengthen the construct validity of the case study conducted as part of the research.

Internal validity

Yin (2009) notes that internal validity is chiefly a concern in explanatory studies, where the purpose is to establish why event x gave rise to event y. The threat arises when a researcher infers a causal link between x and y without recognising that a third factor, z, was in fact responsible for y; a research design that fails to guard against this has not met the test of internal validity (Yin, 2009).

Applied to the present research, this test carries limited weight. The studies undertaken here do not set out to demonstrate that one particular event caused another, and no such causal claims are advanced. Internal validity has therefore not been treated as a priority in assessing the quality of this research design.

External validity

External validity concerns the problem of generalisability: whether the results hold beyond the immediate case study (Yin, 2009). Yin (2009) acknowledges that this has been a major barrier for case study work yet defends its generalisability by distinguishing between two logics. Where survey research relies on statistical generalisation, case studies rely on analytical generalisation, in which the researcher generalises a particular set of results to a broader theory. That theory must then be tested in further case studies, and where the same results are obtained, they may be taken as providing strong support for it (Yin, 2009).

In this research, generalisation is likewise analytical rather than statistical. The findings are not presented as representative of service companies in general, but as support for a broader theoretical account of how ERP use and Lean Six Sigma practices interact in an SME setting, an account that remains open to testing in further case studies.

Reliability

The purpose of the final test, reliability, is to establish that a later investigator following the same procedures and conducting the same case study would arrive at the same findings and conclusions (Yin, 2009). Its aim, in other words, is to keep errors and bias in a study to a minimum. Bias is nevertheless inherent in action research, where the researcher acts as an active participant rather than a passive observer. Herr and Anderson (2005) hold that bias and subjectivity are natural and acceptable in action research provided they are critically examined rather than

ignored, and that further mechanisms may be required to ensure they do not distort the outcomes.

Several measures were adopted in the present research to meet this test. A case study protocol and a case study database were developed to strengthen the reliability of the case studies carried out. Self-reflexivity was applied throughout the action research, both to reduce the effects of bias and to allow me as the researcher to examine my own subjectivity (Herr and Anderson, 2005). Involving a group of people in the action research project further reduced bias (publication co-authors, external consultant and work colleagues), since they challenged my opinions and suggestions.

Quality Criteria of Action Research

Epistemological problems do arise in action research, in the sense that a researcher's unexamined, tacit knowledge of a site tends to be impressionistic and full of bias, prejudice and uninterrogated assumptions, all of which need to be brought to the surface and examined (Herr and Anderson, 2005). Insiders, moreover, are often true believers in their own practices and are therefore too readily tempted to put a positive spin on their data, it is for precisely this reason that mechanisms for dealing with bias must be employed (Herr and Anderson, 2005).

As Coghlan (2011) observed, an action research paradigm requires quality criteria of its own, as does any approach to rigorous inquiry, quality here meaning a grade of excellence. Additional criteria have accordingly been identified for this research method. Herr and Anderson (2005) propose five validity criteria for action research, each of which was addressed in the present study and is described in turn below:

Dialogic validity. The research took on a dialogic character throughout. Collaborative dialogue was maintained with stakeholders inside, publication co-authors and external intervention consultant. These dialogues opened up alternative explanations of the outcomes as they emerged.

Outcome validity. This criterion was met through the use of the plan-do-check-act (PDCA) cycle (Deming, 1986) and through continuous involvement within the implementation team. Both ensured that action actually took place and that it led to a resolution of the problem investigated, an action-oriented outcome.

Catalytic validity. This criterion draws attention to the transformative potential of

action research. Changes to my own understanding, and to that of the participants, were noted as the research proceeded, and my own learning from the process was considerable.

Democratic validity. The research was carried out in collaboration with the majority of the company stakeholders, that is, with those who had a stake in the problem under investigation. This is also referred to as local validity, where collaboration within the company ensures that the results are relevant and applicable to the local setting.

Process validity. This criterion was realised through triangulation, which guarded against an over-simplistic reading of events. Triangulation was achieved through the views of multiple informants in interviews and through multiple sources of evidence, namely interviews, direct observation and documentation.

Validity of design science research

Internal validity was addressed through the DSR approach by examining the case events based on logic, consistency, and control perspectives (Coghlan, 2011), as well as by identifying explanatory cause and effect patterns (Cassell and Johnson, 2006). Additionally, a step-by-step consideration of the case data added to the internal validity of the qualitative study without reducing its external validity (Cassell and Johnson, 2006).

In order to secure the validity of the study, the point made by Herr and Anderson (2005) was addressed: that while bias and subjectivity are natural and acceptable in action research so long as they are critically examined rather than ignored, other mechanisms may need to be put in place to ensure they do not distort the outcomes. Self-reflexivity is one such mechanism for reducing the effects of bias, since it allows the researcher to examine their own subjectivity (Karlsson, 2009). Involving a group of people in the action research project likewise reduces bias in a study, as the group challenges the researcher's opinions (Karlsson, 2009). Although the researcher was embedded in the company in order to gain access to the data, the co-authors of the papers actively challenged the observations, so as to minimise the natural biases that come with "going native" for the purposes of the study. Both approaches were therefore taken, limiting the possible effects of bias in the study and increasing the quality and reliability of the findings.

Furthermore, a number of other approaches were utilised to ensure validity.

Cause and effect propositions were kept deliberately tenuous, since it is on this basis that internal validity is secured in this research (Cassell and Johnson, 2006). Problems were explored and valid data on them generated through the research activity, and the data were then examined to understand the problem in terms of logic, measurement, consistency of prediction and control (Coghlan, 2011). The cases were considered step by step and propositions were built and tested, a procedure which adds to the internal validity of qualitative studies without reducing their external validity (Cassell and Johnson, 2006).

RESEARCH FINDINGS

In this chapter, the findings of the research are presented. Firstly, the findings derived from the pre-research interview with the field expert are presented, followed by the summary of the case narrative. The case narrative appears in its entirety in Appendix 1. The created framework is presented in the third subchapter of the research findings, and the fourth subchapter sets out the mechanisms that support implementation of the ERP and Lean Six Sigma combination.

3.1 Findings from the pre-research interview with the field expert

The purpose of the pre-research interview was to obtain more knowledge as to how continuous improvement was perceived by the consultant who works with the companies and leads them to implement continuous improvement, and thereby to work in a more efficient way. It was important to understand why companies do it, as well as the success / failure factors of the implementation in the real life, which tools are used by the companies, and whether there are considered to be possibilities for the integration of Lean Six Sigma tools with IT or ERP solutions. It was critical to gather this information before planning and commencing actual intervention in the company or undertaking research regarding it. A template was created for analysing that interview, which is presented in Appendix 4. The analysis reveals that the perception of work efficiency is described as work output per time in quantity, and work output per time in quality and energy. The main driving factors mentioned that motivate companies to seek continuous improvement towards enhanced work efficiency were competitors, market pressure, and lack of employees. Success / failure factors for implementing continuous improvement of work efficiency, as noted by the field expert, are involvement of the top management, daily management routines, and systematic problem. The tools for continuous improvement implementation referred to were stand-up meetings, X-matrix, 5 WHYS, A3 form, PDCA, and visualisation.

When discussing the possible interaction between continuous improvement and IT or ERP solutions, the field consultant pointed out two areas where an IT / ERP solution is playing an important role while implementing continuous improvement: Evaluating activities (through KPIs), meaning that ERP can, for example, provide necessary information or metrics to understand situations, and this can lead to decisions concerning what to improve next. The other important role of ERP in

continuous improvement mentioned was process management, as ERP can support and standardise particular routines for the processes in organisations. Though it was very clearly pointed out that “IT systems can create value when management infrastructure is there: problem-solving practices, PDCA, cascade of goals, and others. When companies expect that IT systems will save the world and nothing else is needed – in most of these cases failure and disappointment is guaranteed. “

The pre-research interview and its analysis made some guidelines how to start the intervention in the company towards creating continuous improvement capability and continue the research about the combined ERP and Leans Six Sigma approach.

3.2 Case narrative based on the nine-year intervention study

This chapter represents the description of the interventions in the case company.

Background of the case company before improvement initiatives in 2014

The headquarters of the case company were founded in Estonia in 2002, offering an ERP solution as Software as a Service (SaaS) with a zero-installation architecture. The company was one of the first software providers globally to introduce a SaaS (cloud-based) service to corporate customers. Initially, their focus was the local Estonian market, where cutting-edge technology was well received. While customers expanded their activities to other countries, this company also began operating in other countries, and a company was established in Lithuania in 2008.

A few years earlier, the company’s own ERP system had been implemented in the Lithuanian company, but it did not support execution and monitoring of the core business processes, with just the finance module and some CRM features being introduced at the end of 2013. However, due to its rapid growth, the company also faced a number of organisational challenges, typical for fast-growing start-up SMEs. It became increasingly difficult to control the service process quality.

The initiatives for business process improvements, which were gradually implemented, started at the end of 2014. It was decided to combine Lean Six Sigma initiatives together with a better usage of ERP. Since one of the researchers collaborating on this work was the manager in the LT department, it was decided to implement this change through research.

Scientific research dictated the steps implemented and the construction of a possible ERP and Lean Six Sigma implementation framework. The external Lean Six

Sigma consultant was also involved.

Setting the strategy, creating awareness for Lean and building the first Kaizen capabilities in 2015

A few years earlier, the company's own ERP system had been implemented in the Lithuanian company, but it did not support the execution and monitoring of the core business processes. Merely the finance module and some CRM features had been implemented at the end of 2013. The initiatives for business process improvements, which were gradually implemented, commenced at the end of 2014. It was decided to introduce Lean Six Sigma more formally to the company employees in 2015, at which point the company had expanded to nine people. In the summer of 2015, two workshops were thus conducted, supported by an external Lean Six Sigma consultant, whose purpose was to set a strategic vision for the company and promote the commitment of the workforce to its implementation. The main tasks accomplished during those sessions were as follows:

- The company objectives were set as: Growth of turnover, growth of profit, customer satisfaction, and operational excellence for which specific targets were developed.
- A "policy deployment" X matrix tool was applied to identify actions in the short term, which could contribute to reaching corporate objectives and targets set.
- The core business processes for (1) Sales, (2) Implementation, and (3) Support were identified, mapped, and analysed.

The workshops became essential steps towards further business improvement in two ways, while also instilling a break in daily operations where employees often felt they lacked time to make improvements. At first, the workshops contributed to a broader and shared understanding of customer value and the importance of meeting customer needs. In addition, the policy deployment exercise was essential as it produced a shared overview of actions to be carried out in the short term to reach the set objectives and targets. Furthermore, specific staff members who would be accountable for different tasks / actions in the near future were identified. Regarding objectives, the exercise created a set of very tangible metrics for the key business processes, including, for example, KPIs for: Invoice complaints, overdue works, re-do works in ERP implementation, and time spent to resolve customer support

request, etc. After the workshop, it was decided to implement more visual management processes, leading to the creation of a Kaizen / Lean management dashboard, visible in the office for all participants, where it would be possible to track business improvement efforts and impacts on the main KPIs.

To proceed with improvement initiatives, two subsequent improvement sessions were run, with the same external consultant as facilitator in the autumn of 2015. Each session lasted half a working day and all staff took part. After the workshops, it was agreed to run a trial period with regular Kaizen meetings. Weekly Friday meetings were thus organised with a clear agenda and structure and the purpose of following up on work-related questions and identifying current performance and improvement opportunities. I had to lead the first couple of meetings, as employees were still sceptical towards this way of working with team-based problem-solving and seeking improvements. However, ownership and understanding of the Kaizen meetings were gradually taken over by the employees, who began to lead both Kaizen meetings, and daily stand-up sessions during which yesterday's accomplishments were reviewed, and today's tasks prioritised. Kaizen meetings were also strengthened by integrating previous idea-generation processes and boards into the toolbox and converting templates into A3 forms in line with employee wishes.

Applying a standard and digitally supported Lean process for customers' ERP implementations in 2016

The company continued to increase its revenue, by 34.83 % in 2014 and 31.37 % in 2015. 2016 began with an unforeseen number of new software implementation projects for its clients. The number of new projects resulted in a need to upgrade the core ERP implementation process, as the deficiencies of that process would have had rework and performance implications for post-customer support / service processes. An additional improvement session was thus carried out in March 2016 to tackle this challenge. The ERP implementation process was also scrutinised using Lean Six Sigma tools as Fishbone diagrams, 5WHYs, PDCA, and A3 forms, etc. Subsequently, a follow-up session was held in April to identify ways of improving the main process flaws, again with the previous external consultant facilitating. The following results were obtained from the two workshop sessions: the completion of a detailed map of the current end-to-end process for the client facing ERP implementation activities and defining the roles and responsibilities of key

stakeholders.

After going through the process, there was a shared understanding of the end2end process among all people or teams involved in the process on a daily basis. The sessions, furthermore, generated a list of ideas for how to solve problems upstream in the process and prevent them from cascading downstream to the staff or client aspect of this, or the post-customer support process.

As an outcome, the team decided to begin using the ERP project management module internally to manage the implementation projects, and a set of two project-implementation procedures or workflows was developed to match each client's task situation. Finally, a set of KPIs was developed to monitor the progress of the new ERP implementation process, encompassing duration, revenue from new project implementation works, actual versus planned dates for activities, and re-works per project.

The implementation of the designed EPR improvement process was achieved using PDCA principles and the running of several improvement cycles in the spring and summer.

Improving customer support / service processes and performance in 2017

In early 2017, the CEO of the company headquarters from Estonia was part of the LIT collegial management team. A closer engagement of the EST company in the Lithuanian operations was already visible after the first quarterly collegial meeting, where it was decided to benchmark the number of support requests received from customers in EST versus those in LIT. The EST company received 9.74 times fewer requests per customer than the LIT company. The remarkable difference in customer support requests from LIT compared to partners working in, firstly, Estonia, then Latvia and Finland, was thus chosen as a topic for an improvement workshop.

In March 2017, yet another improvement session with the team and the external consultant was organised. That session produced the following outputs:

- A shared understanding of which customer requests are value-creating activities, and which are non-value-creating activities.
- The completion of a detailed map of the end2end customer support and its handovers and flaws.
- The generation of ideas for reducing the number or help requests per customer as well as reducing support time.

- A vision for a future Lean Six Sigma and Digital customer-oriented support process was created, characterised by instant response, clear specifications from customers, simplicity and automation, professional communication, and good quality and on-time delivery.

KPIs were set for monitoring customer support performance. After the workshop, the ERP system was adjusted to register and classify all future customer requests. Moreover, KPI scores were displayed on a dashboard visible to all. After a couple of months, during which the team had also been implementing different improvement actions, the first improvements were visible.

During the rest of 2017, further adjustments and improvements were made to the standard processes for ERP implementation and customer support.

At end of 2017, working facilities were established for LIT staff within the EST office, enabling LIT staff to work there on a rotational basis to serve their LIT customers from the Tallinn office. This setup was organised in order for LIT employees to learn faster and acquire more knowledge about the system directly from EST staff, where experts were handling more than 3000 customer cases at that time.

During the annual employee conversations at the end of the year, the LIT staff expressed their contentment with how the integration of Lean Six Sigma methods into their regular work routines had progressed, as well as with the many improvement projects running on an ongoing basis, and the latest developments, including closer integration with their EST mother company.

Understanding and improving the customer journey using ERP in 2018

The ambitions to make case company LIT processes and work culture more competitive were maintained throughout 2018. It was decided to organise one more set of improvement sessions with the theme of “Improvement to the customer journey in the case company support process.” The company had now grown to ten people, as three new people had recently joined the team. The first part of the sessions was therefore spent repeating previous messages and teaching the Lean Six Sigma curriculum delivered in previous workshops. The second part of the sessions included training in methods for conducting customer studies and observing work processes. The workshops included visits to five customers with teams of two carrying out observations and interviews. The main goal was to watch the customers’ daily work

with the Directo systems to understand why and when they needed support. Along with my team, I described this as “going to a gemba place” event.

Employees returned home excited about what they had learned and observed, and in many ways, their perceptions of the customers and their behaviour had altered.

It was agreed to arrange five more customer visits within the next two weeks. Following the visits, a half-day session was organised where the scheme was drafted based on observed experiences regarding what customers do step-by-step when they need case company support. Accordingly, what were the actions of the case company support team, and how did both the customers and support team members feel at each process step?

After the workshops, all staff decided that it would be beneficial to continue visiting the customers in the future to understand their preferences and needs better, eventually enabling the delivery of improved case company products and services.

At the end of year 2018, the Lean Six Sigma initiative had thus evolved from being firstly oriented towards improvement of internal case company processes, towards including external partners, and obtaining direct insight into customer processes, as an enabler of accomplishing objectives for ongoing process improvement and the delivery of superior value to clients.

Redesigning of the client-facing integration process independently through continuous improvement in 2019

The first five years of the company’s improvement journey had delivered changes and results. The daily morning stand-ups, structured Friday meetings with a review of KPI process performance, and multiple ongoing A3 improvement projects had become daily activities. By 2019, the staff were able to complete an improvement project for the sub-process of system integrations without using an external consultant. Three workshops were conducted to align the team’s understanding of how projects should be implemented when integrations with other systems were undertaken. The outcome of the improvement project was a visual process delineating clear steps and the responsible people involved, together with a set of mutually agreed instructions for the team. Additionally, the sales process was standardised and implemented in ERP (pipeline, CRM, and signed contract information). The Lithuanian version of this was later rolled out and replicated in the Estonian and Latvian headquarters. Tangible improvements had thus begun to

spread from the Lithuanian office to other countries. Furthermore, the company's revenue increased during 2019.

Maintaining a process improvement culture during COVID in 2020 and 2021

The case company underwent significant organisational adaptations in response to the COVID-19 pandemic restrictions during 2020 and 2021. A transition to remote work became imperative for many months during that time. Nevertheless, staff were executing operations from a home office setup, maintaining efficiency in daily operations, and aligning regarding improvement initiatives. There were two MS Teams stand-up meetings every day, which proved invaluable as they provided a structured space for enquiries, as well as fostering collaboration and coordinated action despite physical distance.

Furthermore, Friday meetings underwent a transformation to accommodate new virtual environment. Instead of traditional whiteboard discussions, all pertinent information was displayed on-screen, ensuring transparency and accessibility for all team members. This digitisation of meetings not only streamlined processes but also facilitated seamless information sharing and decision-making.

The company's growing Kaizen capabilities, in the form of discipline towards new routines, and the staff's adoption of a mindset for improvement and change, proved to be beneficial in navigating and being flexible in the evolving landscape of COVID-19 restrictions and business changes. In the summer of 2020, the team collectively made the decision to return to the office. However, by October 2020, with the resurgence of the pandemic, a shift back to remote work was mandated. The team-wide commitment and ethos or culture of "proactive change" rather than "fear" of the unknown ensured an undisturbed operational efficiency and high-quality service for customers, who also increasingly digitised their own processes. During the pandemic, the company experienced notable growth across several metrics. Revenue growth was up 16% in 2020, and 25% during 2021. Productivity increased by 12% in 2020 and 5% in 2021. The tickets per customer metric improved in both 2020 and 2021. Additionally, ticket-solving per day improved during 2020, but somehow decreased in 2021.

Renewing customer orientation and improving the software implementation process for customers through intervention in 2022

In 2022, following the challenges wrought by the pandemic, the company reinstated a significant improvement project aimed at enhancing the customer orientation of the ERP implementation services team. In the aftermath of COVID-19, the team grappled with delays, prompting an influx of customer complaints which caught the attention of management. Moreover, the average duration of ERP implementation projects for customers increased in 2020, 2021, and 2022. Once again, an external consultant was hired to run five improvement workshops that included all relevant stakeholders, which were dedicated to improving the ERP implementation process value for customers. In addition to the workshops, the improvement team again conducted interviews with five customers who had recently used the company's ERP solution. Results from those interviews and the necessary improvement actions revealed the need to substitute the head of the implementation team. Even though this person had 10 years of work experience, he was replaced by a more customer-oriented manager. The new manager had a clearer understanding of customer priorities, and operations quickly resumed with better performance. The customer complaints regarding ERP implementation declined. The average duration of implementation projects also decreased in 2023.

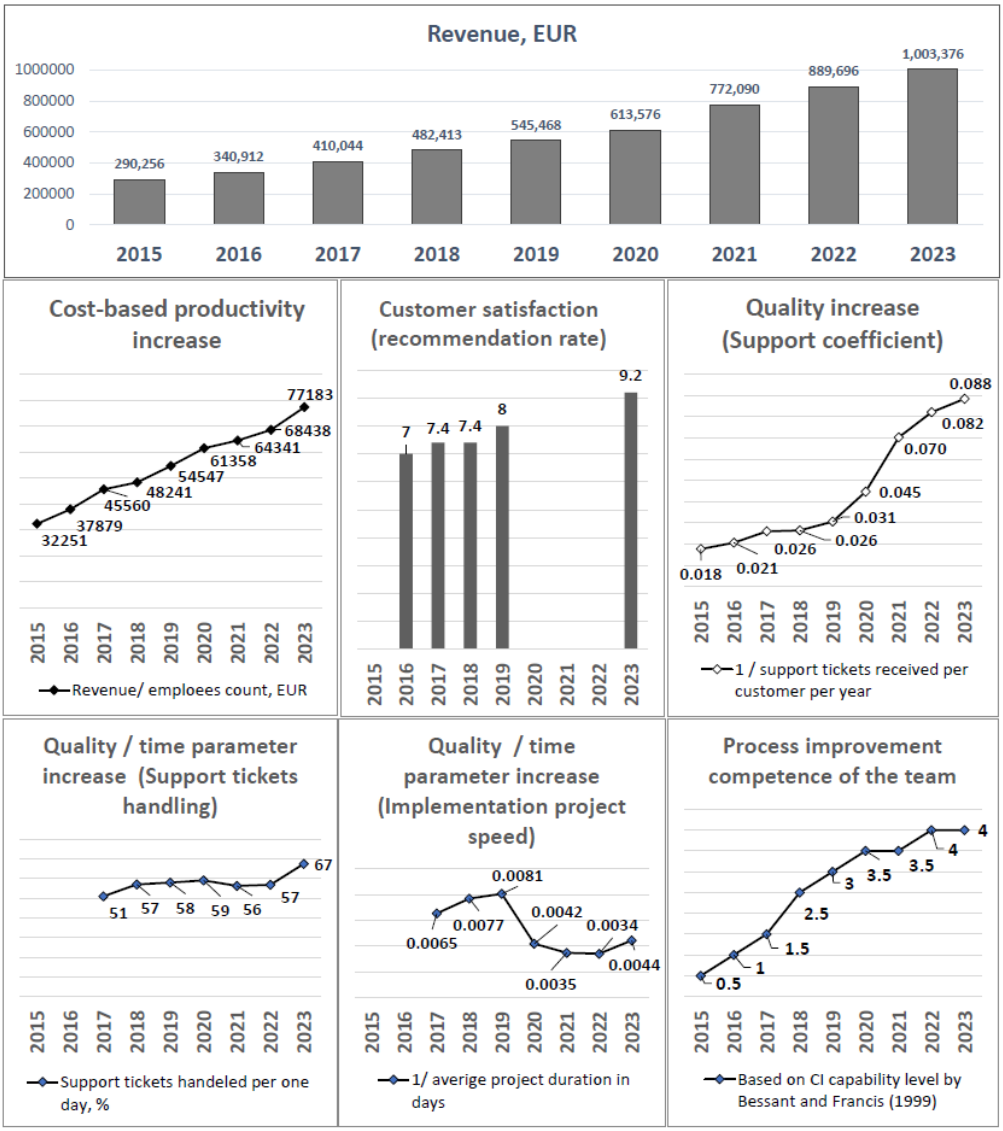
While revenue grew by 16% in 2022, profitability witnessed a decline, primarily as additional costs were incurred due to changing the composition of the implementation team. However, the subsequent developments confirmed the company's ability to be agile and adapt robustly to changes.

The epilogue and outcome in 2023

A summary of the outcomes achieved for multiple metrics across the nine-year period is presented in Figure 17. Revenue growth over these nine years was, on average, 18.8%. Cost-based productivity (revenue versus number of employees) grew year by year from 5% to 20%. The customer recommendation rate (captured for five out of nine improvement journey years) increased from 7 to 7.4. The Lithuanian office had the largest number of support tickets per customer compared to other countries, but the improvement efforts enabled the number of requests to drop throughout the nine years from fifty-seven to eleven tickets per customer per year. Moreover, the percentage of tickets resolved within a single day increased from

51% to 67% over the nine years, despite fluctuations in 2019 and 2020. Project speed improved, and the lead time for customer project implementations decreased due to the interventions dedicated to this process in 2016 and 2022.

Figure 17. Graphical overview of the outcome



Source: Liutkevičienė et al. (2026)

The digitally supported process improvement capability level of the team was evaluated based on the Bessant and Francis (1999) model, and it was shown to

increase every year. This was rated 3–4 for the final year, indicating that the company could achieve incremental problem-solving successfully without external consultants. High levels of experimentation were present in the company. Measurements were established to drive tangible cost reductions, quality improvements and time savings.

The outcomes are presented in Table 9.

Table 9. The outcome information by year

	2015	2016	2017	2018	2019
Cost based productivity (revenue versus no of employees, EUR)	32251 +17% compared to 2014	37879 +17% compared to 2015	45560 +20% compared to 2016	48241 +6% compared to 2017	54547 +13% compared to 2018
Quality (Customer recommendation rate from survey)		7	7.4	7.4	8
Support tickets per year per customer	56.62	48.44	38.47	37.9	32.75
SPEED of solving tickets (1/quantity of tickets)	0.018	0.021	0.026	0.026	0.031
Customer support performance (ticket handling time slots)	No data	No data	within 1 day 51 >1 day <30 days 43% of tickets > 30 days 6% of tickets	within 1 day 57 >1 day <30 days 35% of tickets > 30 days 8% of tickets	within 1 day 58 >1 day <30 days 34% of tickets > 30 days 8% of tickets
Time (Implementation project duration in days)	No data	No data	153	130	124
SPEED (1/days)			0.0065	0.0077	0.0081
Process improvement competence of the team [0-5]	0.5	1	1.5	2.5	3.5

Source: Created by author

Lowering numbers were converted into inversely proportional numbers and marked in grey in the table. For example, a decreasing support tickets number was converted into a better quality parameter and a project implementation days decrease was converted in a project average speed.

3.3 Learnings from the case and findings

The case narrative showed that applying the combined ERP and Lean Six Sigma approach enabled the intervention to produce positive outcomes in terms of productivity, quality, and customer orientation, as well as in developing the continuous improvement capability of the SME service company. Based on the case journey and results, the findings were generalised and presented in the form of a combined ERP - Lean Six Sigma improvement framework and mechanisms in the next sub-chapters.

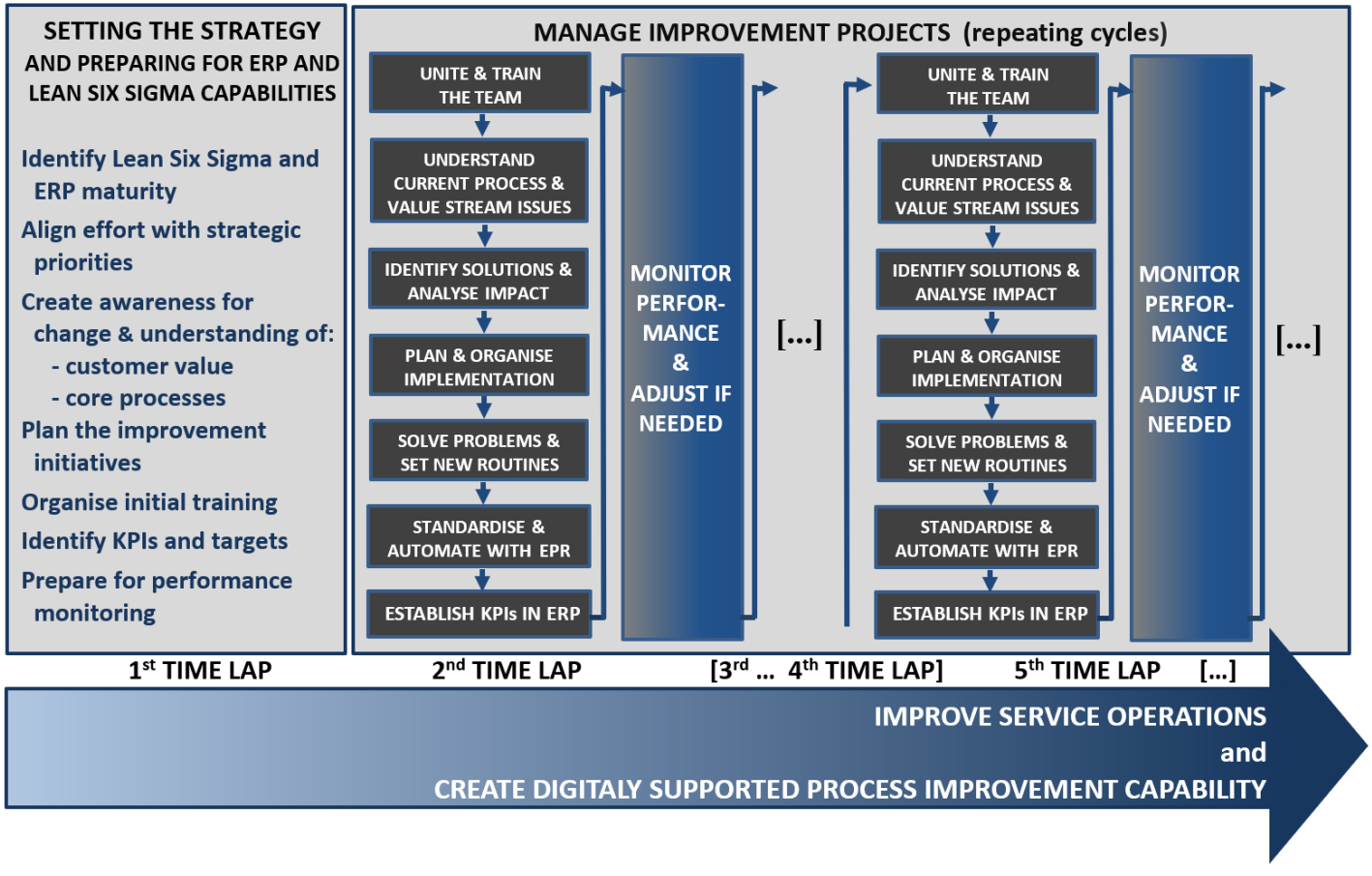
3.3.1 Digital process improvement via the ERP and LSS implementation framework

The findings reveal that applied intervention of a combined ERP and Lean Six Sigma approach enabled the growth of the company as well as positive outcomes in terms of productivity, quality, and customer orientation. Additionally, it most importantly developed the continuous improvement capability of the case company. The business transformation effort was implemented via a synthesis of existing Lean Six Sigma and ERP frameworks and the applied DSR / action research methodology. Based on the case journey and results, I have generalised the findings in the form of a combined ERP - Lean Six Sigma improvement framework, presented in Figure 18.

Setting the strategy and preparing for ERP and Lean Six Sigma capabilities

The proposed framework suggests, in line with previous research and frameworks (Powell et al., 2012; Pellerin and Hadaya, 2008; Nightingale and Mize, 2002), that the preparation stage is crucial to the outcomes. The preparation stage includes that a company must initially clarify its situation regarding the following questions: a) Is ERP and Lean Six Sigma to be implemented from scratch, b) is one of the approaches already present, or c) does the company already have some degree of maturity with respect to both Lean Six Sigma and ERP?

Figure 18. Combined ERP - Lean Six Sigma Framework for improving service operations and process improvement capability



Source: Liutkevičienė et al. (2022)

The starting point determines the set of capabilities and skills that managers and staff should be trained in, as well as the scope, objectives, and content of the initial improvement goals.

The case company had already implemented an ERP solution, and the intervention was about enhancing the existing system via Lean Six Sigma methods to enable both process and customer value improvement. Therefore, most of the initial training covered Lean Six Sigma principles and tools, and the initial projects emphasised deploying these methods to achieve tangible and measurable improvements in productivity and service quality for the customers. However, other companies with a different starting situation could require an alternative focus.

A subsequent key step is to ensure initial (but later also ongoing) alignment of the business strategy and competitive priorities in the long and short-term with Lean Six Sigma and ERP actions. It is particularly relevant that the role of core processes in creating customer value becomes visible, and that managers and employees become aware of it. In the case company, a significant effort was made to create this awareness via applying the X-matrix tool (Barnabè and Giorgino, 2017), which has likely also been supportive for further initiatives and results.

The next step of the preparation stage is to consider how to organise the upcoming ERP or Lean Six Sigma triggered business transformation. The chosen approach might be dependent on the size and resources of the specific company. For example, the case company was an SME, and it was clear that the CEO would play a key role, not just as a sponsor of the initiatives, but also as a kind of “change agent” and dedicated part-time improvement project leader or work resource in collaboration with key employees. The importance of both a strong committed sponsor as well as strong “change agents” able to deal with technical, cultural, and political challenges have been highlighted in previous research (Nightingale and Mize, 2002; Kumar et al., 2013).

Specific needs for training and skill building should be identified, planned, and executed for relevant stakeholder groups at an early stage to facilitate the business and cultural transformation. The employees and managers who will lead the implementation should receive a more in-depth training in relevant ERP / Lean Six Sigma skills, with the training of other stakeholders being focused on building a greater awareness and understanding of actions (Nightingale and Mize, 2002; Vilpola, 2008). Existing research has stressed the value of experiential learning

methods or on-the-job training for gaining skills and competencies in areas of Lean Six Sigma or EPR (Wallace and Kremzar, 2002; Bicheno and Holweg, 2009). As the case company was an SME, it was decided early on to provide training and skill building as part of planned improvement projects, which would offer the opportunity of applying Lean Six Sigma and ERP tools for problem-solving.

Finally, KPIs and improvement objectives should be discussed and set at the preparation stage to enable tracking of whether the whole initiative is delivering the expected business benefits. In the case company, initially only financial measures were in place, and thus there was a need for developing service quality and process performance measures. At the outset, a simple set of KPIs were developed and tracked via manual recording of performance data, however, at a later stage, the performance reporting was automated via ERP, as also recommended by Bortolotti and Romano (2012).

Managing improvement projects

With respect to the improvement project management and execution phase of the above framework, this case has enabled some interesting observations and recommendations. One of the features of the case was that the company business transformation happened in a set or pattern of “Improve-Monitor” cycles. For every cycle, the improvement was first achieved as an expanded Lean / ERP project, or perhaps as a Kaizen event (Van Aken et al., 2010), where a systematic standardised set of improvement steps were accomplished. After having implemented a new work process and digital solutions, followed by a subsequent “monitor” operational period where new routines materialised, only small adjustments were made to ensure further performance improvement (via KPI monitoring). The realised approach was, maybe, due to the size of the company, as there was no full time Lean / ERP change agent dedicated to driving Kaizen events on a regular basis. In addition to that, employees were in need of a stable daily work routine and gaining more familiarity with new processes, before they (mentally) would be able to investigate new improvement options and be energised for new Kaizen efforts.

Some critical aspects which can support the delivery of good outcomes have been identified for each step of the improve and monitor cycle. These aspects are explained below:

- *Unite and train the team*. Van Aken et al. (2010) address the need for uniting

improvement teams, and the importance of ongoing training is mentioned in existing research – both ERP (Pellerin and Hadaya, 2008; Berchet and Habchi, 2005, and etc.) and Lean (Nightingale and Mize, 2002; Malmbrandt and Åhlström, 2013, and etc.). The case indicates that a combined team building and training effort in the tools that could be used during the particular project enabled identification of improvement options, and the subsequent implementation speed is important.

- *Understand / map current process and value stream issues*. Current situation and inefficiencies of the selected process should be mapped, documented and analysed as one of the first improvement project steps, as mentioned by Obwegeser et al., (2019). Estimating baseline performance and the identification of root causes are also typical steps of understanding the current state (Lokkerbol et al., 2012; Kumar et al., 2013; Nadarajah and Kadir, 2016; Sunder M, 2016). In the case company, each improvement cycle included several of these activities to enable understanding of the current value stream issues and challenges.
- *Identify solutions and analyse impact*. Generating or proposing ideas for solutions which can improve current operations and performance is essential after the analysis part, as stated by Harrison et al. (1997). There are complementary methods and tools for identifying solutions (brainstorming techniques, and 5Rs, etc.), but typically, an achieved deep understanding of the current state and root causes of problems must be combined with creative / blue sky approaches, and expanding of targets to foster break-through innovation and systematic problem-solving. Estimation or evaluation of costs and benefits should be completed as a final step before implementation, as also suggested by Nightingale and Mize (2002) and Kumar et al. (2013). The case company illustrates how the CEO and team retreated together from daily operations to accomplish creative and systematic problem-solving tasks. In the case company, pain and gain charts were used for prioritisation and selection concerning implementation.
- *Plan and organise implementation*. Making a more or less detailed plan for the timely implementation of actions, as well as delegating time and resources and assigning roles and responsibilities to people, is part of this step (Obwegeser et al., 2019; Kumar et al., 2013; Harrison et al., 1997; Nightingale

and Mize, 2002). The case company developed a clear plan of implementation activities with a timeline and people from the employee team being assigned to tasks for every improvement project.

- *Solve problems and set new routines*. The actual implementation is the most important part of the transformation process, as confirmed by Obwegeser et al. (2019) and Lokkerbol et al. (2012). The implementation team should execute actions and proactively and persistently deal with relevant obstacles for further process redesign and improvement of performance and customer value. The case company identified an implementation team for every project, and they developed instructions to firm up and support new work processes and routines, particularly during the first two improvement cycles. Maintaining discipline with respect to executing work routines was essential to succeed in practice.
- *Standardise and automate with EPR*. Implementing or materialising new standard work routines within the ERP system plays an important role in improvement projects (Ghobakhloo and Hong, 2014). The automation aspect was achieved without additional challenges in the case company, while IT experience and knowledge enabled the implementation of automating the processes.
- *Establish new KPIs in ERP*. For every improvement project, it is critical that KPIs are selected or established for the purposes of monitoring the performance of new processes. The author recommends keeping this simple in the beginning, and accomplishing the recording and calculation of KPIs manually or via Excel. Following the trial phase, data capture and performance reporting can be implemented into to ERP. Several studies have highlighted the need for KPIs / metrics, as well as for incentives in various ways to encourage organisations and staff to maintain improvement results and Kaizen practices (Done et al., 2011; Pritchard, 2013; Halgeri et al., 2011).
- *Monitor performance and adjust if needed*. After the improvement project steps are completed, a relax phase is recommended based on the case company's experience, where the KPIs are followed at the regular meetings and benchmarked with the goals set. If adjustments are needed based on the KPIs or employee feedback concerning the new routines, small improvements are put in place, that was also stressed by Obwegeser et al. (2019).

3.3.2 Mechanisms supporting digital process improvement capabilities via ERP and LSS

The case description showed that the intervention did not only lead to positive outcomes in terms of productivity and quality, but also enriched continuous improvement capability. The literature review identified a number of factors related to combining ERP and Lean Six Sigma. During the analysis of the intervention, these factors were taken into consideration as possible explanatory mechanisms in the CIMO framework. Some of the factors turned out to be very relevant to the success of the intervention, while others were found to be irrelevant. This was the case for Lean accounting, support for pull and support for flow, as these elements were not included in the intervention. However, a number of additional factors were identified during the case analysis, and these turned out to be important for explaining the success of the intervention. The identified factors supplementing the original list were: establishing organisational processes / routines, organisational understanding via Lean Six Sigma tools, and building improvement skills for people. While the factors that emerged as relevant from the original list were: elimination of waste activities in ERP, elimination of waste data in ERP, support for standardised work routines, data for improvement, and employee engagement while improving ERP and Lean Six Sigma usage.

In order to determine the most important factors for ensuring a successful intervention and the underlying explanatory mechanisms, an assessment adhering to the methodology described above was made. The mechanisms were identified by analysing the improvement session materials (videos, documents, observation notes, and ERP data, etc.) and there was subsequent discussion among the members of the research team. The mechanisms are presented in Table 10.

The identified mechanisms were synthesised into a list of mechanisms that were further analysed with inputs from the participating employees and the external consultant who were tasked with assessing whether they found the mechanisms to be present during the intervention, and whether they found that the mechanisms contributed to the success of the intervention.

Table 10. Mechanisms for the implementation of digital process improvement capabilities

Factors	Interventions	Was it present	Did it contribute to success	Generic mechanism
Organisational understanding via Lean Six Sigma tools	aligned understanding of company strategy and goals	H	H	Understanding & Engagement
	aligned understanding of customer expectations	H	H	
	aligned understanding of core organisational processes	H	H	
Established organisational processes / routines	daily stand-up meetings	H	H	Discipline & Engagement
	structured weekly meetings	H	H	
	regular Kaizen (A3) meetings	M	L	
Building improvement skills for people	coaching of staff in systematic problem-solving activities	M	M	Understanding
	on-job training in Lean Six Sigma methods	M	M	
	training and workshops with external expert	H	M	
Elimination of waste activities in ERP	pen-to-paper process map (before using ERP)	M	H	Understanding & Enabling bureaucracy
	check of process with manual tools before doing it in ERP	L	H	
	automation of data entry	L	L	
Elimination of waste data in ERP	review of data entries during the process improvement	M	M	Understanding & Enabling bureaucracy
	decision of not important data to be skipped	L	L	
Improvement of ERP functionality	review of used functionality during the process improvement	M	M	Understanding & Enabling bureaucracy
	decision to create new functionality or drop to use old one	M	M	
Support for standardised work routine	newly developed templates integrated in ERP	M	H	Discipline & Enabling bureaucracy
	monitoring of standard procedure compilation into ERP	L	L	
Data for improvement	new KPI introduction during improvement projects	H	H	Understanding &

Factors	Interventions	Was it present	Did it contribute to success	Generic mechanism
	KPI visualisation within ERP	M	M	Discipline
	KPI's from ERP for Kaizen and other meetings	L	L	
Employee and management engagement while improving ERP and Lean Six Sigma usage	employee participation in improvement session	H	H	Engagement
	ownership of homework during improvement project	L	M	
	time and resource allocation by management	M	L	
	support from management to employees	H	M	

Source: Liutkevičienė et al. (2026)

The compiled list of mechanisms and the assessment is shown in Table 10. The attribute of High, Medium, or Low was based on inputs from four employees and the external consultant who had to distribute 100 points between the different mechanisms. The results displayed on the table are therefore relative, showing the average assessment. The construction of the table is presented in Appendix 2.

Table 10, above, highlights the factors and identifies the underlying mechanisms that were assessed to be either highly relevant or highly present, and at least medium present. These influential mechanisms were further investigated by the research team using the case material to identify four further generic mechanisms for successful implementation: understanding, engagement, discipline, and enabling bureaucracy. In the following sections, the factors that were found to enable the successful implementation of ERP and Lean Six Sigma will be unfolded and discussed, followed by a discussion of the interactions between ERP and Lean Six Sigma.

Identification of mechanisms enabling SMEs to leverage and adopt digital process improvement

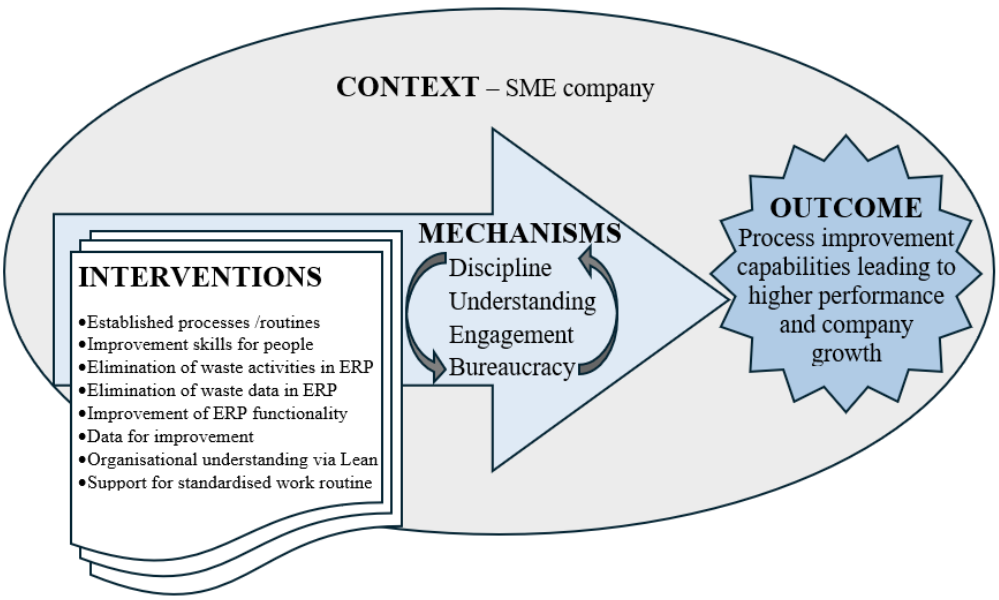
The influential factors and characteristics above were investigated further by the research team. They proposed a set of high-level organisational mechanisms explaining how SMEs can transform their organisation and its culture, along with

adopting digitally supported process improvement practices to produce competitive advantage and growth.

Lorentz et al. (2020) defines mechanisms as a process or system that is triggered by an intervention and through which an outcome is brought about. Pajunen (2008) explains mechanisms as a structured set of interdependent activities and entities that, in combination, can produce specific outcomes. This is close to the definition of Momeni et al. (2023), describing mechanisms as organised, productive activity systems that are used to develop the required capabilities. Based on case evidence, the authors propose four organisational mechanisms that explain why Lean and ERP implementations are effective in developing digitally supported capabilities for process improvement and targeted intervention outcomes: discipline, mutual understanding, engagement, and enabling bureaucracy.

This paper's contribution, which conceptualises how integrated ERP and Lean implementation, supported by organisational mechanisms, can enable the development of process improvement capabilities, performance improvements and business growth for SMEs, and is presented in Figure 19.

Figure 19. Graphical overview of the theoretical contribution developed through the CIMO framework.



Source: Liutkevičienė et al. (2026)

Discipline is crucial at the beginning of a Lean and ERP intervention to maintain new daily routines and drive forward improvement projects. To sustain and grow improvement capability, a unified understanding and common knowledge of Lean and ERP elements must be established within the workforce. When the team has a unified understanding, engagement begins to emerge and encouragement to persist must be present. The stability of mutual understanding and engagement can be maintained through enabling bureaucracy, which allows for the creation of rules, instructions, descriptions, and procedures for digitally supported process improvement. While bureaucracy may have been branded as inherently inhibiting, the concept of enabling bureaucracy opens the way for a more nuanced understanding of which bureaucratic mechanisms can enable and support the work, rather than of the bureaucratic elements that are coercive by limiting behaviour and flexibility (Adler and Borys, 1997).

The backing and maintenance of all these mechanisms must be continuous, as the team can easily revert to old routines over time. Discipline should reinforce new ways of working. When the importance of value creation for customers is reiterated and re-experienced jointly in the company, engagement is restored.

Enabling bureaucracy serves as a reminder of how the company operates, the agreed disciplines and routines, how value is created for customers, and how processes are improved. The case study makes it evident that the mechanisms interact – they reinforce each other and act in a mutually supportive and complex way.

DISCUSSION OF RESEARCH FINDINGS

In this research, I have explored the integration of the ERP and Lean Six Sigma approach. I analysed how they can complement each other when companies are striving for continuous improvement capability. To explore this phenomenon, I used a single case study of a service SME, utilising the action research and DSR approach. In this penultimate section, how the findings of the research complement the extant scientific knowledge is discussed. The first sub-section is dedicated to the framework that provides a generic approach for developing continuous improvement capability by combining Lean Six Sigma and ERP. The most important contributing ideas concerning the improvement framework are discussed in this sub-section. The second sub-chapter addresses the mechanisms supporting the ERP and Lean Six Sigma combined implementation approach, and the mechanisms identified in the research findings are discussed in this sub-chapter.

4.1 Discussing the implementation framework

This section discusses the first part of the findings, namely the implementation framework developed in the study. The aim was to produce a comprehensive generic framework that integrates ERP and Lean Six Sigma in order to improve processes, strengthen continuous improvement capability, and enhance competitive advantage. Its structure and underlying logic are considered below against the theory already proposed in the literature.

While Powel et al. presented a framework for combining Lean Six Sigma and ERP in 2012, that framework was designed for companies starting the process from scratch. The framework developed in this study is generic and capable of modification for application to situations where companies already have ERP or some Lean Six Sigma capabilities. This is a relevant contribution, as both ERP and Lean Six Sigma usage are widespread in most industries. The framework is also generic in the sense that the time-lapsing given in the framework is not strictly defined. The repetition of improvement projects develops the continuous improvement capability (cf. Nightingale and Mize, 2002), but the length of each cycle can be carefully evaluated by the company depending on the context and resources available.

During the five years of the framework's development and testing, other studies focused on combining ERP and Lean Six Sigma were published. Janssens et al. (2020) presented a process for ERP implementation through a collection of coherent

and detailed activities or processes, independent of phases, and viewed over the entire project. Ghobakhloo and Fathi (2019) communicated an overall strategic roadmap for increasing productivity by integrating a firm's IT resources and capabilities to support manufacturing digitisation and leanness. Kobus et al. (2017) discussed the implementation of Lean IT in waves of three to four months in four implementation phases. Obwegeser et al. (2019) presented an IT infrastructure service operations improvement model with steps, guidelines, and a toolbox.

While these more recent studies offer insights and practical knowledge about domains of ERP implementation (Janssens et al., 2020), Lean and IT implementation in combination (Sartal and Vázquez, 2017; Burak Erkayman, 2018), IT for digitalisation and Lean (Ghobakhloo and Fathi, 2019; Kobus et al., 2017), and Lean in IT organizations (Obwegeser et al., 2019), they do not address the development of continuous improvement capability. The framework yielded by this study provides an approach for developing continuous improvement capability, documented through a standardised maturity model (Bessant and Francis, 1999).

The company case illustrates the particular set of challenges faced by a small IT service company that is technology-focused rather than customer oriented, as also explained by Kundu and Bairi (2014). Through five workshops run in the course of the first year, a deliberate attempt was made from the outset to create awareness about the importance of understanding customer needs and delivering customer value, which is fundamental for any ERP or Lean transition to succeed (Womack and Jones,1996; Bortolotti and Romano, 2012). Employees had to learn to adapt their "ERP programming" approach to problem solving to the Lean Six Sigma mindset concerned with the improvement of processes and customer value, and to apply both in combination as part of their ongoing work.

The study also reconfirms the importance of a set of factors, which are generally considered crucial for the success of an ERP - Lean Six Sigma journey, and which should therefore complement the framework. Firstly, an ongoing focus on building improvement skills for managers and employees should prevail throughout the process to ensure a successful journey for the case company (Bortolotti and Romano, 2012; Pellerin and Hadaya, 2008; Malmbrandt and Åhlström, 2013 and others). Forming a common understanding of customer expectations in the case company and making it more customer-oriented spurred the transformation. The CEO's long-term commitment to ERP and Lean Six Sigma, together with their role

as an agent of change, made a noticeable difference for the company, as per the paper of Schniederjans and Yadav (2013). This, in turn, along with career incentives and team orientation, motivated the employees to engage with the efforts. The ongoing execution of repetitive cycles of improvement-monitoring projects, including both Lean / A3 tools and methods, as well as ERP usage / enhancements, were critical for the results. Finally, the role of ERP systems in delivering KPIs, as well as process and performance data to improvement projects, and thereby fostering a data-driven decision-making culture in the company (Pritchard, 2013; Halgeri et al., 2010; Nauhria et al., 2009) was highlighted. This demonstrates how short-term service improvements and continuous improvement capabilities can be supported by human, organisational, and technological solutions, together with automation of processes and performance reporting.

Future research should investigate the extent to which these findings apply to a wider range of contexts, for example, to companies that have more extensive experience of using Lean Six Sigma and ERP. Furthermore, the study shows that future research could investigate the time-lapsing and its impact on the implementation effect and to what extent sustainable implementation could be accelerated.

Perspectives on the role of ERP and Lean Six Sigma in digitalisation of companies. Many companies are under pressure to perform better despite decreasing resources and seek digitalisation as a strategy to move forward. The benefits of digitalisation thus require a continuous improvement capability and the ability to use data in real time (Trstenjak and Cosic, 2019). This research demonstrates how the combination of Lean Six Sigma and ERP can be a successful way of achieving the benefits of digitalisation, as processes are improved and wasteful activities in day-to-day operations are eliminated (Burak Erkayman, 2018; Kobus et al., 2018; Kobus et al., 2017). SMEs could benefit from exploiting the possibilities within an ERP system instead of implementing multiple IT tools while digitalising their processes. This, however, might not be possible for larger companies, which would need to achieve ERP integration in combination with additional specialised IT solutions. Future research could investigate how the combination of Lean Six Sigma, ERP, and other digital components impact the capacity for building continuous improvement capability and competitive advantage.

Reflections on developing the framework with a case company. The study utilised conclusions from the existing scholarship to develop principles for implementing a combined ERP and Lean Six Sigma approach, and then proceeded to test and develop the framework inside the case company. The nature of the chosen methodology allowed for conclusions from the case study to be embedded into the framework. This added additional steps to the framework that were not suggested by the literature, e.g., clarification of the role of ERP for each improvement step and the importance of training and uniting the team before each improvement cycle. The presentation of the framework also benefits from contextualisation in the case description, which allows the reader to obtain practical insights about the use of the framework. Furthermore, the methodology acknowledges that the development of Lean Six Sigma (in combination with ERP) as an emergent system requires a systems view that integrates people, processes, and tools, as well as the evolving culture (Liker and Morgan, 2011). In this way, the timeframe of the study made it possible to assess the development of improvement capabilities in practice, not simply the initial ideas of the future work processes.

However, the methodology limited the developed framework to findings from a single case and the practical knowledge that arose in the case, which might have inhibited findings that could have been uncovered through a deductive study whereby a proposed framework was tested in multiple companies. Project governance is one example of a topic that was not covered in the framework. In the case company, project governance could be accomplished ad hoc, as the top management had a dedicated focus on implementing ERP and Lean Six Sigma through the framework and the company was small in size. In medium-sized or large corporations, project governance may already be established as a system. This study, however, does not provide any recommendations concerning the requirements for governance implementation, which is surely of importance in most organisations.

4.2 Discussing mechanisms supporting ERP and Lean Six Sigma

In the following sections, the mechanisms that were found to enable successful implementation of ERP and Lean Six Sigma – based on the case evidence – will be discussed in more detail, followed by an examination of the interactions between ERP and Lean Six Sigma.

Discipline-enabling activities for transforming change to the new routine. The analysis identified a number of factors and interventions that were important to implementation success by enabling discipline. Firstly, establishing organisational processes was identified to be highly present, and contributing to success in the form of three intervention characteristics: daily stand-up meetings, structured weekly meetings, and regular Kaizen (A3) meetings. Furthermore, the study found that support for standardised work routines, utilising templates created during the improvement workshops and integrated into the ERP, was important for fostering the discipline that contributed to successful implementation. Furthermore, the data for improvement and new KPIs introduced were found to be important to the implementation process via creating a focused view of the business performance and variation that contributed to the disciplined behaviour. Finally, the external coaching contributed to facilitating some of the other factors, and this may play an even more significant role than Table 10 suggests. For example, the establishment of organisational processes and routines would barely have been possible without the encouragement given by the external consultant.

All improvement sessions held throughout the years were carried out by the same external consultant – a fact that contributed to the disciplined behaviour of all employees participating in the change process. While the consultant got to know the company, its processes, and people, the staff received reminders through the repetition and consistency of the improvement sessions. This concurs with the findings by Done et al. (2011), which indicate that business process improvements are unlikely to develop sufficient capability for long-term success in SMEs without ongoing support.

Obviously, challenges were encountered while implementing changes in the work routines. Even when employees feel excited during an improvement session, they will return to old routines quickly if the change process is not managed in a disciplined way that internalises the new ways of working. During 2017, when the external consultant visited to check on the company's progress, the management found they had become very undisciplined, with no follow-up scheduled on the planned tasks. The consultant pointed out that, in not carrying out the planned activities, there was a visible lack of the right culture. Without external support to get the discipline back on track, this could have been the end of the transformation journey.

Based on these observations, improvement workshops need to be planned with enough frequency to maintain a disciplined mindset for continuous improvement. Ensuring the execution of these activities, as well as supporting the initiated activities from the workshops, is an important management task. This is particularly true in an SME setting, where there may be a lack of dedicated staff resources to implement improvements. A long-term partnership with a skilled external workshop facilitator, who is also familiar with the company and key stakeholders, is critical for a successful transformation. As SMEs often do not have the resources to hire a full-time expert, they will usually need to rely on the expertise and stamina of an external consultant who occasionally participates. For this case, the same external consultant delivered between ten and twenty days of annual support over many years, and this level of engagement can be justified for many other SMEs providing the services are of visible strategic and economic value to the company.

In some cases, sustained external consultancy will not be feasible, so the potential role of internal champions or other approaches in supporting SMEs may warrant future research and discussions.

Creating understanding is the foundation for successful implementation. Creating a shared understanding of company strategy and objectives among both management and employees, along with the role of core digital and Lean organisational processes capable of meeting customer expectations, were found to be critical to implementation. This finding is consistent with that of Terra et al. (2023), who state that a better organisational and process understanding facilitates continuous improvement and Industry 4.0 practices.

Shared understanding is the basis for process improvement. In this case, an organisational understanding via Lean tools was enhanced by three intervention characteristics: aligned understanding of the company goals and strategy, aligned understanding of customer expectations, and aligned understanding of core organisational processes. The interventions of workshops with an external expert created understanding and built improvement skills among employees. Two intervention characteristics contributed to understanding and skills via the elimination of waste activities in ERP: pen-to-paper process mapping and a process check with manual tools before using ERP. Finally, one intervention characteristic helped to create understanding by providing data for improvement: the introduction of new KPIs

during implementation.

The seven intervention characteristics mentioned above were found to be important for creating a shared understanding of ERP – Lean and contributed to the development of mindsets supportive of new improved ways of working by the employees. During the follow-up interviews, the improved understanding and skills among the employees became clear, as interviews revealed that they were impressed by the changes and clarity brought about by the transformation process. The development of Lean in combination with ERP as an emergent system requires a system view that integrates tools, processes, and people, and takes an evolving culture into consideration (Liker and Morgan, 2011).

Building engagement and relevant external support ignites change initiatives. Recent research states that the success of continuous improvement, Industry 4.0 and similar initiatives depends on employee engagement (Marin-Garcia et al., 2024; Terra et al., 2023, Naik et al., 2023; Zanon et al., 2021).

The study we conducted found that engagement played a key role in contributing to successful implementation. The factors related to organisational understanding contributing to engagement because these developed the skills necessary for process improvement. Furthermore, the factor of employee engagement while improving ERP usage and Lean practices emerged through intervention characteristics, such as employee participation in improvement sessions and ownership of work during improvement projects.

In a follow-up interview, the external consultant revealed that the transformation process was characterised by stronger engagement and commitment than had been encountered in many other cases. Moreover, the external consultant noted that along with a better understanding of ERP and Lean Six Sigma, the employees were motivated by better insights into customer needs and improvements in process performance. Similar observations were made by Lyngstadaas and Berg (2024) in their study of digital business environments, highlighting that employees who feel competent, connected, and autonomous in digital environments are more likely to be engaged and contribute to improved performance.

Enabling bureaucracy operationalises successful implementation. The study also found two key factors related to “enabling bureaucracy” (Adler and Borys,

1996), i.e., support for standardised work routines and elimination of waste activities in ERP, which were aligned with the five influential interventions, as shown in Table 10. The integration of ERP into the templates created during the improvement sessions, combined with an enabling social structure of continuous improvement and learning-by-doing, were important contributing factors to the implementation. Furthermore, the use of bureaucracy-enabling objects, such as boundary objects (Carlile, 2002), supported employee involvement in improving ERP usage and were visible when general improvement ideas were addressed in the company. For example, A3 forms, created to support the improvement projects for ERP usage, were also used in areas such as the implementation process, support processes, and integrating customer calls information into ERP. The intervention characteristic of creating a pen-to-paper process map before using ERP and checking the process with manual tools before doing it in ERP is also a method related to enabling bureaucracy. The activity of trying things out manually before programming can be repeated every year.

Interactions between ERP and Lean Six Sigma implementation. The case study shows how the integrated implementation of ERP and Lean initiatives can increase the success and outcomes of both approaches individually. They can support each other due to the factors, intervention characteristics, and mechanisms inherent in both. Lean improvement projects initiate a more effective use and enhanced functionality of ERP, while ERP provides the needed KPIs and structure for Lean transformation. This synergy can help in leading a company to more efficient digitally supported processes and continuous improvements. This finding is aligned with Powell, Alfnes, et al. (2013), who describe ERP as a tool in the Lean toolbox, and the ERP implementation process as an imperative process of the Lean implementation process. It could, however, be argued that the interactions are more than merely supplementary tools (Liutkevičienė et al., 2022).

ERP enables Lean process standardisation and is an increasingly useful structure for continuous improvement and an enabler of sustainable transformation. The handling of support tickets in ERP (ticket types, statuses, start / end times) via usage of one unified template was an example of this in the case study. The ERP system was upgraded to handle support tickets, but it also received employee complaints over its quality. After several rounds of ERP module upgrades, the ticket support tool functioned as intended. There was now a digitally standardised and

improved customer service process, again facilitating elevated understanding and further employee engagement with continuous improvement along the way.

ERP also enables KPIs and real-time performance monitoring, and consequently, the successful implementation of Lean business processes, Kaizen procedures, and culture. These KPIs are particularly important for providing transparency of performance and progress at the beginning of the implementation of Lean. The case company managers and staff had lacked an overview and KPIs for tasks, workload, and completion status in the beginning. The introduction of KPIs helped by making it clear which ERP modules customers were asking for, and based on this, the training requirements for customers were determined. If bugs kept repeating in the same module, special attention was paid to that module and bug fixing. It was relatively easy to implement new KPIs in ERP when needed. Firstly, a KPI would be written on the board for a defined period. If it was assessed as useful for work process monitoring and continuous improvement, then the KPI reporting would be implemented in ERP and made visible on a monitor every day.

In an analogous way, the Lean approaches for minimising waste and increasing flow turned out to be something that improved ERP design, implementation, and use. Because the elimination of waste was actively applied in all company activities, the employees also began to suggest types of data that were unnecessary and should not be entered in ERP. For example, numerous information fields were reduced due to this new way of thinking. Although the elimination of waste data was not graded as highly important in Table 10, its interaction effects were most likely significant.

Implications of the mechanisms for SMEs. The identified four organisational mechanisms and twenty-four intervention characteristics appearing in Table 10 provide SME managers with a set of concrete or practical actions, as well as an explanatory framework and guidelines, which they can apply when implementing Lean and ERP in combination to improve operations or service excellence. This paper thus contributes to practice by providing novel insights and practical advice on how SMEs, and particularly service operations with increased use of digital and AI technologies, can integrate Lean Six Sigma and ERP methods and build digitally supported continuous improvement capabilities. Guidance is provided as to how to create understanding and skills, as well as how to subsequently build the necessary engagement, discipline, and bureaucracy to sustain continuous improvement

routines and make either Lean Six Sigma and / or ERP implementations succeed. Our results show positive synergies with recommendations from other studies on digital and organisational transformations of SMEs. For example, in their study of 201 Chinese SMEs, Wang and Zhang (2025) identify a clear and mediating relationship between organisational culture, organisational structure, and management practices, and the successful adoption of digital technologies. They propose mechanisms such as “digital drive” and “digital culture” to explain how the adoption of digital technologies enables business transformation, innovation of processes and products, and improved business performance.

We expect that the findings and recommendations from our study may be of relevance for organisations other than SMEs in Europe or globally, given that they pertain to the IT service industry, but that would only apply if the results were properly incorporated into the culture, practices, and systems of such organisations. However, we also call for further studies to investigate if and to what degree our findings regarding the impact of these factors, intervention characteristics, and mechanisms on Lean and ERP business transformations can be replicated. Future research could investigate the specific sequence and synergies of these four mechanisms in SME business transitions. It could also connect this research to the growing body of literature on the adoption of AI-related solutions in combination with ERP within SMEs and the IT industry in general. Preferably, future studies could cover a broader category of SMEs with respect to age, size, industry, and country, etc. The SME category of companies covers businesses with between 1 and 250 employees, and our case company had just 20 employees. To reach more generalisability in its conclusions, future studies could be replicated using larger samples of SMEs, or companies with 100+ employees to validate the impact of these mechanisms and intervention factors in different situations. Additionally, future studies of Lean and ERP transformations or digitally supported process improvement initiatives could also preferably be accomplished using methods other than design science or single case studies; instead, they could be carried out using multiple case studies or survey / quantitative methods. In addition, future research could explore other new theoretical concepts and lenses, as posited by Wang and Zhang (2025), which could provide further insights into the role of mechanisms and factors in driving a successful SME adoption of digital, e.g., ERP and AI technologies as well as Lean Six Sigma or process improvement capabilities.

CONCLUSIONS AND IMPLICATIONS

Since the emergence of Lean Six Sigma and ERP decades ago, the need for effective processes and the ability for continuous improvement has not decreased. While papers on combining Lean Six Sigma and ERP were already published 10 years ago, the focus in the existing literature has been on implementing from scratch. In the business context of the 2020s, most organisations already have a version of Lean Six Sigma and ERP, but they may struggle with developing continuous improvement capability and continuing the journey of digitalisation to support operational excellence (Trstenjak and Cosic, 2019).

This study sets out to propose and evaluate a generic framework for a combined ERP and Lean Six Sigma implementation for developing continuous improvement capability and identifying mechanisms that can enable process-orientation in SMEs, while implementing the integrated framework. A case study narrative is presented with examples showing how the developed framework for the combined implementation of ERP and Lean should be utilised. The work shows how the framework delivers tangible productivity improvement (by double digits year-by-year) and quality improvements, together with an increase in continuous improvement capability. This research provides a generic framework that can address the needs of these organisations today: an implementation guide for how to develop process improvements and measure the development of continuous improvement capability in order to achieve a competitive advantage. The study yields a generic framework that can address this need: an implementation guide for how to develop and measure business process improvement capability and thereby improve productivity, quality, and competitive advantage. The provided framework for ERP-Lean implementation was tested and validated in the service context of an SME, demonstrating how it can be deployed to raise productivity by double digits year-by-year, deliver quality improvements, and increase continuous improvement capability. The framework is generic and should be applicable for organisations in other industries and for larger enterprises if properly incorporated into existing practices and systems.

This particular research study has been expanded to include a Lithuanian SME in the IT service industry undergoing a thorough ERP and Lean transformation as part of its organisational development and growth strategy, with the mechanisms and outcomes of this initiative being thoroughly investigated. A number of key mechanisms that can explain the successful intervention and provide guidance for

others who want to use ERP - Lean Six Sigma are identified. Twelve mechanisms that contribute highly to successful implementation are reported upon, as well as being categorised into four more generic mechanisms demonstrating the following: a) creating understanding is the foundation for successful implementation, b) discipline-enabling activities transform the transition to the new daily schedule, c) building engagement ignites the change efforts, and d) enabling bureaucracy operationalises successful implementation. These mechanisms show how ERP and Lean Six Sigma interact and can be used together to help SMEs overcome the challenge of process-orientation that often stop them from developing into a more mature organisation.

Furthermore, the longitudinal study using an implementation process model provides practical guidance for the implementation of ERP - Lean Six Sigma in SMEs, including relevant metrics for the monitoring of progress during the implementation project. The research presents a case study narrative and the framework developed for combined implementation of ERP and Lean, together with supporting mechanisms. When deployed, the framework delivers tangible productivity and quality improvements, as well as increased continuous improvement capability, with the latter being based on Lean Six Sigma and being digitally supported by ERP.

The study contributes to the scientific literature by providing insights concerning how SMEs and service operations can integrate Lean and ERP methods, build both digital infrastructure and business process improvement capabilities, and enabling organisational growth and profitability (Liutkevičienė et al. 2026). The framework could also be applicable for organisations in other industries and for larger enterprises if properly incorporated into existing practices.

Finally, the case utilises Design Science Research to provide pragmatic advice, thereby contributing to the practice of this research methodology (Liutkevičienė et al. 2022).

Implications for theory

The key contributions to the existing theories and the novel aspects of this research are as follows:

- The research has provided evidence regarding the results that are realistically achievable from a combined ERP and Lean Six Sigma implementation (the intervention was successful from a practical

perspective, but it took longer than expected).

- Both the proposed theoretical framework and the case study illustrate the main steps required, as well as the essential strategic, tactical, social, and human factors to succeed in building and executing an integrated ERP and Lean Six Sigma approach, eventually supporting a Kaizen approach to all company processes.
- The identified mechanisms show how ERP and Lean interact and how together they can help SMEs overcome the challenge of implementing the type of digitally supported process improvement required for them to develop a more mature organisation.
- The study confirms several of the observations / conclusions that have been found in equivalent studies in relation to, for example, manufacturing industries. However, such conclusions are particularly interesting as they are based on an SME and IT service company context, in contrast to previous studies of a similar kind.

Implications for practice

The findings provide practical guidance how SME managers can deploy a combined ERP–Lean implementation in SMEs, and that this approach can lead to increases in productivity of double digits year-on-year, quality improvements, and increased continuous improvement capability. The implementation framework is generic and should be applicable for organisations in other industries and for larger enterprises if properly incorporated into existing practices and systems. The key organisational mechanisms show how ERP and Lean can be integrated and how they supplement each other when it comes to enabling the type of digitally supported process improvement in SMEs that can lead to company growth and the creation of competitiveness.

Limitations and suggestions for future research

The main limitation of the study is that the case company's maturity level with ERP and Lean Six Sigma might not be generalisable. Therefore, further research should investigate how the findings apply to a wider range of contexts, for example, companies in different industries, with more extensive experience of using Lean Six Sigma methodologies and ERP systems. Future studies could cover a broader

category of SMEs with respect to age, size, and country, etc. The SME category of companies covers businesses with between 1 and 250 employees, and the case company had just 20 employees. To achieve greater generalisability of conclusions, future studies could be replicated using larger samples of SMEs or companies with 100+ employees to validate the impact of these mechanisms and intervention factors. The specific sequence and synergies of the four mechanisms in SME business transitions could also be analysed. Such research could also be connected to the growing body of literature on the adoption of AI-related solutions in combination with ERP within SMEs and the IT industry in general (Liutkevičienė et al., 2026). Future studies of Lean and ERP transformations or digitally supported process improvement initiatives could also preferably be achieved using methods other than design science or single case studies; instead, multiple case studies or the usage of survey / quantitative methods could be employed. In addition to this, future research could explore other new theoretical concepts and lenses such as those of Wang and Zhang (2025), which could provide further insights into the role of mechanisms and factors involved in driving successful SME adoption of digital technologies such as ERP and AI, as well as Lean Six Sigma for process improvement capabilities.

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ISM VADYBOS IR EKONOMIKOS UNIVERSITETAS

Indrė Liutkevičienė

PROCESŲ TOBULINIMO GEBĖJIMŲ, PAREMTŲ SKAITMENINĖMIS TECHNOLOGIJOMIS, UGDYMAS MAŽOSE IR VIDUTINĖSE ĮMONĖSE

Daktaro disertacijos santrauka

Socialiniai mokslai, vadyba, S 003

Vilnius, 2026

Daktaro disertacija rengta 2013-2020 ir 2026 metais ISM Vadybos ir ekonomikos universitete. Doktorantūros teisė suteikta ISM Vadybos ir ekonomikos universitetui su Aarhus universitetu (Danija), BI Norvegijos verslo mokykla ir Tartu universitetu (Estija).

Disertacija ginama eksternu.

Mokslinis vadovas:

Doc. dr. Niels Gorm Maly Rytter (Pietų Danijos universitetas, Danija, socialiniai mokslai, vadyba – S 003).

Disertacija ginama ISM Vadybos ir ekonomikos universitete, Vadybos mokslo krypties taryboje:

Pirmininkė:

Prof. dr. Ilona Bučiūnienė (ISM Vadybos ir ekonomikos universitetas, socialiniai mokslai, vadyba, S 003)

Nariai:

Prof. dr. Vita Akstinaitė (ISM Vadybos ir ekonomikos universitetas, socialiniai mokslai, vadyba, S 003)

Doc. dr. Jannis Angelis (KTH Karališkasis technologijos institutas, Stokholmas, Švedija, socialiniai mokslai, vadyba, S 003)

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ĮŽANGA

Tyrimo aktualumas. Mažos ir vidutinės įmonės (MVĮ) palaiko pramonės plėtrą, skatina savarankišką užimtumą ir užtikrina tvarų ekonomikos augimą (Bhat ir kt., 2021). Kaip aprašo Greiner (1998), augdamos MVĮ susiduria su organizaciniais ir lyderystės iššūkiais, kuriuos būtina įveikti siekiant išlikti konkurencingomis ir toliau augti. MVĮ augimo analizė išlieka itin svarbi šiuolaikinės ekonomikos ir mokslinių tyrimų kontekste (Garcia-Martinez ir kt., 2023). Augdamos MVĮ susiduria su iššūkiu, kai dėmesį, skiriamą produktų ar paslaugų inovacijoms, reikia suderinti su sprendimų priėmimo perdavimu, darbuotojų mokymu, bei procesų standartizavimo ir tobulinimo gebėjimo ugdymu. Papildomas iššūkis MVĮ plėtrai yra didėjantis poreikis diegti naujausias skaitmenines technologijas, įskaitant dirbtinį intelektą (DI), siekiant ateityje padėti vykdant pagrindines verslo funkcijas ir procesus (Shahin ir kt., 2024; Saghiri ir kt., 2025). Per pastaruosius kelis dešimtmečius tokiems gebėjimams ugdyti MVĮ taikė du vyraujančius metodus: diegė verslo valdymo sistemas (ERP), skaitmenizavo procesus (Terra ir kt., 2023; Abd Rahman ir kt., 2021; Sun ir kt., 2015) arba taikė Lean Six Sigma vadybos sistemas (Bhat ir kt., 2021).

Atskirai vertinant, ERP sistemos ir Lean Six Sigma vadybos sistema yra du skirtingi organizacijos tobulinimo metodai. ERP sistemomis (Davenport, 1998) skaitmenizuojami informacijos tarp funkcijų srautai ir pateikiami įvairūs funkcionalumai, kurie yra kasdienių veiklos procesų pagrindas, sudarant infrastruktūrą procesų tobulinimui (Masini ir Wassenhove, 2009). Taigi ERP vertė glūdi ne technologiniuose ištekliuose, o gebėjime, jais pasinaudojant, sukurti vertę kuriančias veiklas (Masini ir Wassenhove, 2009). Tuo tarpu, Lean Six Sigma koncepcija literatūroje apibūdinama įvairiai (Arlbjørn ir Freytag, 2013). Lean mąstysena grindžiama penkiais pagrindiniais principais: vertės nustatymu, vertės srauto žemėlapio sudarymu, srauto sukūrimu, tiekimo pagal poreikį nustatymu ir nuolatinio tobulėjimo siekimu (Womack ir Jones, 2003). Six Sigma – tai struktūrizuotas verslo tobulinimo metodas, kurio tikslas – nustatyti ir pašalinti defektų bei proceso svyravimų priežastis, sutelkiant dėmesį į klientams svarbius rezultatus (Antony ir kt., 2017). Kartu Lean ir Six Sigma sudaro integruotą procesų valdymo metodiką, suteikiančią galimybių nuolat tobulinti organizacijos pagrindinių veiklos procesų vykdymą (Salah ir kt., 2010).

Problema ir tyrimų spraga. MVĮ sunkiai sekasi šiuos metodus įgyvendinti po vieną atskirai (Powell ir kt., 2012). Empiriniais tyrimais nustatyta, kad įmonės,

sugebančios kombinuoti ir integruoti šias dvi viena kitą papildančias iniciatyvas, turi didesnę tikimybę pasiekti ne tik trumpalaikės naudos, bet ir ilgalaikės veiklos bei paslaugų kokybės (Busto Parra ir kt., 2021; Erkayman, 2019; Powell ir kt., 2013; Powell ir kt., 2012).

Nors yra daug įrankių ir gairių, skirtų ERP ir Lean Six Sigma diegimui, daugumai jų trūksta teorinio pagrindo, pavyzdžiui, aiškinamųjų organizacinių mechanizmų aprašymo arba bendrosios sistemos, skirtos skaitmeninėmis technologijomis paremtų (STP) veiklos procesų tobulinimo gebėjimų plėtrai, derinant ERP ir Lean Six Sigma diegimą. Todėl organizacijos susiduria su metodų diegimo ir taikymo iššūkiais, nes nežino, kurie įrankio ar technologijos elementai yra esminiai, kodėl bei kaip juos įgyvendinti (Kumar ir kt., 2022). Atsižvelgiant į pastaruoju metu išaugusias skaitmeninimo ir automatizavimo galimybes, pasitelkiant dirbtinio intelekto (DI) ir generatyvinio dirbtinio intelekto (GDI) sprendimus, būtini išsamūs tyrimai, kuriuose būtų siūloma ir vertinama bendroji sistema bei tiriami organizaciniai mechanizmai, turintys įtakos skaitmeninių procesų tobulinimo gebėjimų diegimui. Tai būtų galima užtikrinti išsamiu Lean Six Sigma ir ERP diegimo tyrimu, kuris papildytų teorinį pagrindą ir išgrynintų poveikį trumpalaikei ir ilgalaikei konkurencingumo plėtrai bei MVĮ augimui. Tokie tyrimai gali padėti pagrindą parengti patikimų rekomendacijų rinkinį, kurį MVĮ vadovai turėtų galimybę naudoti veikloms tobulinti ar paslaugų kokybei gerinti.

Tyrimo problemą galima apibrėžti taip: ERP ir Lean Six Sigma yra plačiai naudojami metodai, skirti veiklos tobulinimui, bet yra nedaug tyrimų apie jų sąveiką, kai šios sistemos diegiamos kartu, išnaudojant tiek IT procesų, tiek veiklos meistriškumo privalumus. Todėl kyla poreikis gilinti žinias, kaip organizacijos gali pasinaudoti Lean Six Sigma iniciatyvų integravimą su ERP, kad nuolat gerintų savo klientų aptarnavimo greitį, paslaugų kokybę, veiklos rezultatus, tuo pačiu išlaikydamos lankstumą ir mažas sąnaudas (Gijo ir kt., 2019; Obwegeser ir kt., 2019).

Tyrimo klausimas, tikslas ir uždaviniai. Šio darbo tikslas – nustatyti, kaip ERP ir Lean Six Sigma derinį galima panaudoti siekiant paversti MVĮ labiau į procesus orientuotomis organizacijomis ir pagerinti jų veiklos rezultatus; sukurti ERP ir Lean Six Sigma kombinuotą diegimo sistemą, siekiant plėtoti STP nuolatinio tobulinimo gebėjimą; taip pat nustatant tokį diegimą remiančius mechanizmus, padedančius didinti įmonių produktyvumą, kokybę ir konkurencinį pranašumą.

Šio darbo tikslą galima suskirstytas į du smulkesnius tyrimo klausimus:

- *Kaip galima sukurti ir įvertinti bendrą metodų diegimo sistemą, apjungiančią ERP*

ir Lean Six Sigma principus, padedančią vystyti STP veiklos procesų tobulinimo gebėjimus?

- Kokie yra pagrindiniai organizaciniai mechanizmai, įgalinantys STP procesų tobulinimo gebėjimų įgyvendinimą?

Tikslui pasiekti formuluojami tokie uždaviniai:

1. Remiantis literatūra išanalizuoti, kokia ERP diegimo ir Lean Six Sigma vadybos metodų taikymo vertė STP veiklos procesų tobulinimo gebėjimams.

2. Sukurti teorinį modelį su įgyvendinimo žingsniais, siekiant STP nuolatinio gebėjimų tobulinimo, integruojant ERP ir Lean Six Sigma metodiką, bei nustatyti galimus organizacinius mechanizmus, remiančius tokį modelį jo diegimo metu.

3. Nustatyti procesų tobulinimo ir STP nuolatinio tobulinimo gebėjimų matavimo rodiklius, skirtus įvertinti integruoto ERP ir Lean Six Sigma modelio diegimo sėkmę.

4. Patvirtinti ir išbandyti sukurtą teorinį modelį bei organizacinius mechanizmus pasirinktos įmonės atveju, taikant veiklos tyrimą (angl. Action Research) kartu su projektavimo mokslo tyrimu (angl. Design Science Research, sutr. DSR).

5. Parengti rekomendacijas įmonėms, kaip diegti integruotą ERP ir Lean Six Sigma vadybos modelį, gilinant STP procesų tobulinimo gebėjimus ir taip siekiant didesnės investicinės grąžos.

DISERTACIJOS REZULTATŲ SKELBIMAS IR PRANEŠIMAI KONFERENCIJOSE

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TRUMPA TEORINIŲ PAGRINDŲ APŽVALGA

Tiriant, kaip MVĮ šiuolaikinėje tarptautinėje verslo aplinkoje diegia STP procesų tobulinimo gebėjimus, verta atidžiau panagrinėti ERP tiekėjų siūlomas IT sistemas ir Lean Six Sigma vadybos praktikas.

ERP akcentuoja veiklos procesų integraciją visose funkcijose ir tarp jų (Davenport, 1998; Jacobs ir Weston, 2007), o Lean Six Sigma pabrėžia nereikalingų elementų eliminavimą, proceso srautą, svyravimų mažinimą ir vertės kūrimą (Womack ir Jones, 1996; Liker, 2004; Kadry, 2018). Tyrimų apie ERP ir Lean Six Sigma metodikų sąveiką bei jų diegimą apžvalga atskleidžia, kad tyrėjai sutaria dėl abipusės naudos, kurią galima pasiekti kombinuojant abu metodus, o ne taikant juos atskirai (Powell, 2013). Tačiau tyrimų apie integruotus metodus organizacijose nėra daug. Todėl čia galima matyti galimybių prisidėti prie mokslinių tyrimų, atliekant išsamų ir ilgalaikį tyrimą apie kombinuotą Lean Six Sigma ir ERP diegimą MVĮ bei nustatant mechanizmus, kurie padeda diegti STP procesų tobulinimo galimybes, taip darant tiek trumpalaikį, tiek ilgalaikį poveikį įmonių konkurencingumui ir augimui.

Teorinis pagrindas, kuriuo remiasi kombinuoto ERP ir Lean Six Sigma diegimo modelis

Remiantis individualia ir integruota Lean bei ERP diegimo sistemų analize, buvo pasiūlyta sintezė, skirta sukurti modeliui, padedančiam gerinti verslo procesų tobulinimo gebėjimus. modelis sukurtas remiantis literatūros analize ir vėliau patvirtintas projektavimo mokslo tyrimais, atliktais per aštuonerius metus trukusį veiklos tyrimą, pagrįstą toliau išdėstytais principais:

1) Pasirengimo etapas. Didelė dalis mokslinės literatūros pabrėžia būtinybę parengti transformacijos programą, kurioje numatytas realus įgyvendinimo veiklų tempas. Į pasirengimą įeina ir ERP bei Lean brandos įvertinimas bei suinteresuotųjų šalių įsipareigojimas dalyvauti procese, nustatant projekto apimtį ir tikslus, organizuojant projektą.

2) Tobulinimo projektų vykdymo etapas. Šis etapas turėtų būti grindžiamas DMAIC arba panašia nuolatinio tobulinimo metodologija, kurią galima taikyti kiekvienam projektui atskirai. Tokia standartizuotų žingsnių seka turi būti pritaikoma daugeliui įvairių tobulinimo ciklų ir turėtų būti pritaikyta prie konkrečios įmonės poreikių bei išteklių (Lokkerbol ir kt., 2012). Projektas suskirstomas į šiuos žingsnius:

• Apibrėžti esamą padėtį ir veiklos rezultatus (Lokkerbol ir kt., 2012; ir kt.).

• Nustatyti tobulinimo variantus (Harrison ir kt., 1997) ir išanalizuoti galimus sprendimus (Kumar ir kt., 2012).

• Suplanuoti konkretaus tobulinimo projekto užduotis (Kumar ir kt., 2012; ir kt.).

• Įgyvendinti sprendimus (Nightingale ir Mize, 2002; ir kt.).

• Vertinti ir stebėti patobulinimus (Nightingale ir Mize, 2002).

• Kontroliuoti ir koreguoti (Lokkerbol ir kt., 2012; ir kt.).

3) Dėmesys nuolatinio procesų tobulinimo ciklams turi būti įtrauktas į aukščiau nurodytus etapus, taikant DMAIC sistemą.

4) Veiklos rezultatų rodikliai ir procedūros turėtų būti šios sistemos dalimi. Tai matyti keliose dabartinėse rekomenduojamose sistemose, pavyzdžiui, Bessant ir Francis (1999) gebėjimų/brandos sistemoje arba Delgado ir kt. (2014) numatytame veiklos ir procesų veiklos rezultatų rodiklių rinkinyje, pagrįstame produktyvumo sąnaudomis, kokybe, laiku ir klientų pasitenkinimu.

Yra du būdai, kaip ERP sistema gali prisidėti prie nuolatinio tobulinimo projektų. Pirma, ERP sistema gali palaikyti ir automatizuoti standartizuotus darbus, užtikrindama, kad darbai būtų atliekami pagal tikslią seką ir formatą (Ghobakhloo ir Hong, 2014). Antra, ERP sistemos teikia procesų ir veiklos rezultatų duomenis Lean tobulinimo projektams bei įmonėse sudaro sąlygas vadinamajai „duomenimis pagrįstai sprendimų priėmimo kultūrai“ (Halgeri ir kt., 2011; Nauhria ir kt., 2009), kurioje dera greitas tobulinimas ir tobulinimo gebėjimų plėtojimas (Hansen, 2015).

Veiksniai, darantys įtaką integruoto ERP ir Lean Six Sigma diegimo rezultatams

Buvo išnagrinėti mokslinės literatūros tyrimai apie ERP ir Lean Six Sigma siekiant nustatyti veiksnius, įgalinančius MVĮ suderintai ar net integruotai juos įgyvendinti. Remiantis literatūros apžvalga, buvo nustatyta dešimt elementų, lemiančių, kaip ERP ir Lean Six Sigma derinys gali prisidėti stiprinant procesų tobulinimo gebėjimus, didinti konkurencingumą, skatinti augimą. Šie veiksniai apibendrinti žemiau.

Pirmasis veiksnys, pabrėžtas dabartiniuose tyrimuose, paaiškina, kad Lean įrankiai ir veiklos gali padėti šalinant nereikalingas veiklas ERP projektuose. Tiek Ghobakhloo ir Fathi (2019), tiek Powell ir kt. (2012) teigia, kad Lean praktikas galima naudoti siekiant supaprastinti ir patobulinti duomenų rinkimo bei paruošimo procesus ERP sistemose. Atitinkamai antrasis nustatytas veiksnys rodo, kad Lean taikymas gali

pašalinti nereikalingus duomenis ERP sistemose. Powell ir kt. (2012) ragina taikyti Lean praktikas kaip aiškią strategiją duomenų vientisumui gerinti ir nereikalingų duomenų rinkimui pašalinti.

Trečiasis veiksnys – ERP funkcionalumo gerinimas dėl įdiegtos Lean Six Sigma įmonės į savo ERP sistemas įtraukia gerąsias Lean Six Sigma praktikas. Į tai įeina įvairūs nauji moduliai, įrankių rinkiniai ir funkcionalumai, sukurti esamoje programinėje įrangoje (Blijleven ir kt., 2019). Ketvirtasis veiksnys – tai gebėjimas, pasitelkiant ERP, sukurti standartizuoto darbo procedūras. Vykdant Lean Six Sigma projektus, darbo procedūroms nustatomi standartai, o ERP gali juos išlaikyti, kartu užtikrindama, kad darbai būtų atliekami pagal tikslią seką ir formatą (Sartal ir Vázquez, 2017). Penktasis veiksnys paaiškina, kaip ERP gali remti srautą ir sudaryti sąlygas nuolatinėms Lean veikloms. ERP sistemos gali teikti duomenis, leidžiančius nustatyti srauto apribojimus ir trukdžius, ir taip prisidėti toliau kuriant gamybą, labiau pagrįstą srautu ir paklausa (Powell ir kt., 2013). Informacijos srauto automatizavimas yra iš esmės svarbus grynai paslaugų įmonėms, kuriose informacija yra paslaugos branduolys, o fizinių prekių nėra (Bortolotti ir Romano, 2012). Šeštasis veiksnys nustato, kaip ERP sistemos gali sudaryti sąlygas tiekimo pagal poreikį gamybai (Erkayman, 2019). Kad tinkamai veiktų, tiekimo pagal poreikį gamybos sistemos, kurios naudojamos prognozavimui, atsargų valdymui. reikia tikslių duomenų, kuriuos teikia ERP sprendimas (Powell ir kt., 2013). Septintasis veiksnys paaiškina, kaip ERP sistemos teikia procesų ir veiklos rezultatų duomenis Lean tobulinimo projektams ir sudaro sąlygas vadinamajam duomenimis pagrįstam sprendimų priėmimui (Maguire, 2016; Ghobakhloo ir Fathi, 2019).

Aštuntasis ir devintasis veiksniai susiję su darbuotojų įtraukimu ir vadovybės parama, kurie vertinami kaip esminiai tobulinant ERP naudojimą ir diegiant Lean Six Sigma praktikas. Lean kultūra skatina darbuotojus ir vadovybę būti labiau suinteresuotais naujais efektyviais darbo procesais ir įrankiais, kuriuos siūlo ERP sprendimai. IT vadovaujami projektai, kurie ankstyvoje stadijoje neatsižvelgia į procesų veiklos ir žmogiškąjį aspektus, greičiausiai žlugs (Powell ir kt., 2012; Erkayman, 2019).

Papildomų veiksnių rinkinys, skirtas suderintam ERP ir Lean Six Sigma diegimui, galėtų būti labiau strateginio pobūdžio. Powell ir kt. (2012) teigia, kad tiek ERP, tiek Lean metodikų taikymas turėtų prasidėti nuo sprendimo dėl įmonės strateginės vizijos ir vertybių. Išankstinis strateginis ir organizacinis pasirengimas procesų standartizavimui ir tobulinimui įmonėje yra būtina sąlyga ir Lean, ir ERP sėkmei

(Ghobakhloo ir Fathi, 2019).

Identifikuoti veiksniai pateikia svarbių aspektų sąrašą, kaip galima derinti ERP ir Lean Six Sigma iniciatyvas ir pasiekti rezultatų. Tačiau šie veiksniai nepateikia nei pakankamai konkrečių Lean ir ERP veiksmų, skirtų paveikti intervencijos rezultatus, nei paaiškinamųjų teorinių mechanizmų, kaip ERP ir Lean kartu gali transformuoti organizaciją. Todėl šiuos veiksnius reikia toliau tirti taikant labiau pagrįstą modelį. Toks tyrimas turėtų ne tik padėti suformuluoti konkretesnius veiksmus, bet ir suteikti gilesnį teorinį supratimą apie transformuojančius organizacinius mechanizmus, kuriais MVĮ gali sėkmingai įsisavinti skaitmeninėmis technologijomis grindžiamus procesų tobulinimo gebėjimus. Tai galima padaryti taikant konteksto–intervencijos–mechanizmo–rezultato (angl. context–intervention–mechanism–outcome, CIMO) modelį (Van Aken, 2004), kuris pristatomas metodologijos skyriuje.

Lean Six Sigma ir ERP gebėjimų bei projekto rezultatų vertinimas

Siekiant įvertinti, ar Lean Six Sigma ir ERP integracija sudaro sąlygas procesų tobulinimui, konkurencingumui ir augimui, tyrime taikomos dvi įrodymų rūšys: brandos modelis ir verslo bei procesų veiklos rodikliai, pagal kuriuos lyginami atvejo tyrimo duomenys. Įmonės brandai, procesų tobulinimui ir kultūrai vertinti veiklos tyrime taikomas plačiai paplitęs Bessant ir Francis (1999) modelis, nes jame pateikiami aiškiai įvardinti brandos lygiai (Hansen ir Møller, 2016). Siekiant įvertinti apčiuopiamus patobulinimus, įmonės paprastai naudoja PVR (angl. sutr. KPI) ir veiklos rezultatų matavimo sistemas (Tan ir kt., 2004). Į rekomenduojamus ERP ir (arba) Lean Six Sigma diegimo rodiklius įeina produktyvumas, kokybė, laikas ir klientų pasitenkinimas (Delgado ir kt., 2014). Šiame veiklos tyrime naudojamos keturios PVR kategorijos, taikomos tiriamojoje įmonėje. Konkretūs rodikliai pateikiami tyrimo išvadose.

TRUMPA TYRIMO METODOLOGIJOS APŽVALGA

Atsižvelgiant į šio tyrimo kokybinį pobūdį ir tyrimo klausimo tipą, metodologinis požiūris buvo grindžiamas veiklos tyrimu. Pastarąjį taip pat galima palyginti su ilgalaikiu, dalyvaujamuoju atvejo tyrimu. Veiklos tyrimas (Coughlan ir Coghlan, 2009; Reason ir Bradbury, 2007) bei ilgalaikis dalyvaujamojo pobūdžio atvejo tyrimas buvo įkvėpimo šaltinis čia aprašytai sistemai, kurioje dera ERP ir Lean Six Sigma. Tyrimo metodologiją įkvėpė ir projektavimo mokslo tyrimai (DSR; Van Aken ir kt., 2016), ypač į praktikus orientuoti DSR, kuriuose pabrėžiamas empirinis indėlis ir praktinis aktualumas (Bagni ir kt., 2024). Naudojant konteksto – intervencijos – mechanizmo – rezultato modelį (angl. sutr. CIMO) (Van Aken, 2004; Denyer ir kt., 2008), tyrime nustatomi paaiškinamieji mechanizmai, skirti įgyvendinti integruotas ERP ir Lean Six Sigmą, atliekant realią intervenciją organizacijos kontekste.

Remiantis šiais argumentais, buvo sukurta tokia metodologija. Pirma, remiantis literatūra buvo sukurtas kombinuoto įgyvendinimo modelis ir veiksniai. Antra, buvo atliktas ilgalaikis intervencijos veiklos tyrimas, padedantis geriau suprasti intervenciją, įgyvendinant kombinuotos sistemos žingsnius, mechanizmus ir rezultatus konkretaus atvejo kontekste. Trečia, buvo panaudoti empiriniai duomenys siekiant patobulinti kombinuotą modelį, nustatyti išplėstinį veiksnių sąrašą, paaiškinantį, kaip galima kombinuoti ERP ir Lean Six Sigma, bei sukurti konkrečias, į veiksmus orientuotas intervencijas. Tai buvo pasiekta taikant CIMO logiką, lyginant rezultatus su faktinėmis intervencijomis praktikoje ir analizuojant rezultatus atsižvelgiant į kontekstą. Galiausiai buvo taikyta analizė, siekiant tobulinti diegimo modelį ir nustatyti keturis bendruosius organizacinius mechanizmus, skirtus ERP ir Lean Six Sigma diegimui.

Atvejo pasirinkimas ir duomenų rinkimas

Myers (2013) teigia, kad, atliekant tyrimus su intervencijomis, bendradarbiavimas su tiriamąja įmone ir jos įsitraukimas yra itin svarbūs. Kadangi esu tyrėja, užimanti vadovaujančias pareigas tiriamojoje įmonėje, turėjau galimybę naudotis įmonės informacija, ištekliais ir duomenimis, užtikrindama ir intensyvų bendradarbiavimą bei įsitraukimą. Pasirinkta tiriamoji įmonė buvo maža Lietuvoje įsikūrusi IT įmonė, atsakinga už programinės įrangos sprendimo, sukurto Estijoje, pardavimą, diegimą ir techninį aptarnavimą vietos rinkoje. Problemos apimtis buvo nustatyta 2015 m., remiantis klientų pasitenkinimo tyrimo rezultatais, kurie parodė, kad įmonei reikalingi

veiksmingesni ir STP procesai. Tai paskatino suformuluoti intervencinį veiklos tyrimą 2014 – 2023 m. laikotarpiui. Įmonė turėjo aiškią paskatą (Myers, 2013) dalyvauti šiame mokslinių tyrimų projekte, kadangi taip ji gavo galimybę sustiprinti savo konkurencinį pranašumą.

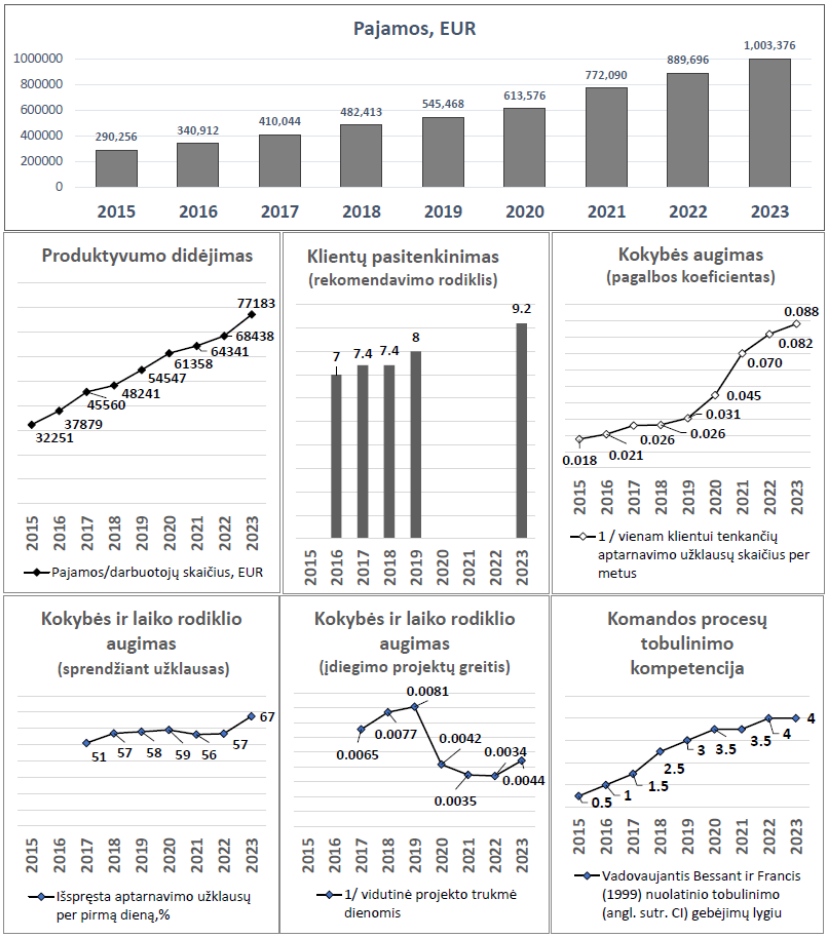
Intervencijai ištirti buvo naudojami įvairūs duomenų rinkimo metodai ir įvairūs duomenų šaltiniai remiantis Coughlan ir Coghlan (2009).

Surinkti duomenys buvo panaudoti atvejo aprašymui, suskirstytam į devynias chronologines dalis, pradedant nuo tiriamosios įmonės konteksto ir situacijos iki tobulinimo iniciatyvų. Tada pateikti 2015 – 2022 m. vykdytų intervencijų aprašymai. Įmonės atvejo aprašymas baigtas epilogu ir rezultatais iki 2023 m.

PAGRINDINIŲ TYRIMO REZULTATŲ SANTRAUKA

Devynerių metų laikotarpio rezultatų santrauka, vertinta pagal pasirinktus rodiklius, pateikta 1 paveikslėlyje. Per šiuos devynerius metus pajamų augimas vidutiniškai siekė 18,8 %. Darbo našumas (pajamos lyginant su darbuotojų skaičiumi) kasmet didėjo nuo 5 % iki 20 %. Klientų rekomendacijų rodiklis (fiksuotas 5 iš 9 tobulinimo proceso metų) padidėjo nuo 7 iki 7,4 ir 9,2. Dėl tobulinimo veiklos per devynerius metus užklausų skaičius žymiai sumažėjo – nuo 57 iki 11 incidentų užklausų vienam klientui per metus.

1 pav. Rezultatų grafinė apžvalga



Šaltinis: Liutkevičienė ir kt. (2026)

Be to, per devynerius metus per vieną dieną išspręstų incidentų užklausų

nuošimtis išaugo nuo 51 % iki 67 %, nepaisant svyravimų, įvykusių 2019 ir 2020 metais. Projekto sparta pagerėjo, o klientų projektų įgyvendinimo trukmė sutrumpėjo dėl 2016 ir 2023 m. šiam procesui skirtų intervencijų.

Komandos STP tobulinimo gebėjimai, įvertinti pagal Bessant ir Francis (1999) modelį, kasmet didėjo ir paskutiniais metais pasiekė 3 – 4 lygį, o tai rodo, kad įmonė galėjo spręsti laipsniškas problemas be išorinių konsultantų pagalbos. Mažinant sąnaudas, gerinant kokybę ir taupant laiką, buvo įdiegtas eksperimentavimas, matavimas ir stebėsena.

Skaitmeninis procesų tobulinimas naudojant ERP ir LSS diegimo modelį

Rezultatų duomenimis, taikant kombinuotą ERP ir Lean Six Sigma metodiką pavyko paskatinti įmonės augimą, pasiekti teigiamų rezultatų produktyvumo, kokybės ir orientavimosi į klientus srityse, o svarbiausia – išugdyti tiriamos įmonės nuolatinio tobulinimo gebėjimus. Veiklos transformavimo veiksmai buvo įgyvendinti atliekant Lean Six Sigma ir ERP sintezę bei taikant projektavimo mokslo tyrimo ir veiklos tyrimo metodologijas. Remiantis tiriamosios įmonės veikla ir pasiekimais, apibendrinti rezultatai pateikti kaip kombinuotas ERP – Lean Six Sigma tobulinimo modelis, pavaizduotas 2 paveikslėlyje.

Strategijos formavimas ir pasirengimas ERP bei Lean Six Sigma diegimui

Pirmoji kombinuotos ERP – Lean Six Sigma modelio dalis skirta strategijos formavimui ir organizacijos paruošimui: pradinės ERP ir Lean Six Sigma brandos įvertinimui, prioritetų suderinimui su tobulinimo veiksmais, pokyčių iniciatorių vaidmenų apibrėžimui, suinteresuotųjų šalių mokymų planavimui bei PVR nustatymui prieš pradedant diegimą (Powell ir kt., 2012; Pellerin ir Hadaya, 2008).

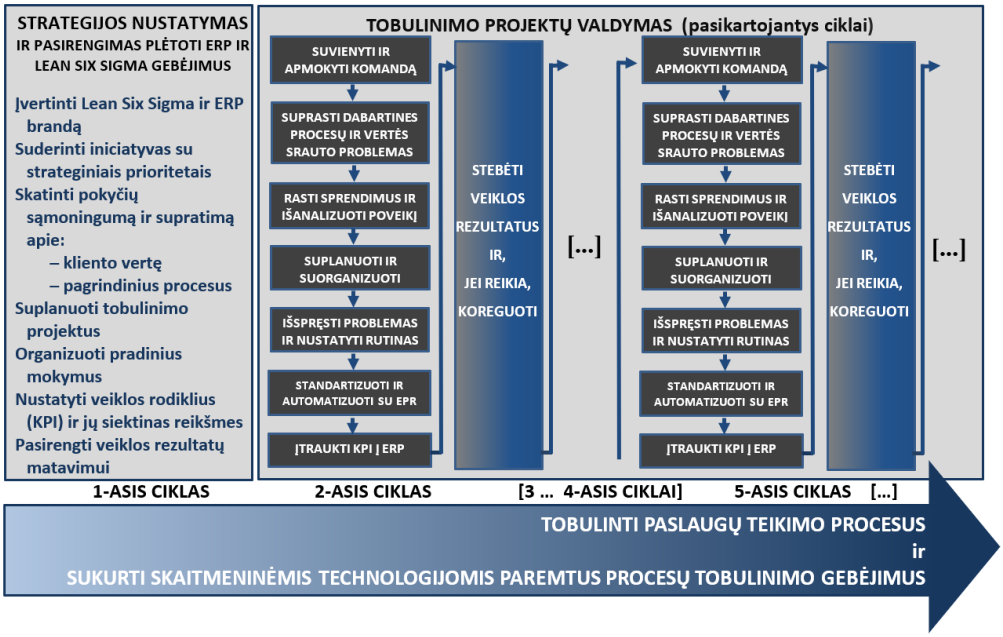
Tiriamojoje įmonėje, kurioje ERP sistema jau buvo įdiegta, modelis buvo pritaikytas taip, kad sustiprintų esamos sistemos teikiamą naudą, naudojant Lean Six Sigma metodus. Pokyčiai buvo įgyvendinami naudojant X-matricą, vadovo parama ir lyderystė bei išoriniai mokymai taip pat buvo svarbūs tobulinimo projektuose (Barnabė ir Giorgino, 2017; Schniederjans ir Yadav, 2013; Kumar ir kt., 2012).

Tobulinimo projektų valdymas

Sistemos tobulinimo projektų valdymo ir vykdymo etapas iliustruojamas tobulinimo – stebėsenos ciklais. Kiekvienas ciklas prasidėdavo Kaizen renginiu, kurio metu buvo taikomi standartizuoti tobulinimo žingsniai (Aken ir kt., 2010), po to eidavo stebėjimo laikotarpis, kurio metu nusistovėdavo, stabilizuodavosi naujos rutinos bei

procedūros ir buvo daromi tik nedideli koregavimai. Šis principas atspindėjo mažą įmonės dydį, ribotus pokyčių iniciatorių gebėjimus ir darbuotojų poreikį turėti stabilų kasdienį darbą, prieš pradedant ieškoti tolesnių tobulinimo galimybių. Svarbiausi aspektai, padėję pasiekti rezultatų, 2 paveikslėlyje pateikti kaip tobulinimo projekto žingsniai.

2 pav. Kombinuotas ERP – Lean Six Sigma modelis, skirtas tobulinti paslaugų veikloms ir procesų tobulinimo gebėjimams



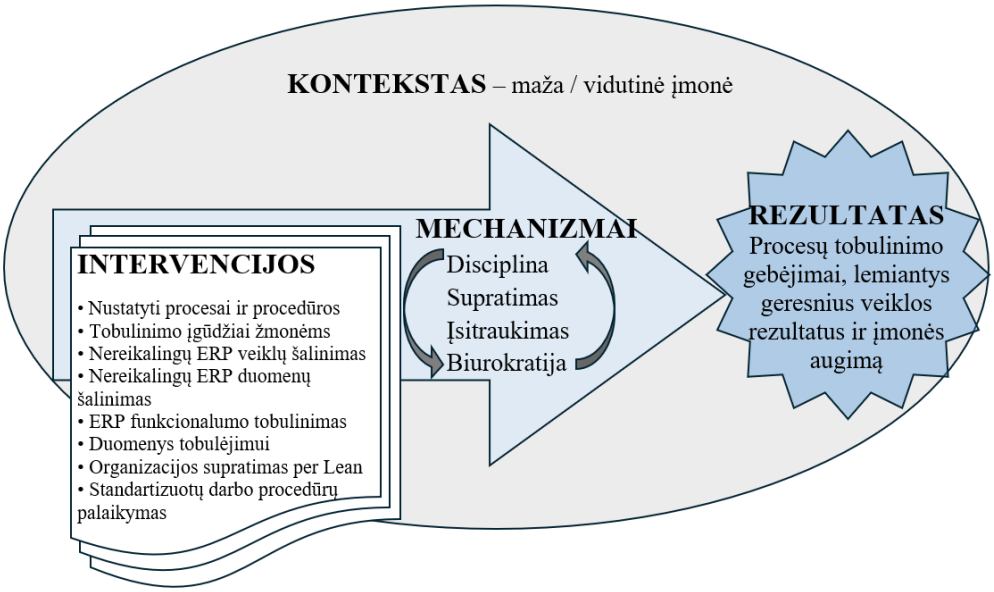
Šaltinis: Liutkevičienė ir kt. (2022)

Mechanizmų, kurie įgalina MVĮ panaudoti ir įdiegti skaitmeninį procesų tobulinimą, nustatymas

Išnagrinėjus įtaką darančius veiksnius ir charakteristikas, buvo pasiūlyti bendro pobūdžio organizaciniai mechanizmai, paaiškinantys, kaip MVĮ gali transformuoti savo organizacijos veiklas ir kultūrą. Mechanizmai apibrėžiami kaip veiklos arba struktūruoti procesai, kurie suaktyvinami intervencijų, siekiant konkrečių rezultatų (Lorentz ir kt., 2020; Pajunen, 2008; Momeni ir kt., 2023). Remiantis tiriamosios įmonės intervencijų analize, keturi organizaciniai mechanizmai (disciplina, situacijos supratimas, įsitraukimas ir įgalinanti biurokratija) paaiškina, kaip Lean Six Sigma ir ERP paveikia STP procesų tobulinimo gebėjimus ir veiklos rezultatus. Šis poveikis parodytas 3

paveikslėlyje, konceptualizuojant, kaip integruotas ERP ir Lean Six Sigma diegimas, padedant organizaciniams mechanizmams, gali sudaryti sąlygas MVĮ procesų tobulinimo gebėjimų ugdymui, veiklos rezultatų gerinimui ir verslo augimui.

3 pav. Remiantis CIMO modeliu parengta grafinė teorinių rezultatų apžvalga



Šaltinis: Liutkevičienė ir kt. (2026)

DISKUSIJA IR IŠVADOS

Nuo tada, kai prieš dešimtmečius atsirado Lean Six Sigma ir ERP, nesumažėjo poreikis turėti veiksmingus procesus ir gebėjimą nuolat tobulėti. Šio amžiaus antro dešimtmečio veiklos kontekste dauguma organizacijų jau turi Lean Six Sigma ir ERP, tačiau joms gali būti sunku plėtojant nuolatinio tobulinimo gebėjimus ir tęsiant procesų skaitmeninimą, užtikrinti veiklos meistriškumą (Trstenjak ir Cosic, 2019).

Šiame darbe pristatomas integruotas ERP ir Lean Six Sigma diegimo modelis, skirtas nuolatinio tobulinimo gebėjimams ugdyti, bei įvardinami mechanizmai, kurie, diegiant integruotą modeli, gali įgalinti MVĮ orientavimąsi į procesus. Pateiktas ERP – Lean Six Sigma diegimo modelis buvo išbandytas ir patvirtintas MVĮ paslaugų sektoriuje, taip parodant, kaip jį galima pritaikyti siekiant kasmet padidinti produktyvumą, pagerinti kokybę ir sustiprinti nuolatinio tobulinimo gebėjimą.

Tyrime nustatyti keli esminiai mechanizmai, kuriais galima paaiškinti sėkmingą intervenciją ir pateikti rekomendacijas kitiems, norintiems naudoti ERP – Lean Six Sigma kartu. Tyrimo išvadose pateikti 12 mechanizmų, prisidedančių prie sėkmingo sistemos diegimo. Šie mechanizmai buvo suskirstyti į keturis bendresnius mechanizmus, parodančius, kad: a) supratimo ugdymas yra sėkmingo diegimo pagrindas; b) discipliną įgalinančios veiklos paverčia pokyčius nauja kasdienine praktika; c) įsitraukimo auginimas paskatina pokyčių veiklas; d) įgalinanti biurokratija užtikrina sėkmingą įdiegimą. Šie mechanizmai parodo, kaip sąveikauja ERP ir Lean Six Sigma bei kaip kartu gali padėti MVĮ įveikti orientavimosi į procesus iššūkį, kuris dažnai trukdo joms tapti brandesnėmis organizacijomis.

Ilgalaikis tyrimas, kuriame taikomas kombinuoto diegimo modelis, pateikia praktines gaires ERP ir Lean Six Sigma diegimui MVĮ, įskaitant rodiklius pažangai stebėti projekto diegimo metu.

Galiausiai tyrime taikomas projektavimo mokslo tyrimo metodas, siekiant pateikti pragmatines rekomendacijas ir prisidėti prie šios tyrimų metodologijos taikymo praktikoje.

Disertacijos mokslinis naujumas

Pagrindinis indėlis į esamas teorijas ir tyrimo naujumo aspektai yra tokie:

• Tyrimas pateikė įrodymų apie rezultatus, kuriuos realiai galima pasiekti derinant ERP ir Lean Six Sigma diegimą (praktiniu požiūriu intervencija buvo sėkminga, tačiau

užtruko ilgiau nei tikėtasi).

• Pasiūlytas teorinis diegimo modelis ir atvejo tyrimas atskleidžia pagrindinius reikalingus žingsnius, taip pat esminius strateginius, taktinius, socialinius ir žmogiškuosius veiksnius, lemiančius sėkmę kuriant ir įgyvendinant integruotą ERP ir Lean Six Sigma metodą, galiausiai sudarantį prielaidas Kaizen principams taikyti visuose įmonės procesuose.

• Nustatyti mechanizmai parodo, kaip ERP ir Lean sąveikauja ir kaip kartu jie gali padėti MVĮ įveikti iššūkį įdiegti skaitmeninėmis technologijomis grindžiamą procesų tobulinimą, kokio reikia brandesnei organizacijai išugdyti.

• Tyrimas patvirtina keletą pastebėjimų ir išvadų, gautų analogiškuose tyrimuose, pavyzdžiui, gamybos pramonės sektoriuose. Vis dėlto šio tyrimo išvados įdomios tuo, kad, skirtingai nei ankstesniuose panašaus pobūdžio tyrimuose, jos grindžiamos MVĮ ir IT paslaugų įmonės atveju.

Reikšmė praktikai

Tyrimo rezultatai pateikia praktines gaires, kaip MVĮ vadovai gali įgyvendinti integruotą ERP ir Lean Six Sigma diegimą ir kaip toks metodas gali lemti dviženklį kasmetinį produktyvumo augimą, kokybės gerėjimą bei stipresnį nuolatinio tobulinimo gebėjimą. Diegimo modelis yra bendrinis, todėl turėtų būti pritaikomas kitų sektorių organizacijoms ir didesnėms įmonėms, jei bus tinkamai integruotas į praktikas ir sistemas. Pagrindiniai organizaciniai mechanizmai parodo, kaip ERP ir Lean Six Sigma gali būti integruojami ir kaip jie vienas kitą papildo, sudarydami sąlygas STP procesų tobulinimui MVĮ, kuris gali lemti įmonės augimą ir konkurencingumo didėjimą.

Tyrimo apribojimai ir rekomendacijos tolesniems tyrimams

Pagrindinis tyrimo apribojimas yra tai, kad tiriamojo atvejo organizacijos brandos lygis, taikant ERP ir Lean Six Sigma metodus, gali riboti rezultatų pritaikymą kitose organizacijose ir kontekstuose. Todėl tolesniais tyrimais tikslinga nagrinėti, kokius rezultatus duotų kombinuoto modelio diegimas įvairesniuose kontekstuose – pvz., kitų sektorių įmonėse, turinčiose daugiau patirties naudojant Lean Six Sigma metodologijas ir ERP sistemas. Atvejų tyrimai turėtų aprėpti platesnę MVĮ kategoriją pagal vykdomą veiklos trukmę, MVĮ dydį, šalį ir pan. Į MVĮ kategoriją įeina įmonės, turinčios nuo 1 iki 250 darbuotojų, o tiriamojoje įmonėje buvo 20 darbuotojų. Siekiant užtikrinti didesnį išvadų taikomumą bei patvirtinti integruoto modelio ir mechanizmų

poveikį, ateityje atvejų tyrimus tikslinga pakartoti naudojant didesnes MVĮ imtis arba įmones, turinčias daugiau darbuotojų.

Būtų verta išanalizuoti keturių mechanizmų konkrečią seką ir sinergiją pertvarkant MVĮ veiklos procesus. Taip atsirastų galimybė šį tyrimą susieti ir su gausėjančia literatūra apie su dirbtiniu intelektu (DI) susijusių sprendimų diegimą kartu su ERP tiek MVĮ, tiek apskritai IT sektoriuje. Būtų naudinga, kad būsimi Lean Six Sigma ir ERP transformacijų arba STP procesų tobulinimo tyrimai būtų atliekami naudojant ir kitus, ne tik projektavimo mokslo metodus ar pavienių atvejų tyrimus; vietoj to juose būtų tikslinga naudoti daugelio atvejų tyrimus arba apklausų ir (arba) kiekybinius metodus. Be to, būsimuose tyrimuose būtų tikslinga nagrinėti kitas naujas teorines koncepcijas ir aspektus, pavyzdžiui, Wang ir Zhang (2025), kurie galėtų suteikti daugiau įžvalgų apie mechanizmų ir veiksnių vaidmenį skatinant sėkmingą skaitmeninių, t. y. ERP ir DI technologijų, taip pat Lean Six Sigma ar procesų tobulinimo gebėjimų plėtojimą MV.

ISM UNIVERSITY OF MANAGEMENT AND ECONOMICS

Indrė Liutkevičienė

DEVELOPING DIGITALLY SUPPORTED PROCESS IMPROVEMENT CAPABILITIES IN SMALL AND MEDIUM ENTERPRISES

Summary of the Doctoral Dissertation

Social Sciences, Management, S 003

Vilnius, 2026

The Dissertation was prepared 2013-2020 and 2026 at the ISM University of Management and Economics under the right of Doctoral studies granted to ISM University of Management and Economics, UAB (together with Aarhus University [Denmark], BI Norwegian Business School and Tartu University [Estonia]).

The dissertation is defended on an external basis.

Supervisor: Assoc. Prof. Dr. Niels Gorm Maly Rytter (University of Southern Denmark, DK, Social Sciences, Management – S 003).

Doctoral dissertation will be defended at the Scientific Council of Management at ISM University of Management and Economics:

Chairperson:
Prof. Dr. Ilona Bučiūnienė (ISM University of Management and Economics, Social Sciences, Management, S 003)

Members:
Prof. Dr. Vita Akstinaitė (ISM University of Management and Economics, Social Sciences, Management, S 003)
Assoc. Prof. Dr. Jannis Angelis (KTH Royal Institute of Technology, Stockholm, Sweden, Social Sciences, Management, S 003)
Prof. Dr. Alfredas Chmieliauskas (ISM University of Management and Economics, Social Sciences, Management, S 003)
Prof. Dr. Valdonė Darškuvienė (ISM University of Management and Economics, Social Sciences, Management, S 003)

The public defence of the doctoral dissertation will be held on 1st of October 2026 at 11 A.M., room 210, at ISM University of Management and Economics. Address: Gediminas av. 7, Vilnius, Lithuania.

The dissertation is available at Martynas Mažvydas National Library and the library of ISM University of Management and Economics.

INTRODUCTION

The relevance of the research. Small and Medium size Enterprises (SMEs) support the development of industries, boost self-employment and ensure sustainable growth of the economy (Bhat et al., 2021). As SMEs grow, they face organisational and leadership challenges that must be overcome to maintain competitiveness and further growth, as described by Greiner (1998). The analysis of SME growth remains crucial in the context of contemporary economics and research (Garcia-Martinez et al., 2023). A challenge to SMEs' growth journey occurs when a focus on product or service innovation needs to be complemented by the delegation of decision-making powers, development of staff, autonomy and capabilities for process standardisation and improvement. An additional challenge for scaling SMEs is the increased need for adopting the latest digital technologies, including Artificial Intelligence (AI), to support key business functions and processes going forward (Shahin et al., 2024; Saghiri et al., 2025). During the last few decades, SMEs have had two dominant approaches for building such capabilities: adopting and implementing either Enterprise Resource Planning (ERP) & digitalisation (Terra et al., 2023; Abd Rahman et al., 2021; Sun et al., 2015) or Lean Six Sigma management systems (Bhat et al., 2021).

When considered independently, ERP systems and Lean Six Sigma management framework represent two distinct approaches to organisational improvement. ERP systems (Davenport, 1998) digitalise the information flow across functions and offer a range of functionalities supporting daily business processes by offering an infrastructure for process improvement (Masini and Wassenhove, 2009). Thus, the value of ERP resides not in the technological assets, but in the ability to develop repeatable patterns of value-creating actions using these assets (Masini & Wassenhove, 2009). In contrast, Lean Six Sigma has been conceptualised in multiple ways within the literature (Arlbjørn & Freytag, 2013). Lean thinking is grounded in five core principles, identifying value, mapping value streams, creating flow, establishing pull, and pursuing continuous improvement (Womack & Jones, 2003). Six Sigma is a structured business improvement approach aimed at identifying and eliminating the causes of defects and process variation by focusing on outputs that are critical to customers (Antony et al., 2017). Together, Lean and Six Sigma form an integrated process management approach that enables continuous improvement in the

performance of an organisation's core business processes (Salah et al., 2010).

Problem and the research gap. SMEs struggle to implement just one of these approaches on its own (Powell, Alfnes, et al., 2013). Empirical studies have even demonstrated a higher likelihood of achieving not only short-term benefits but also long-term operations and service excellence for companies that are able to combine and integrate these two complementary initiatives (Busto Parra et al., 2021; Erkayman, 2019; Powell, Riezebos, et al. (2013); Powell, Alfnes, et al., 2013).

While there are many tools and guidelines for the implementation of ERP and Lean Six Sigma, most lack a theoretical foundation such as a description of the underlying explanatory organisational mechanisms or a generic framework for developing digitally supported business process improvement capability by combining ERP and Lean Six Sigma implementation. Managers therefore struggle with implementation because they do not know which elements of a tool or technology are crucial and why, nor how to go about implementing them (Kumar et al., 2024). With the recent increase in opportunities for digitalisation and automation through the use of AI and generative AI (GAI) solutions, there is a clear need for in-depth research that propose and evaluate a generic framework and investigates the organisational mechanisms impacting the adoption of digital process improvement capabilities. An in-depth study of Lean Six Sigma and ERP implementation could provide this through the consequent theoretical contribution of the framework and specific mechanisms of aligned efforts, as well as their impact on the short-term and long-term development of competitiveness, particularly in the context of how they enable SMEs in their growth and competitiveness creation journey. Such research can establish a foundation for creating a set of robust recommendations that SME managers can use to improve operations or service excellence.

Research problem could be defined in a way that ERP and Lean Six Sigma are widely used approaches to operational excellence, nevertheless, the research on their interactions when implemented in combination, leveraging the advantages of both IT processes and industrial operations, is limited. There is thus a business need for further knowledge about how this category of companies can benefit from integrating Lean Six Sigma initiatives on top of their ERP implementations with the purpose of achieving ongoing improvements of service speed, quality, delivery performance etc. towards their customers while maintaining flexibility and keep costs low (Gijo et al., 2019; Obwegeser et al., 2019).

Research question, goal and objectives. The purpose of this work is to create an understanding of how the combination of ERP and Lean Six Sigma can be used to transform SMEs into more process-oriented organisations and improve process performance. The generic framework for implementing ERP and Lean Six Sigma in combination should be composed in order to develop digitally supported continuous improvement capability, also the mechanisms supporting such an implementation should be identified to help improve productivity, quality, and competitive advantage in the companies.

The purpose of this work can be itemised in two research sub questions:

- *How can a generic framework be designed and evaluated that combines ERP systems and Lean Six Sigma principles to support the development of digitally supported business process improvement capabilities?*
- *What are the key organisational mechanisms that enable the adoption of digitally supported process improvement capabilities?*

The research includes the following objectives:

1. To investigate from the literature how ERP implementation and deployment of Lean Six Sigma management approaches are valuable for digitally supported business process improvement and its capabilities.
2. To develop the theoretical framework with the steps for achieving digitally supported continuous improvement capabilities while integrating ERP Lean Six Sigma approach and identify possible organisational mechanisms supporting such an approach during its implementation.
3. To define process improvement and digitally supported continuous improvement capabilities measures for evaluation of combined ERP and Lean Six Sigma approach implementation success.
4. To validate and test the framework and organisational mechanism on a selected case company through the action research in combination with design science research.
5. To develop recommendations for the companies on how implement ERP and Lean Six Sigma management approaches in combined manner for achieving digitally supported process improvement capabilities to reap more benefits from their investments.

PUBLICATION OF DISSERTATION RESULTS AND CONFERENCE PRESENTATIONS

Peer-reviewed publications:

1. Liutkevičienė, I., Rytter, N. G. M., & Hansen, D. (2022). Leveraging capabilities for digitally supported process improvement: a framework for combining Lean and ERP. *Business Process Management Journal, 28*(3), *765-783*. DOI:10.1108/BPMJ-05-2021-0296
2. Liutkevičienė, I., Hansen, D., Rytter, N. (2026). Organisational mechanisms for building digital process improvement capabilities to foster SME competitiveness and growth. Production Planning & Control, 1–17. DOI:10.1080/09537287.2025.2605310

Presentations of research at conferences:

1. Liutkevičienė, I. (2017). A combined ERP and Lean approach for continuous business process improvement. *The 16th EurOMA Doctoral Seminar.* Edinburgh, Scotland.
2. Liutkevičienė, I. (2015). A combined Lean - Six Sigma and ERP implementation approach. *The 14th EurOMA Doctoral Seminar.* Neuchâtel, Switzerland.
3. Liutkevičienė, I., Rytter, N. (2014). A combined Lean-Six Sigma and ERP approach towards Operations and Service Excellence. *21st EurOMA Conference.* Palermo, Italy.

BRIEF OVERVIEW OF THE THEORETICAL FOUNDATIONS

When investigating how SMEs adopt capabilities for digitally supported process improvement in today's international business environments, it is sensible to closely examine the IT systems offered by ERP vendors and Lean Six Sigma Management practices.

ERP places emphasis on business process integration across and within all functions (Davenport, 1998; Jacobs & Weston, 2007), whereas the emphasis of Lean Six Sigma is on waste elimination, process flow, reducing variation, and value creation (Womack & Jones, 1996; Liker, 2004; Kadry, 2018). The review of existing research on the interaction of ERP and Lean Six Sigma approaches and their implementation reveals a strong consensus regarding mutual benefits to be achieved from combining both initiatives, rather than applying them in isolation (Powell, 2013). SMEs especially struggle to implement even one of these approaches on its own (Powell, Alfnes, et al., 2013), and there is little research on the integration of ERP and Lean Six Sigma. The new study has the capacity to contribute to the dominant stream of research via conducting an in-depth and longitudinal study of a combined Lean Six Sigma and ERP implementation for SMEs and identifying the mechanisms that support the adoption of digitally supported process improvement capabilities, thereby creating both short-term and long-term impact on competitiveness and growth for companies.

Theoretical grounding for the combined ERP and Lean Six Sigma implementation framework

Based on the analysis and comparison of the relevant frameworks for both the isolated and integrated implementation of Lean and ERP systems, a synthesis of principles was proposed for constructing a framework to achieve business process improvement capability. The framework itself has been developed using design science research in an eight-year case study, based on the principles below:

1) *The preparation phase* is important in a framework, as most of the existing contributions highlight the need for developing a transformation program with a realistic pace for implementation activities. The preparation also includes assessing ERP and Lean maturity and ensuring stakeholder commitment to the journey via project scoping and setting targets, as well as organising the project.

2) *A method for managing and executing improvement projects* should

preferably be based on DMAIC or a similar continuous improvement approach, which can be applied on a project-by-project basis. Such a sequence of standardised steps must be applicable to a broad set of improvement cycles and should be tailored to the individual company needs and resources (Lokkerbol et al., 2012). A project will usually be broken into the following steps:

• Define the current situation and performance. (Lokkerbol et al., 2012; etc.).

• Identify improvement options (Harrison et al., 1997), and analyse the possible solutions (Kumar et al., 2013).

• Plan tasks for the particular improvement project (Kumar et al., 2013; etc).

• Implement solutions (Nightingale and Mize, 2002; etc).

• Measure and monitor improvements (Nightingale and Mize, 2002).

• Control and adjust (Lokkerbol et al., 2012; etc.).

3) *Emphasis on cycles of continuous process improvement* must be included in the steps above within the DMAIC framework.

4) *Performance metrics and procedures* should be part of the framework. This is seen in several of the existing recommended frameworks such as Bessant and Francis (1999) with their capability / maturity framework, or Delgado et al. (2014), with a set of business and process performance metrics based on productivity-costs, quality, time, and customer satisfaction.

There are two ways ERP can be helpful in continuous improvement projects. Firstly, ERP can maintain and automate standardised work while ensuring that tasks are accomplished in exact sequence and format (Ghobakhloo and Hong, 2014). Secondly, ERP systems deliver process and performance data to Lean improvement projects and enable so-called “data-driven decision-making cultures” in companies (Halgeri et al., 2011; Nauhria et al., 2009), combining immediate improvement and the development of improvement capability (Hansen, 2015).

Factors impacting the outcomes of integrated ERP and Lean Six Sigma implementations

Existing ERP and Lean Six Sigma research in scientific literature was examined to identify the factors that enable SMEs to achieve an aligned, or even an integrated, implementation of these approaches. From the literature review, ten elements were identified determining how ERP and Lean Six Sigma in combination can support

building capabilities for process improvement, competitiveness, and growth, which are summarised below.

The first factor, highlighted by the existing research, demonstrates that Lean tools and activities can support the elimination of waste activities in ERP projects. Both Ghobakhloo and Fathi (2019) and Powell, Alfnes, et al. (2013) state that Lean practices can be used to simplify and improve data capture and preparation processes for ERP systems. Accordingly, the second factor identified indicates that applying Lean can eliminate waste data in ERP. Powell, Alfnes, et al. (2013) call for Lean practices as a clear strategy to improve data integrity and eliminate the collection of unnecessary data.

The third factor is improving ERP functionality, delivered by Lean Six Sigma deployment. Companies incorporate Lean best practices into their ERP systems. This includes a variety of new modules, toolsets and functionalities created in existing software (Blijleven et al., 2019). The fourth factor is the ability, with the help of ERP, to create routines of standardised work. As part of Lean projects, standards are set for routine work, and ERP can maintain this aspect, while also ensuring that work is completed in an exact sequence and format (Sartal & Vázquez, 2017). The fifth factor explains how ERP can support flow and enable ongoing Lean efforts. ERP systems can provide data that support the identification of flow constraints and bottlenecks and thereby facilitate the subsequent creation of more flow and demand-driven manufacturing (Powell, Riezebos, et al., 2013). The automation of information flow is fundamental for pure service companies, where the information is the core of the service, without any physical goods (Bortolotti & Romano, 2012). The sixth factor identifies how ERP systems can enable pull production (Erkayman, 2019). Pull production systems used for forecasting, inventory and capacity management require accurate data to function correctly, which is provided by an ERP solution (Powell, Riezebos, et al., 2013). Factor seven explains how ERP systems deliver process and performance data to Lean improvement projects and create data-driven decision making (Maguire, 2016; Ghobakhloo & Fathi, 2019).

Factors eight and nine concern employee involvement and management support, which is considered critical when improving ERP usage and deploying Lean Six Sigma practices. A Lean Six Sigma culture encourages staff and management to be more interested in the efficient new work processes and tools offered by ERP solutions. IT

led projects that do not capture the business and human dimensions of processes at an early stage are likely to fail (Powell, Alfnes, et al., 2013; Erkayman, 2019).

A set of additional factors for aligned ERP and Lean Six Sigma implementations could be more strategic in nature. Powell, Alfnes, et al. (2013) state that both ERP and Lean approaches should commence by deciding on the strategic vision and values of a company. Pre-existing strategic and organisational readiness for process standardisation and improvement in the company are prerequisites for both Lean and ERP success (Ghobakhloo & Fathi, 2019).

The factors identified provide an informative list of the important ways ERP and Lean Six Sigma initiatives can be combined and obtain results together. However, the factors do not sufficiently propose concrete Lean Six Sigma and ERP actions designed to impact intervention outcomes, nor do they provide explanatory theoretical mechanisms for how ERP and Lean Six Sigma can transform an organisation together. Therefore, these factors require further investigation using a more substantiated framework. This should both devise more concrete actions and provide a deeper theoretical understanding of the transformative organisational mechanisms by which SMEs can successfully adopt digitally supported process improvement capabilities. This can be accomplished by using the context–intervention–mechanism–outcome (CIMO) framework (Van Aken, 2004), which is introduced in the methodology section.

Measuring Lean Six Sigma and ERP capability and project outcomes

To evaluate whether Lean Six Sigma and ERP integration enable process improvement, together with competitiveness and growth, the study applies two forms of evidence: a maturity framework and business and process performance metrics for benchmarking the case evidence. Regarding company maturity, process improvement and culture, the study applies the widely disseminated Bessant and Francis (1999) model because it provides clearly operationalised maturity levels (Hansen & Møller, 2016). To evaluate tangible improvements, companies typically use KPIs and performance measurement systems (Tan et al., 2004). Recommended ERP and / or Lean Six Sigma implementation metrics include productivity, quality, time and customer satisfaction (Delgado et al., 2014). This study uses the four KPI categories applied in the case company; the specific metrics are presented in the findings.

SHORT OVERVIEW OF THE RESEARCH METHODOLOGY

Due to the qualitative nature of this investigation and the type of research question, the methodological approach was informed by action research, which can also be compared to longitudinal, participative case study research. Action research (Coughlan and Coghlan, 2009; Reason and Bradbury, 2007) and longitudinal, participative case study research were a source of inspiration for the framework combining ERP and Lean Six Sigma outlined in this study. The research methodology was also inspired by design science research (DSR; Van Aken et al., 2016), particularly practitioner-focused DSR, which emphasises empirical contribution and practical relevance (Bagni et al., 2024). Using the context–intervention–mechanism–outcome framework (CIMO) (Van Aken, 2004; Denyer et al., 2008), the study identifies explanatory mechanisms for implementing integrated ERP and Lean Six Sigma through a real-life intervention in its organisational context.

Based on these arguments, the methodology was devised as follows. Firstly, the combined implementation framework and factors were identified from the literature. Secondly, a longitudinal intervention study was conducted to gain a deeper understanding of the intervention while implementing the combined framework steps, mechanisms and outcomes in the specific case context. Thirdly, empirical data were used to enhance the combined framework, identify an extended list of factors explaining how ERP and Lean Six Sigma can be combined, and develop concrete, action-oriented interventions. This was achieved by applying the CIMO logic, comparing outcomes with the actual interventions in practice and analysing them in relation to the context. Finally, the analysis was used to refine the implementation framework and identify four generic organisational mechanisms for ERP and Lean Six Sigma implementation, forming a key theoretical contribution of the dissertation.

Case selection and data collection

Myers (2013) argues that the collaboration and engagement of a case company is crucial when doing research with intervention. Being a researcher who also holds a management role in the case company enabled access to company information, resources, and data, as well as high levels of collaboration and engagement. The selected case company was a small IT company based in Lithuania, which is responsible for the sales, implementation and technical support in the local market for

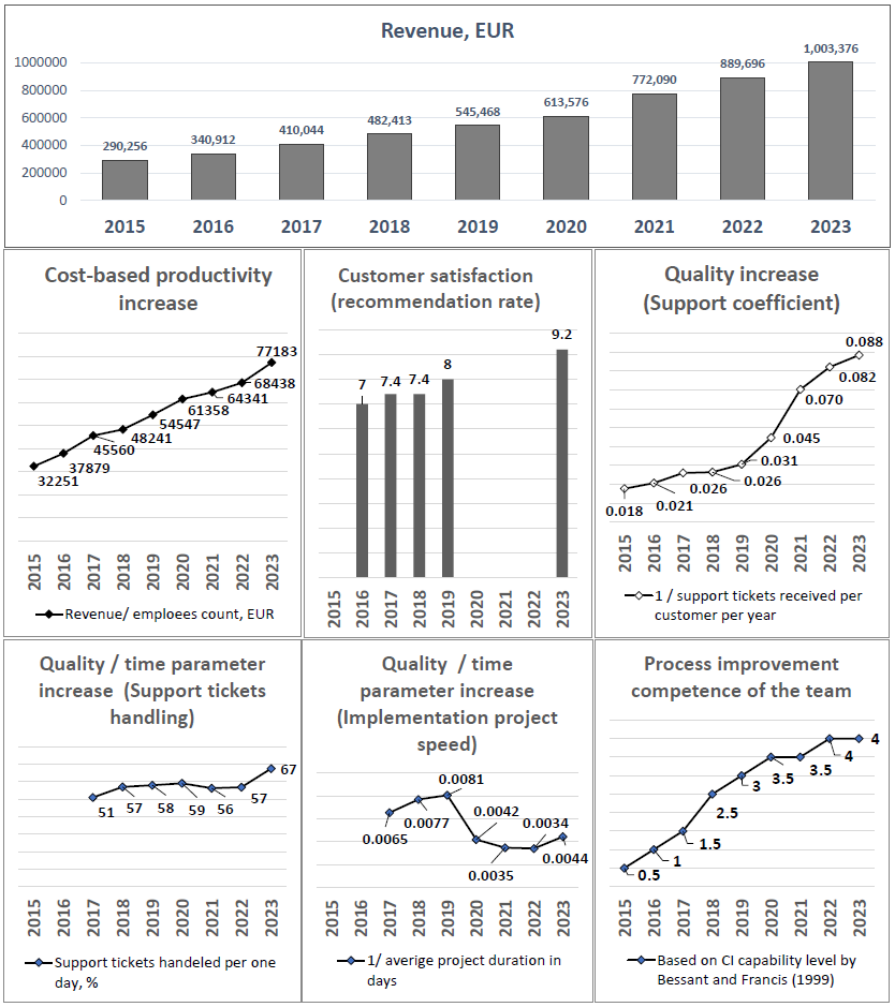
a software solution that was initially created in Estonia. The scoping of the problem was carried out in 2015, based on the results of a customer satisfaction survey that showed a need for more effective and digitally supported processes in the company. This led to the formulation of the intervention study for the period of 2014–2023. The company had a clear incentive (Myers, 2013) to take part in this research project, as it also enabled the development of its competitive edge.

In order to investigate the intervention, abundant methods of data collection and a variety of data sources were used based on Coughlan & Coghlan (2009). The collected data were used to write a case narrative in nine chronological parts, starting with the background and situation of the case company before the improvement initiatives. This was followed by descriptions of the interventions conducted from 2015 to 2022. The case narrative concluded with an epilogue and results by the year 2023.

SUMMARY OF KEY RESEARCH FINDINGS

A summary of the outcomes achieved for multiple metrics across the nine-year period is presented in Figure 1. Revenue growth over the nine years was, on average, 18.8%. Cost-based productivity (revenue versus number of employees) grew year by year from 5% to 20%. The customer recommendation rate (captured for five out of nine improvement journey years) increased from 7 to 7.4 and 9.2. The improvement efforts caused the number of requests to drop significantly throughout the nine years from 57 to 11 tickets per customer per year.

Figure 1. Graphical overview of the outcome



Source: Liutkevičienė et al. (2026)

Moreover, the percentage of tickets resolved within one day increased from 51% to 67% over the nine years, despite fluctuations in 2019 and 2020. Project speed improved, and the lead time for customer project implementations decreased due to the interventions dedicated to this process in 2016 and 2023.

The team's digitally supported process improvement capability, assessed using the Bessant and Francis (1999) model, increased annually and reached level 3–4 in the final year, indicating that the company could solve incremental problems without external consultants. Experimentation, measurement and monitoring were established to support cost reduction, quality improvement and time savings.

Digital process improvement via the ERP and LSS implementation framework

The findings reveal that applied intervention of the combined ERP and Lean Six Sigma approach enabled the growth of the company as well as positive outcomes in terms of productivity, quality, and customer orientation, and the most importantly developed the continuous improvement capability of the case company. The business transformation initiative was implemented via a synthesis of existing Lean Six Sigma and ERP frameworks and the applied DSR / action research methodology. Based on the case study journey and results, there are generalised findings in the form of a combined ERP - Lean Six Sigma improvement framework, presented in Figure 2.

Setting the strategy and preparing for ERP and Lean capabilities

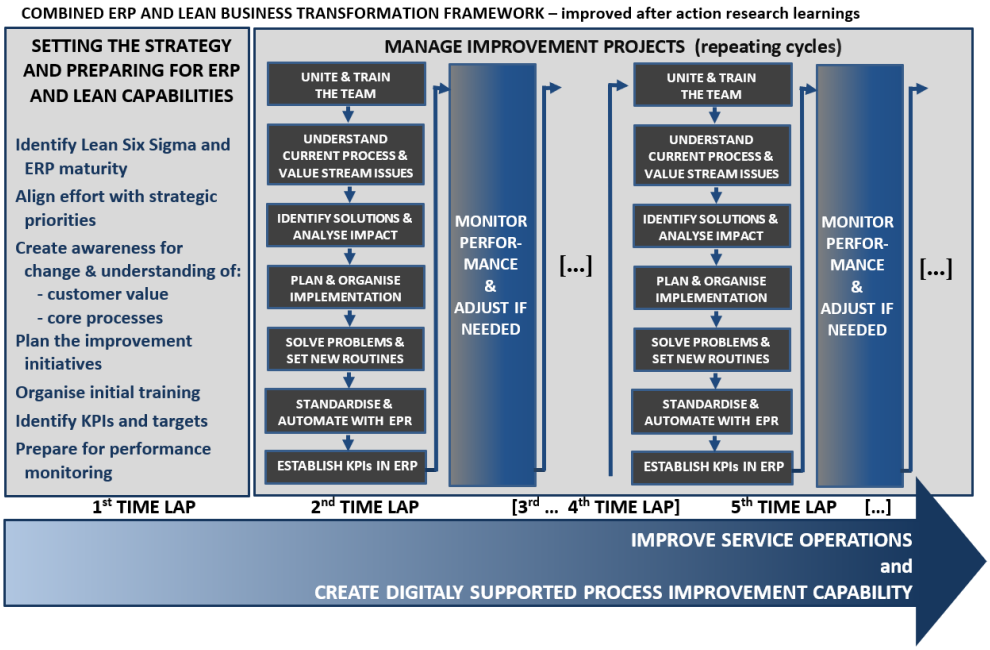
The first part of the combined ERP – Lean Six Sigma framework focuses on setting the strategy and preparing the organisation by assessing initial ERP and Lean Six Sigma maturity, aligning competitive priorities with improvement actions, defining sponsorship and change-agent roles, planning stakeholder training, and establishing KPIs before implementation commences (Powell, Alfnes, et al., 2013; Pellerin and Hadaya, 2008).

In the case company, where ERP was already implemented, the framework was applied to strengthening the existing system through Lean Six Sigma methods, supported by strategy deployment through the X-matrix, CEO sponsorship and improvement leadership, and experiential training embedded in improvement projects (Barnabè and Giorgino, 2017; Schniederjans and Yadav, 2013; Kumar et al., 2013).

Managing improvement projects

The improvement project management and execution phase of the framework is illustrated through Improve – Monitor cycles. Each cycle began with a Kaizen event, in which standardised improvement steps were applied (Aken et al., 2010), followed by a monitoring period during which new routines were stabilised, and only minor adjustments were made. This approach reflected the company's small size, limited change-agent capacity and the need of employees for stable daily work before further improvement opportunities could be explored. The critical aspects contributing to the results are presented as improvement project steps in Figure 2.

Figure 2. Combined ERP - Lean Six Sigma Framework for improving service operations and process improvement capability



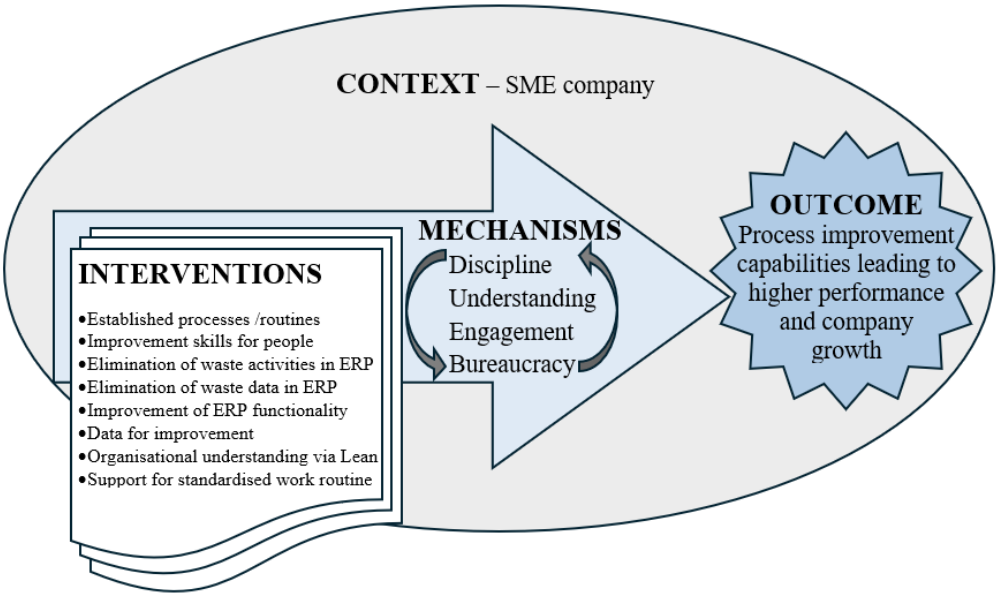
Source: Liutkevičienė et al. (2022)

Identification of mechanisms enabling SMEs to leverage and adopt digital process improvement

The investigation of influential factors and characteristics led to the proposal of high-level organisational mechanisms explaining how SMEs can transform their organisation and culture. The mechanisms were understood as structured processes

or activity systems triggered by interventions to produce specific outcomes (Lorentz et al., 2020; Pajunen, 2008; Momeni et al., 2023). Based on the case evidence, four organisational mechanisms (discipline, mutual understanding, engagement and enabling bureaucracy) explain how Lean Six Sigma and ERP support digitally enabled process improvement capabilities and targeted outcomes. Figure 3 shows a graphical representation explaining the contribution, which conceptualises how integrated ERP and Lean Six Sigma implementation, supported by organisational mechanisms, can enable the development of process improvement capabilities, performance improvements and business growth for SMEs.

Figure 3. Graphical overview of the theoretical contribution developed through the CIMO framework.



Source: Liutkevičienė et al. (2026)

DISCUSSION AND CONCLUSIONS

Since the emergence of Lean Six Sigma and ERP decades ago, the need for effective processes and creating the ability for continuous improvement has not decreased. In the business context of the 2020s, most organisations already have a version of Lean Six Sigma and ERP, but they may struggle with developing continuous improvement capability and continuing their journey of digitalisation to support operational excellence (Trstenjak and Cosic, 2019).

This case study proposes and evaluates a generic framework for a combined ERP and Lean Six Sigma implementation for developing continuous improvement capability and identifying mechanisms that can enable process-orientation in SMEs while implementing the integrated framework. The provided framework for ERP – Lean Six Sigma implementation was tested and validated in the service context of an SME, thereby demonstrating how it can be deployed to raise productivity by two digits year-by-year, deliver quality improvements, and increase continuous improvement capability.

The study identifies a number of key mechanisms that explain the successful intervention and provide guidance for other companies who want to use ERP - Lean Six Sigma. The study reports twelve mechanisms that contribute highly to successful implementation. The mechanisms were categorised into four more generic mechanisms showing that a) creating understanding is the foundation for successful implementation, b) discipline-enabling activities transform change to the new daily schedule, c) building engagement ignites the change efforts, and d) enabling bureaucracy operationalises successful implementation. These mechanisms show how ERP and Lean Six Sigma interact and that together they can help SMEs overcome the challenge of process-orientation that often prevents them from developing into a more mature organisation.

Furthermore, the longitudinal study using an implementation process model provides practical guidance for the implementation of ERP - Lean Six Sigma in SMEs, including relevant metrics for monitoring progress during the implementation project.

Finally, the case uses Design Science Research to provide pragmatic advice and contributes to the practice of this research methodology.

Theoretical contributions

The key contributions to the existing theories and the novel aspects of this research are as follows:

• The research has provided evidence regarding the results that are realistically achievable from a combined ERP - Lean Six Sigma implementation (the intervention was successful from a practical perspective but took longer than expected).

• The proposed theoretical implementation framework and the case study illustrate the main steps required, as well as the essential strategic, tactical, social, and human factors to succeed in building and executing an integrated ERP and Lean Six Sigma approach, eventually supporting a Kaizen approach to all company processes.

• The identified mechanisms show how ERP and Lean interact and how together they can help SMEs overcome the challenge of implementing the type of digitally supported process improvement required for them to develop a more mature organisation.

• The study confirms several of the observations / conclusions that have been found in equivalent studies in relation to, for example, manufacturing industries. However, such conclusions are particularly interesting as they are based on an SME and IT service company context, in contrast to previous studies of similar kind.

Implications for practice

The findings provide practical guidance how SME managers can deploy a combined ERP – Lean Six Sigma implementation in SMEs, and that this approach can lead to increases in productivity of double digits year-on-year, quality improvements, and increased continuous improvement capability. The implementation framework is generic and should be applicable for organisations in other industries and for larger enterprises if properly incorporated into existing practices and systems. The key organisational mechanisms show how ERP and Lean Six Sigma can be integrated and how they supplement each other when it comes to enabling the type of digitally supported process improvement in SMEs that can lead to company growth and the creation of competitiveness.

Limitations and suggestions for future research

The main limitation of the study is that the case company's maturity level with ERP and Lean Six Sigma might not be generalisable. Therefore, further research

should investigate how the findings apply to a wider range of contexts, for example, companies of different industries, with more extensive experience of using Lean Six sigma methodologies and ERP systems. Future studies could cover a broader category of SMEs with respect to age, size, and country, etc. The SME category covers businesses with between 1 and 250 employees, and the case company had 20 employees. To achieve greater generalisability of conclusions, future studies could be replicated using larger samples of SMEs or companies with more employees to validate the impact of the integrated framework and mechanisms with intervention factors.

The specific sequence and synergies of the four mechanisms in SME business transitions could also be analysed. Such research could also be connected to the growing body of literature on the adoption of AI-related solutions in combination with ERP within SMEs and the IT industry in general. Future studies of Lean Six Sigma and ERP transformations or digitally supported process improvement initiatives could also preferably be achieved using methods other than design science or single case studies; instead, multiple case studies or the usage of survey / quantitative methods could be employed. In addition to this, future research could explore other new theoretical concepts and lenses, such as those of Wang and Zhang (2025), which could provide further insights into the role of mechanisms and factors involved in driving successful SME adoption of digital, for example, ERP and AI technologies, as well as Lean Six Sigma for process improvement capabilities.

SHORT BIO

Indrė Liutkevičienė obtained her Master's degree in Business Administration and Management from Vilnius University in 2008, following a Bachelor's degree in the same field from the Faculty of Economics at Vilnius University. In 2013, she commenced her doctoral studies at ISM University of Management and Economics.

Her primary research interests include business process improvement, enterprise resource planning (ERP) systems, and digitalisation, with particular emphasis on the organisational conditions that enable improvement efforts to evolve into sustained organisational capabilities rather than isolated projects. She is especially interested in how SME integrate digital technologies with business process improvement methodologies and how the resulting capabilities contribute to organisational competitiveness and growth.

Indrė has published her research in *Production Planning & Control* and the *Business Process Management Journal*, co-authoring these publications with Niels Gorm Malý Rytter of the University of Southern Denmark and David Hansen. She has presented her work at several international conferences, including the annual conference of the European Operations Management Association (EurOMA) in Palermo and EurOMA doctoral seminars in Neuchâtel and Edinburgh.

At ISM University of Management and Economics, she has taught since 2016 and has managed the Business Process Management module at the Executive School since 2022. In 2016, she also taught as a visiting lecturer at the Copenhagen campus of Aalborg University.

Indrė is also the Business Manager and co-owner of UAB “Directo”, the exclusive Lithuanian partner of the Directo ERP system. She has held this position since 2005, directing business development, market expansion, and organisational growth while leading ERP implementation projects that help Lithuanian and pan-Baltic companies enhance their operational capabilities, with a focus on creating business value through digital transformation. Prior to joining Directo, she served as a member of the Board of UAB “Pristis”, a company specialising in low-voltage systems and building engineering solutions, where she was responsible for financial management activities.

Combining more than twenty years of management experience with her academic work, Indrė acts as a managing insider in relation to the organisational setting examined in this thesis, bringing practitioner and researcher perspectives to the study.

APPENDICES

Appendix 1. The case narrative

Background and situation of Directo before improvement initiatives

Directo was founded in 2002 in one of the Baltic states, Estonia, via the development of an innovative zero-installation architecture. A Software as a Service (SaaS) business model was offered for providing ERP solutions to companies. In a global context, Directo was one of the first software providers to introduce a SaaS (code-based) service and business model to corporate customers. Initially their focus was the local Estonian market where the cutting-edge technology was well received, and they steadily increased their customer base. They began expanding to other countries, and in 2008, Directo Lithuania was established. The Lithuanian market entry progressed slowly and required additional financial support. However, the success of the Estonian mother company, with a revenue of 2 million EUR and making 1 million EUR in profits in the year 2011, became the driving factor behind their continued pursuit of the business opportunity in Lithuania during those early years.

The main author joined Directo LIT at the start, becoming the managing director in addition to managing the client sales and support, but additional employees were hired shortly afterwards. In 2013, the company in LIT had increased its customers base by 32 (98-66) clients and had expanded its workforce to 4 employees, as well as achieving turnover of app. at 150.000 EUR, placing it on the desired market entry track. However, the rapid growth also imposed a number of organisational challenges that are typical for a fast growing start up SME. It was increasingly difficult to control the service process quality as the customer base grew and new people were gradually hired. Occasionally, customers complained about long response times regarding support requests, however, such complaints increasing over time. There was no system in place for assigning customer requests to specific employees and it was not possible to set deadlines for tasks to provide customers with information. Furthermore, the number of emails received by the office on a daily basis continued to grow, and as the manager, the author was very busy handling implementations and face-to-face customer contact.

A few years earlier, the company had implemented its own ERP system, but it was not adequate to support the execution and monitoring of the core business processes, which consisted of the implementation of Directo ERP solutions for customers as well as service support of customers. At the end of 2013, just the finance module and some CRM features were used internally. It was therefore decided to enable the internal ERP solution to handle customer e-mails (help requests) in an event module which enabled logging of all actions / events for support tasks. Despite these good intensions, in early 2014 the project ran into problems in the form of delays, resources overused, and the resistance of employees, who were not deploying the systems and outlined work procedures. In Directo LIT, we thus faced the typical managerial and organisational challenges we observed in many of our client companies. The situation became a key trigger for me to pursue a PhD scholarship on the topic of Lean and ERP implementations,

with the hope of eventually expanding my personal competencies and skills in solving such problems, and thereby supporting the company in creating more value and better service for clients. Officially, I commenced my PhD studies in November 2013, and from 2014 I began initiating several ides for business process improvement, and these were gradually implemented.

Setting the Strategy, creating awareness for Lean and building the first Kaizen skills / capabilities

The company decided to deliver a more formal introduction of Lean to the company employees in 2015, with the company having grown to 9 people. Thus, in summer 2015, two workshops were conducted, supported by an external LEAN consultant, with the purpose of setting a strategic vision for the company and building staff commitment to its implementation. The main tasks accomplished during those sessions were as follows:

- The company objectives were set as: Growth of turnover, growth of profit, customer satisfaction, and operational excellence, for which specific targets were developed. Furthermore, a discussion took place concerning how staff could contribute to the company goals, both individually and in teams.
- A "policy deployment" X matrix tool was applied to identify actions which, in the short term, could contribute to reaching corporate objectives and targets set (*Case evidence 2 – The X matrix).*
- The core business processes for (1) Sales, (2) Implementation, and (3) Support were identified, mapped, and analysed / diagnosed *(Case evidence 1 – The main process and steps within)*
- A vision for a future Lean and Digital customer-oriented support process was created, characterised by instant response, clear specifications for customers, simplicity and automation, professional communication, and good quality and on-time delivery.

The workshops were part of essential steps towards further business improvement in two ways, while also instilling a break in daily operations where employees often felt they lacked time to make improvements. At first, the workshops contributed to a broader and shared understanding of customer value and the importance of meeting customer needs. The work pace was hectic with many customer requests, and employees would often express frustrations over the "stupid questions" posed by the customers. Moreover, employees would sometimes express the attitude of an employer or the "boss being more important than satisfying than the customer" in daily work. However, the workshops significantly challenged those perceptions, and it became clear that better teamwork and resource utilisation would ultimately create improved customer satisfaction, as well as company and individual performance. Furthermore, the policy deployment

exercise was essential, as it produced a shared overview of actions to be carried out in the short term to reach the set objectives and targets, as well as identifying specific staff to be accountable for different tasks / actions in the near future. Regarding objectives, the exercise created a set of highly tangible metrics for the key business processes including, for example, KPIs for: Invoice complaints, overdue works, re-doing works in the ERP implementation, and time spent to resolve customer support request, etc. Following the workshop, it was decided that more visual management processes would be implemented, leading to the creation of a Kaizen / lean management dashboard, visible in the office for all participants, where it would be possible to track business improvement efforts and impacts on the main KPIs. (*Case evidence 3 – KPIs and other information as visual management)*

To proceed with the initiatives, two subsequent improvement sessions were run with the same external consultant as facilitator in autumn 2015. The two sessions introduced the team to LEAN principles, methods, and tools. Each session persisted over half a working day, and all staff were involved. Following the workshops, it was agreed that a trial period with regular Kaizen meetings would operate. Weekly Friday meetings were, thus, organised with clear agendas and structure for the purpose of following up on work related questions, monitoring current performance, and identifying improvement opportunities. The main author had to lead the first couple of meetings, as employees were still sceptical towards this way of working with team-based problem solving and improvements. However, ownership and understanding of the Kaizen meetings gradually shifted to the employees, who began to lead both the Kaizen meetings and the daily stand-up sessions where yesterday's accomplishments were reviewed, and today's tasks prioritised. Kaizen meetings were also strengthened by integrating the previous idea generation processes and boards into the toolbox and converting templates into A3 forms in line with employee wishes. (*Case evidence 4 – New ideas board and ideas to be discussed).*

The team became more engaged in clarifying how additional ERP and Lean initiatives, including the main author's own ongoing research results, could contribute to better processes and customer value creation to the benefit of all. Thus, at the end of 2015, the company had accomplished the first successful steps towards becoming a Lean and digital ERP solution / service provider, though there was still much work to do going forward. A careful judgement of the situation at the annual employee conversations, revealed that approximately half of the employees were concerned about the daily problems at work not being fully fixed yet, despite the Lean efforts, and that the other half were more optimistic about the future benefits of improved internal communication, better teamwork, and recently acquired skills in Lean and Kaizen, etc. Why and how processes had to improve further was, however, clear for all employees, and that either additional features of

ERP and / or Lean would need to be implemented to maintain competitiveness in the future.

Implementing a standard and Lean processes for ERP Implementation (2016)

The company had continued to increase its revenue, by 34.83 % in 2014 and 31.37 % in 2015. Year 2016 started out with an unforeseen number of new software implementation projects for clients. 15 new projects were implemented during the first two months of the year alone. The number of new projects caused a need to upgrade the core ERP implementation process, as the deficiencies of that process would have had rework and performance implications for post-customer support / service processes. Thus, an additional improvement session was completed in March 2016 to deal with this challenge. The ERP implementation process was scrutinised, as well as utilising Lean tools such as Fishbone diagrams, 5WHYs, PDCA, and A3 forms, etc. Subsequently, in April, a follow-up session was held to identify ways of improving the main process flaws, once again facilitated by the previous external consultant. The following results were derived from the two workshops: A detailed map was completed of the current end2end process for the client facing ERP implementation activities and also addressing involvement, i.e., making the roles and responsibilities of key stakeholders visible. *(Case evidence 5 – the map of current state of the ERP implementation process).*

Going through the process had ensured there was a shared understanding of the end2end process among all people and / or teams involved in the process on a daily basis. Additionally, the session generated a list of ideas for resolving problems upstream in the process, thus, preventing them from cascading downstream to staff or to the client aspect as part of this, or within the post-customer support process.

As an example as an outcome, the team decided to begin using the ERP project management module internally to manage the implementation projects, and a set of two project implementation procedures or workflows were developed to match each of their client task situation (situations differ whether the whole database import is done from competitive ERP software or not). Finally, a set of KPIs were developed to the monitor progress of undertaking the new ERP implementation process: Duration, no. of invoices, actual versus planned dates for activities, and reworks per project.

Directo LIT began tracking KPI performance during summer 2016 with weekly follow up and ad hoc actions if required.

The implementation of the designed EPR improvement process was achieved using PDCA principles and running several improvement cycles in spring and summer.

At the end of year, the implementation of a new standardised (configurable) and Lean ERP implementation procedure had delivered visible improvements in team performance which could also be tracked, for example:

- The internal Directo ERP application was now used to manage and monitor the implementation process for all client cases
- Process rework had decreased by 40% per new implementation project.
- Project lead times had shortened to the benefits of the customer (from 50 days average project duration in 2015 to 37 days average project duration in 2016)
- Customer complaints were reduced (from 20 complaints per month in 2015 to 12 complains per month in 2016).

During the year, I chose to delegate responsibility to one of the staff members, who generally carried out the project successfully, despite different obstacles along the journey and little support from me.

During the annual employee conversations at the end of 2016, nearly all of the employees expressed that the implementation process review and recent ERP system utilisation for the implementation process were one the best accomplishments of the year. Moreover, the use of Kaizen and stand-up meetings, and A3s, etc. was appreciated. On the negative side, it was mentioned that communication with our EST partners needed to improve further, and that a lack of teamwork, both internally and across sites, should be addressed.

Improving customer support / service processes and performance (2017)

Early in 2017, the EST Directo CEO got involved in the LIT collegial management team. A closer engagement of the mother company with the Lithuanian operation was already visible after the first quarterly collegial meeting, where it was decided to benchmark the number of support requests received from customers in EST versus those in LIT. The Estonian unit had 0.59 requests per customer, whereas LIT received 5.75 requests per customer. The remarkable difference in customer support requests for LIT compared to partners working in, first of all, Estonia, then Latvia and Finland were thus chosen as a topic for an improvement workshop.

In March 2017, yet another improvement session with the external consultant was organised for the team, with the session producing the following outputs:

- A shared understanding of which customer requests are value creating activities, and which are non-value creating activities was formed.
- A detailed mapping of the end2end customer support process, along with its handovers and flaws was completed (*Case evidence 6 – the current state of the support process).*
- Ideas for reducing the number of help requests per customer, as well as reducing support time, were generated.

KPIs were set for monitoring customer support performance, for example regarding Clarification of requests (split between system bugs versus new

development, and module type, etc.), time before feedback to customers, non-dealt with or unsolved requests per number of days, etc. Following the workshop the ERP system was adjusted to register and classify all future customer requests. Moreover, KPI scores were displayed on a dashboard which everyone could see. After a couple of months, during which the team had also worked on implementing different improvement actions, the first improvements were visible:

- ERP was used to manage and monitor the support process and enabling the support requests from customers to be classified into types (B- bug, Q- question, D – development)

The average duration of solving a request has decreased from 10.6 to 7.8 days by the end of the year.

- However, as yet, the number of help-requests per customer was unchanged (*Case evidence 7 – the help requests from customers in 2017 by quarter).*

In parallel with discovering these promising results, the management team also gave attention to the behaviours of staff, for the purpose of further improving the numbers.

During the remainder of 2017, further adjustments and improvements were made to the standard processes for ERP implementation and customer support operations. For example, automatic e-mail messages were generated to remind staff about not-completed tasks, with unfinished projects designated deadlines, and A3 project templates being integrated into the ERP solution. Overall, 8 A3 projects were accomplished in 2017.

At the end of the year, working facilities were established in the EST office for LIT staff. This was set up so that LIT staff would work there on a rotational basis and serve their LIT customers from the Tallinn office. This setup was achieved to enable LIT employees to learn faster and gain more knowledge about the systems directly from the EST staff and experts, who were now handling more than 3000 customer cases.

At the end of year, during the annual employee conversations, the LIT staff expressed their happiness with how the Lean methods were integrated into regular work routines, the many improvement projects running on an ongoing basis, and the latest developments, together with the closer integration with the EST mother company.

Understanding and improving the customer journey while using Directo (2018)

The ambitions to make the Directo LIT processes and work culture more competitive were maintained during 2018. A decision was taken to organise a set of workshop sessions during the year with the theme of “improvement to the customer journey in the Directo support process“. The company had grown again, and now had 11 people, with three new people having recently joined the team. The first part of the sessions was therefore spend repeating previous messages and teaching the Lean Sigma Six curriculum from the earlier workshops. The second part of the

sessions included training in methods for conducting customer studies and observing work processes. The workshops included visits to 5 customers with teams of 2 persons carrying out the observations and interviews. The main goal was to observe customers in their daily work with the Directo systems to understand why and when they needed support. We referred to this as “going to a gemba place” event.

Employees returned home excited about what they had learned and observed, and in many ways, their perceptions of the customers and their behaviour had altered. They now understood that:

- Customers are patient and persistent and they often do not call for help when needed but often try to find solutions themselves first.
- Several customer users did not know that they can contact Directo for support.
- Customers frequently abused Directo due to a lack of simple system knowledge, for example, not knowing that WIKI instructions are available for the main Directo functions.
- There are different expectations from Directo users versus Directo buyers (owners or managers of the companies)

Some pictures were drawn after the visits. (*Case evidence 8 – these pictures were drawn by employees after customer visits).*

It was agreed that five more customer visits would be arranged within the next two weeks. Following the visits, a half-day session was organised where the scheme was drafted based on observed experiences and what costumers actually do step by step when they need Directo support. Accordingly, the actions of the Directo support team and how both sides (customer and support team members) feel in each process step was considered. (*Case evidence 9 – The Scheme reflects the customers perspective in each step when they need Directo help until they obtain the help).*

After the workshops, all staff decided that it would be beneficial to continue with visits to customers in the future to get to know their preferences and needs better, eventually enabling them to deliver improved Directo products and services. At future Friday meetings, planning the next customer visits would be a regular point on the agenda. In addition to this, a set of initiatives was also implemented, with the purpose of improving customer support for their clients. For example, it was decided that all customers whose status transferred from implementation to customer support should be contacted every two to three months to proactively detect any issues of concern. Furthermore, compliance issues were dealt with, and after each service request customers were offered the opportunity to confirm whether they considered their service request to be closed or not.

At the end of 2018, the Lean initiative had thus evolved from being firstly oriented towards the improvement of internal Directo LIT processes, towards including external partners, and obtaining direct insight into customer processes, as an enabler of accomplishing objectives for ongoing process improvement and delivering superior value to clients. The annual employee conversations revealed that improvement practices and customer orientated thinking was embraced very well by the employees. additionally, ERP was fully deployed and essential for the efficient execution of at least two out of the three core business processes in the company.

Epilogue (2019)

The five-year-long improvement journey yielded results. The stand-up meeting every morning had become an essential routine. Every Friday there would be a structured meeting where the most important KPI's were reviewed and decisions made, and A3 improvement projects were common day-to-day activities.

At first, process mapping and improvement for the sub-process of integrations projects was done independently – without an external consultant. Furthermore, the sales process was implemented in ERP (pipeline, CRM, signed contract information). (*Case evidence 10 – Pipeline adaptation in ERP)*. When the CRM process was set up in ERP and other improvements accomplished during 2019 were presented during the annual meeting for the group of companies, the headquarters in EST immediately decided to replicate this sales process in the EST office. The Latvian office was asking lot of questions about the process improvements, and it was decided that the external consultant who worked with Directo LIT should conduct the same improvement sessions in Latvia as well.

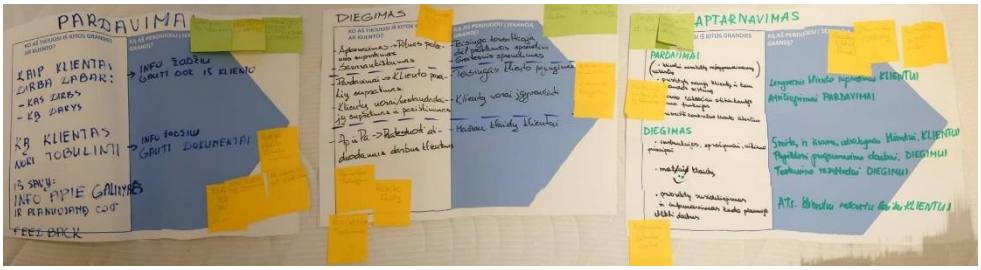
The improvement works were beneficial, not only for the LIT office but they had begun to extend across other countries as well.

The precedent case was that the police department heard about the Directo improvements and expressed a wish to see how the Directo office works, with the intention of replicating the same routines within their own IT department.

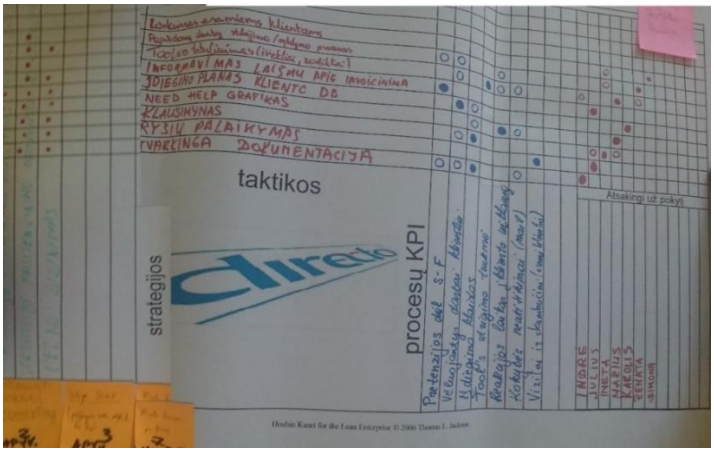
However, the company grew in 2019. The service license turnover grew by 18%, and additional series sales grew by 60%. The ability for continuous improvement was furthermore demonstrated as the company continued to grow by 12% in turnover in the year 2020. This was impressive, since the implementation process has concluded and it coincided with the challenging pandemic situation.

List of case evidence

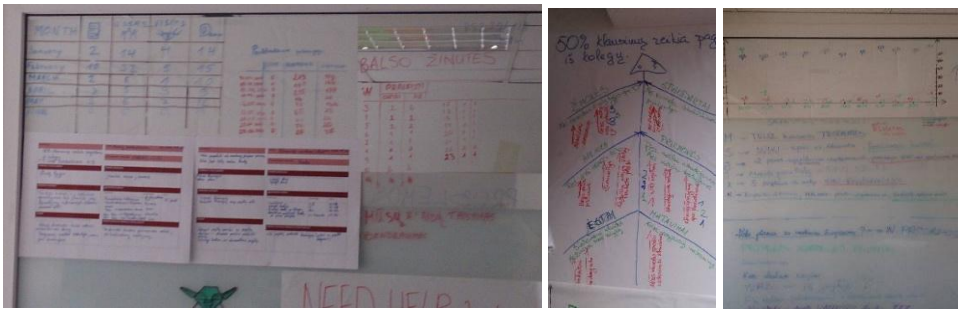
Case evidence 1. The main process and steps within it



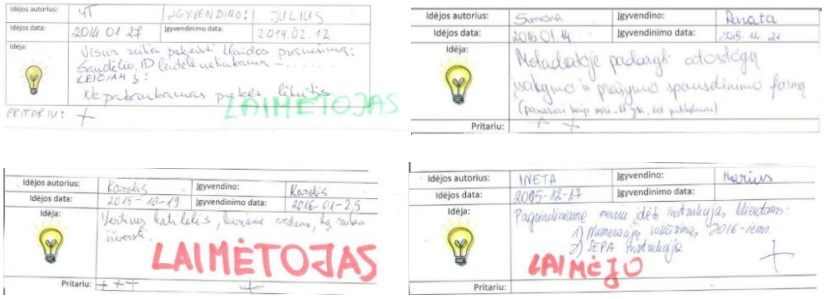
Case evidence 2. The X matrix



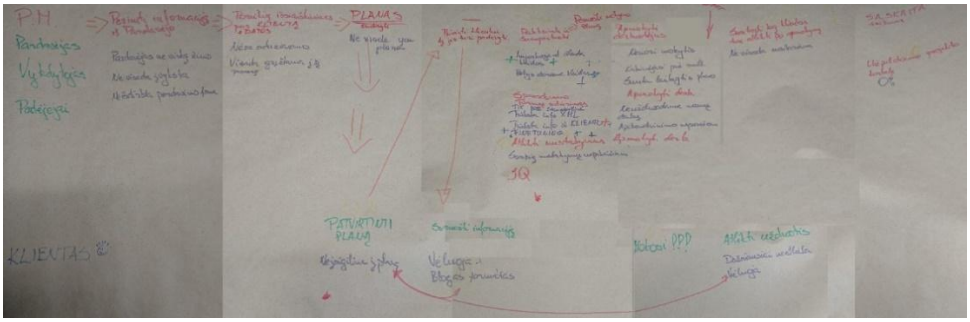
Case evidence 3. KPIs and other information as visual management



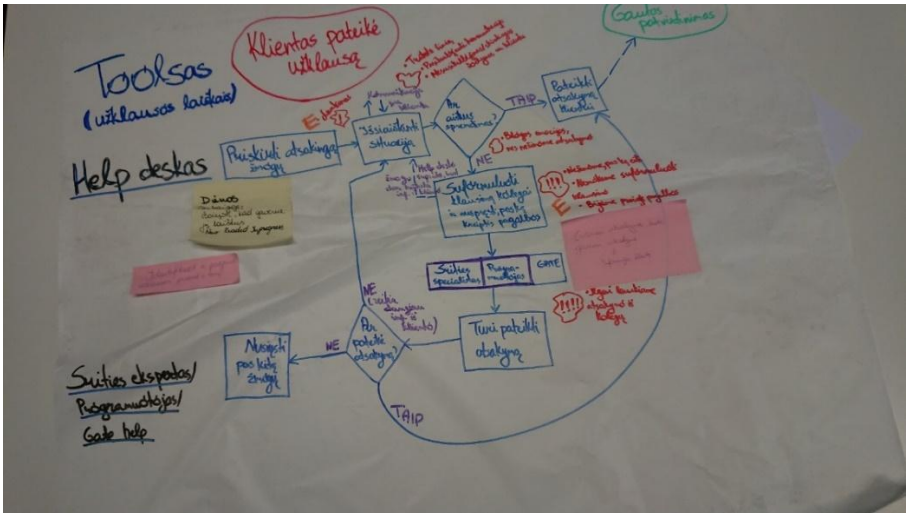
Case evidence 4. KPIs and other information as visual management



Case evidence 5. Map showing the current state of the ERP implementation process



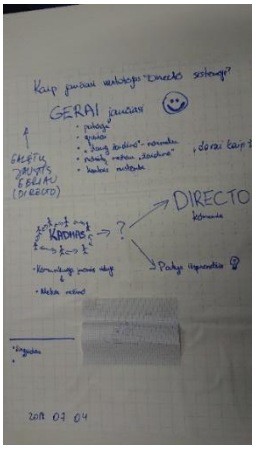
Case evidence 6. Diagram showing the current state of the support process

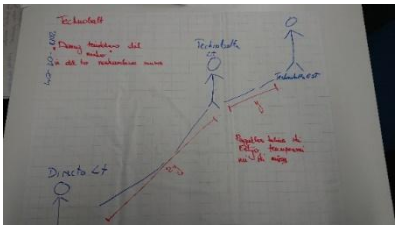


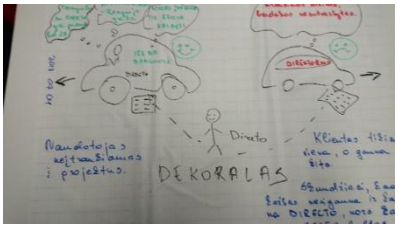
Case evidence 7. Table showing help requests from customers in 2017 per quarter (HELP – not assigned, B-bug, Q-question, D-development)

	I quarter	II quarter	III quarter	IV quarter
HELP	1528	239	87	176
B	5	104	133	86
Q	28	306	1028	1161
D	39	675	230	179
TOTAL	**1600**	**1324**	**1478**	**1602**

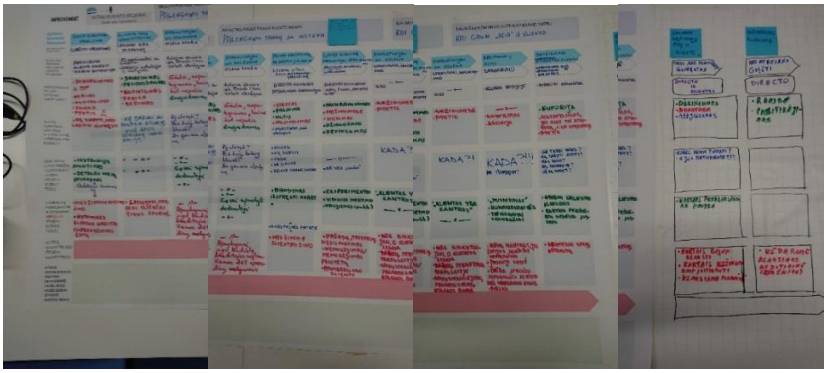
Case evidence 8. Pictures drawn by employees after customer visits



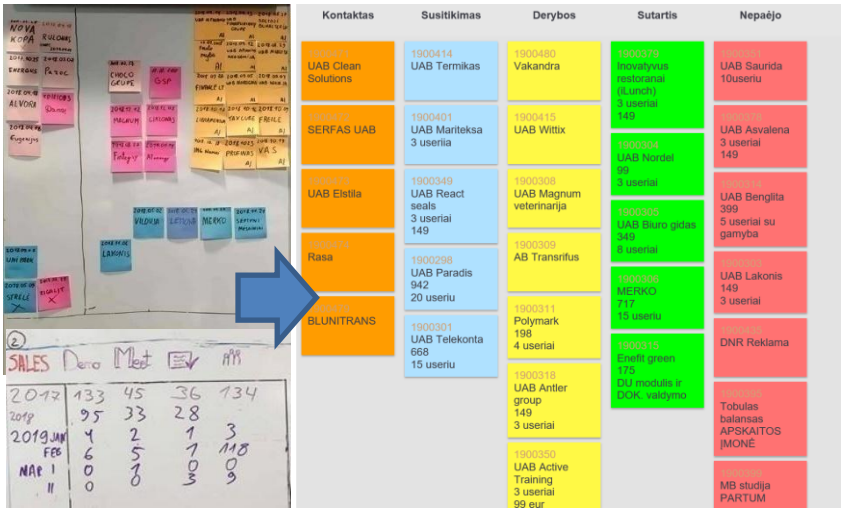




Case evidence 9. The Scheme reflects the customer perspective at each step from when required Directo's help until they received it.



Case evidence 10. The ERP adaptation pipeline



Appendix 2. Compilation of mechanisms for successful implementation of business process improvement

Elements/Factors for successful implementation of ERP and Lean Six Sigma based continuous business process improvement	Identified mechanisms	Is present? (number)	Contribution to success (number)	Is present? (H/M/L)	Contribution to success (H/M/L)
Established organisational processes/routines	Daily stand-up meeting	14.75	23.67	H	H
	Structured weekly meeting	14.17	26.42	H	H
	Regular Kaizen meetings	12.33	11.58	M	L
Building improvement skills for people	Coaching staff in systematic problem-solving activities	13.00	20.33	M	M
	On-job training in lean methods	13.75	17.92	M	M
	Trainings and workshops with external expert	15.17	20.83	H	M
Elimination of waste activities in ERP (remove unnecessary activities in ERP)	Process mapping pen-to-paper (before using ERP)	13.00	28.25	M	H
	Checking process with manual tools for couple month before doing it in ERP	11.17	24.58	L	H
	Automating data entering	10.25	11.75	L	L
Elimination of waste data in ERP	Review of data entries during the process improvement	12.25	16.67	M	M
	Decision what data is not important and can be skipped	10.67	14.00	L	L
Support for standardised work routine	Templates created during the improvement that are integrated in ERP and must be used	13.42	18.33	M	H
	Monitoring if standard procedures are complied with while working with ERP	11.75	14.67	L	L
Employee engagement while improving ERP and lean usage	Employee participation in improvement session	16.00	22.58	H	H
	Ownership of homework during the improvement project	11.67	17.42	L	M
	Time and resources provided by management	13.42	15.83	M	L
	Support from management to employees	15.00	18.83	H	M
DATA for improvement	New KPI's introduced during improvement projects	13.17	27.83	H	H
	KPI's are visualised with help of ERP	12.50	15.00	M	M
	During the meetings (Kaizen and other) required KPI's are taken from ERP	11.67	15.00	L	L
Organisational understanding via lean tools (Creating a customer-oriented, Lean and Kaizen mindset)	Aligned understanding of company strategy and goals	14.50	31.67	H	H
	Aligned understanding of customer expectations	13.83	41.17	H	H
	Aligned understanding of core organisational processes	14.50	41.67	H	H

Appendix 3. Direct transcription of the interview with the efficiency expert

Direct transcription of the interview with a business consultant about work efficiency and its continuous improvement in the companies.
(BOLD text is interviewers' questions)

Q-1. For you, as a business consultant, what work is efficiency?

I understand the work efficiency as an output per time, meaning how much it will create value added during the working time. When I talk about work efficiency I probably can separate or highlight [a] couple of points:

- How people use working time / how much of the time they do what they [are] supposed to do and how much time is pure waste.
- How good or not good they are in doing daily operations. This is related with their skills and sometimes motivation. We see a lot of examples when [a] job with [a] similar quality takes [a] different amount of time for different people.

And I would like to stress quality issue from my consultancy experience. I had several conversations with managers. They [were] kind of calculating the output, and only then they are checking the quality. For me, output is qualitative issue. The service or item produced has to meet quality requirements. Company managers are measuring manufacturing floor, for example, they have measurements or indicators for [the] amount produced and quality check[ing] is behind this. When I talk about output, that means it is meeting quality requirements.

Q-2. From Your work experience – how business managers perceive efficiency. You mentioned [at] **one point that they are concentrating on quantity but not on the quality. What other issues could you mention** [about] **how efficiency is perceived in the companies.**

You know, [the] interesting thing is that I did [a] survey of managers of the companies last year. They were not necessary CEO but different level managers. I had [a] question related to efficiency in survey. I put [out a] formula [for] how I would like to get data about efficiency. That it is calculated: profit (value added) divided by number of employees and some other factors [are] involved there. Managers had [the] formula and they had question[s] about it and a lot of managers find it too difficult to answer. This calculation is part of [the] statistical evolution of the companies that [the] department of statistics in Lithuania is using [for] it. This is like you should do only three mathematical movements to get the number. For managers that was not interesting or too difficult. I do not know, but many of them just ignored the question. So, this makes me think that, maybe, they look somehow different[ly at] what efficiency is.

They do not look into it in [a] very detailed way, but they look [at] how fast we are growing, how much we are earning. If human resources are [a] significant cost how much it cost for us. Also, sometimes they talk about efficiency in terms of energy. It is not work efficiency like operations, but they care about efficiency in [a] situation when employees are significant in terms of cost.

They start to worry about efficiency when competitors to do more or [are] earning more profit, with more or less the same amount of people. Or, they have problems with people, and they want to achieve more or less the same result with [a] smaller amount of people.

Q-3. Competitors are the drivers to look for efficiency?

Competitors and market pressure is. In terms [of] if they lack employees and if there are issues to find new people in the market, these are also possible drivers to look for efficiency.

Q-4. OK. When companies understand that they have a need to improve efficiency what steps do they usually take?

[The] first target is related to the processes. If we talk about manufacturing companies, probably 99% is related to the processes. They get to the point – we should do something. And then [it] depends. They try to look for some information themselves. Some companies try to hire consultants to do something with the process.

Q-5. So, processes are the main target to increase efficiency?

Processes and quality are. It depends on situation in [the] company. Sometimes companies are telling [us] that they want [to] improve processes but when you talk with them more about the situation and [their] needs, it seems that they mean quality.

Q-6. OK. If [a] **consultant is invited to help, how** [do] **companies perceive him or her? Is there understanding that** [the] **consultant will only guide them through though** [and] **all improvement must be done by themselves?**

I should say that most of my clients have [an] understanding that this is going to be their work. But I had situations in quite many cases when companies expect [the] consultant:

- to fix things in the company
- to do Lean
- to fix flow
- to give [a] recipe how to do that and that.

Q-7. How can consultant succeed in this situation? How do you usually explain to companies that this is your work? [The] **consultant is only guiding.**

My clients have passed this stage, that Lean implementation of flow fixing could be started and finished as a project. Anyway, sooner or later they start to realise that, OK, people still do not care. They still have many problems with quality and other issues. They have to make other changes and employees do not care that they are not offering solutions or improvement ideas. And then it comes to change management with the attitude and belief in [the] people, involvements of the teams and encouraging ideas to go from [the] bottom to top. If somebody came and fixed something in the company (reviewed the process and gave recommendations), you have some result,

at least for the short period of time. Unless, the recommendations were ignored totally, then there is no result at all.

For [a] stronger position companies want more. This could be achieved by involvement of the team (not only management but all team[s] of the company: management and all employees). This question is very important. Usually there are two basic scenarios:

- they decide to hire somebody, but it happens that they do not know what [role] they should hire [for]. Should they send their people to some seminars and trainings? What to do? How to change these attitudes in the company? How to change [the] behaviour of people?
- Other part[s] of [the] companies think if consultants can do fixes in the company our internal people also can do that. They start to build [an] internal competence centre. They start assigning efficiency responsibilities for certain manager or employee. If that person is the only one or he / she will start building the team, it depends on the size of the company. These companies start to work from [the] inside and start achieving good results.

Q-8. May I say that companies that build internal competence centres and work [for] **efficiency improvement all the time,** [that] **they have** [a] **continuous improvement process?**

Yes.

Q-9. Some companies reach that continuous improvement point. Some companies drop it on the way. What are the success / failure factors for the companies to implement continuous improvement in their work?

This is my personal belief. I would say that the most important factor is involvement of the top management. They should not only support ideas, but they have to be role models and manage the changes.

Another factor that is very important is daily management routines. Open internal communication, situation[s] when people feel involved and somebody cares what they think and what they say. They can give proposals.

[The] third success factor, I would say, is structural problem solving. When management is not only working with consequences but also analysing root causes and does it in systematic way.

Q-10. Could You go a little bit deeper and explain what [the] **daily management routines** [are]?

Daily management routines are based on feedback. People should know how they are performing. If they do not know how they are performing, they do not have motivation to improve. Also, it is about obligations. If employees are getting feedback, they are able to talk, propose things and be active [and] they feel responsibility, they feel more attached to the company.

Q-11. What are the most common tools to implement continuous improvement?

One example of tools [which] could be presented, is stand-up meetings. All companies from bottom to top have short meetings in groups with visual management tools. They discuss the outcome of [the] previous day: situations, problems, and proposals. They get feedback from the manager. I call it [a] system because it has to be constructed that way, that problems can easily move from bottom to the top if they need more power for solution.

Other tools:

X matrix – a tool from lean. It is good for strategy deployment.

Problem solving tools: 5 whys, A3 and other.

There are many tools. I would strongly suggest that at all company levels the same toolbox is used. Maybe 5-6 simple tools, but everybody is using the same ones. Then it is much easier to communicate and implement the mission.

Of course, it is very important to use visual management. Visual tools help to save time and to draw attention. There is a big variety of tools. The most useful ones for the company should be chosen and used.

And if you want [a] company to be efficient, [the] management itself has to be efficient. It also requires a lot of discipline. Tools help to create that discipline. Behind all tools you can see PDCA. Most tools are connected to the Lean. I found them very useful, and not only for the process, but for [the] managerial part as well. They are easy, there is no need for a lot of effort to adopt them, just some practical examples and you know the essence.

Q-12. Very last question. When companies [are] **deploying continuous improvement do they involve IT solutions (ERP / IMS) as well?**

In my opinion, [the] company has to be mature – right attitude, right employee involvement, and right management. Systems could be used in two ways: evaluating activities (KPIs) and process management. It actually depends on business type and context. The highlights are different, but [they] can be very overlapping. IT systems can create value when management infrastructure is there: problem solving practice, PDCA, cascade of goals, and others.

When companies expect that IT systems will save the world and nothing else is needed – in most of these cases failure and disappointment is guaranteed.

Thank you very much for the interview.

You are welcome.

Appendix 4. The template created from the interview with the field expert consultant

IMPLEMENTING CONTINUOUS IMPROVEMENT OF WORK EFFICIENCY

1. Perception of work efficiency
1.1. Work output per time in quantity
1.2. Work output per time in quality
1.3. Energy
2. Driving factors for seeking continuous improvement of work efficiency
2.1. Competitors
2.2. Market pressure
2.3. Lack of employees
3. Success / failure factors for implementing continuous improvement of work efficiency
3.1. Involvement of the top management
3.2. Daily management routines
3.3. Problem solving
4. Tools for continuous improvement implementation
4.1. Stand-up meetings
4.2. X matrix
4.3. 5 WHYS
4.4. A3 form
4.5. PDCA
4.6. Visualisation
5. Continuous improvement and IT solutions
5.1. Evaluating activities (KPIs)
5.2. Process management

Indrė Liutkevičienė

Developing Digitally Supported Process Improvement Capabilities in Small and Medium Enterprises [Procesų tobulinimo gebėjimų, paremtų skaitmeninėmis technologijomis, ugdymas mažose ir vidutinėse įmonėse]

Daktaro disertacija

Išleido ISM Vadybos ir ekonomikos universitetas, Gedimino pr. 7, LT- 01103 Vilnius
Spausdino leidyklos „Technologija“ spaustuvė, Studentų g. 54, LT-51424 Kaunas
27,25 leidyb. apsk. Tiražas 17 egz. Užsakymas 161

Gedimino pr. 7, Vilnius, LT-01103, Lietuva
+370 687 08080
ism@ism.lt