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Systematic Review

Exploring Lean Six Sigma as Dynamic Capability to Enable Sustainable Performance Optimisation in Times of Uncertainty

Vera Ndrecaj [1,*], Mohamed Ashmel Mohamed Hashim [1], Rachel Mason-Jones [1], Valentina Ndou [2] and Issam Tlemsani [3]

[1] Cardiff School of Management, Cardiff Metropolitan University, Western Avenue, Cardiff CF5 2YB, UK; mmohamedhashim@cardiffmet.ac.uk (M.A.M.H.); rkmason-jones@cardiffmet.ac.uk (R.M.-J.)
[2] Campus Ecotekne, University of Salento—IBIL "Aldo Romano" Building, Via Monteroni sn, 73100 Lecce, Italy; valentina.ndou@unisalento.it
[3] The Centre for International Business, London KT3 6DR, UK; i.tlemsani@tcib.org.uk
* Correspondence: vndrecaj@cardiffmet.ac.uk

Abstract: The purpose of this study is to develop a nested theoretical model (LSS-DC) by critically examining two distinct theoretical concepts, including Lean Six Sigma (LSS) and Dynamic Capabilities (DC), for achieving organizational sustainable performance optimizations (PO). The robust integration of this dynamic concept is achieved using a systematic literature review, synthesis, and empirical evidence derived from 2005 to 2022. The vital benefits of LSS-DC are identified. This study utilizes a systematic literature review method adapted. It reveals the cross-sectional literature search strategy deploying selective keywords DCs, LSS, DCs and LSS, DCs and LSS and PO. In this niche domain employing descriptive and thematic analysis, key insights are extracted from the literature, encompassing a total of 21 peer-reviewed journals. The selection criteria revolve around three aspects: 'Purpose', 'Authorship', and 'Credibility and Accuracy'. The authors gathered the secondary data from credible databases such as Scopus, Web of Science, PubMed, ERIC, and IEEE using the keyword search. The study reveals the robust integration of theoretical concepts of LSS and DCs and their impact on organisational performance. The findings suggest that integrating the micro-foundations of DCs (sensing, seizing, and transforming) with LSS allows organisations to not only identify improvement opportunities but also efficiently and effectively act upon them, ultimately leading to sustainable performance optimisation across various aspects of the business. The specific type of DC integration with LSS depends on the organisation's goals and priorities. The findings of this study are subjective to some extent due to the applied research methodology. Further empirical research is needed to gain a deeper understanding of the phenomenon. This study considers LSS as DC providing an empirical (LSS-DCs) model for sustainable performance optimisation. This is achieved by robustly integrating two distinct theoretical concepts derived from an extensive literature review and the analysis of the data-driven implementation. Finally, the study offers a deeper understanding in terms of how contextual organisational characteristics enhance the outcome of LSS-DC.

Keywords: Lean Six Sigma (LSS); dynamic capabilities (DCs); sustainable performance optimisation (SPO)

Citation: Ndrecaj, V.; Mohamed Hashim, M.A.; Mason-Jones, R.; Ndou, V.; Tlemsani, I. Exploring Lean Six Sigma as Dynamic Capability to Enable Sustainable Performance Optimisation in Times of Uncertainty. *Sustainability* **2023**, *15*, 16542. https://doi.org/10.3390/su152316542

Academic Editor: Cristina Raluca Gh. Popescu

Received: 28 June 2023
Revised: 5 November 2023
Accepted: 9 November 2023
Published: 4 December 2023

1. Introduction

The volatility of the business environment has made organisational sustainable performance optimisation a pressing challenge [1]. Hence, they are constantly seeking opportunities for cost reduction, improved product and service quality, and enhanced employee and organisational satisfaction [2]. In this context, exploring the integration of Lean Six Sigma (LSS) as dynamic capabilities (DCs) becomes crucial [3,4]. The recent studies conducted by [5] argue that LSS should be recognised as a dynamic capability that extends beyond

its operational application, reinforcing the strategic orientation of LSS as a performance optimisation practice. LSS combines two management philosophies, System Thinking (ST) and Six Sigma (SS), which have been widely used for performance optimisation initiatives, enhancing productivity and reducing non-value-added activities while improving product quality through process variation elimination [5–11]. LSS aims to enhance operational capabilities within organisations and maximise value by improving quality [10,12,13]. Moreover, LSS is increasingly being employed by organisations as an efficient approach not only for quality improvement but also for reducing delivery time, minimising waste and defects, and enhancing customer satisfaction [14–16].

The literature highlights the need for integrating LSS with strategic management tools to achieve sustainable performance in dynamic environments [3,17]. However, the integration of LSS as a performance optimisation methodology is acknowledged to be challenging [9,15], and its examination within the context of strategic management is still limited [5]. Moreover, [15], suggests that the integration of LSS with sustainability tools is necessary to achieve both environmental and operational benefits. The question of whether LSS alone is sufficient to deliver operational excellence and its ongoing development remains unanswered. Nevertheless, [9] argue that LSS is not a standalone solution, but rather a piece in the operational excellence puzzle, requiring integration with strategic themes aligned with the broader business strategy. They also emphasise that LSS will continue to evolve and improve as an integrated methodology, rather than being replaced by a new approach. In addition, [5] suggests that the attributes of LSS may depend on the specific context. Hilton and Sohal [18] emphasised the importance of having technically and interpersonally competent facilitators in an organisation to successfully develop and implement LSS projects.

The strategic importance of Dynamic Capabilities (DCs) within dynamic environments has gained significant attention in strategic management research [19–26]. Initially introduced by [27,28] and since then DCs have become a prevalent theoretical framework in the private sector to understand performance enhancement and effectiveness in rapidly changing contexts. The purpose of this study is to examine the potential strategic integration of Lean Six Sigma (LSS) methodologies with the concept of Dynamic Capabilities (DC) for sustainable performance optimisation in uncertain business environments as shown in Figure 1.

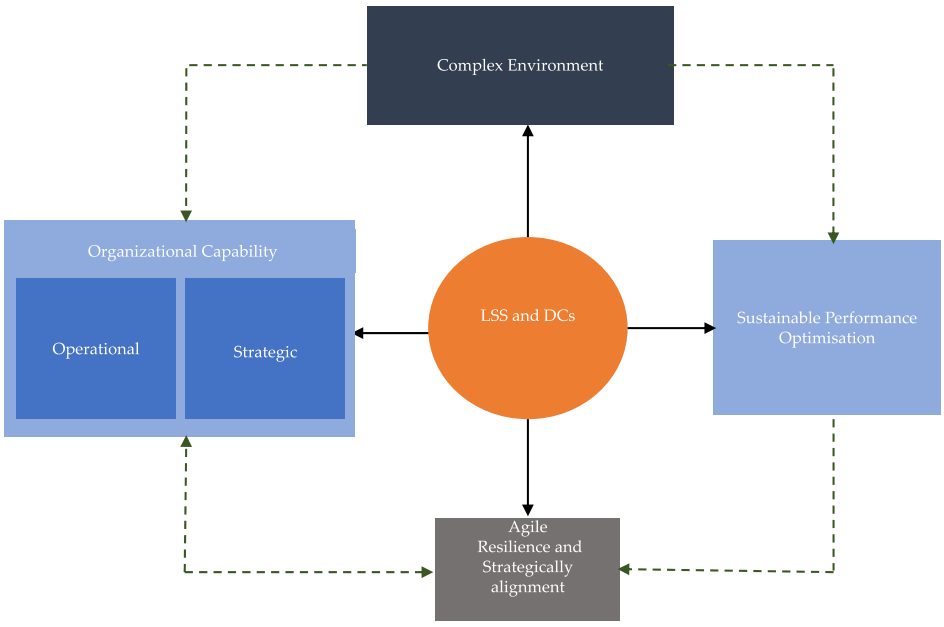


Figure 1. Research framework. Source: authors.

The study seeks to explore how the integration of LSS as DCs can contribute to sustainable performance optimisation in volatile and unpredictable conditions.

Specifically, the study aims to delve into the strategic implications of viewing LSS beyond its traditional operational applications and recognising it as a dynamic capability that enhances an organisation's ability to respond, adapt, and thrive in times of uncertainty. Hence research seeks to address the central research question: How does the integration of LSS as DCs contribute to sustainable performance optimisation in times of uncertainty?

This paper stands out as one of the few studies that examines the strategic significance of integrating LSS as DCs advancing theory development and providing practical insights outlining how this integration empowers organisations to achieve and sustain sustainable performance optimisation. Additionally, the research provides a foundation for future empirical investigations, establishing a fundamental analytical framework for further exploration.

The structure of the paper is as follows: Section 2 offers a critical evaluation of LSS and DCs, accompanied by the development of a conceptual framework. Section 3 focuses on the research methodology, while Section 4 presents the discussion of findings. Finally, Section 5 concludes the paper and provides recommendations for future research.

2. Literature Review

2.1. Lean Six Sigma (LSS)

With the increased global competition Lean approach was developed within the Toyota production system as a diverse force to eliminate waste, decrease process flow time, enhance communication, improve system capabilities, eliminate inventory loss and bottleneck, and finally increase customer satisfaction [29–33]. Lean has become known by different names to different people as it has evolved [34–36]: a philosophy or a clear way; a process or a concept; a set of tools and techniques [37–40].

However, Six Sigma (SS) has been practiced for the last 30 years, developed by Motorola to improve product quality through an improved process that eliminates wasted activity [32,41,42]. SS can be defined as a management "method", "tool", "philosophy", "benchmark" or a "goal" that attempts to increase efficiency and effectiveness at the same time [43,44]. It has a proven track record of successfully eliminating process variation and reducing defect rate to 3.4 units per million opportunities (Figure 2). It therefore improves process performance and capability by using both statistical and non-statistical tools [45]. The focal point of both Lean and Six Sigma methods is the process, but they have very different perspectives [42]. While SS heavily focuses on collecting data and using statistical tools to analyse and solve the baffling problem, Lean takes a more behavioural and knowledge-based approach to reduce wastage and increase productivity [46,47].

Figure 2. Three categories of the impact factors of the Lean Six Sigma. Source: Adapted from [2].

Nonetheless, when problems fall outside the Lean principles, there is no obvious way to resolve this by just applying the Lean philosophy [48,49]. In other words, to eliminate the limitations that are posed by both Lean and Six Sigma methods, but to still enjoy the advantages of both, a combined method has been developed, known as LSS [48,50,51]. It was developed in an effort to achieve both the reduction of process variation, elimination of non-value-added activities as well as rationalisation of process activities [15,42,48,50,51]. By combining these two approaches, organisations aim to achieve a fast and flexible flow of goods and services while simultaneously eliminating any factors that might hinder the path of achievement in excellence regarding product or service development [52]. An early study by [50] suggests that the combination of two-method qualities of SS and Lean increases and reduces non-value-added cost by up to 90%. However, a more recent study conducted by [2] identified thirteen different impact factors categorised into three main themes: cost reduction, quality improvement, and enhancement of customer satisfaction as shown in Figure 2.

These LSS impact factors (cost, quality, and customer satisfaction) can be linked with DCs clusters (sensing, seizing, and transforming) by using them as critical inputs and strategies to continuously adapt and improve organisational processes for sustainable performance optimisation. It is evident that both the LSS and DCs as organisational capabilities offer common critical success factors such as cost, quality, and satisfaction clusters. This is progressively achieved by the organisation in distinct phases—sensing, seizing, and transforming. Furthermore, the monetary impact is well recognised in the literature and LSS and DC have been positively correlated with diminishing cost, increasing quality, and enhancing customer satisfaction.

Furthermore, the literature observed suggests that LSS is gaining wider acceptance within manufacturing, service, and public sector industries [53,54] in the current competitive market where demands are made excessively for the highest quality, lowest cost, shortest possible delivery time, and total elimination of wastage [2,55]. This is especially so within the manufacturing and production environment that provides systematic and rigorous applications such as the SS-oriented DMAIC (Define, Measure, Analyse, Improve, and Control) approach: this approach enables tracking of how a product is created through the manufacturing process and efficient identification of wastage [56]. LSS is one of the most utilised systematic methods that address the specific issue through the effective use of Lean and SS tools such as Value Stream Mapping (VSM), Design of Experiment (DOE), 5s (Sort, Set in order, Shine, Standardise, and Sustain) and SIPOC (Supply, Input, Process, Output, and Customer) [57–64] It is important to know and understand the most used and powerful tools because most popular tools are less complex but still capable of providing a visual representation [65]. Many researchers also argue that most organisations failed to achieve effective outcomes from the LSS implementation not because they were incapable but because the organisation underestimated the importance of selecting the correct tool in terms of complexity and usefulness [66,67].

However, several criticisms and challenges exist regarding LSS. Some argue that it can be a time-consuming and resource-intensive methodology, requiring significant investments in training and infrastructure [68]. Additionally, the focus on standardisation and efficiency may neglect creativity and innovation, potentially limiting the organisation's ability to adapt to dynamic market conditions [69].

Another criticism relates to the potential overemphasis on statistical tools and methodologies, which may lead to a rigid and formulaic approach. Critics argue that this narrow focus may hinder holistic problem-solving and fail to address root causes or systemic issues [70].

2.2. Dynamic Capabilities

The concept of Dynamic Capabilities (DCs) provides a structured framework for understanding organisational success or failure in the face of changing environments [22,23]. The concept has been defined as an organisation's ability to integrate, build, and reconfigure internal and external competencies to address a rapidly changing environment [19,22,23,27,28,71–77]. Similarly, [78–80] depicted that DCs emerged due to the challenges posed by dynamic and uncertain environments.

An early study by Teece [27,28] suggested that DCs serve to evaluate existing internal and external competencies, not only to adapt to changing demands but also to align with customer needs, technological advancements, and business opportunities for long-term competitive advantage. More recently, several studies e.g., [72,75,81] argued that organisations with DCs not only adapt to their environment but also actively shape it. Whereas [82–85] emphasised that DCs enhance technical efficiencies, drive organisational changes, and manage transformations by employing suitable organisational and managerial processes.

The ongoing discourse in DC literature suggests that organisations must cultivate unique and hard-to-replicate skills and capabilities through internal development and external sourcing to effectively renew and excel over time [83–85]. However, [76] depicted DCs as the capacity to sense and shape opportunities and threats, seize these opportunities, and sustain competitiveness by enhancing, combining, protecting, and reconfiguring both tangible and intangible assets within the business enterprise [71,75,86].

This underscores that the concept of sensing embodies the foundational cluster of strategic activities, encompassing the recognition, cultivation, co-development, and evaluation of opportunities tied to customer needs [76,84,86], thereby forming the 'business ecosystem' [76] (p. 1320). In contrast, seizing capabilities determine the organisation's swiftness in responding to identified and significant opportunities and threats [74,75]. While sensing capabilities offer access to external knowledge and the flexibility to adapt firm operations [87–89], seizing capabilities focuses on realising and exploiting this knowledge [76]. Once opportunities are identified and seized, transforming capabilities come into play, facilitating the attainment of ongoing asset orchestrations and corporate revitalisation [76] (p. 1335). Transforming capabilities are instrumental in aligning organisational systems with each other and with the overarching strategy [28,71,72,74,75].

The authors' focus on defining the micro-foundations of DCs is well-aligned with recent research by [75,76,82,88,90–92], which underscores the significance of the three DC clusters—sensing, seizing, and transforming—in navigating uncertainty effectively. These capabilities empower organisations to proactively identify opportunities, swiftly capitalise on them, and adapt their operations for sustained success in dynamic environments.

Sensing capabilities encompass an organisation's structure, processes, designs, and incentives for identifying technological opportunities, customer needs, and strategic challenges [76,93]. Effective sensing enables recognition of emerging market trends, customer preferences, and technological advancements [88]. Seizing capabilities involve agile resource allocation and decision-making, allowing organisations to swiftly mobilise resources and reconfigure operations for new product launches or market entries [75,81,88,93].

Transforming capabilities hinge on an adaptable culture and continuous learning, enabling organisations to reshape business models and strategies in response to changing conditions [82,91]. Figure 3 shows the taxonomy of the DCs providing the overview of the attributes of three clusters: sensing, seizing, and transforming against outcomes, enables, and questions [92] (p. 491).

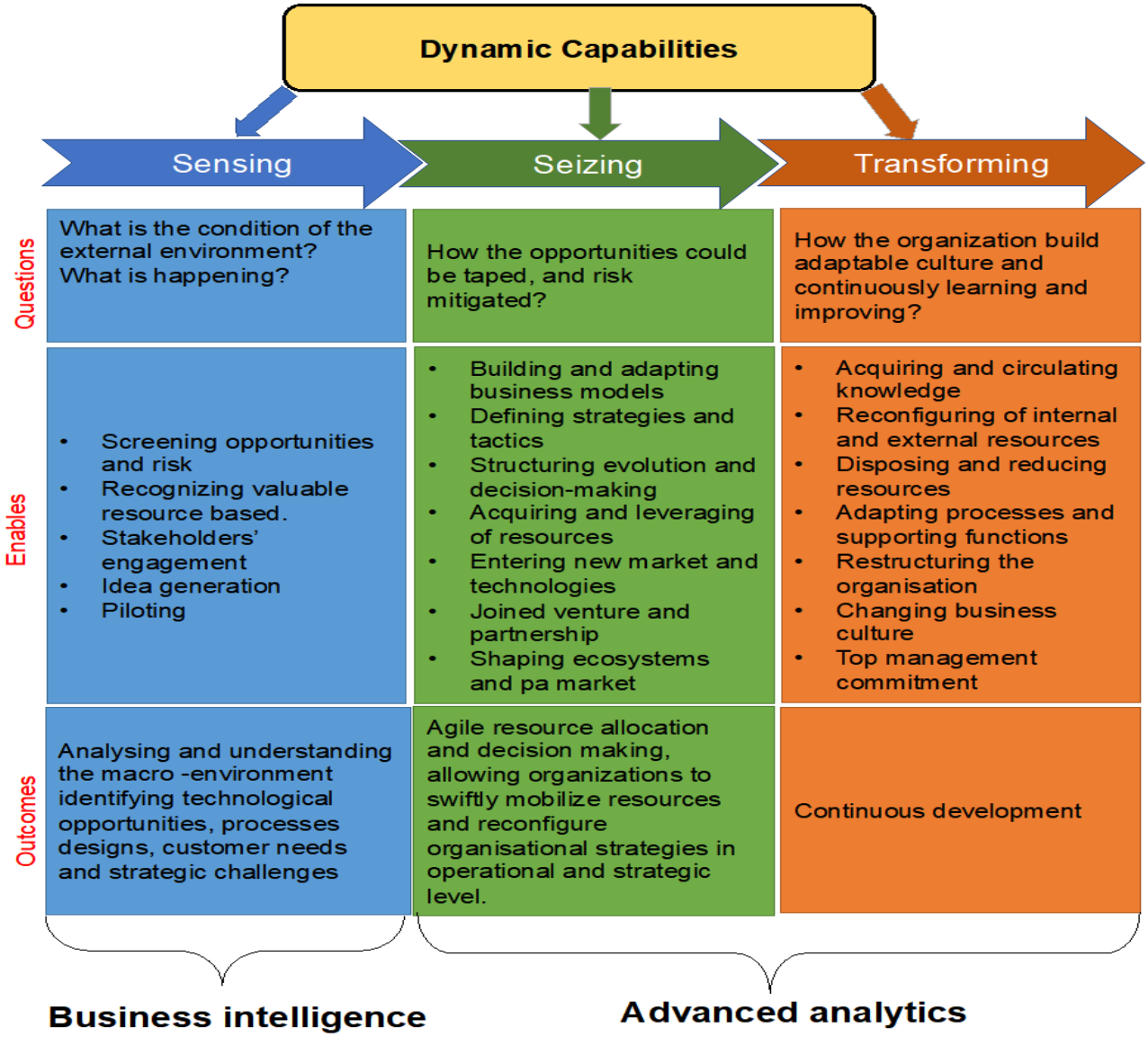


Figure 3. The taxonomy of the dynamic capabilities: Source: adapted from [92] (p. 491).

2.3. The Integration of the LSS as DCs

Recent studies underscore the pivotal role of integrating the clusters of sensing, seizing, and transforming capabilities with Lean Six Sigma (LSS) in achieving sustainable performance optimisation. Integrating the micro-foundations of DCs (sensing, seizing, and transforming) with LSS allows organisations to not only identify improvement opportunities but also efficiently and effectively act upon them, ultimately leading to sustainable performance optimisation across various aspects of the business. The specific type of DC integration with LSS depends on the organisation's goals and priorities. Sensing capabilities, encompassing the identification of opportunities and threats, align seamlessly with LSS's focus on process improvement, quality enhancement, and waste reduction [94]. LSS provides tools for data-driven decision-making that amplify the effectiveness of sensing by enabling organisations to detect emerging trends and customer needs promptly [93].

The integration of seizing capabilities with LSS emphasises the importance of agile resource allocation and quick decision-making to capitalise on identified opportunities [74,76,85,88,91–93]. LSS aids in streamlining processes, which is crucial for organisations with robust seizing capabilities to swiftly reconfigure operations, launch new products, or penetrate new markets [90].

Transforming capabilities, vital for continuous adaptation, find synergy with LSS's emphasis on ongoing improvement and innovation [72,91]. LSS methodologies like Kaizen promote a culture of continuous improvement, aligning with the need for transformative changes during shifting business conditions [95]. Integrating LSS's transformative principles enables organisations to reshape their strategies, processes, and structures, fostering resilience and agility in dynamic environments.

The literature observed highlights the symbiotic relationship between LSS and the clusters of DCs (sensing, seizing, and transforming). This integration empowers organisations to proactively identify, capitalise on, and adapt to opportunities and challenges, resulting in sustained performance optimisation in uncertain business landscapes.

Figure 4 offers a comprehensive depiction of the DC clusters (sensing, seizing, and transforming) suggested by [76,77] and the impact factors and attributes of the LSS [2] outlining a fundamental framework for sustainable performance optimisation. This amalgamation forms the foundational basis for the convergence of DCs and LSS principles, and the pursuit of enhanced sustainable performance optimisation. Although, Table 1 offers a summary of scholarly perspectives that delineate the fundamental traits and features of both LSS and DCs.

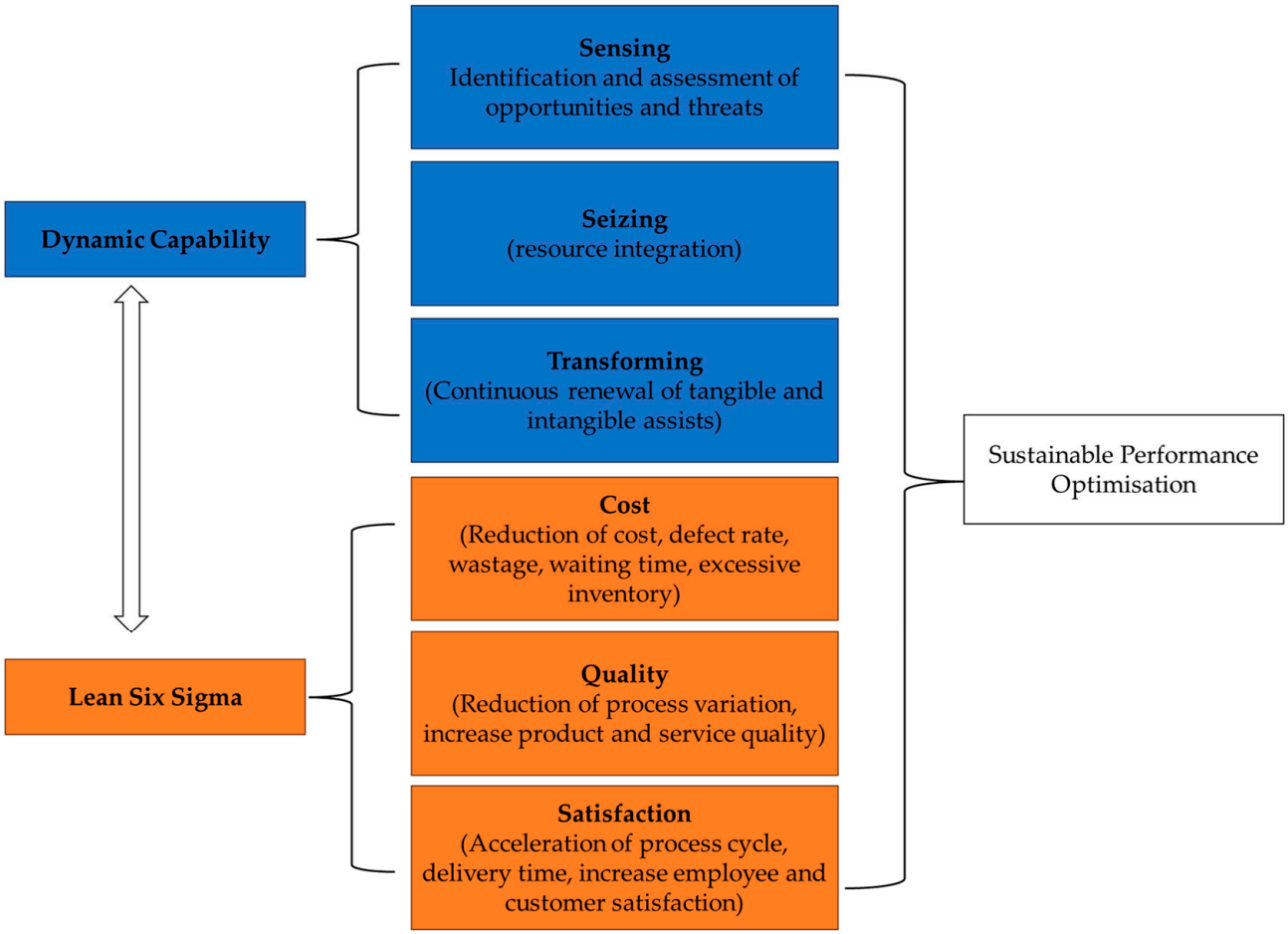


Figure 4. DC clusters and the impact factors of the LSS. Source: authors (Adapted from [2,76]).

Table 1. The assessment of Lean Six Sigma and dynamic capabilities. Source: authors.

Features	Dynamic Capabilities	Lean Six Sigma
Disciplinary Orientation	Evolutionary economy and strategy [19,83] Organisational sociology [83] Technology [19,83,84] Organisational theories, science, behaviour, information system [82]	LSS—integration of two philosophies namely lean and Six Sigma [16,30,48,53,66]
Main Characteristics	[19,74,76] Sensing capability Learning capability Integrating capability Coordinating capability [74,76] Sensing capability Seizing capability Transformational capability [96] Absorptive capability Innovative capability Adaptive capability [79]. Incremental DCs—stable environment Renewal DCs—dynamic environment Regenerative DCs—respond to the need to change DCs themselves (the way firms modify their resource base)	Define scope and purpose. Measure—determine the current situation. Analyses—identification of causes. Improve—remove wastes and opt for optimal solutions. Control—Keep process in control [11,58] Reduce cost, Enhance quality, and employee and customer satisfaction [2,18,32,48,51] Improve communication and information systems [14,61]
Customer Orientation	Customer value and relationship management [21,25,97–99]	Makes provision for customers [51]. Achieve good customer satisfaction [94,95]
Resource Optimisation	Facilitates the deployment of resources to generate new value-creation strategies [23,78,79,82,99] An interaction of cross-functional processes to renew the resource base [82,100,101].	Eliminates waste and creates an efficient system [6,36,54,62]
Organisational Performance	DCs are the mechanisms by which firms achieve competitive advantage [19,23,76–78,81,90,102] DCs enhance organisational performance [26,74,75,77,103–106]	LSS improves the quality, efficiency, and effectiveness of processes while meeting environmental regulations [42,48,53,107–118]
The Integration of LSS and DCs	Enhances agility and adaptability in uncertain environments.	
	Enables organisations to effectively manage risks during uncertain times.	
	Improve performance measurement and monitoring systems.	
	Supports innovation and continuous improvement efforts during uncertain times.	

3. Methodology

This study aims to evaluate the combined impact of integrating Lean Six Sigma (LSS) and dynamic capabilities (DCs) on sustainable performance optimisation. To achieve this, a systematic review methodology was utilised, encompassing the identification, assessment, and synthesis of relevant studies. This approach ensures rigor and facilitates interdisciplinary exploration by revealing cross-disciplinary themes [119–122]. Systematic reviews have gained prominence as essential scientific endeavours that assess existing knowledge within a domain [120,123], aiding in understanding the field's current state [119,121,122]. Furthermore, [124–126] highlights that systematic literature reviews aim to consolidate past knowledge in a specific domain, identifying gaps for future research.

The methodology employed here has been widely used to explore the concept of DCs from various angles [79,82,89,96,105,127–129]. The literature offers diverse approaches to gathering sample articles, which involve distinct phases suggested by [126,130–132]. The phases are summarised in Figure 5.

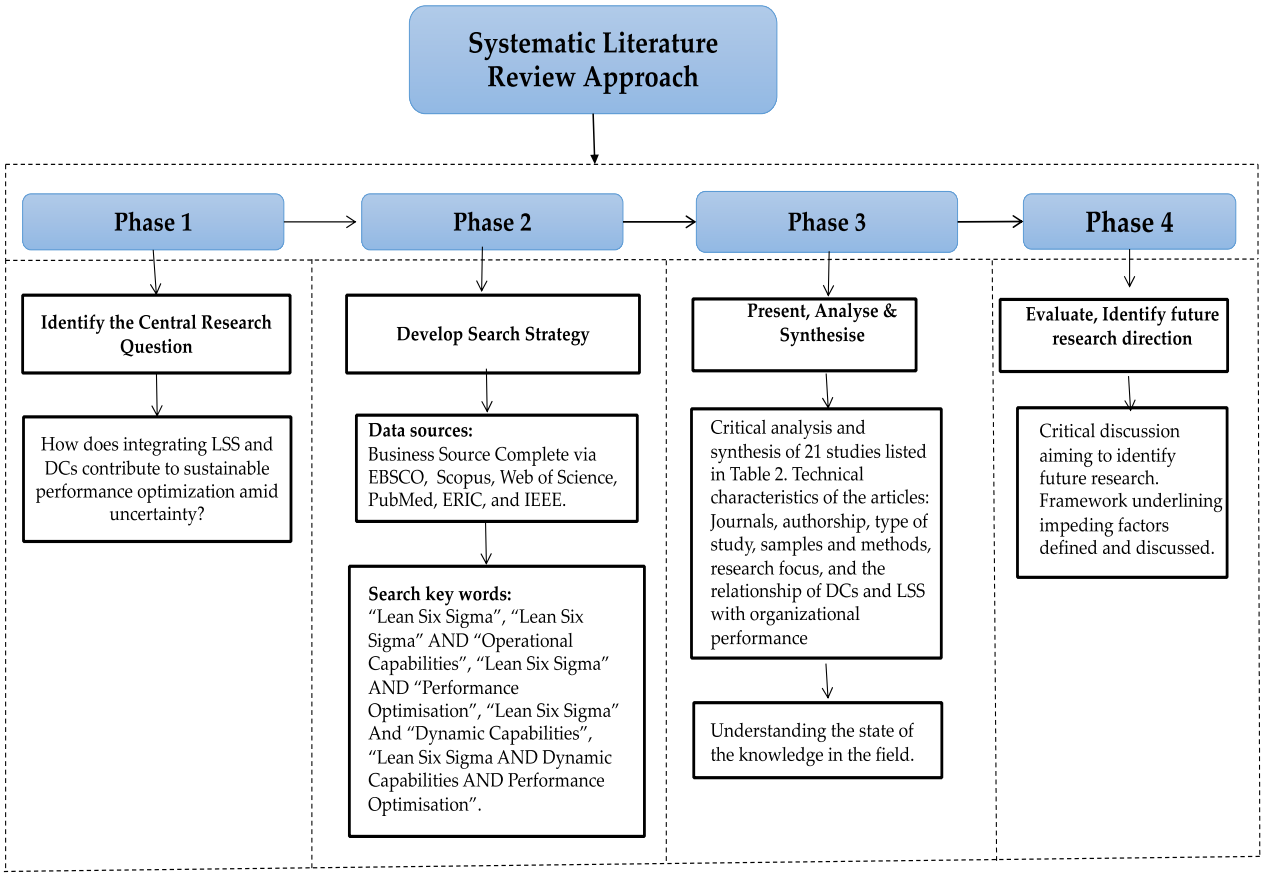


Figure 5. The systematic literature review approach: Source. Adapted from [130–132].

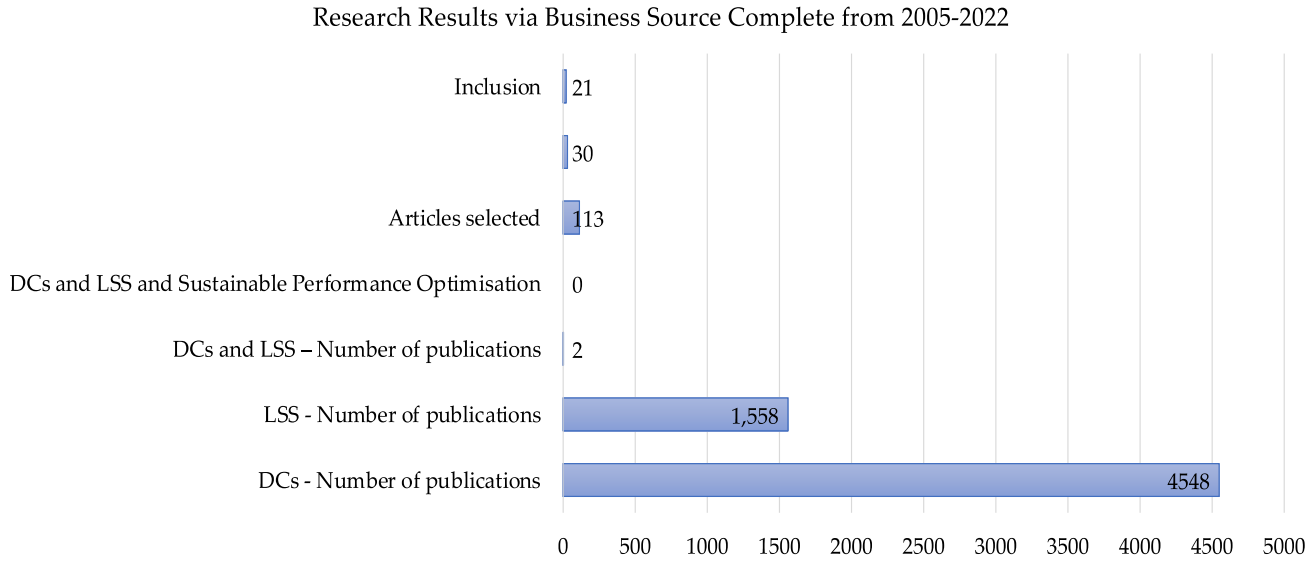
3.1. Phase 1: Identifying the Central Research Question

In this phase, a research question or questions are formulated to understand the current state of the literature and identify potential areas for future research [126].

Research Question: How does integrating LSS and DCs contribute to sustainable performance optimisation amid uncertainty? This research question serves to analyse existing relevant literature on dynamic capabilities and Lean Six Sigma and identifies potential avenues for further research.

3.2. Phase 2: Defining Search Strategy and Keywords

This phase involves developing a research protocol that includes information sources, methods, and tools for analysis [133]. For this research, a methodological approach based on [86] was employed. Key conceptual and empirical articles from reputable journals were reviewed, focusing on journals sourced from the Business Source Complete database via EBSCO, Scopus, Web of Science, PubMed, ERIC, and IEEE (Table A1). The search keywords shown in Figure 5 are used to map the scholarly work mentioning DCs, LSS, DCs and LSS, DCs and LSS, and performance optimisation from 2005 to 2022 and the results of the search are shown in Figure 6.



DCs - Number of publications	LSS - Number of publications	DCs and LSS – Number of publications	DCs and LSS and Sustainable Performance Optimisation	Articles selected		Inclusion
				DCs	LSS	
4548	1558	2	0	113	30	21

Figure 6. Search results via Business Source Complete. Source: authors.

3.3. Phase 3: Analysis and Synthesis

This phase involves critical analysis and synthesis of selected papers to identify commonalities, differences, and interdependencies [134,135]. It aims to comprehend the state of the field, its evolution over time, and emerging themes. Technical characteristics of the articles were extracted and analyzed, including journals, authorship, type of study, sample and methods, research focus, key findings, and the relationship of DCs with organisational performance. This information was categorised in tables for initial descriptive analysis.

The validation of study results is a crucial step in this research process to ensure the accuracy, reliability, and credibility of findings. Authors employ various methods to validate their study results. Here are some common approaches:

- **Triangulation:** This involves using multiple sources of data or different methods to examine the same phenomenon. By converging data from various angles, authors have established the consistency and reliability of their findings.
- **Credibility Checks:** Authors have discussed their findings and interpretations with colleagues, mentors, and advisors to receive feedback and ensure that their interpretations are grounded in the data.

- **Longitudinal Studies:** Conducting research over an extended period allows for the observation of changes, patterns, and trends, increasing the reliability of conclusions drawn from the data.

3.4. Phase 4: Discussion and Future Research

In this phase, a critical discussion of the analysis is presented, aiming to identify future research directions and frameworks for understanding impeding factors [29].

In summary, this study employs a systematic review methodology to investigate the integration of LSS and DCs for sustainable performance optimisation, following a structured process of research question formulation, search strategy development, analysis and synthesis, and discussion of findings and future paths.

4. Key Findings

4.1. The Role of DCs in Performance Optimisation

The literature highlights a continuous debate centered on the attributes of Dynamic Capabilities (DCs) in enhancing organisational performance within dynamic environments. Various studies, including those by [79,82,83,85,90,102,125,136,137], indirectly link DCs to organisational performance by emphasising their role in renewing operational capabilities and the underlying routines that guide daily organisational activities such as logistics, marketing, and manufacturing [78,88–90,138,139] Recent empirical support for this suggestion has emerged in studies by [24,140,141].

However, further research suggests that the impact of DCs on organisational performance is more pronounced in dynamic environments [87,90]. In contrast, other researchers such as [19,28,76,136,142] have found a direct association between DCs and organisational performance. They propose that DCs serve as unique signature processes that transform the resource base within an organisation, contributing to performance enhancement. While some like [82] argue that long-term competitive advantage lies in resource configurations rather than DCs [137], the ongoing discourse continues to explore the intricate relationship between DCs, resource configurations, and organisational performance.

DCs are based on three key organisational processes: sensing, seizing, and transforming capabilities [72,74–77]. These clusters play a crucial role in enabling companies to harness the advantages of open innovation effectively [69]. The sensing process involves analysing the external organisational environment to identify opportunities and manage threats [22,71,75,76,143]. Seizing capabilities, on the other hand, focus on translating opportunities into actionable responses, ensuring the organisation's readiness to address identified significant opportunities and threats [22,75,85,91,92].

Once opportunities have been identified and seized, transforming capabilities come into play, facilitating ongoing asset orchestration and corporate renewal [76]. This framework underscores the essential capabilities that organisational management needs to sustain high-level business performance in rapidly changing environments. Table 2 provides an overview of the relationship between DCs and organisational performance optimisation.

The conceptual framework of DCs highlights the interplay of these capabilities in achieving adaptive, responsive, and innovative strategies that ultimately contribute to sustained superior performance. However, the effectiveness of these capabilities in real-world scenarios may be influenced by various contextual factors and organisational dynamics that warrant further empirical investigation.

Table 2. The contribution of DCs on performance optimisation. Source: authors.

The role of DCs in Performance Optimisation	Innovation—High-level capabilities [47,69,72,97,104,144].
	Long-term CA and wealth creation in a dynamic environment [19,25,27,28,47,75,76].
	Enhance organisational performance by addressing strategic changes [74,80,85,92].
	Reconfigure business model and strategy—Continuous Improvement [97,99,102].
	Innovation and adaptability—flexibility [47,58,69,72,84,97,104,114,144].
	New resource configuration [76,137].
	Redeploy and reconfigure ordinary capabilities [69,71–77].
	Superior performance and survival in changing environmental conditions [71–77].
	Indirect links between DCs and performance [82,84].
	Modifies organisational resources and/or routines [82–90,100].
	Generate change—an alternative approach to the 'ad hoc problem solving' [71–77].
	Upgrade and reconfigure core capabilities in response to the changing environment and improve market-based performance and financial performance [97,98,102].
	Sense market signals, seize opportunities, and transform their capabilities to adapt to uncertain conditions [115,126].
	Create CA through new resource configuration [34].
	Sensing and seizing capabilities contribute to entrepreneurial behavior and innovation [58,114].
	Respond to strategic changes [124,131,132].
	New product development performance [95].
	Creates ambidexterity and effective management of the business ecosystem [41].
	Determined the speed and degree (and associated cost) of aligned firms' resources—continuously sense and seize opportunities and periodically transform an aspect of organisation and culture [76,85].
	Support high performance based on new product and process development. Change-orientated organisational culture. Prescient assessment of the business environment and technological opportunities [101–106].
	DCs contribute to organisational performance only if the VRIO criteria have been met [25]. Competitive advantage in complex and dynamic environments [19,20,23,27,28].

4.2. Dynamic Capabilities, Lean Six Sigma and Performance Optimisation

The theoretical exploration of the relationship between Lean Six Sigma (LSS) and Dynamic Capabilities (DCs) has been relatively limited, as evident from Table 3. Among the 21 studies considered in this systematic literature review, only four have examined the interplay between these concepts: [3,17,42,97].

Table 3. Research on the Lean Six Sigma and DCs. Source: authors.

Authors	Type of Study	Research Focus	Key Findings
[115]	Qualitative	To eliminate many misconceptions regarding Six Sigma and lean management.	The joint implementation of the programs will result in a lean, Six Sigma (LSS) organisation, overcoming the limitations of each program when implemented in isolation.
[109]	Qualitative	Explains how lean compares to the Six Sigma and outline the benefits of integrating them	The paper proposes a new lean Six Sigma (LSS) approach and provides a detailed description of its phases.
[42]	Mix method	Evaluates LSS from a middle manager's perspective.	Findings indicate that developing DCs in middle management along with a learning culture will facilitate participation in strategic formation.
[18]	Qualitative	Examines the relationship between the successful deployment of Lean Six Sigma and a number of key explanatory variables.	The study identified several variables that could impact the success of the deployment of the Lean Six Sigma such as leadership, communication, behaviour and awareness, policies, culture, and organisational support and strategy; education, training, and competency of the Six Sigma experts.
[116]	Mixed	Aims to present an overview of the implementation of LSS in Dutch manufacturing SMEs and to explore the critical success factors (CSFs) for the implementation of LSS.	The research highlights the importance of leadership and organisational culture. They found that linking to customer, vision and plan statement, communication and management involvement and participation are the highest ranked CSFs.
[97]	Quantitative	Examines the interaction effect of continuous improvement and organisational process alignment on innovation.	Findings indicate that firms increase their innovation performance when they implement both DCs and LSS—a process-oriented organisational design and continuous improvement methodologies.
[54]	Qualitative	Explores the most common themes within LSS in the manufacturing sector.	Research found that LSS is most popular in large organisation, especially in the US, UK, and the Netherlands, however also becoming popular in developing countries such as India. Most common tools found no statistical significance such as VSM. 5s.
[112]	Qualitative	Aim the research gap in regard to lean implementation in SMEs	The study found that SMEs focus on lean implementation very limited to internal operation. It also found the range of lean tools available to adopt in SMEs, however no rationale behind selecting the right tools. Study shows how Lean and Six Sigma can be integrated in SMEs to gain extra benefits and finally the impact and CSF of implementing Lean in the SME sector.
[31]	Quantitative	Examine lean manufacturing versus Six Sigma was conducted, and the success factors relevant to these two methodologies were identified.	CSR for SS was found to be Skills and Expertise, and for Lean, employee involvement and culture change.
[118]	Mixed method	Provides framework for Green, Lean, and Six Sigma implementation method	The results showed that the integration of Lean Six Sigma and Green helped organisations to averagely reduce their resource consumption from 20 to 40% and minimise the cost of energy and mass streams by 7–12%.
[2]	Qualitative survey and bibliographical research model	Verifies how LSS could influence organisational sustainability.	The study identified the correlation between LSS and organisational sustainability, principally due to impacts that significantly influence the financial pillar of TBL.

Table 3. *Cont.*

Authors	Type of Study	Research Focus	Key Findings
[14]	Qualitative	Shares the experiences and perspectives of three practitioners from two continents about LSS from both academic and industrial viewpoints	Provided tread of LSS popularity and future direction
[52]	Qualitative	Describes the novel implementation of an integrated LSS framework and outlines how it was used to identify the factors that affect supply chain performance in an aerospace Maintenance Repair and Overhaul (MRO) facility	The study outlines the application and measures of the effectiveness of the integrated LSS framework through its ability to achieve new and enhanced performance by simultaneously reducing late material calls and reducing and stabilising Order To Receipt (OTR) times.
[15]	Qualitative	Review the literature on Lean Six Sigma from six different perspectives pertaining to manufacturing firms.	A generic framework for the implementation of Lean Six Sigma with environmentally benign tools was developed. The developed framework incorporates environmental aspects while implementing Lean Six Sigma which helps in reducing cost, waste, environmental impacts, and other inefficiencies associated with the manufacturing process
[47]	Quantitative	Investigates the dynamics of the key drivers of innovation-led lean approaches and their influence on sustainable performance over a long time in the manufacturing supply chain	The dynamic behaviour of 'Government regulations' and 'Conducive working conditions' influence sustainable performance exponentially over a long time in the manufacturing supply chain. the study also reported the dynamics of 'Cash availability' and 'Fundamental knowledge' and indicated that they are not highly influential on sustainable performance over a long time
[111]	Qualitative	Reviewing the existing literature review on Lean Six Sigma for services, construct of morphological analysis framework, and identify research gaps to point to future research possibilities and priorities.	The MA framework constructed based on six dimensions, namely, organisational context of applications, desired outcomes, implementation systems, LSS tools and techniques, integration with other management philosophies and evaluation methods, involving 40 focused themes, has revealed 355 distinct research gaps as opportunities for future research.
[32]	Qualitative	Describes how human factors and cognitive engineering methods can be combined with LSS to create an enhanced productivity framework for complex manufacturing.	This research showed the successful use of the DMAIC structure as a guide for the deployment of these new methods in conjunction with normal LSS tools
[11]	Qualitative	This paper seeks to discover convergences between studies and LSS implementations carried out in organisations comprising various business areas and systematises principles and practices of the Lean Six Sigma (LSS) method to encourage and facilitate its implementation and management in different contexts.	This study suggested that the number of the LSS publication significantly increased between 2008-2018 and the main disciplines related to LSS are business management and accounting (25%), Computer science (6%), Nursing (4%), and social science (3).
[9]	Empirical	This paper builds on previous studies that explored the research patterns over 15 years and considers the status of the integration of Lean and Six Sigma. This research specifically, addresses whether Lean and Six Sigma are strong together and explores the reasons why Lean researchers and practitioners may be less likely to integrate Six Sigma in their work.	Findings indicate that LSS has developed over time and will continue to develop and improve as a methodology rather than being replaced with a new methodology.

Table 3. *Cont.*

Authors	Type of Study	Research Focus	Key Findings
[5]	Qualitative	Chapter 6 of the book focuses on the LSS as a DC in the banking sector exploring the strategic value of the LSS through iterative triangulation offering an evolutionary dynamic perspective of LSS.	Findings indicate that the nature of the LSS as a DC could be established through a cross-case analysis. The presence of input factors shows that LSS as a CI practice could be consciously created as an organisation by focused efforts and does not exist as mere chance. LSS as an organisational capability needs to be nourished for progress, as it gets influenced by both internal and external factors of the organisation. LSS also contributes to the organisational learning process due to its ability to contribute towards first-order (Exploitative/reactive) learning, second order (explorative/proactive) learning, and meta-learning (learning to learn) for creating a culture of CI on an ongoing basis.
[14]	A case study of a kindergarten.	The application of the Six Sigma methodology blended and supported by the application of various Lean tools is demonstrated in a case study of a kindergarten	The study suggests that the application of the Six Sigma methodology blended and supported by the application of various Lean tools improve the efficiency and effectiveness of business processes.

Anand et al. [3] conducted interviews with executives from five companies implementing Six Sigma (SS) and highlighted the potential of LSS as a dynamic capability for performance improvement within a comprehensive organisational context. Similarly, three years later, [42], revealed a connection between LSS and DCs through surveys and interviews, emphasising that LSS success hinges on an organisation's ability to cultivate dynamic capabilities.

Gutierrez et al. [17], investigated European firms using structured questionnaires to analyze the relationship between LSS, DCs, and organisational flexibility. Their findings indicated that DCs mediate the relationship between LSS practices and flexibility, aligning with Kohlbacher's perspective that continuous improvement initiatives enhance an organisation's agility and overall performance.

Contrary to traditional static resource management, ref. [145] contends that organisations that adhere to conventional operating methods may struggle to succeed. Sunder and Ganesh [5,111], challenge the notion that LSS is solely a performance improvement tool, asserting that it embodies higher-order organisational capabilities functioning as dynamic capabilities, which offer a unique perspective on quality advantage and competitive positioning.

Overall, these studies emphasise a shift towards dynamic maneuvering, suggesting that the integration of LSS and DCs represents a counter-intuitive yet effective approach to enhancing performance optimisation and responding to the evolving business landscape [3,76].

Table 3 summarises the findings of the 21 studies highlighting the gap in the literature. indicating the state of knowledge in the field is limited and there is a need for further study and research that enhances understanding of LSS through the lens of DCs. This review is not exhaustive and intends to provide an overview of the most relevant and more recent work on this topic.

5. Discussion

This section discusses the findings from the systematic literature review. Our research question is *"how does the integration of LSS as DC contribute to sustainable performance optimisation in times of uncertainty?"* In response to the central research question, we aim to demonstrate that the integration of the DCs micro-foundations has not only theoretical but also practical significance in the context of integrating them with the LSS.

How Does the Integration of LSS as DCs Contribute to Sustainable Performance Optimisation in Times of Uncertainty?

The integration of Lean Six Sigma (LSS) and DCs promotes organisational agility and flexibility [76]. LSS emphasises streamlining processes and eliminating non-value-added activities, while DCs enable organisations to sense and respond to market changes and adapt their processes accordingly. This combination allows organisations to quickly adjust their operations, seize opportunities, and stay competitive in dynamic environments. This means that it provides a strategic perspective as a response to a dynamic environment through the improvement of operational capabilities [15,42,97].

The integration of LSS and DCs can have a significant strategic impact on organisations' sustainable performance. We argue that effective integration of the LSS as DCs leads to organisational sustainable performance optimisation by improving the efficiency and effectiveness of systems, processes, or organisations while simultaneously considering and minimising their negative environmental, social, and economic impacts. Figure 7 outlines the DCs and LSS micro-foundations offering a holistic approach towards sustainable performance. The figure indicates that integrating the micro-foundations of DCs with LSS allows organisations to not only identify improvement opportunities but also efficiently and effectively act upon them, ultimately leading to sustainable performance optimisation across various aspects of the business. Figure 7 also provides a holistic approach, fostering sustainable performance optimisation through enhanced agility, resilience, and strategic alignment amid uncertainties. LSS supplies quantitative metrics for process evaluation, while DCs allow adaptable measurements to capture emerging opportunities and challenges. This tandem enables consistent performance optimisation amidst uncertain settings [86].

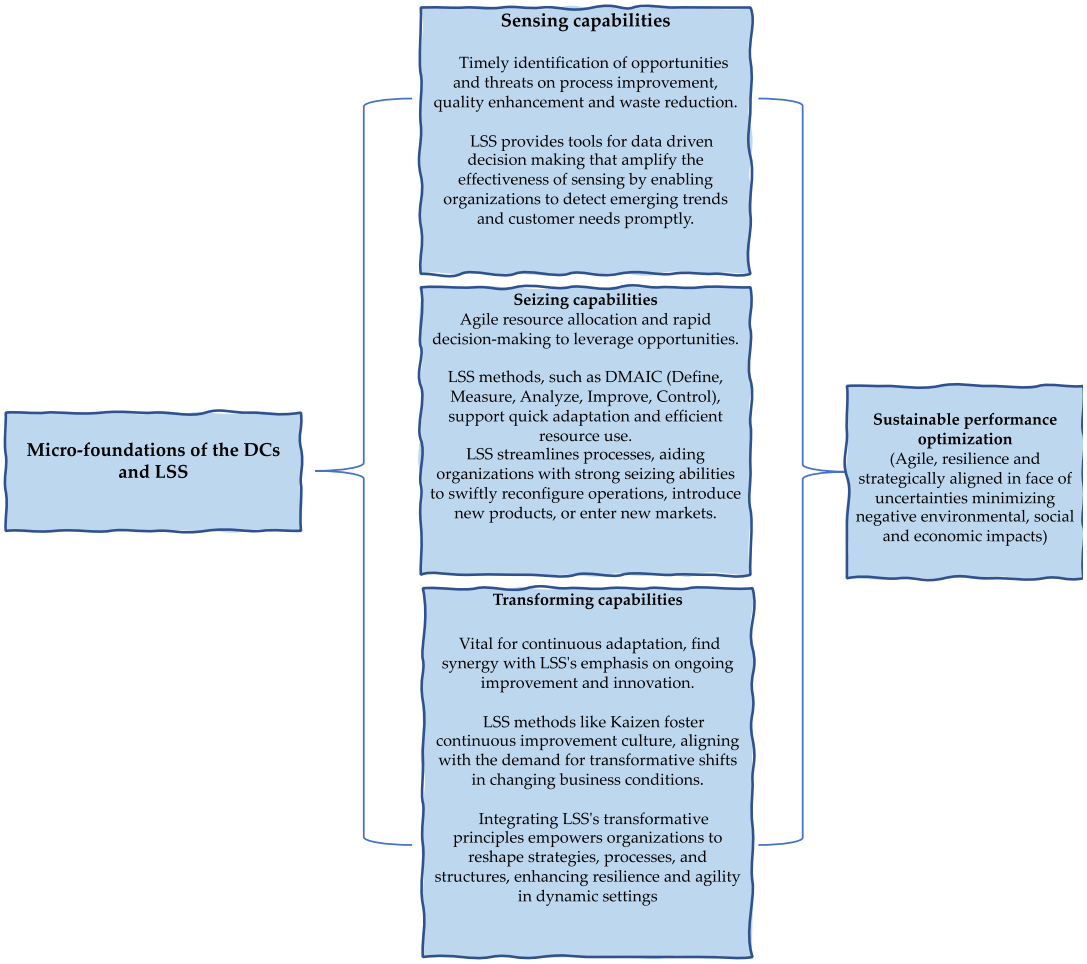


Figure 7. The micro-foundations of the DCs and LSS. Source: Authors.

The micro-foundation of the DCs integrating LSS indicates that sensing, the first cluster fosters a 'business ecosystem' [76,86] encompassing the identification of opportunities and threats on process improvement, quality enhancement, and waste reduction. LSS provides tools for data-driven decision-making that amplify the effectiveness of sensing by enabling organisations to detect emerging trends and customer needs promptly. This also refers to an organisation's ability to detect changes in its environment and internal operations. When integrated with LSS, it means using data-driven approaches like Six Sigma to continuously monitor processes for variations, defects, or inefficiencies. This allows for quick identification of issues that require improvement.

Seizing capabilities enables swift responses to opportunities and threats, transforming potential into valuable outcomes like innovative products and business models [47,58,69,72,76,84,97,104,114,144]. While sensing provides access to external knowledge and flexibility [87], seizing focuses on harnessing and utilising this knowledge. LSS, on the other hand, emphasises agile resource allocation and prompt decision-making to capitalise on opportunities. Techniques like DMAIC within LSS support rapid adaptation and effective resource utilisation, streamlining processes for organisations with strong seizing capabilities to swiftly adjust operations, introduce new products, and penetrate new markets. In the context of LSS, it means applying Lean principles to eliminate waste and improve processes based on the insights gained from sensing. This ensures that opportunities for improvement are not just identified but acted upon efficiently.

After seizing opportunities, transforming capabilities becomes crucial for "semi-continuous asset orchestrations and corporate renewal" [76]. It is about the ability to adapt and change the organisation's processes, structures, and strategies. These capabilities preserve alignment between organisational systems and strategy, especially during significant shifts, encompassing strategic renewal and the replacement of attributes that impact long-term prospects [69,71–77,83,90]. Semi-continuous asset orchestration includes core elements like coordination, learning, and reconfiguration, vital for dynamic capabilities [28,76,90–93], to achieve evolutionary fitness [19,83,85]. Transformation capabilities are vital for continuous adaptation and finding synergy with LSS's emphasis on ongoing improvement and innovation. LSS methods such as Kaizen fosters a continuous improvement culture, aligning with the demand for transformative shifts in changing business conditions. Integrating LSS's transformative principles empowers organisations to reshape strategies, processes, and structures, enhancing resilience and agility in dynamic settings. This ensures the sustainability of performance improvements.

Additionally, the synergy of LSS and DCs fosters innovation and continuous improvement. LSS tools facilitate structured problem-solving and process optimisation, while DCs cultivate a culture of learning, experimentation, and knowledge exchange. This collaboration motivates organisations to uncover innovative solutions, adapt processes, and drive continuous performance enhancement [16,52,53,64,113,118]. In other words, LSS and DCs offer a holistic approach to optimising organisational performance in uncertain times. This fusion enhances agility, risk management, performance measurement, and innovation, forming a dynamic strategy to navigate unpredictable environments effectively.

6. Conclusions and Future Research

In conclusion, this study has sought to illuminate the potential of strategically integrating Lean Six Sigma (LSS) methodologies with Dynamic Capabilities (DC) to achieve sustainable performance optimisation amidst uncertain business landscapes. Our exploration delves into how this integration can empower organisations to thrive despite unpredictable conditions. Specifically, the study aims to delve into the strategic implications of viewing LSS beyond its traditional operational applications and recognising it as a dynamic capability that enhances an organisation's ability to respond, adapt, and thrive in times of uncertainty. Hence research seeks to address the central research question: How does the integration of LSS as DCs contribute to sustainable performance optimisation in times of uncertainty?

Studying the outcome of integrating LSS and DCs in the context of sensing, seizing, and transforming phases contributes to practitioners by optimising their operations and decision-making. Additionally, it benefits society by fostering environmentally and socially responsible practices, ultimately creating a more sustainable and eco-conscious business landscape. This paper does not only contribute to the theoretical development, but it also provides insights for both practitioners and society. It provides practitioners with valuable insights into the effectiveness of combining LSS and DCs in their processes. They can understand how these integrated methodologies impact efficiency, product quality, and sustainability across different stages of sensing (identifying opportunities and issues), seizing (capturing opportunities), and transforming (implementing sustainable changes). By assessing the outcomes, practitioners can fine-tune their strategies, enhance decision-making, and achieve operational excellence, resulting in cost savings, improved product design, and minimised waste. The study outcomes have broader implications for society. They highlight the potential for organisations to create products and services that are not only efficient and high-quality but also environmentally and socially responsible. The integration of LSS and DCs can lead to sustainable practices, resource conservation, and a reduced carbon footprint, aligning with societal demands for eco-friendly and ethical business operations. Ultimately, this benefits society by promoting sustainability and reducing the environmental impact of products and services.

The literature survey revealed that LSS serves as a strategic approach, not only enhancing operational capabilities but also fostering quality, efficiency, and customer satisfaction while minimising waste and costs. Simultaneously, DCs emerged as crucial performance drivers, aligning with customer relationships and innovation. Our findings align with the assertion that combining DCs and LSS yields optimal results, fostering a synthesis of process-oriented design and performance enhancement methodologies.

In essence, the integration of LSS as DCs creates a holistic approach that enhances an organisation's ability to sense emerging opportunities, capitalise on them swiftly, and adapt its operations for sustainable success. This alignment results in improved performance optimisation, as organisations become more agile, resilient, and strategically aligned in the face of uncertainty.

The study suggests that integrating the micro-foundations of DCs with LSS allows organisations to not only identify improvement opportunities but also efficiently and effectively act upon them, ultimately leading to sustainable performance optimisation across various aspects of the business. The specific type of DC integration with LSS depends on the organisation's goals and priorities.

Much has been written about DCs and LSS, but relatively little research has explored the contribution of the integration of LSS and DCs. This perspective offers more avenues for organisations to understand how they can optimise their performance in times of uncertainty by enhancing agility, risk management, performance measurement, and innovation. However, empirical research is required to fully understand the strategic contribution of the integration of LSS and DCs. Another area that requires attention is the role of leadership and organisational culture as impeding factors; how they influence the formulation and implementation of the new paradigm remains unknown.

Author Contributions: Conceptualization, V.N. (Vera Ndrecaj) and M.A.M.H.; methodology, V.N. (Valentina Ndou) and I.T.; software, V.N. (Vera Ndrecaj) and M.A.M.H.; validation, V.N. (Vera Ndrecaj) and R.M.-J.; formal analysis, V.N. (Vera Ndrecaj) and R.M.-J.; investigation, V.N. (Vera Ndrecaj), M.A.M.H. and R.M.-J.; resources, V.N. (Vera Ndrecaj) and M.A.M.H.; data curation, V.N. (Vera Ndrecaj), M.A.M.H. and R.M.-J.; writing—original draft preparation, V.N. (Vera Ndrecaj); writing—review and editing, R.M.-J., I.T., V.N. (Valentina Ndou) and M.A.M.H.; visualization, V.N. (Vera Ndrecaj). All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors extend their gratitude to Md Mahabubur Rahman and Gioconda Mele for their initial contributions and valuable insights.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Overview of Selected Journals.

Lean Six Sigma	DCs
Journal of High Technology Management, International Journal of Quality & Reliability Management, Journal of Operations Management, International Journal of Quality & Reliability Management, Journal of the Operational Research Society, International Journal of Lean Six Sigma, Journal of Industrial Engineering and Management, Journal of Manufacturing Technology Management, Journal of Production & Manufacturing, Research Cleaner Production, International Journal of Production Economics.	Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly, British Journal of Management, Journal of Management, Journal of Management Studies, Management Science, Organisation Science, Strategic Management Journal, Industrial and Corporate Change, Strategic Organisation and Academy of Management Perspective, Productive & Management Review, Journal of Change Management, Research and Theory, International Journal of Operations & Production Management, Journal of Operations Management, (Peer Reviewed Journal) Strategic Change, Journal of Strategic Change, International Business Review, and Strategic Management Journal.

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