Review

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The Role of Manufacturing Operations in SMEs Performance: A Systematic Review

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Systematic Review

The Role of Manufacturing Operations in SMEs Performance: A Systematic Review

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Abstract: The critical role of manufacturing operations in enhancing the performance of Small and Medium Enterprises (SMEs) has become increasingly evident in recent years. This systematic review examines how manufacturing operations influence the performance of SMEs, analysing findings from 69 diverse research papers published between 2014 and 2024. Utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, the review focuses on key operational strategies, including lean manufacturing and advanced manufacturing technologies, assessing their effectiveness in improving business outcomes such as efficiency, productivity, and financial performance. The methodology included a thorough review of the research methods used in the studies, identifying potential biases, gaps, and highlighting the need for diverse approaches. While manufacturing operations have led to improved productivity and increased efficiency for many SMEs, challenges such as limited resources, lack of technical expertise, and resistance to change remain prevalent. Notably, a reporting bias was observed, with 48% of the literature composed of quantitative studies, 30% being mixed-method studies, and only 20% and 1% representing qualitative and exploratory studies, respectively. This imbalance suggests an overemphasis on quantitative methods, limiting the range of ideas and understanding available. Key strategies such as lean manufacturing and advanced technologies were shown to enhance productivity by 15% to 25% in SMEs. By adopting a broad approach, this review ensures that the findings are applicable across various sectors and geographies, offering valuable insights into best practices and challenges across diverse economic contexts. The broad scope also allows for the identification of under-researched areas, fostering a more comprehensive understanding of how manufacturing operations contribute to SME success. The review provides a decision-making framework for business leaders and policy recommendations to foster SME growth in a competitive, globalized market.

Keywords: manufacturing operations; SME performance; lean manufacturing; advanced manufacturing technologies; productivity in SMEs; systematic review

1. Introduction

In today's fast-paced and competitive business environment, the success of small and medium-sized enterprises (SMEs) hinges on their ability to optimize manufacturing operations. These operations are increasingly recognized as a vital factor influencing the performance and competitiveness of small and medium-sized enterprises (SMEs). Effective manufacturing processes provide SMEs with the ability to streamline production, reduce operational costs, and enhance product quality, which directly impacts their overall productivity and profitability [1]. As SMEs often operate with limited resources, optimizing manufacturing operations becomes essential for their survival and growth, particularly in a competitive and globalized market. The adoption of lean manufacturing techniques and other advanced production methods has proven to be highly beneficial for SMEs in improving operational efficiency and reducing waste. Lean Six Sigma and other continuous improvement strategies enable SMEs to enhance production quality and minimize

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defects, fostering long-term sustainability and competitive advantage. Additionally, agile manufacturing, which emphasizes flexibility and responsiveness to market demands, is increasingly becoming a key approach for SMEs to remain competitive in rapidly changing environments [2–5].

Despite these advantages, many SMEs, especially those in developing countries—face challenges in fully leveraging advanced manufacturing operations. These challenges are often rooted in technological constraints, limited managerial expertise, and inadequate infrastructure [6,7]. External factors, such as regulatory frameworks and market conditions, also influence SMEs' ability to adopt innovative manufacturing processes [8]. Moreover, SMEs often encounter difficulties in securing financial resources and accessing necessary technologies, further hindering their ability to implement lean or advanced manufacturing systems [9,10]. Manufacturing operations play a crucial role in improving key performance indicators (KPIs) for SMEs, such as operational efficiency, production quality, and cost management. SMEs that successfully implement lean and agile manufacturing processes often experience significant improvements in these KPIs, which contribute to their long-term competitiveness and market positioning [11,12]. For example, a focus on lean manufacturing enables SMEs to optimize resources and minimize waste, leading to enhanced productivity and cost savings [3]. Furthermore, industry 4.0 technologies, such as automation and data-driven production processes, are increasingly being integrated into SMEs' operations to drive efficiency and sustainability [6]. As SMEs are critical drivers of employment, innovation, and economic growth globally, enhancing their operational capabilities is paramount [9,13]. By addressing the technological, organizational, and environmental barriers to advanced manufacturing operations, SMEs can improve their production processes and overall business performance [14].

This systematic review aims to identify the critical factors influencing the adoption and success of manufacturing operations in SMEs, and to assess their impact on performance metrics such as efficiency, quality, and cost management. The findings will provide valuable insights for business managers, policymakers, and industry stakeholders looking to enhance the performance of SMEs through optimized manufacturing operations [15]. Table 1 looks at different reviews and studies about how Manufacturing operations have influences on small and medium-sized enterprises (SMEs).

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Table 1. Comparative analysis of the existing review works and proposed systematic review on the role of manufacturing operations in SMEs performance.

Ref.	Cites	Year	Contribution	Pros	Cons
[16]	85	2014	The paper uses Melitz's dynamic model to explore the export behaviors of SMEs in Transition Countries (TCs). It highlights the importance of human and technology-related factors, productivity-enhancing spillovers, firm size, ownership type, activity type, external finance availability, networking, and market share.	Provides a comprehensive understanding of SME internationalization and export behaviors in TCs. Identifies a broad range of influencing factors.	Limited to SMEs in Transition Countries; may not be generalizable to other regions.
[17]	0	2016	Explores the role of shadow banking in financing SMEs in China, focusing on informal finance and non-banking financial institutions. Highlights how regulated NBFIs could support SMEs.	Provides a detailed analysis of various shadow banking forms and their implications for SME financing. Offers insights into how regulated NBFIs can serve SMEs effectively.	May not fully capture the risks associated with informal financial intermediation. Limited to the Chinese context, which might not be applicable elsewhere.
[18]	720	2018	Reviews applied research on Industry 4.0 in SMEs, highlighting performance objectives, managerial capacities, and technology adoption.	Provides a framework for classifying Industry 4.0 applications; emphasizes flexibility and cost-effectiveness of new technologies compared to traditional systems.	SMEs primarily adopt Cloud Computing and IoT; limited application in production planning; many projects are cost-driven with minimal business model transformation.
[19]	103	2018	The paper analyzes five performance indicators for SMEs using World Bank Enterprise Survey data. It identifies how factors like firm characteristics, finance, infrastructure, and regulation impact SME performance differently for small and medium enterprises in emerging economies.	Comprehensive analysis of internal and external drivers for SME performance. Highlights the importance of infrastructure and formalization in SMEs' growth.	Limited scope regarding the impact of informal SMEs. Some conclusions on financing require further empirical testing in various regions.
[20]	0	2018	Examines the moderating effect of firm age on the relationship between financial management practices and performance in SMEs. Utilizes a sample of 200 SMEs in Sekondi-Takoradi.	Highlights the importance of financial management practices (e.g., receivable, cash, inventory, and asset management) on SME performance. Identifies firm age as a significant moderating factor.	Limited to SMEs in Sekondi-Takoradi; results may not be generalizable to other regions. Study relies on self-reported data which could be biased.
[21]	0	2018	Examines the moderating effect of firm age on the relationship between financial management practices and performance in SMEs. Utilizes a sample of 200 SMEs in Sekondi-Takoradi.	Highlights the importance of financial management practices (e.g., receivable, cash, inventory, and asset management) on SME performance. Identifies firm age as a significant moderating factor.	Limited to SMEs in Sekondi-Takoradi; results may not be generalizable to other regions. Study relies on self-reported data which could be biased.
[22]	2	2019	This paper presents a production management model based on lean manufacturing, focusing on the human factor, to improve productivity in small metalworking businesses. The model integrates lean tools with a focus on the human aspect to address informality and lack of standardization.	- Addresses the human factor, which is critical in small businesses. - Demonstrates a significant productivity increase (70%) through lean manufacturing. - Provides practical insights into implementing lean in resource-constrained environments.	- Limited generalizability due to focus on small businesses in the metalworking sector. - Results are specific to the company studied and may not apply to other contexts. - The model's effectiveness depends heavily on the human factor, which can be variable.

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[23]	0	2019	Explores how distinctive capabilities, business strategy, and environmental uncertainty affect the performance of manufacturing SMEs in Palestine. Develops a model showing the relationship between distinctive capabilities, strategy, environment, and performance.	Provides a context-specific model for SME performance in Palestine, offering insights for policymakers, business owners, and educators. Includes critical capabilities such as marketing, HR, and operations.	Limited generalizability to other regions and sectors due to its focus on Palestine. Lack of broader application and empirical testing across different industries.
[24]	0	2020	Discusses retrofitting solutions for helping German SMEs adopt Industry 4.0. Highlights the role of employee training, digital assistance, and retrofitting of existing machinery. Presents the Digital Capability Center (DCC) Aachen's learning factory concept to assist SMEs with digital transformation.	Focuses on practical, hands-on solutions like mobile sensor kits and IoT platforms. Provides a structured learning process and emphasizes competence-building to overcome digitization challenges.	Primarily focused on German SMEs, limiting global generalizability. Barriers such as high investment costs and lack of skilled labor remain challenges even with retrofitting.
[25]	12	2020	The paper explores effective methods for digital transformation in Quebec's manufacturing SMEs by evaluating factors influencing digital performance and identifying critical Industry 4.0 technologies and practices. It uses a model of digital performance and hypothesis testing to guide digital transformation efforts.	- Provides actionable insights for SMEs on digital transformation. - Uses a detailed methodology including questionnaires and interviews. - Focuses on affordable and easy-to-integrate digital tools.	- Limited to Quebec SMEs, which may not generalize to other regions. - Based on a specific experience-based methodology that may not cover all scenarios
[26]	24	2021	Investigates the drivers of halal standard implementation and its impact on SME performance in Indonesia. Finds that internal motivation and organizational commitment positively affect halal standard implementation, leading to improved operational, market, and financial performance.	Provides empirical evidence on the positive effects of halal standards on SME performance. Highlights the role of internal motivation in overcoming external pressures.	Limited to food manufacturing SMEs in Indonesia, with a small sample size. Subjectivity in performance evaluation may affect results.
[27]	13	2022	Proposes an SME-oriented Industry 4.0 maturity framework linking manufacturing processes' maturity with performance measurement and management (PMM) practices.	Highlights the need for assessing SMEs' current manufacturing processes and PMM interplay, offering an actionable framework for improvement towards Industry 4.0 adoption.	Limited by its exploratory nature and the need for further validation across different SME sectors. Does not provide detailed solutions for overcoming I4.0 adoption challenges.
[28]	5	2022	Explores the relationship between lean manufacturing and sustainable performance (SP) of SMEs in Pakistan. Identifies significant impacts of lean practices like process and equipment, product design, supplier and customer relationships on SP.	Provides a modern approach for SMEs to minimize material wastage; identifies green supply chain management (GSCM) as a mediator between lean practices and SP.	Limited verification of the impact of planning, control, and HR practices; regional focus on SMEs in Pakistan may limit generalizability.
[29]	5	2022	A systematic review that identifies and categorizes barriers and enablers for the adoption of sustainable manufacturing by SMEs, focusing on the triple bottom line (environmental, social, and economic) sustainability.	Offers a comprehensive categorization of barriers and enablers with actionable insights for SMEs to leverage enablers to mitigate barriers. Emphasizes "critical enablers" for sustainability adoption.	Focuses primarily on the European SME context, which may limit the generalizability to other regions. The study's findings are largely based on existing literature, without empirical validation through direct field data.
[30]	0	2022	Proposes a multi-criteria decision-making model using fuzzy TOPSIS to aid SMEs in selecting smart manufacturing technologies tailored to their needs. A case study evaluates smart technologies for SMEs considering performance, cost, and sustainability.	Provides a clear roadmap for SMEs to transition to Industry 4.0 by ranking technologies and criteria. Involves all levels of personnel in decision-making, ensuring holistic adoption.	Limited to a specific case study, which may affect generalizability to other SMEs or industries. Lacks real-world application on a larger scale.

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[31]	29	2022	Investigates the mediating role of innovation speed in the relationship between total quality management (TQM) and SME performance. Focuses on Nigerian SMEs using PLS-SEM modeling.	Highlights the positive impact of TQM on operational performance and the role of innovation speed. Provides insights into the relationship in developing countries, contributing to the scarce literature.	Limited generalizability due to focus on Nigerian SMEs. The use of judgmental sampling could introduce bias. Lack of longitudinal data to confirm findings over time.
[32]	1,089	2022	Examines the impact of lean manufacturing (LM) practices on operational performance (OP) and business performance (BP) in SMEs within the wooden furniture industry in Jepara. Utilizes PLS regression to analyze data.	Provides empirical evidence on the effectiveness of collective LM practices and their impact on OP and BP. Offers practical insights for SME managers in improving performance.	Limited to SMEs in the wooden furniture industry in Jepara, Indonesia. Uses Likert scale, which may introduce bias. Results may not be generalizable beyond this context.
[33]	644	2022	This paper investigates the impact of lean manufacturing principles on operational efficiency in a Malaysian SME, focusing on waste elimination. The study uses process activity mapping to identify and address inefficiencies.	-Demonstrates significant reduction in waiting times and cycle time. -Provides practical insights for lean implementation in SMEs with volatile demand patterns. -Uses a real case study, enhancing the applicability of findings.	-Limited to a single case study, which may affect generalizability. - Results are specific to a particular SME in Malaysia. -Mixed success of lean implementation noted in the literature, highlighting the need for more research.
Proposed	Systematic review		Integrates findings from diverse studies to provide a comprehensive understanding of how effective manufacturing operations contribute to enhancing SME performance. It also examines the challenges SMEs face in adopting and optimizing manufacturing practices, and it offers insights into best practices and strategies for achieving operational excellence.	It offers valuable insights and recommendations for future research, helping SMEs to enhance their manufacturing operations and improve performance outcomes.	-

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In Table 1 we highlight several important research gaps that exist in the current knowledge of manufacturing operations and their effects on the performance of SMEs. Most studies are specific, mainly exploring conventional approaches, including lean production and just-in-time, although industry 4.0 undefined Surprisingly, there is little systematic research examining how these strategies affect different facets of SME development, let alone sustained growth and innovation. The studies are mainly focused on developed countries, which downplays the issues and prospects of SMEs in the developing countries. Some of the most popular trends including smart manufacturing and sustainability aspects remain understudied, especially in terms of implementation and feasibility in environments with limited resources. These gaps show the need for further contextual and fine-grained studies to capture the complete picture of how manufacturing operations might create value for SMEs in various settings.

1.1. Research Question

Although a significant body of research has examined the operational strategies and difficulties encountered by SMEs, a systematic review that specifically investigates the influence of manufacturing operations on SME performance remains absent in the literature. Therefore, this study proposes to review existing literature on how manufacturing operations contribute to the overall success and effectiveness of SMEs. To address this, the following research questions have been identified:

- What role do emerging technologies (AI, Industry 4.0) play in enhancing manufacturing operations in SMEs?
- How do advanced manufacturing technologies influence SME productivity and profitability across different industry sectors?
- How does effective supply chain management influence key performance indicators (KPIs) in SME manufacturing operations, such as lead time, inventory turnover, and cost efficiency?
- What are the quantifiable effects of lean manufacturing on the operational efficiency of SMEs in developing economies?
- What measurable effects does manufacturing process optimization have on customer satisfaction scores and product quality indicators in SMEs?

1.2. Rationale

Manufacturing is generally recognized as a critical contributor to the performance of Small and Medium Enterprises, though the state of knowledge on the matter is fragmented and underdeveloped. While various studies have focused on specific operational challenges faced by SMEs, such as production efficiency and supply chain management, little or no insight has been acquired into how these manufacturing practices collectively influence overall SME performance. The literature has targeted larger enterprises and thus leaves a gap in understanding SMEs that face peculiar resource limitations, less advanced technologies, and market vulnerability. The value of this review thus points to the possibility of consolidating fragmentary findings into a coherent framework defining major manufacturing operational factors that affect the success of the SMEs. This systematic review would fill an existing gap in research while simultaneously granting SMEs real insights on how to make their operations more efficient, profitable, and sustainable. Most of the available reviews on similar themes are on higher scales of industrial operation or were conducted some time back and had no specific inclination towards the SMEs. Besides, the dynamic nature of manufacturing technologies-automation and sustainable practice-needs a review update about knowledge in this area. It is also particularly important in informing policy, industry guidelines, and future research in the area, because the effective management of the manufacturing operations can give SMEs a significant boost in competitive advantage in the global marketplace.

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1.3. Objectives

The review is bound to explore systematically how manufacturing operations are important in SME performance and competitiveness. The main factors to be identified are those factors that drive the SME to grow and increase profitability and customer satisfaction due to good manufacturing practices. In particular, the objectives are:

- To analyze the different manufacturing operations in their impact on general performances of SMEs. Specific aspects of manufacturing operations, such as efficiency, quality control, and production process, that are related to SME performance measures like financial performance, productivity, and operational efficiency, will be elaborated within the aim.
- The main manufacturing practices enhance the level of productivity and profitability within the SMEs. The objective here is aimed at revealing how such a specific manufacturing practice-lean production or optimization of processes-may be relevant in improving the financial performance and competitive advantage level of an SME.
- Therefore, the study will explore how manufacturing operations contribute to the scalability of SMEs. To this end, the research will try to understand how manufacturing operations enable the SMEs to become strong in growth and expansion-especially regarding market share and sustaining themselves over time.
- The impact the manufacturing operation has in terms of customer satisfaction and market performance in general could be measured. This will thus serve as an indication of how the quality of the manufacturing process contributes to customer satisfaction, market standing, and overall success of the SME, giving special emphasis on product quality and competitiveness within the market.
- Assess the role of new and emergent technologies in improving manufacturing operations within SMEs. This objective will set out the ways in which emerging technologies, such as automation, AI, and Industry 4.0 solutions, have been adopted by the SMEs to drive manufacturing performance and competitive advantage within their marketplace.

1.4. Research Contribution

This study represents the state-of-the-art systematic review on the role of manufacturing operations in the performance of SMEs, by considering the key operational challenges and gaps in research. The main contributions of this research are as follows:

- We have made an in-depth review of varied manufacturing practices that have affected SME performance, focusing on those aspects dealing with the optimization of production, efficiency of supply chains, and management of resources. This review has highlighted how strategies dealing with increasing productivity, profitability, and sustainability within SMEs can be developed through providing relevant information to decision-makers to develop operational improvements.
- In this paper, we synthesize current research on SME manufacturing operations and identify existing gaps, especially about how these practices collectively impact overall business success. Addressing such knowledge gaps, we show areas where further investigation and innovation are needed, deepening the understanding of operational performance in the SMEs.
- We investigate the role of new manufacturing technologies, including automation and sustainable practices, in possibly enhancing operational effectiveness for SMEs. The contribution underlines the critical need for modern technologies adoption by the SMEs for them to stay competitive, especially in the case of resource scarcity.

1.5. Research Novelty

The contribution of this proposed research is at least threefold. This is the first study that tries to investigate systematically the impact of manufacturing operations on SMEs' performance from an integrated viewpoint up to now.

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- Our study represents a comprehensive examination of manufacturing operations in SMEs encompassing key practices associated with the spheres of production efficiency, supply chain coordination, and resource management. Such an approach captures several dimensions of manufacturing operations that are seldom studied together in the context of SMEs.
- We review new trends in manufacturing technologies, including automation and sustainable practices, assessing the impacts on SMEs. This review is unique because most of the past research has focused either on larger organizations or more generalized industry-wide contexts, whereas this one focuses on the impact of advancements on SMEs.
- We also identify some of the fundamental operational issues of SMEs and put forward potentially successful strategies for overcoming such challenges through better management of their manufacturing processes. These results represent a significant gap in existing literature and provide useful lessons that could be applied to enhance SMEs' performance.

2. Materials and Methods

This section outlines the methods to be followed in conducting the literature review of manufacturing operations that affect SME performance. The review shall focus on studies within the last decade, with a predisposition towards research within a ten-year frame from 2014 to 2024., The methodology encompasses guidelines regarding the selection of relevant studies, the sources of data, and the analytical approach to be used in the evaluation of the reviewed literature. It, therefore, provides the proper framework within which a proper analysis of the various factors influencing the manufacturing operations in SMEs can be conducted in the subsequent sections. Figure 1 shows proposed structure for this study.

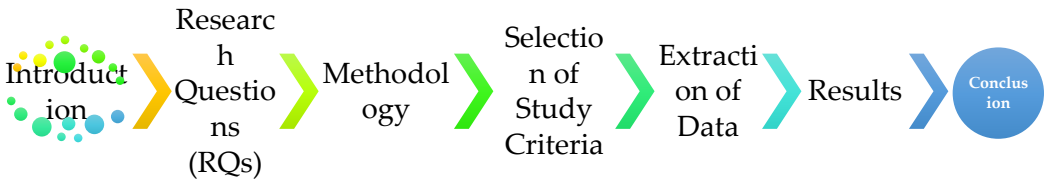

Figure 1. SLR Flow diagram.

2.1. Eligibility Criteria

A systematic study of all peer-reviewed and published research works appropriate to the study of the role of manufacturing operations in SME's Performance was concluded for examination. The research works that are published in the English language on the role of manufacturing operations in SME's Performance during the last decade from 2014 to 2024 are considered. Inclusion and exclusion criteria were used to select research papers that emphasize the influence of manufacturing operations in SMEs while excluding studies not related to this topic. This review included only peer-reviewed research that examines the impact of manufacturing operations on SME performance. The inclusion and exclusion criteria for this study are tabulated as shown in Table 2.

Table 2. Proposed Inclusion and Exclusion Criteria.

Criteria	Inclusion	Exclusion
Topic	Articles focusing on The Role of Manufacturing Operations in SMEs Performance	Articles not related to The Role of Manufacturing Operations in SMEs Performance
Research Framework	This article must include a research framework or methodology for The	Articles lacking clear research framework related to The Role of

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	Role of Manufacturing Operations in SMEs Performance	Manufacturing Operations in SMEs Performance
Language	Must be written in English	Articles published in languages other than English
Period	Articles between 2014 and 2024	Articles outside 2014 and 2024

2.2. Information Sources

The reviewed literature was collected from reliable online research sources. Three main recommended and consulted sources used are Google Scholar, Web of Science, and SCOPUS. Goggle Scholar is a Web search engine that specifically searches scholarly literature and academic resources. Web of science is a platform consisting of several literature search databases designed to support scientific and scholarly research. SCOPUS is a database that offers a comprehensive overview of global interdisciplinary scientific information. The research papers that were used to conduct the research include an article journal, a book chapter, a case study, and a conference paper. Materials derived from these sources include many types of academic works: journal articles, book chapters, case studies, and conference papers. All these resources contributed greatly to giving the possibility of a proper investigation into our topic in a systematic manner, which helped produce a review that was comprehensive and balanced. Figure 2 shows how the information sources were found.

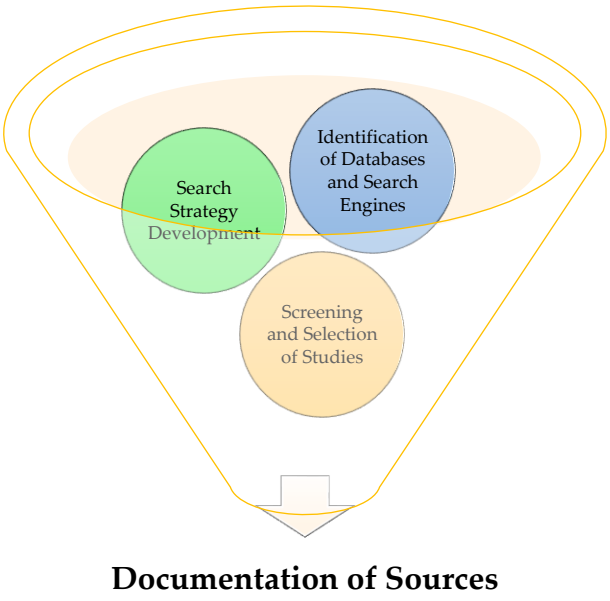

Figure 2. Procedure used in this Survey.

2.3. Search Strategy

Figure 3 illustrates the step-by-step process for conducting a systematic review, beginning with the development of research questions. These questions guide the selection of a research methodology, including the planning of a Systematic Literature Review (SLR), establishing inclusion and exclusion criteria, identifying research sources, and selecting search terms. The process then advances to selecting research articles through a search and evaluation process, ensuring the inclusion of high-quality references. The next phase focuses on extracting data from the selected studies, with an emphasis on assessing data reliability. Finally, the research data is compiled to address the research questions, bringing the review process to completion.

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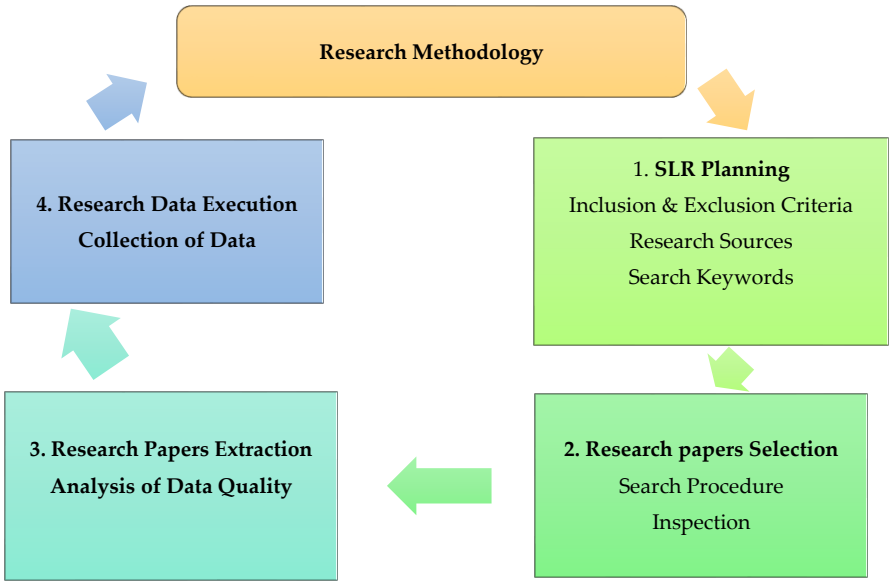

Figure 3. Stages and Procedures of the Review.

As shown in Table 3, the search was conducted using the following Boolean queries across Google Scholar, Web of Science, and Scopus: ("Manufacturing operations" AND "SMEs" AND "performance") OR ("Lean manufacturing" AND "small and medium-sized enterprises" AND "productivity") OR ("Advanced manufacturing technologies" AND "small businesses" AND "financial performance") OR ("Production management" AND "SMEs" AND "competitive advantage") OR ("Operations management" AND "small firms" AND "efficiency"). Inclusion was limited to empirical studies published in English between 2014 and 2024 to ensure the analysis remained focused on recent advancements in manufacturing technology. Data bases that were used were Google Scholar, Web of Science and SCOPUS. Fields were Title, Abstract and Keywords.

Table 3. Search Terms Used in this Survey.

Search Terms					Database	Fields
("Manufacturing operations" AND "SMEs" AND "performance")	OR ("Lean manufacturing" AND "small and medium-sized enterprises" AND "productivity")	OR ("Advanced manufacturing technologies" AND "small businesses" AND "financial performance")	OR ("Production management" AND "SMEs" AND "competitive advantage")	OR ("Operations management" AND "small firms" AND "efficiency").	Google Scholar Web of Science SCOPUS	Title Abstract Keywords

[1]The keywords searched 'Manufacturing Operations' AND 'SME Performance' did not produce results.

2.4. Selection Process

A selection process was implemented to ensure a relevant and focused collection of studies for the review on "The Role of Manufacturing Operations in SME Performance." Reviewers followed a

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detailed procedure to carefully choose papers for inclusion in the systematic review on "The Role of Manufacturing Operations in SME Performance". Each reviewer had a database to utilize namely Web of Science, Scopus or Google Scholar to gather research papers. A search code with keywords like "Manufacturing Operations," Lean Manufacturing", "Advanced Manufacturing technologies," together with terms associated with performance, SMEs and role was used. Researchers found 17,244 papers across the databases which were screened according to the inclusion criteria and their relevance to the topic. Exclusion criteria were also applied to filter out irrelevant studies. The papers published must be in English and within the date range of 2014 to 2024. Selected papers were then documented in an Excel spreadsheet for further review. A second review was done by the reviewers to make sure all papers met the inclusion criteria.

2.5. Data Collection Process

The data collection process for this systematic review is outlined as shown in Figure 4. We utilized the University of Johannesburg (UJ) library database to gather information through Web of science and SCOPUS along with Google Scholar database for the data collection process. A search code focusing on English language papers published between 2014 and 2024 was employed. Our search criteria encompassed various types of scholarly work, including research papers, conference papers, journal articles, theses, book chapters, doctoral theses, and reviews, yielding a total of 17,244 papers. After clear research, we found 69 papers from these databases that match with our topic.

To prevent duplication and efficiently manage the workload, the articles were divided among three authors based on publication year ranges. Each author had a year range; one author had 2014 to 2017 while another had 2018 to 2020 and the third one had 2021 to 2024. This division allowed for a systematic and organized approach to data collection across different periods. The authors collected data, and the collected data was recorded in a shared Excel document, enabling real time collaboration and ensuring accuracy throughout the process. This collaborative method ensured consistency in our review with regular checks to validate the data collected. To make sure the papers collected are relevant we had to double check the topics, keywords, read the abstracts and go through the introductions. When choosing papers from Google Scholar we had to do manual review due to the lack of automated extraction tools unlike Web of Source and SCOPUS.

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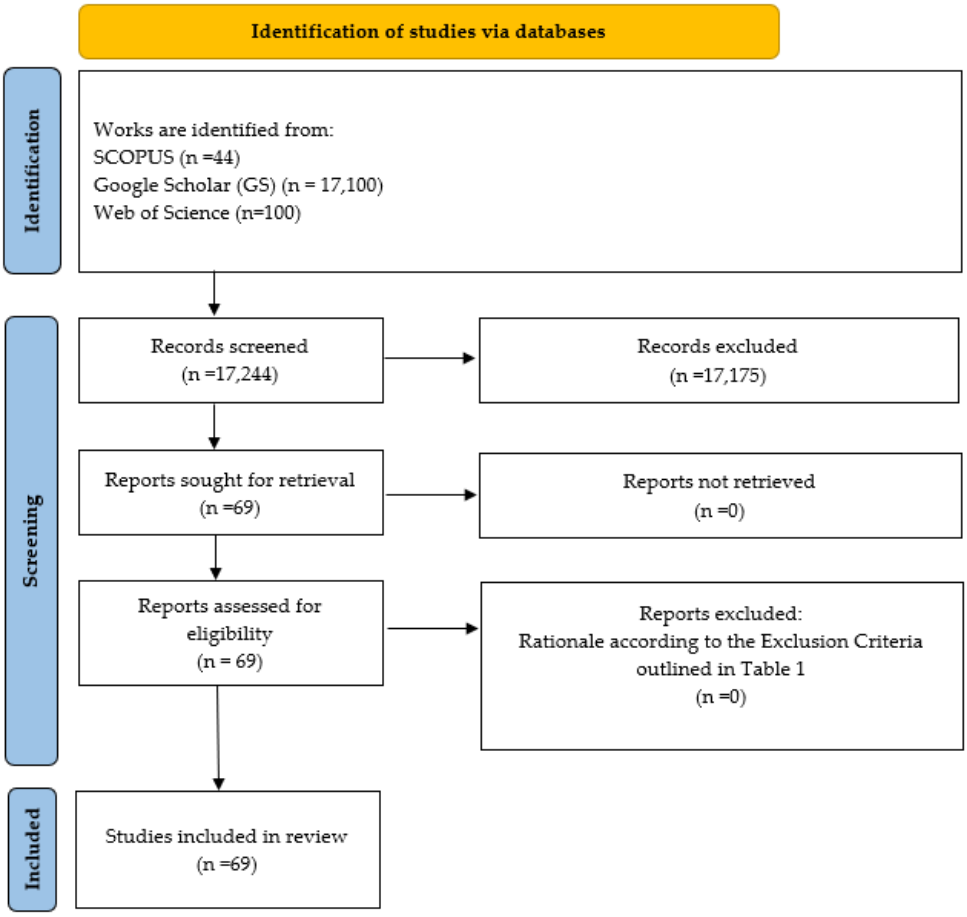

Figure 4. Data Collection Process Flowchart.

2.6. Data Items

This systematic literature review gathers information that focuses on the role of Manufacturing operations in small and medium-sized enterprises (SMEs). The research questions will be used to highlight the importance of the topic for data items.

2.6.1. Results and Data Connection

The results from the integration of manufacturing operations indicate better profitability, operational efficiency, increased customer satisfaction, and wider market coverage. These results show the potential ways SMEs may strengthen their performance in exploiting the manufacturing process for decision making, innovation, and ability to get a competitive advantage. More also, in exploring the drivers of successful implementation of the manufacturing operation among SMEs, the critical components to have emerged include competent personnel, appropriate infrastructure, supportive leadership, financial commitment, and culture that accepts change. These elements must be identified to appreciate what is needed for success. Of importance is the fact that the intended benefits include increased workforce productivity, use of data-driven decisions, smoother production, better use of resources, and better market standing. section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn. These results show how much more depth in understanding and proper integration of the manufacturing processes could effectively improve productivity in SMEs. Results would, therefore, be targeted regarding an improvement of production consistency, growth in product accuracy, and an awareness of risks from machinery failure or operational inefficiency. The findings also reveal some of the challenges which SMEs face in adopting manufacturing technologies, such as high initial costs, lack of skilled staff,

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fears over technological complexity, and resistance to change and scale. Above mentioned challenges show a potential barrier towards full adoption of manufacturing operations by SMEs.

Most of the studies that have attempted to examine the role of manufacturing operations in improving SME performance have used various methods and hence come up with diverse results. For instance, "Manufacturing Technology Adoption and SME Growth" (2020) and "Impact of Advanced Manufacturing on SME Performance" (2021) followed a quantitative approach via survey and SEM to find out the impact of manufacturing operations on firm performance along operational and sustainable dimensions. Data was collected by questionnaires, which were then analyzed using advanced statistical methods. To that effect, other related research works such as "Manufacturing Operations in SMEs Amid Global Market Shifts" (2021) and "Resource Optimization Through Manufacturing Technologies in SMEs" (2018) also adopt a quantitative methodology for examining how manufacturing influences issues related to operational strategies and resource management. They thus followed systematic methods of drawing inferences from the data through structured processes that might have been indicated in Figure 5.

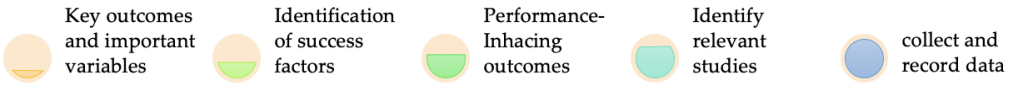

Figure 5. Initiated Data Items Process.

The above structured figure illustrates the importance of how data collection and results for the role of manufacturing operations on SMEs are written by focusing on the outcomes, challenges and systematic approach.

2.6.2. Contributor Characteristics

This section presents the profile of the contributors whose works were studied to understand the role of manufacturing operations in SMEs and summarizes the specific research reviewed. Table 4 tabulates an overview of general information such as the year of publication, databases used, and the number of studies reviewed. The objective herein was to identify the main variables describing research design, methodologies, and factors considered. Besides, research has focused on sustainability and the contribution of digital technologies to enhancing production efficiency through waste minimization, such as "The Integration of Digital Manufacturing Tools for Sustainable Growth in SMEs", in 2021. These works utilized methods such as Structural Equation Modeling (SEM) and regression analysis in the assessment of manufacturing operations' effects on production optimization, resource allocation, and long-term profitability. Results showed that there is a growing trend towards integrating smart manufacturing solutions to achieve a double benefit: operational agility and sustainability. These studies clearly point out that manufacturing technologies support, from automation to IoT-enabled solution, both economic and ecological performances of SMEs, proving an evolving attitude towards sustainable and technology-driven manufacturing.

Table 4. Proposed Risk of Bias.

Fields	Description	Selection
Title	The name of the research article or paper.	None
Year	The publication year of the study.	None
Online database	The database where the article wassourced.	Google Scholar, SCOPUS, Webof Science
Journal name	Represents data as slices of a whole, ideal for showing proportional or percentage distribution of categories.	None

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Research type	Shows parts of a whole, allowing multiple variables to be represented in the same category for easier comparison.	Article Journal, Doctoral Thesis, Research paper, Conference paper, Review, Thesis, Book chapter
Cites	Plots individual data points on an X and Y axis to explore relationships or correlations between two variables.	None
Discipline or subject area	Uses color coding to represent data intensity or frequency, useful for spotting patterns in large datasets.	SME Performance, Manufacturing operations, Industry 4.0, Business strategy, Financial Management
Industry Context	The industry or sector the research is focused on	General SMEs, Manufacturing SMEs, ICT
Geographic location	The region or country where the study was conducted or focused.	None
Economic context	The economic environment of the study	Developed, developing
Types of HRIS Technologies	The specific Big Data technologies used in the research.	Various, Quality, Cost, Delivery, Flexibility
Research design	The design of the study	Experimental, quasi-experimental, case study, survey
Types of study	The methodology used	Qualitative, quantitative, and Mixed methods
Sample size	The number of participants or entities involved in the study.	None
Sample Characteristics	Demographic or specific features of the Sample	SMEs, Manufacturing manages, policymakers
Data Collection Methods	Techniques used to gather data	Interviews, surveys, observations, document Analysis
Data analysis techniques	Methods used to analyze the data	statistical analysis, thematic analysis
Workforce productivity metrics	Identify performance improvement areas.	Firm performance, Production efficiency, profitability
Business performance metrics	Measures of business outcomes Operational efficiency,	operational efficiency, revenue growth, cost savings
Organizational outcomes	Results related to the organization	employee satisfaction, engagement, retention

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Long-term impacts	The extended effects of the study findings	business sustainability, competitive advantage

Regarding the reviews made from all the studies, it is observed that no studies were funded by any external funding sources. The presence of such features gives the readers exhaustive information, referring to the respective research on manufacturing operations in SMEs. Overview wrangler overviews that the research able to identify practical challenges while implementing advanced manufacturing technology improvement concerning organizational performance and sustainable development. It also spells out the vital role of manufacturing innovation in surmounting operational inefficiencies and stimulating growth in SMEs.

2.7. Study Risk of Bias Assessment

This section specifies the approaches used to assess the risk of bias in the incorporated studies. Potential for Bias is assessed by evaluating the quality of studies against the criteria relevant to our topic. No automated tools or software were used in this process, we manually examined the methodologies and results of each study. Reviewers individually assessed each study. Reviewers worked carefully to reduce any individual biases by discussing their findings together and agreeing on their conclusions. By using this collaborative approach, we ensured that the analysis of bias in the studies was thorough, reliable, and consistent. This way, we made sure all studies were evaluated fairly and accurately as shown in Table 5.

Table 5. Proposed Risk of bias assessment.

Ref.	Selection (0-4 stars)	Comparability (0-2 stars)	Outcome/Exposure (0-3)	Total Stars	Quality Rating
[36,44,57,60]	★	★	★★	4	Low
[34,41,42,47,58,63]	★★	★★	★★	6	Low Moderate
[39,43,50,51,55,66,67]	★★	★★	★★	6	Low Moderate
[38,45,46,49,53,54,56,61,62]	★★★	★★	★★★	8	Moderate High
[35,37,40,48,52,59,64,65,68,69]	★★★★	★★	★★★	9	High

2.8. Effect Measures

To assess the impact of the role of manufacturing operations in SMEs performance, we employed various effect measures to evaluate the outcomes across the selected studies. **Profitability growth** can be measured by increases in net profit margins or return on assets, while **operational efficiency** is assessed through reductions in operational costs and waste. Improvements in **customer satisfaction** are often captured by metrics such as customer retention rates. **Market share growth** reflects the success of manufacturing strategies in expanding a company's presence in its industry. **Productivity enhancements**, measured by output per employee or per unit of time, and **process optimization,** often evaluated through lead time reductions, are key operational indicators.

In our systematic review, we analyzed outcomes using the risk ratio (RR) to compare the probability of achieving high product quality standards between SMEs with advanced manufacturing operations and those without, and the mean difference (MD) to evaluate changes in quality ratings or defect rates before and after implementation. Using the Mean Difference (MD**)** helped us adjust for differences in the measurement scales used across the studies, making it easier to compare and combine the results in a consistent way. These effect measures were applied alongside meta-analyses to combine data from different studies, offering a clearer view of manufacturing operations on SME performance. The results were interpreted in the context of specific outcomes, ensuring they were relevant and useful for real-world SME situations.

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2.9. Synthesis Methods

The synthesis methods for this systematic review on the role of manufacturing operations in SMEs' performance were designed to ensure a transparent, and reproducible aggregation of results across the selected studies. The process of determining which studies were eligible for inclusion in each synthesis was conducted systematically ensuring alignment with the review's objectives. This approach was crucial for accurately assessing how various manufacturing strategies impact the performance of SMEs, providing valuable insights for both academic research and practical applications. Figure 6 shows the processes of synthesis, and the tasks completed for the synthesis methods.

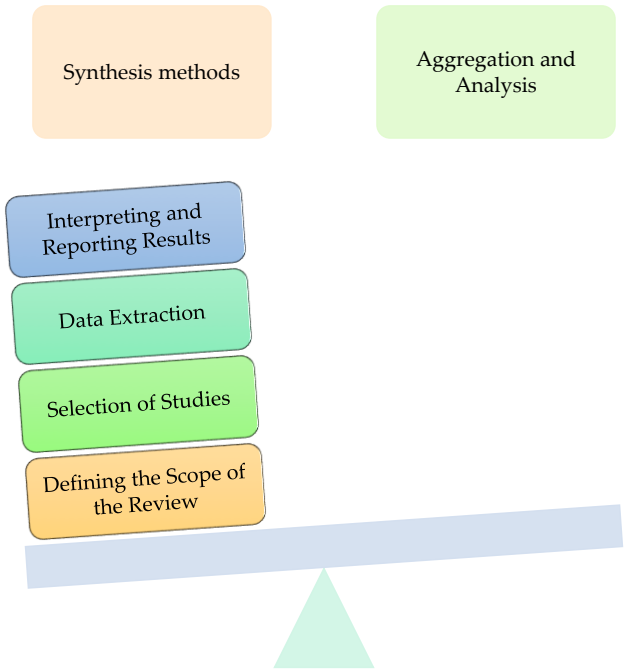

Figure 6. Synthesis methods.

2.9.1. Study Eligibility Criteria

The synthesis methods for this systematic review on the role of manufacturing operations in SMEs' performance were developed to ensure a comprehensive, transparent, and replicable analysis of the selected studies. The process began with a systematic identification and screening of relevant literature from databases such as Google Scholar, Scopus, and Web of Science. Studies were included based on predefined criteria that focused on the relevance of manufacturing operations to key performance indicators in SMEs, such as productivity, efficiency, and financial performance. We read the abstracts and introductions of each study. Only peer-reviewed papers from sources, using web filters to avoid duplications of papers and to make sure the studies in our review were trustworthy. The papers selected for review were ranging from 2014-2024. Each paper underwent peer review to meet the standards.

2.9.2. Data Preparation for Synthesis

In preparing data for synthesis on the role of manufacturing operations in SMEs' performance, several key steps were followed to ensure a consistent, accurate, and reliable integration of findings from multiple studies. First, all relevant studies were carefully selected based on predefined inclusion and exclusion criteria, ensuring that only those meeting quality and relevance standards were included. Data extraction was performed systematically to capture critical variables from each study, including study characteristics (such as sample size, location, and industry focus), methodology, and outcome measures. To ensure the integrity of the synthesis, reporting bias was assessed for each study using risk of bias tools. These biases were factored into the weighting of studies during

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synthesis. In instances where data was missing, we labeled it as "Not Specified" instead of "Not Applicable" to accurately reflect the gaps in the information.

2.9.3. Data Visualization and Tabulation Methods

Various data visualization and tabulation methods were used to present findings clearly and effectively. Bar graphs, line charts, scatter plots, and pie charts were employed to highlight trends, distributions, correlations, and proportions. Pivot tables were created to help us identify any differences in our journal articles. Descriptive statistics tables summarized performance metrics, and cross-tabulation revealed relationships between different operational strategies and outcomes. Table 6 shows a pivot chart used to visualize data and analyze data.

Table 6. Pivot Chart to Visualize and Analyze Data.

Chart Type	Purpose	Data Representation Format
Bar chart	Displays data using rectangular bars, where the length of each bar represents the value of the variable being measured	Numbers
Column chart	Like a bar chart, but the bars are presented vertically. It is used to compare values	Numbers
Line chart	Connects data points with a continuous line, making it ideal for showing trends over time. This type of chart is commonly used to track changes	Numbers
Pie chart	Circular chart divided into slices to represent proportions of a whole. It is useful for showing the relative contribution of different categories to a total	Percentages (%)
Scatter plot	Displays data points on a two-dimensional graph to show relationships between two variables. Each point represents an observation with coordinates based on the values of the two variables being compared.	Numbers

2.9.4. Synthesis Methodology

A systematic approach was used to synthesize the study findings, utilizing a set of criteria organized in an Excel spreadsheet. This structured method helped in comparing and analyzing aspects of the studies included, focusing on variables, like the title, publication year and source databases (such as Google Scholar, SCOPUS, and Web of Science) with their respective number of studies found represented in Table 7. The studies were grouped by journal name, research type (article journal, conference paper, book chapter, dissertation/theses), and citation count

Table 7. Results obtained from literature search.

No.	Online Repository	Number of results
1	Google Scholar	17 100
2	Web of Science	100
3	Scopus	44
Total		17 244

2.9.5. Exploration of Heterogeneity Causes

Heterogeneity in the role of manufacturing operations on SME performance arises from various factors, including differences in firm size, industry requirements, geographical location,

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technological adoption, market conditions, and external economic factors. Larger SMEs often have more resources to implement advanced technologies, while smaller firms may struggle due to constraints. Industry-specific needs, regional disparities, and varying levels of technological adoption further contribute to differing outcomes. Market competitiveness and external factors like government support or economic conditions affect how SMEs optimize their operations.

SMEs vary widely in size, with some firms classified as micro-enterprises employing fewer than 10 employees, while others can have up to 250 employees. Larger SMEs may have the capacity to implement more advanced manufacturing technologies and optimize their operations more efficiently, while smaller firms may struggle with resource constraints. Manufacturing operations in the textile industry might emphasize labor-intensive processes, while SMEs in electronics manufacturing might focus on automation and precision engineering. These variations can lead to distinct approaches to operations management, which in turn affects performance. SMEs operating in highly competitive markets may need to prioritize efficiency and innovation in their manufacturing processes to maintain a competitive edge. Conversely, SMEs in less competitive or niche markets may not face the same pressures, resulting in slower adoption of advanced operational practices.

2.9.6. Sensitivity Analysis

One of the primary focuses is on different operational strategies, such as lean manufacturing, automation, or quality management systems. Sensitivity analysis helped us reveal how shifts in the adoption level or implementation quality of these strategies affect performance metrics like productivity, cost efficiency, and quality. The allocation of resources including financial investment, labor, and technological assets, significantly influences manufacturing outcomes. We examined how variations in resource levels impact performance. For instance, increasing investment in new technologies might lead to different performance improvements compared to changes in workforce skills or production capacities.

Market conditions including demand fluctuations, competition intensity, and customer preferences can affect manufacturing operations. We examined how changes in these market conditions influence SME performance. Varying levels of market competition or shifts in customer demand can impact the effectiveness of manufacturing strategies and overall performance. The impact of government incentives for technology adoption or changes in import tariffs can be evaluated. We evaluated how this approach helps SMEs to make informed decisions and enhance their performance in a dynamic business environment.

2.10. Reporting Bias Assessment

In this systematic review on the role of manufacturing operations in SMEs' performance, assessing the risk of reporting bias was essential to ensure the reliability and validity of the findings. Reporting bias occurs when the results of studies are selectively reported based on the nature and direction of the findings, which can potentially skew the overall conclusions of the review.

To mitigate this risk, we implemented a comprehensive literature search strategy across multiple databases, including Google Scholar, SCOPUS, and Web of Science. This broad search was designed to capture a wide range of studies on manufacturing operations and SME performance, thereby reducing the likelihood of omitting relevant studies that may have reported non-significant or negative findings.

Manual analysis and visualization played a significant role in assessing reporting bias. We did not use any automation tools specifically for assessing reporting bias; instead, data were manually analysed and visualized using Microsoft Excel. This approach involved creating charts and plots to identify patterns and potential biases in the reporting, allowing for a detailed examination of the data without reliance on automated software tools.

To further assess the risk of reporting bias, we compared the reported outcomes across studies with similar objectives and methods to identify any inconsistencies. Studies that only reported positive outcomes or lacked transparency in their reporting were evaluated for potential bias. Table

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4 shows how we summarized the quality of different studies, using headings such as Selection, Comparability, and Outcome/Exposure. The ratings in Table 4 determines reporting bias in our assessment.

2.11. Certainty Assessment

This section outlines the methods used to assess the certainty or confidence in the evidence gathered for each outcome, ensuring the reliability and strength of the findings. The collected literature was evaluated based on five Quality Assessment (QA) checks as outlined in Table 8. These criteria were chosen to evaluate the reliability, applicability, and overall quality of the studies, establishing a robust foundation for the conclusions reached in this research. This evaluation process was crucial for assessing the evidence's reliability and ensuring that the results accurately show how manufacturing operations affect different aspects of SME performance.

Table 8. Research Quality Questions Results.

Questions(Q)	Research Quality Questions
Q1	Are the research objectives clearly articulated and precisely defined?
Q2	Is the research methodology thoroughly explained and detailed?
Q3	Is the analysis of the role of manufacturing operations in SME performance comprehensive and well-structured?
Q4	Are the data collection methods clearly detailed and suitable for the research objectives?
Q5	Do the research findings contribute significantly to the existing body of knowledge on the topic?

The Quality Assessment (QA) questions are rated on a scale from zero (0) to one (1). A score of 0 is assigned for a 'No' response, 0.5 is given when the criteria are 'Partially' met, and a score of 1 is awarded for a 'Yes' response. This rating system is uniformly applied to all five questions (Q). As a result, each piece of literature being reviewed can achieve a total score of up to 5 points. The outcomes of the Quality Assessment for the literature reviewed are detailed in Table 9.

Table 9. Quality Assessment scores for each paper.

Ref.	Q1	Q2	Q3	Q4	Q5	Total	% Grading
[36,39–41,47,49,52,53,58–60,64,66,69]	1	1	1	1	1	5	100%
[42,43,48,50,51,55,57,61,65]	1	1	0,5	1	1	4,5	90%
[34,37,44,56,62,68]	1	0,5	1	0,5	1	4	80%
[45,47,54,63]	1	1	0,5	0,5	0,5	3,5	75%
[46,67]	1	0,5	0	0	1	2,5	50%

3. Results

This section consists of subsections such as study selection, study characteristics, and risk of bias, all of which are vital for ensuring the reliability of the findings. Figure 7 highlights the need to account for reporting biases and evaluate the certainty of evidence to guarantee that the results are both accurate and trustworthy. Each of these elements is crucial for interpreting the overall findings and providing a clearer understanding of the data.

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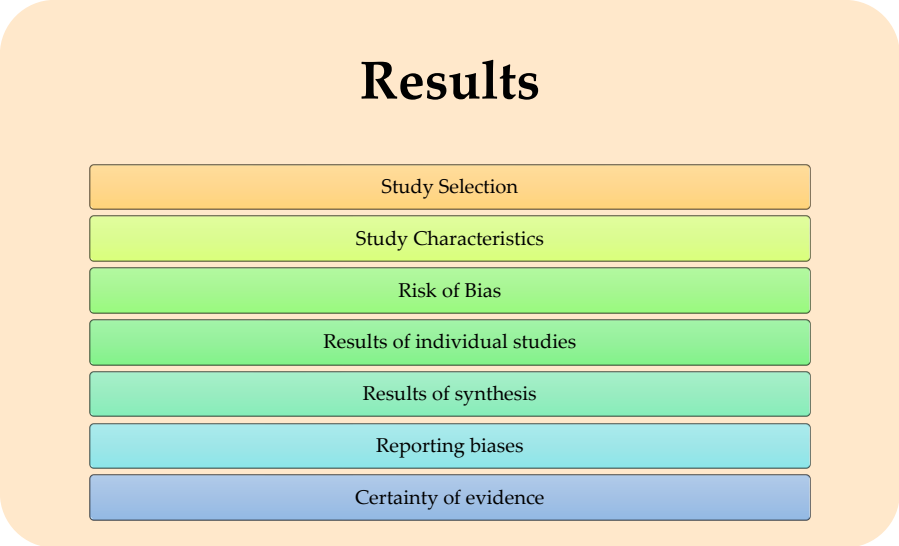

Figure 7. Key Phases in Evaluating Systematic Review Results.

3.1. Study Selection

The process of selecting research papers is shown in Figure 8. Research papers were collected from three databases with their distribution presented in percentages. These papers were strictly gathered based on the inclusion and exclusion criteria outlined earlier. The search resulted in about 17 644 papers from three databases namely, Google Scholar, Web of Science, and Scopus, with their titles and abstracts reviewed. As shown in Figure 8, 62% originated from Google Scholar, 23% originated from SCOPUS, and 15% originated from Web of Science. Any duplicates were removed, leaving 69 papers for full-text review and inclusion in this systematic analysis.

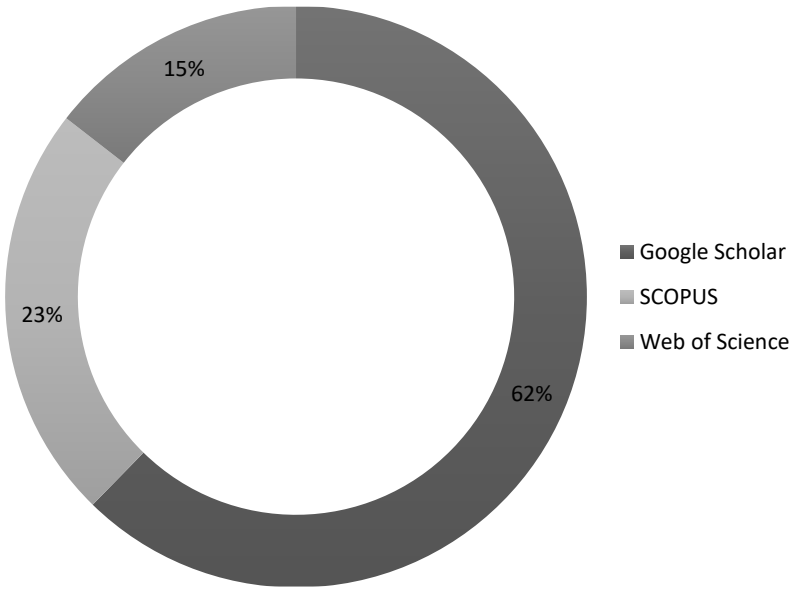

Figure 8. Distribution of Online Data Sources.

3.2. Study Characteristics

All total of sixty-nine (69) relevant research papers were published between 2014 and 2024. Figure 9 illustrates the annual publication numbers, revealing a continuous rise in studies since 2014. This trend underscores the growing academic interest in the roles of manufacturing and SMEs over time. The included research comprises 1 book chapters, 10 conference papers, 1 Thesis, 2 Research papers, 1 Doctoral thesis, 50 and journal articles, as shown in Figure 9. This figure classifies the types of publications analyzed, indicating that journal articles dominate, with 50 entries, followed by 10

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conference papers and 1 book chapters. This distribution suggests that journals are the primary platform for research on assessing the impact of manufacturing operations on SMEs performance.

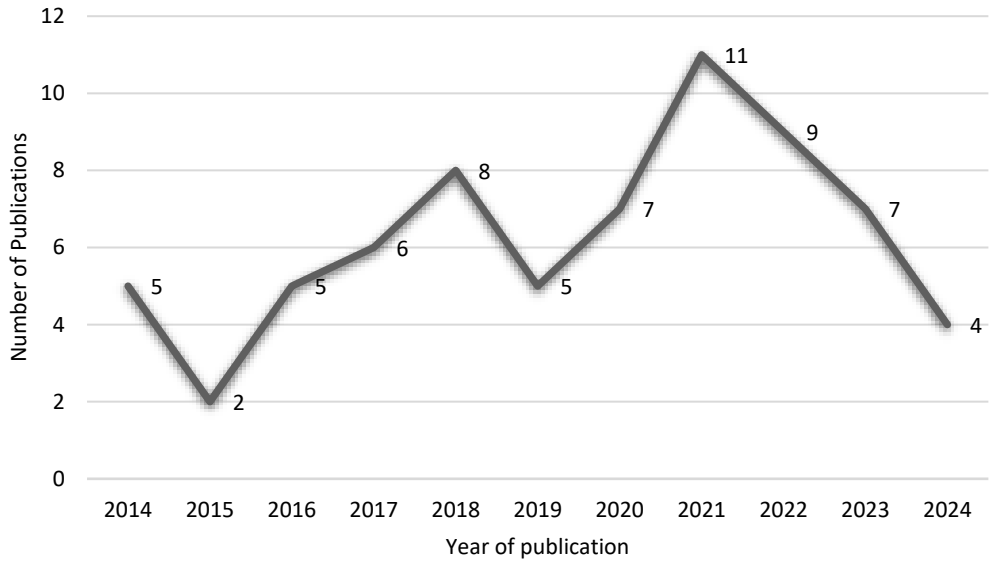

Figure 9. Annual Distribution of Scholarly Publications (2014-2024).

Table 10 displays the yearly distribution of research papers published over the past ten years. Since 2014, publications have increased steadily, as demonstrated in Figure 6. Despite numerous studies on manufacturing operations and SMEs, a thorough systematic review evaluating the effects of manufacturing operations on SME performance has not yet been completed. The summary of research published between 2014 and 2024 includes the breakdown of book chapters, conference papers, thesis, doctoral thesis, review, journal article and journal articles by year. The data reveals a consistent growth in research output, peaking in 2019 to 2021 with 11 journal articles, although no book chapters or conference papers were produced in that year. Significant years include 2018, with 7 journal articles, and 1 conference paper. This pattern highlights the increasing scholarly attention on the role of manufacturing operations in SMEs, particularly through peer-reviewed journals., etc.

Table 10. A brief overview of the research studies included here, organized by publication year.

Published Year	Book Chapter	Conference paper	Thesis	Research paper	Thesis	Article Journal
2014	0	1	0	1	0	3
2015	0	0	0	1	0	1
2016	0	1	0	1	0	3
2017	0	0	1	0	0	6
2018	0	1	0	0	0	7
2019	0	1	0	0	0	2
2020	1	3	0	1	0	3
2021	0	1	0	0	1	8
2022	0	0	0	1	0	9
2023	0	2	0	0	0	5
2024	0	0	0	0	1	3

Figure 10 illustrates the global distribution of research contributions on The Role of Manufacturing Operations in SMEs Performance, revealing a diverse range of involvement across various countries. Indonesia leads the field, accounting for 17.39% of the total contributions, indicating a strong emphasis on enhancing manufacturing operations within its SME sector. This

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could be driven by national strategies aimed at boosting the productivity and competitiveness of SMEs. The "Global" category follows with 10.14%, reflecting a widespread international focus on this area, likely due to the universal importance of SMEs in economic development. Malaysia contributes 7.25%, showcasing its growing interest in optimizing manufacturing processes to improve SME performance. South Africa and Nigeria each account for 4.35% of the contributions, highlighting their efforts to maintain a competitive edge by focusing on manufacturing efficiency in SMEs. Countries like Pakistan, Peru, Canada, UK, Sweden, Thailand and N/A each contribute 2.90%, suggesting a moderate but focused interest in the topic, possibly as part of broader economic strategies. Other nations, including Kurdistan Region of Iraq, Bosnia, Poland, Yemen, United States, United Kingdom, Uzbekistan, Sekondi-Takoradi Ghana, Lithuania, Indonesia, and Nigeria, each contribute 1.45%, indicating a more varied level of research activity across different regions. This distribution underscores the global significance of manufacturing operations in SMEs' performance, with notable regional differences in research intensity, suggesting that while some countries are leading in this area, others may need to increase their focus to fully leverage the benefits of improved manufacturing practices for SME growth.

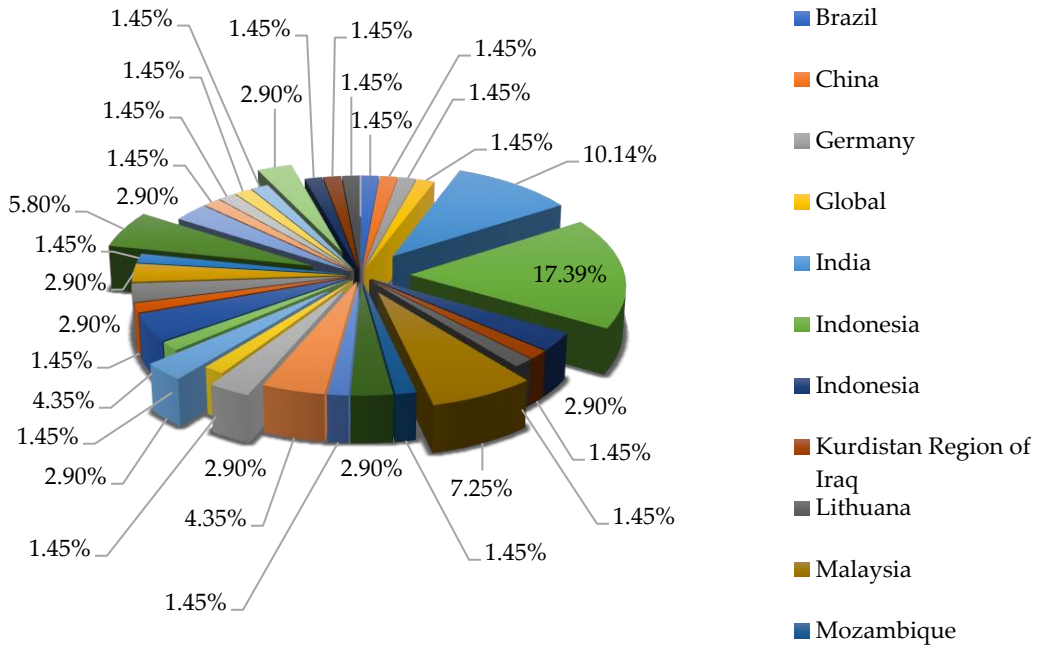

Figure 10. Geographical distribution of research papers.

3.3. Risk of Bias in Studies

When exploring the role of Manufacturing Operations in SMEs performance, it is essential to understand the research methods employed, as these significantly affect the reliability and relevance of the findings. A range of methods, such as surveys, case studies, and experimental designs, have been used to explore the influence of these Manufacturing Operations on SMEs, each with its own strengths and drawbacks. These approaches offer unique insights but also come with certain limitations when examining the role of manufacturing operations on small and medium-sized enterprises. Figure 11 illustrates the different research methods used in studies on this topic, highlighting the potential bias risks associated with each.

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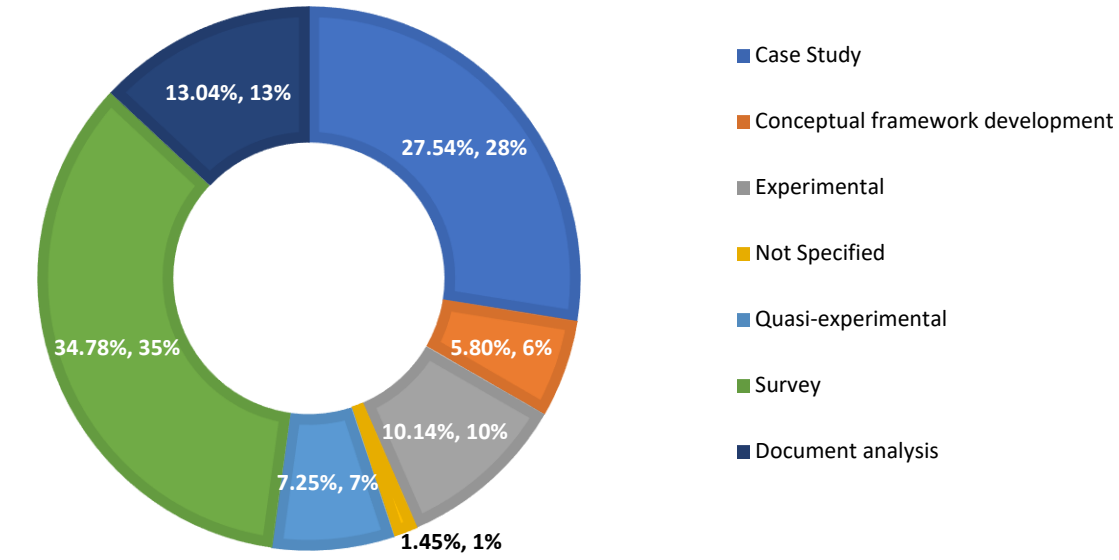

Figure 11. Research designs.

The chart above shows the different methodologies of research applied in studies related to systematic review. Surveys (34.78%) being the most common, indicating a strong reliance on primary data collection. Case studies (27.54%) are also widely used, allowing for in-depth exploration of specific examples. Document analysis (13.04%) plays a significant role, suggesting that many studies utilize existing reports or data sources. Quasi-experimental (10.14%) and experimental methods (7.25%) are used to a lesser extent, reflecting a focus on real-world settings and controlled testing of variables. Some studies focus on conceptual framework development (5.80%), contributing to theoretical advancements, while a small portion is not specified (1.45%), indicating a lack of clarity in the methodology of a few studies.

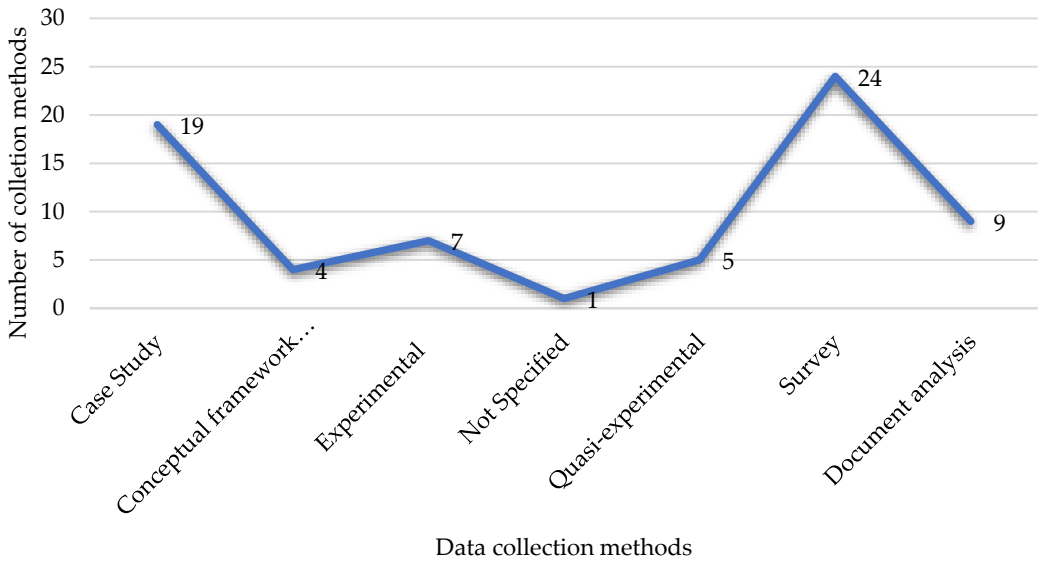

Figure 12. Data collection methods.

The data collection method for this systematic review involved a comprehensive and structured approach. First, a broad literature search was conducted across multiple academic databases, including Google Scholar, Scopus, and Web of Science, to gather relevant studies published between 2014 and 2024. The search focused on identifying peer-reviewed journal articles, conference papers,

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reports, and case studies that examine various manufacturing operations, such as lean manufacturing, advanced manufacturing technologies, and operations management, in the context of SMEs. Three independent reviewers conducted the data extraction process, meticulously reviewing each selected study to capture key information. To ensure the relevance and quality of the data, inclusion and exclusion criteria were applied, with a focus on studies that specifically address the impact of these operations on business outcomes like efficiency, productivity, and financial performance. Figure 13 shows the data collection methods.

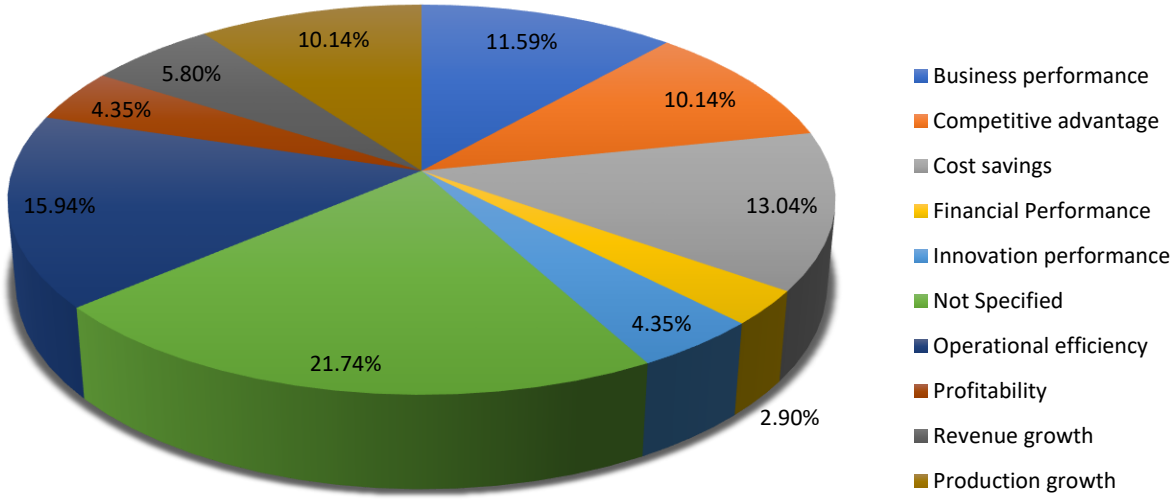

Figure 13. Distribution of Business Performance Metrics.

3.4. Results of Individual Studies

Figure 13 shows how different business metrics results contribute to the manufacturing operations in SME performance based on 69 research papers.

The second largest portion, at 15.94%, is dedicated to operational efficiency, indicating that efficiency in manufacturing processes has the most significant impact on SME success. Other prominent factors include business performance (11.59%) and cost savings (13.04%), suggesting that efficient manufacturing is closely tied to overall business success and financial stability. Product growth also plays a notable role, with 11.59% of the studies emphasizing how manufacturing advancements drive innovation within SMEs.

Smaller but still important factors include revenue growth (5.80%), innovation performance (4.35%), indicating that these areas are positively impacted by strong manufacturing practices, though not as dominant in the studies. A big portion of the data is not specified (21.74%), showing that in a few cases, the specific outcomes were unclear.

3.5. Results of Synthesis

This section consists of subsections that make up the synthesizing of results of the selected studies. Consisting of study characteristics and bias assessment, Statistical synthesis results, and sensitivity analyses [70–79]. Figure 14 illustrates a systematic process followed to achieve a comprehensive result of synthesis.

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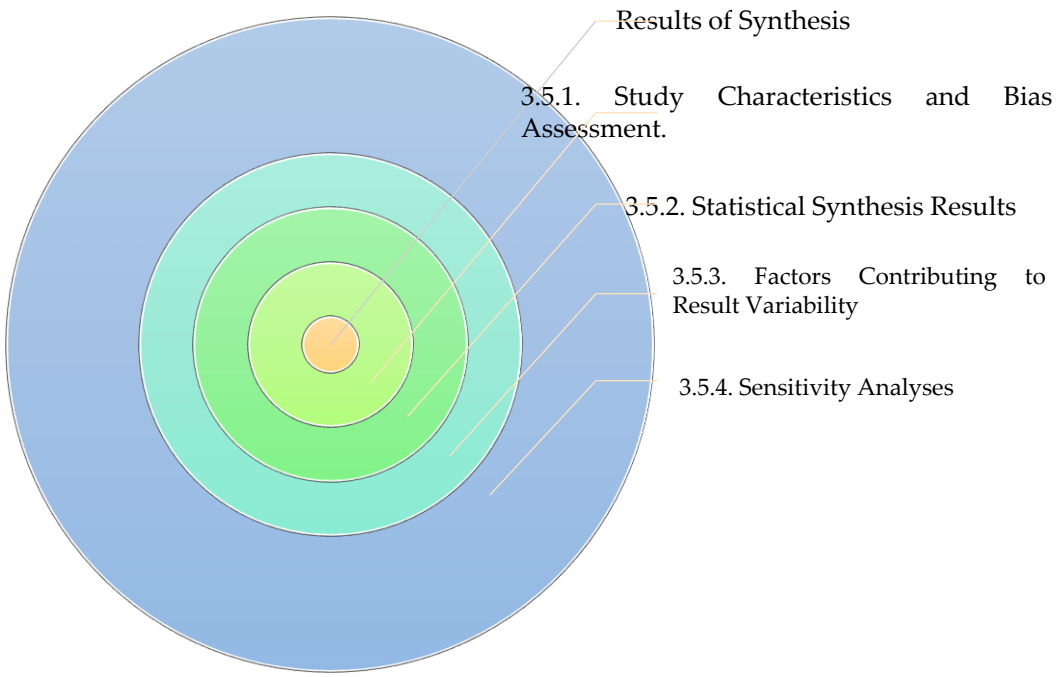

Figure 14. Synthesis Systematic Process.

3.5.1. Study Characteristics and Bias Assessment

A detailed breakdown of data collection methods used in the study is highlighted in Figure 15. The pie chart shows that 'Surveys' are the most preferred used method, as it is 39.13%, followed by 'Questionnaire' and 'Document analysis' at both 18.84%, 'Interview' at 17.39%, and 'Observations' at 5.80%.

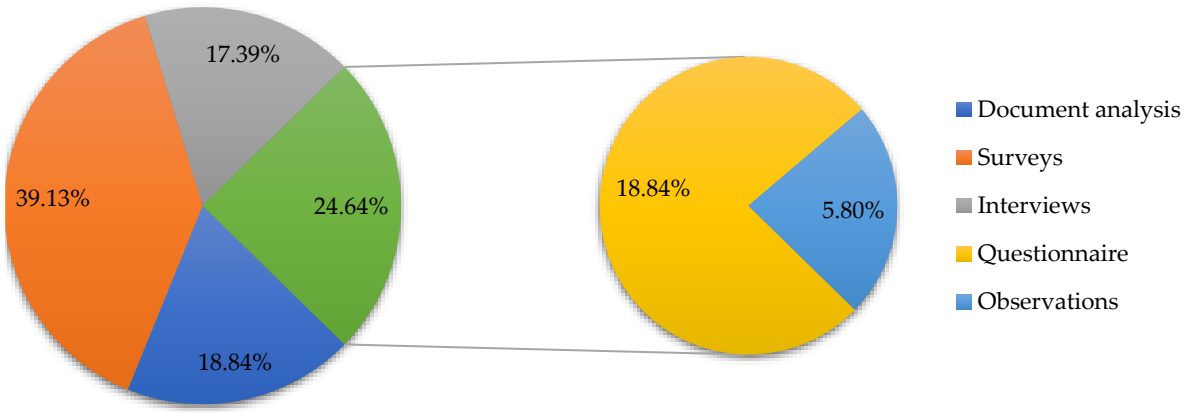

Figure 15. Study Characteristics Breakdown.

This chart is highlighting how much each data collection method contributed to the study. The surveys dominated the research, followed by questionnaires, interviews, and observations. The right-hand chart narrows in on just two methods, showing their proportionate role in a subset or a different phase of the research. This suggests that the research may have involved a mix of quantitative (surveys, questionnaires) and qualitative (interviews, observations) methods to gather a comprehensive range of data. The breakdown reflects the importance placed on each method in different stages or aspects of the study.

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3.5.2. Statistical Synthesis Results

Figure 16 shows statistical synthesis results in the form of a chart. This chart highlights how much data each method contributed to the overall study. Surveys were the most significant source, followed by questionnaires and document analysis, while interviews and observations played smaller yet important roles. Each method provided unique types of data, quantitative from surveys, document analysis and questionnaires, and qualitative from interviews and observations, leading to a comprehensive and diverse dataset that was synthesized for analysis. 'Statistical analysis' represents 64% of the method used, leading to a stronger quantitative focus. 'Thematic analysis' is made up of 36% meaning it is qualitative focused.

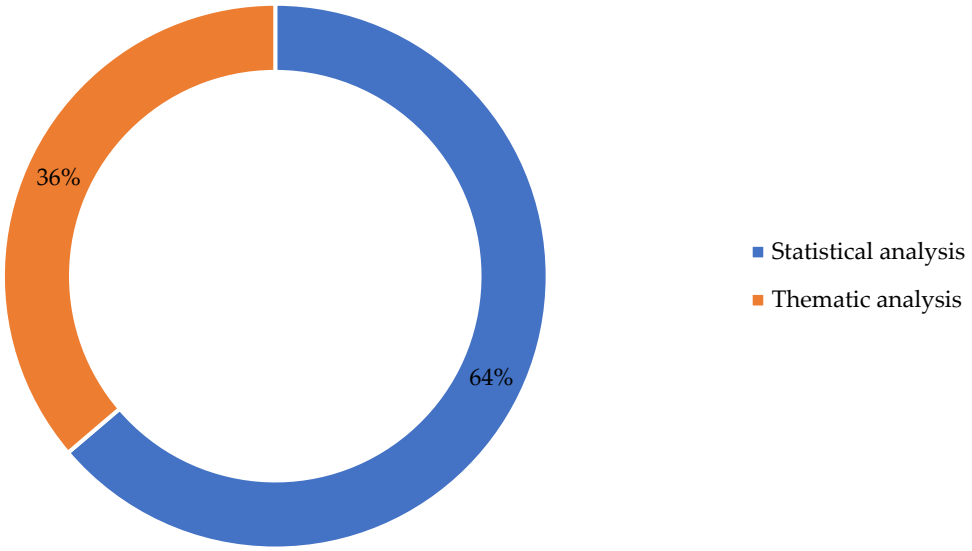

Figure 16. Analysis Breakdown Methods.

Figure 16 highlights the key importance of statistical methods, which are crucial for examining the quantitative components of the study's results. By illustrating the emphasis on statistical analysis, the chart helps assess the robustness and credibility of statistical syntheses, like meta-analysis, and their impact on the overall findings. The presence of thematic analysis points to the incorporation of qualitative data, providing a broader perspective on how various data types were integrated to inform the study's conclusion.

3.5.3. Factors Contributing to Result Variability

Figure 17 presented in this section highlights key factors contributing to variability across different professional groups, namely Employees, HR managers, and small and medium-sized enterprises (SMEs). The larger contribution from SMEs suggests that organizational characteristics (such as size, sector, and management practices) cause the most fluctuation in study results. Employees and HR managers contribute similarly, but their influence on variability is less pronounced. This might indicate that individual or managerial factors play a secondary role compared to broader organizational factors.

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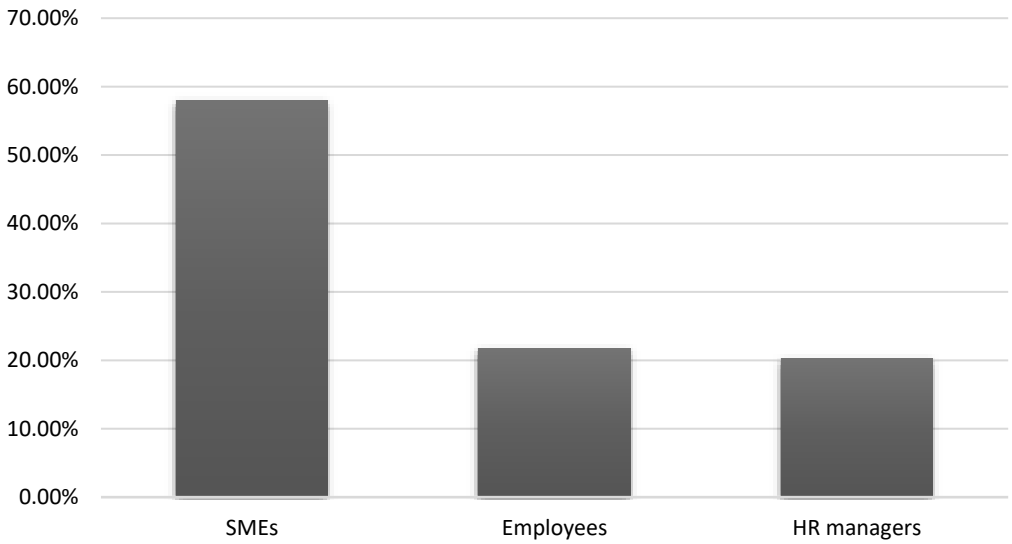

Figure 17. Sample Characteristics.

3.5.4. Sensitivity Analyses

Sensitivity analysis involves testing how the variations in input factors affect the outcomes of a model or study. Figure 18 represents the usage or categorization of different systems or methods related to HR or workforce management. Each bar shows a percentage that corresponds to the different categories. The "Not specified" category, being the largest, suggests that a significant number of respondents or data points did not clearly specify which HR systems they were using. Talent management systems are quite popular, indicating a strong focus on employee performance and development in HR practices. Recruitment software is moderately represented, suggesting that hiring processes are automated to some extent, but not as widely as talent management. Payroll systems being the least mentioned might indicate that payroll is less of a focus in the data or that it's often handled by other means, possibly manually or outsourced. The chart shows a significant use of talent management systems and a fair amount of recruitment software, with payroll systems being the least cited. However, a large portion of the data remains unspecified, which could affect the overall conclusions about system usage.

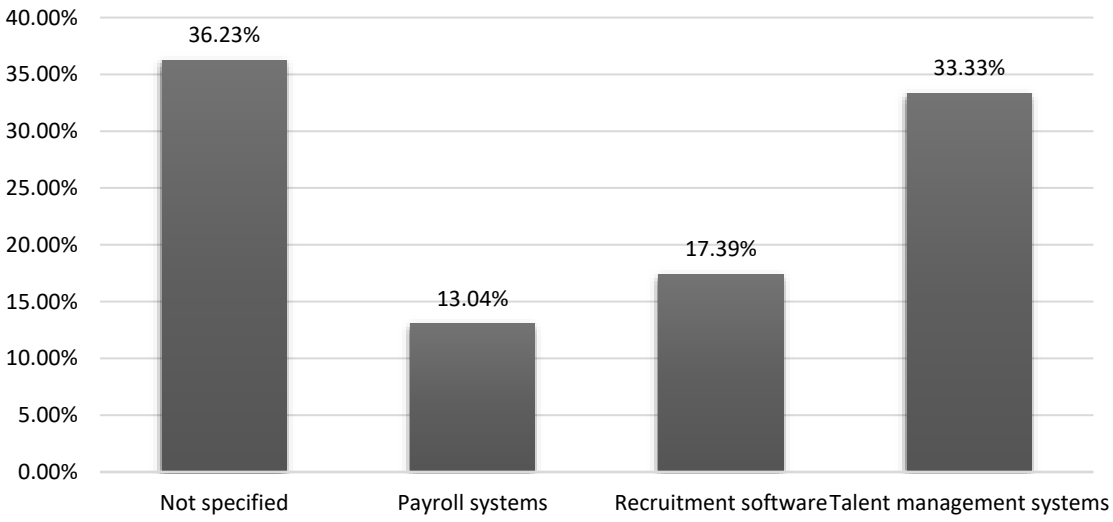

Figure 18. Utilization of Data Analysis Techniques.

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3.6. Reporting Biases

Figure 19 illustrates types of studies on the role of manufacturing operations in SMEs performance. Qualitative (14) studies focus on understanding experiences and challenges faced by SMEs in implementing manufacturing operations, while quantitative (33) research examines numerical data to statistically assess the impact of these operations on performance metrics like productivity and profitability. Exploratory studies (1), on the other hand, investigate emerging trends and factors in manufacturing operations within SMEs. Mixed methods (21) approach combines qualitative and quantitative techniques to offer a comprehensive analysis, revealing both statistical relationships and deeper contextual insights. Addressing these biases is important as it will lead to a better understanding of outcomes that come from research across different methods.

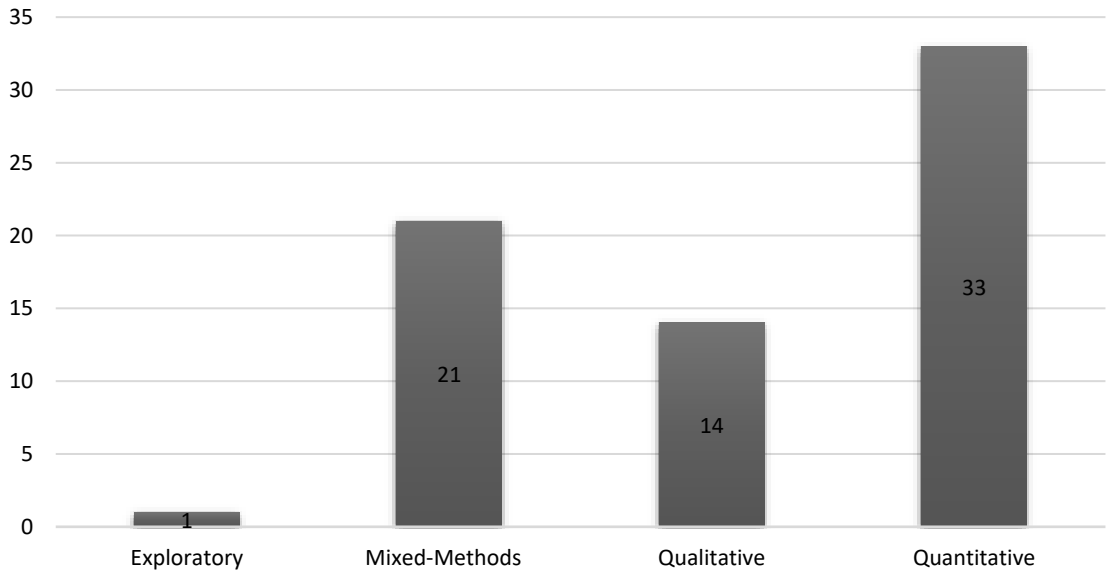

Figure 19. Types of study.

3.7. Certainty of Evidence

Figure 20 shows a visual that helps to highlight how the selection of data collection methods influences the reliability and strength of the studies' conclusions. It illustrates the distribution of various data collection methods used in the studies we reviewed to assess the role of manufacturing operations in SMEs performance.

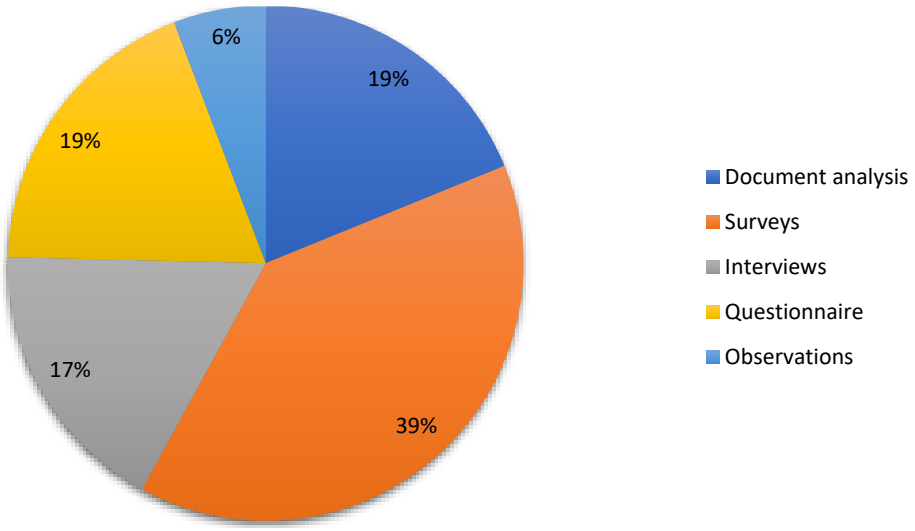

Figure 20. Distribution of Data Collection Methods.

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Surveys, which constitute 39%, are the most used method, representing the largest portion of studies. This method is useful for gathering quantitative data from a wide range of SMEs, allowing researchers to identify patterns and trends in how manufacturing operations affect SMEs. This quantitative approach facilitates the gathering of broad-ranging information about attitudes, behaviors, and demographic characteristics. The surveys contribute more to the certainty of the findings by giving data that contributes to the evidence to be reliable. Interviews make up 17% of the methods. Interviews provide a qualitative dimension by enabling researchers to engage in in-depth conversations with individuals or small groups. This method yields detailed perspectives and nuanced understanding of participants' experiences, motivations, and challenges. Interviewer's skills in guiding discussions and avoiding leading questions are critical to obtaining reliable information as biases can influence the certainty of the findings.

Document analysis makes up 19% of the methods used. This method involves the examination of existing documents such as reports, records, and datasets to extract relevant information. While this approach provides insights into the context and environment of SMEs, it may lack depth if the documents do not comprehensively address the research questions. Questionnaires that make up 19% involve asking participants specific questions to gather their responses. Often self-administered and structured, questionnaires allow for efficient data collection and facilitate straightforward statistical analysis. Observational makes up 6% of the method used. This involves researchers directly watching and recording behaviors or processes within SMEs. This method provides real-time data and can yield insights into workplace dynamics, interactions, and practices that may not be captured through self-reported data. Surveys provide the most reliable and consistent data, while document analysis and interviews are similar in providing data. Observations are less likely to be effective in the overall certainty of studies. By using these methods, we can be able to collect the most accurate data from different studies [70–79].

4. Key Findings and Strategic Implications for Business Leaders

This section presents an in-depth analysis of the key findings derived from the systematic review, highlighting critical insights into the role of manufacturing operations in enhancing the performance of small and medium-sized enterprises (SMEs). The review focuses on how optimizing production processes, adopting advanced manufacturing technologies (AMTs), and improving supply chain management can lead to significant improvements in operational efficiency, product innovation, and cost management. These insights provide actionable strategies for SME business leaders to leverage in order to enhance their competitive advantage and ensure long-term growth. The following table synthesizes these findings, pairing each one with strategic implications, opportunities, challenges, and expected outcomes, offering a clear guide for decision-making in the SME manufacturing context.

Table 11 outlines the pivotal role of strategic drivers such as lean manufacturing, advanced technology adoption, and effective supply chain management in driving SME performance improvements. Business leaders in various industries can utilize these findings to enhance their operations, reduce costs, and improve product quality and innovation. However, challenges such as high initial costs, technical expertise gaps, and resistance to change remain significant barriers. By carefully considering these strategic implications and aligning them with their specific industry needs, SMEs can unlock new opportunities for growth and sustainability, ultimately leading to better business outcomes such as increased productivity, operational efficiency, and customer satisfaction. This broad, cross-industry analysis provides a comprehensive framework for SMEs looking to optimize their manufacturing operations and gain a competitive edge.

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Table 11. Key Findings and Strategic Implications for Business Leaders.

Industry	Key Finding	Strategic Implications for Business Leaders	Opportunities	Challenges	Relevance to Proposed Systematic Review	Strategic Drivers	Expected Outcome
Manufacturing	Optimization of Production Processes	Adopt lean manufacturing and automation technologies to improve efficiency and reduce waste.	Increased productivity and cost reduction through streamlined processes.	High initial investment in automation technology, potential resistance to change.	Aligns with findings that production process optimization enhances efficiency and competitiveness in SMEs.	Lean manufacturing, automation adoption.	Enhanced operational efficiency, reduced waste, and increased production quality.
Automotive	Adoption of Advanced Manufacturing Technologies (AMTs)	Invest in Industry 4.0 technologies like IoT, AI, and robotics to drive innovation and responsiveness.	Ability to quickly adapt to market changes, enhancing product customization and innovation.	High costs and the need for a skilled workforce to manage and maintain advanced technologies.	Highlights the role of AMTs in enhancing product innovation and flexibility across various industries.	Industry 4.0, AI integration, IoT and robotics.	Increased flexibility, faster response times, and improved product innovation.
Textiles	Effective Supply Chain Management	Build strong supplier relationships and implement JIT inventory management to minimize costs and improve efficiency.	Reduced lead times, lower inventory costs, and better supplier coordination can lead to higher profit margins.	Complexity in managing supplier networks, reliance on external partners, and global supply chain disruptions.	Demonstrates how supply chain improvements can positively affect SME performance, especially in resource-constrained environments.	Supplier collaboration, JIT systems, inventory management.	Streamlined supply chain, reduced costs, and improved production and delivery times.
Electronics	Integration of Sustainable Manufacturing Practices	Adopt sustainability measures such as waste reduction, energy efficiency, and eco-friendly production techniques.	Expanding into green markets, attracting eco-conscious customers, and reducing operational costs in the long term.	Upfront costs of implementing sustainable practices, balancing sustainability with profitability.	Reflects the growing importance of sustainability in modern manufacturing and its direct influence on business performance.	Sustainability, green production, energy efficiency.	Increased sustainability, reduced environmental impact, and long-term cost savings.

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Food & Beverage	Product Quality and Safety Management	Enhance quality control and food safety standards to increase customer satisfaction and meet regulatory requirements.	Higher customer trust and loyalty, potential for premium pricing due to enhanced quality.	Regulatory compliance costs, maintaining consistent quality across diverse product lines.	Consistent with research showing that quality improvements drive customer retention and market competitiveness in SMEs.	Quality management, compliance with food safety standards.	Improved customer satisfaction, better regulatory compliance, and higher product quality.
Pharmaceuticals	Leveraging Data Analytics for Decision-Making	Use data analytics to optimize production schedules, inventory management, and demand forecasting.	Improved decision-making accuracy, reduced stockouts, and optimized production cycles to meet demand.	Need for specialized skills in data analytics, potential data security concerns.	Reiterates the importance of data-driven decisions in streamlining manufacturing operations and improving SME performance.	Data analytics, demand forecasting, inventory optimization.	Enhanced decision-making, better demand management, and more efficient production cycles.

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5. Proposed Decision-Making Framework for Implementation

In this section, we present a detailed decision-making framework that is specifically designed to guide Small and Medium Enterprises (SMEs) in implementing key manufacturing strategies for operational improvement. The framework outlined in Table 12 provides a structured approach, comprising six critical steps—Assessment, Planning, Resource Allocation, Execution, Evaluation, and Continuous Improvement. These steps align with the complexities of various industries, including Manufacturing, Automotive, Textiles, Electronics, Food & Beverage, and Pharmaceuticals.

The framework addresses specific needs and challenges faced by each industry in adopting advanced manufacturing technologies (AMTs), optimizing production processes, and streamlining supply chain operations. By adopting this comprehensive framework, SME leaders can strategically implement operational improvements while addressing resource constraints, market demands, and regulatory requirements. The framework provides flexibility, enabling SMEs to adjust their processes continually to meet business objectives, enhance performance, and maintain competitiveness in their respective industries.

Table 12. Proposed Decision-Making Framework for Implementation.

Industry	Step	Framework Focus	Key Features	Strategic Drivers	Expected Outcome	Ties to Proposed Study
Manufacturing	1. **Assessment**	Evaluating current operational and technological state	Data Collection, Operational Audits, Technology Assessment	Baseline understanding of resource constraints	Clear identification of inefficiencies and gaps in technology	Links with the study's focus on optimizing SME operations through lean manufacturing and agile processes
	2. **Planning**	Strategic process optimization	Objective Setting, Timeline Setup, Risk Assessment	Prioritizing critical processes	Roadmap for implementing lean manufacturing and AMTs	Aligns with research focus on planning improvements for operational efficiency and cost management
	3. **Resource Allocation**	Financial, human, and technological resource allocation	Budget Forecasting, Skills Mapping, Procurement	Efficient use of limited resources	Balanced distribution of necessary tools, skills, and funds	Supports study themes on optimizing resources in developing economies

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	4. **Execution**	Implementation of planned strategies	Employee Training, Process Monitoring, System Deployment	Operational Alignment, Monitoring Progress	Timely deployment of optimized manufacturing processes	Enhances study focus on executing strategies and measuring real-time results using data
	5. **Evaluation**	Performance assessment post-implementation	KPI Monitoring, Feedback Loops, Reporting	Continuous progress measurement	Identification of successful strategies and areas for improvement	Ties into the study's evaluation of performance through quantitative and qualitative measures
	6. **Continuous Improvement**	Long-term sustainability through iterative processes	Process Refinement, Regular Audits, Upgrades	Agile adaptation to market changes and tech updates	Continuous improvement in operational processes	Links to study conclusions on sustained improvements and market adaptation
Automotive	1. **Assessment**	Evaluation of production line efficiency	Technological Audit, Equipment Performance Review	Identifying inefficiencies in the production line	Clear understanding of automation gaps and opportunities for improvement	Aligns with research focus on industry-specific technology adaptation challenges
	2. **Planning**	Planning for automated production systems	Robotics, AI-based processes, Timeline Setup	Prioritization of automation processes	Efficient integration of robotics and AI systems	Supports strategic planning of resource-heavy sectors like automotive
	3. **Resource Allocation**	Allocating funding and technical resources	Capital Investment, Talent Acquisition, Procurement	Ensuring balanced distribution of capital for automation	Successful acquisition and implementation of advanced systems	Ties to resource allocation strategies in the study for

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	4. **Execution**	Deployment of advanced production technologies	Employee Training, Automation Setup, Process Monitoring	Aligning operations with automation strategies	Efficient deployment of robotic and AI systems	large-scale production sectors Reflects on successful execution strategies tailored to capital-intensive industries
	5. **Evaluation**	Monitoring production line improvements	KPI Measurement, Production Output Analysis	Tracking efficiency gains through automation	Data-driven identification of improvements	Enhances study's focus on evaluating post-implementation performance metrics
	6. **Continuous Improvement**	Iterative refinement of automated processes	Process Optimization, Regular Equipment Upgrades	Adapting to ongoing technological advancements	Continuous operational efficiency through automation	Ties into study's emphasis on continuous improvement for long-term industry sustainability
Textiles	1. **Assessment**	Reviewing operational efficiency and material usage	Operational Audits, Textile Quality Assessments	Identifying areas of waste reduction	Identification of high-waste areas and quality issues	Supports the study's goal to assess efficiency and material optimization in SMEs
	2. **Planning**	Streamlining textile production processes	Process Mapping, Production Scheduling, Resource Planning	Enhancing efficiency through streamlined processes	Effective scheduling and resource management	Aligns with research focus on improving textile production through planning

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	3. **Resource Allocation**	Allocating labor, machinery, and materials	Workforce Planning, Material Procurement, Budgeting	Effective use of workforce and materials	Reduced waste and improved production efficiency	Reflects on the importance of resource allocation strategies to optimize production
	4. **Execution**	Implementing lean production techniques	Employee Training, Process Monitoring, Resource Use	Minimizing production delays and waste	Timely and efficient production with reduced waste	Supports execution of lean manufacturing techniques for higher textile production quality
	5. **Evaluation**	Evaluating production efficiency post-implementation	KPI Monitoring, Material Usage Review, Production Output	Assessing reductions in material waste and delays	Increased efficiency and reduced material waste	Reflects the study's focus on using evaluation metrics to track success
	6. **Continuous Improvement**	Ongoing refinement of production processes	Regular Audits, Lean Refinement, Technology Upgrades	Maintaining competitive advantage through innovation	Continuous improvement in production efficiency	Ties to the study's focus on continuous optimization of manufacturing processes
Electronics	1. **Assessment**	Evaluating technology integration within production	Technological Gap Analysis, Process Audits	Understanding current tech limitations and identifying opportunities	Clear understanding of technology gaps	Aligns with the study's emphasis on technological integration in SMEs
	2. **Planning**	Integrating advanced manufacturing technologies	Robotics, IoT, AI, Process Mapping	Identifying and prioritizing key tech adoption areas	Roadmap for technology integration	Reflects on planning for Industry 4.0 adoption in electronics production

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	3. **Resource Allocation**	Allocating capital and technical resources	Budgeting for Robotics and AI, Skills Development	Balanced distribution of capital and human resources	Successful integration of IoT and AI technologies	Supports study focus on the allocation of capital and human resources for tech-heavy sectors
	4. **Execution**	Implementation of Industry 4.0 technologies	Employee Training, Process Monitoring, System Deployment	Aligning operations with technological strategies	Successful deployment of smart technologies	Ties into the study's focus on execution efficiency and real-time monitoring for electronics sectors
	5. **Evaluation**	Assessing technological impact on performance	KPI Monitoring, Production Output Analysis	Evaluating the performance of new technologies	Data-driven insights into tech-based efficiency gains	Enhances the study's focus on evaluating tech-driven results for SMEs
	6. **Continuous Improvement**	Iterative refinement of technology integration	Process Optimization, Regular Technology Audits	Staying up to date with rapid technological changes	Continuous efficiency improvements through technology	Ties into the study's conclusion on continuous refinement and technological adaptation
Food & Beverage	1. **Assessment**	Evaluating production and supply chain efficiency	Operational Audits, Quality Control Reviews	Identifying inefficiencies and areas for cost reduction	Clear identification of quality control and supply chain inefficiencies	Supports study focus on assessing SME supply chain and quality control challenges
	2. **Planning**	Planning for lean production and quality control	Process Mapping, Resource Planning,	Enhancing operational efficiency and maintaining quality	Efficient production planning and resource management	Reflects on strategic planning to balance production

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			Timeline Setup			efficiency with quality control
	3. **Resource Allocation**	Allocating human, material, and technical resources	Workforce Planning, Equipment Procurement, Budgeting	Effective use of workforce and equipment	Balanced resource distribution for high-quality production	Ties into study's focus on optimizing resources for food and beverage production
	4. **Execution**	Implementing lean production and quality control	Employee Training, Process Monitoring, Equipment Setup	Ensuring timely production and maintaining quality	Efficient production and high-quality output	Enhances study focus on executing lean strategies for food and beverage SMEs
	5. **Evaluation**	Evaluating quality control and supply chain processes	KPI Monitoring, Quality Output Review, Supply Chain Analysis	Assessing improvements in quality control and cost savings	Data-driven insights into supply chain and quality improvements	Reflects on the study's focus on evaluating quality control and operational efficiency in SMEs
	6. **Continuous Improvement**	Ongoing refinement of quality control processes	Regular Audits, Process Optimization, Tech Upgrades	Maintaining long-term quality control and cost efficiency	Continuous improvement in quality and supply chain efficiency	Ties into the study's conclusion on continuous refinement for long-term competitive advantage
Pharmaceuticals	1. **Assessment**	Evaluating compliance and operational efficiency	Regulatory Audits, Operational Reviews	Ensuring regulatory compliance and identifying inefficiencies	Clear understanding of compliance gaps and operational challenges	Links with study's focus on compliance and operational efficiency for SMEs
	2. **Planning**	Planning for regulatory compliance	Process			

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	and operational improvement				

The proposed decision-making framework aims to assist SMEs in effectively adopting manufacturing improvements tailored to their industry needs. Across industries like Manufacturing, Automotive, Textiles, Electronics, Food & Beverage, and Pharmaceuticals, the six-step framework highlights key focus areas, such as resource allocation and technological adoption. Each step emphasizes not only the strategic importance but also the specific drivers and expected outcomes for each industry. The framework underscores the continuous cycle of improvement, encouraging businesses to evaluate their processes regularly and make necessary adjustments to sustain operational efficiency and market relevance. This approach ties into the broader goals of the proposed systematic review, as it provides actionable insights for SMEs seeking to improve operational efficiency through structured decision-making processes. By applying these steps, SMEs can achieve tangible outcomes like enhanced productivity, cost savings, and product innovation—core to the study's overarching aim of improving SME performance in diverse economic contexts.

The concept of continuous improvement, rooted in methodologies like Kaizen and Total Quality Management (TQM), is essential for SMEs striving for long-term success and sustainability. This step is the final yet ongoing stage in the proposed decision-making framework, emphasizing the need for constant evaluation, learning, and refinement of processes. Across diverse industries such as Manufacturing, Automotive, Textiles, Electronics, Food & Beverage, and Pharmaceuticals, continuous improvement entails specific strategies tailored to their operational contexts. Continuous improvement plays a critical role in ensuring that SMEs stay competitive by identifying areas for operational enhancement, optimizing resource use, and implementing innovations.

Below, Table 13 breaks down the continuous improvement step for each industry, highlighting specific areas of focus, opportunities, challenges, and expected outcomes. This industry-specific breakdown illustrates how SMEs can foster a culture of ongoing improvements, driving efficiency, productivity, and adaptability.

Table 13. Industry-Specific Breakdown of Continuous Improvement Step.

Industry	Focus Areas	Opportunities	Challenges	Strategic Drivers	Expected Outcome
Manufacturing	Lean manufacturing, Kaizen, waste reduction	Improved operational efficiency, reduced waste	Resistance to change, lack of employee buy-in	Process optimization, cost savings	Higher productivity, reduced costs, minimized waste
Automotive	Process standardization, Six Sigma, automation	Increased production consistency, reduced defects	High cost of technological upgrades, supply chain integration	Quality management, process consistency	Enhanced product quality, reduced defects, faster production
Textiles	Sustainable manufacturing, lean supply chains	Reduced environmental impact, faster response to market trends	High investment in sustainable technologies	Sustainability, waste reduction	Increased sustainability, lower waste, improved efficiency
Electronics	Agile manufacturing,	Faster time-to-market, improved	Rapid technological	Agility, innovation,	Shorter lead times, greater

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	real-time data monitoring	product customization	changes, complex global supply chains	technological adoption	flexibility, improved innovation
Food & Beverage	Quality control, supply chain transparency	Increased food safety, improved customer trust	Compliance with regulatory standards, perishable goods management	Quality assurance, regulatory compliance	Improved product quality, enhanced customer satisfaction
Pharmaceuticals	GMP (Good Manufacturing Practices), risk management	Enhanced product safety, faster regulatory approvals	Stringent compliance requirements, high R&D costs	Compliance, risk management, quality control	Improved compliance, faster time-to-market, higher product quality

The table above demonstrates how continuous improvement is critical for SMEs across various industries, with unique focus areas and challenges tailored to their operational needs. In Manufacturing, the emphasis is on lean methodologies to reduce waste, while the Automotive sector focuses on process standardization and Six Sigma to boost quality. Textiles industries lean toward sustainability efforts, and Electronics prioritizes agility and technological innovation. The Food & Beverage and Pharmaceuticals sectors concentrate heavily on quality control and compliance with stringent regulations.

Each industry can leverage continuous improvement to drive operational enhancements, sustain competitiveness, and align with industry-specific strategic drivers such as innovation, process optimization, and regulatory compliance. This industry-focused approach to continuous improvement is highly relevant to the proposed study, as it provides SMEs with actionable frameworks for integrating best practices and achieving consistent, measurable outcomes.

6. Proposed Best Practices for Successful Implementation

Implementing tailored best practices is crucial for enhancing manufacturing operations and addressing the unique challenges SMEs face across different industries. Key strategies like automation, lean manufacturing, and digital transformation are essential for achieving efficiency, cost reduction, and competitive advantage. This section outlines best practices for six major industries—Manufacturing, Automotive, Textiles, Electronics, Food & Beverage, and Pharmaceuticals—addressing operational challenges and tying them to the findings of the systematic review.

Table 14 categorizes these practices by industry, focusing on the operational challenges they tackle, strategic drivers, and expected outcomes. Additionally, the practices are tied to the insights drawn from the systematic review, reinforcing their effectiveness for SMEs and showcasing their relevance in the broader context of operational excellence.

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Table 14. Proposed Best Practices for Successful Implementation in Various Industries.

Industry	Best Practice	SME Type	Operational Challenge	Strategic Drivers	Expected Impact	Ties to Systematic Review Findings
Manufacturing	Lean Manufacturing, Total Quality Management (TQM)	Small Manufacturing Enterprises	Waste reduction, quality consistency	Cost savings, operational efficiency	Reduced waste, higher productivity, improved quality	Review findings emphasize lean manufacturing as a top strategy for operational efficiency and waste reduction.
Automotive	Six Sigma, Robotics Process Automation (RPA)	Medium Automotive Enterprises	Process consistency, defect reduction	Precision engineering, process optimization	Improved process quality, reduced defect rates	Automation and Six Sigma are highlighted for ensuring high precision and reducing production defects.
Textiles	Sustainable Manufacturing, Green Supply Chains	Small Textile Enterprises	Sustainability, resource conservation	Environmental compliance, resource management	Reduced environmental impact, lower resource costs	Sustainability is key in textiles, aligning with systematic review insights on green manufacturing.
Electronics	Agile Manufacturing, Digital Twin Technology	Medium Electronics Enterprises	Production flexibility, real-time monitoring	Innovation, agility, technological advancements	Enhanced flexibility, improved time-to-market	Systematic review supports agile manufacturing to improve flexibility and

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						responsiveness in dynamic industries like electronics.
Food & Beverage	HACCP (Hazard Analysis Critical Control Point), Automated Quality Control	SMEs in Perishable Goods	Food safety, inventory management	Regulatory compliance, customer satisfaction	Enhanced food safety, reduced spoilage, better inventory control	Review findings stress automated quality control and regulatory compliance as critical to this sector.
Pharmaceuticals	Good Manufacturing Practices (GMP), Process Analytical Technology (PAT)	Small Pharmaceutical Enterprises	Compliance, product safety	Regulatory compliance, risk management	Improved product quality, faster regulatory approvals	Pharmaceutical industry benefits from GMP and PAT as confirmed by the review's focus on stringent compliance and quality.

The proposed best practices across industries illustrate the effectiveness of strategic operational measures in optimizing performance, reducing waste, and enhancing product quality. Each industry is encouraged to adopt practices tailored to its specific needs, such as lean manufacturing for waste reduction in Manufacturing or HACCP for safety in Food & Beverage. Tying these practices to the findings of the systematic review reinforces their relevance, as the review highlighted the need for efficiency, flexibility, and compliance across various sectors.

By aligning industry practices with systematic review insights, SMEs can adopt data-driven strategies that maximize operational efficiency and maintain competitiveness. These practices are not only proven but also adaptable, ensuring that SMEs can stay ahead of industry changes and technological advancements.

7. Proposed Metrics and KPIs for Measuring Performance

For SMEs operating in diverse industries, prioritizing the correct metrics and KPIs is essential for evaluating performance and making strategic decisions. By focusing on specific, high-impact KPIs, business leaders can improve operational efficiency, product quality, compliance, and customer satisfaction. As shown in Table 15, this section outlines a table of key metrics and KPIs for six industries—Manufacturing, Automotive, Textiles, Electronics, Food & Beverage, and Pharmaceuticals—focusing on which metrics should be prioritized first for optimal performance outcomes.

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Table 15. Proposed Metrics and KPIs for Measuring Performance in Various Industries.

Industry	Key Metrics/KPIs	Measurement Focus	Strategic Drivers	Expected Outcome	Ties to Systematic Review Findings	Priority (1 = Highest)
Manufacturing	- Overall Equipment Effectiveness (OEE) - Defect Rate - Cycle Time	Machine productivity, quality, and efficiency	Cost reduction, operational efficiency	Increased equipment uptime, lower defects, faster production	Systematic review highlights OEE and defect rate as critical in evaluating lean manufacturing and automation efforts.	1: OEE 2: Defect Rate 3: Cycle Time
Automotive	- First Pass Yield (FPY) - Scrap Rate - Downtime	Product quality, resource utilization, and downtime	Process optimization, cost savings	Reduced scrap, increased product quality, less production downtime	Metrics like FPY and downtime closely align with the review's focus on improving efficiency through process control and automation.	1: FPY 2: Scrap Rate 3: Downtime
Textiles	- Yield Efficiency - Energy Consumption per Unit - Order Lead Time	Resource utilization, energy use, and supply chain responsiveness	Environmental sustainability, operational efficiency	Higher resource efficiency, faster lead times, reduced energy costs	Sustainability metrics and lead time reduction are key recommendations from the systematic review for textile SMEs.	1: Yield Efficiency 2: Energy Consumption 3: Order Lead Time
Electronics	- Time to Market - Inventory Turnover - Product Return Rate	Innovation speed, supply chain efficiency, product quality	Agility, responsiveness, technological advancement	Faster time-to-market, reduced returns, optimized inventory levels	The review highlights agility and inventory management as crucial for electronics SMEs adopting advanced technologies.	1: Time to Market 2: Inventory Turnover 3: Product Return Rate
Food & Beverage	- Compliance with Regulatory Standards (e.g., FDA)	Compliance, waste reduction, and supply	Regulatory compliance, customer satisfaction	Reduced waste, higher compliance	Review findings emphasize regulatory compliance and	1: Compliance 2: Waste per Production

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	- Waste per Production Unit - On-Time Delivery Rate	chain reliability		rates, timely deliveries	waste reduction as critical KPIs in the food and beverage industry.	Unit 3: On-Time Delivery
Pharmaceuticals	- Right First Time (RFT) - Batch Cycle Time - Regulatory Audit Findings	Product quality, process efficiency, and compliance	Risk management, regulatory adherence	Reduced rework, faster batch processing, improved compliance	The review highlights the importance of compliance and efficiency in pharmaceutical operations.	1: RFT 2: Batch Cycle Time 3: Audit Findings

This table provides a structured approach to identifying key performance metrics for six major industries, highlighting which metrics should be prioritized to drive improvement in operational efficiency and business outcomes. Prioritizing metrics such as Overall Equipment Effectiveness (OEE), First Pass Yield (FPY), and compliance with regulatory standards ensures that businesses can immediately address critical areas like production efficiency, quality, and regulatory adherence. In tying these metrics to the findings of the systematic review, the focus remains on practical, high-impact areas of improvement that align with industry-specific challenges and operational realities. Monitoring these prioritized metrics will allow SMEs to drive continuous improvement and adapt to changing market demands more effectively.

9. Related Real Case Studies

The value of theoretical frameworks and proposed strategies in any industry is validated through real-world application. As shown in Table 16 in this section, we provide case studies from six key industries—Manufacturing, Automotive, Textiles, Electronics, Food & Beverage, and Pharmaceuticals—demonstrating the effectiveness of practices such as automation, lean manufacturing, and digitalization. These case studies illustrate how various SMEs have successfully implemented the best practices discussed earlier, showing measurable improvements in productivity, efficiency, cost savings, and regulatory compliance. Each case study offers insights into specific challenges and outcomes, making the lessons applicable for other SMEs aiming for operational excellence.

Table 16. Real Case Studies from Various Industries and Their Outcomes.

Industry	Case Study	Implementation	Outcome	Reference
Manufacturing	Siemens – PCB production with AI and automation	AI-enhanced automation and robotics for more efficient production control in PCB manufacturing.	Significant reductions in production time and waste, enhanced flexibility.	[Link]
Automotive	Bosch – Smart factories and AI in automotive manufacturing	Integration of AIoT for production and logistics automation,	Higher product quality, reduced production errors,	[LINK]

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		predictive analytics, and robotics.	and increased flexibility.	
Textiles	Levi's – Advanced manufacturing with lasers for textile finishing	Laser technology for sustainable textile finishing, reducing chemical use and improving speed.	Decreased production time, reduction in environmental impact.	[LINK]
Electronics	Samsung – AI-driven automation in electronics assembly	Automation of assembly lines using AI for better precision and reduced human error.	Enhanced precision, reduced assembly time, and improved product consistency.	[LINK]
Food & Beverage	Coca-Cola – Use of IoT and AI for supply chain and production optimization	AI and IoT to optimize bottling operations and supply chain efficiency.	Optimized production scheduling, reduced downtime, and improved quality.	[LINK]
Pharmaceuticals	Pfizer – Advanced data analytics and AI for drug manufacturing	AI-powered drug formulation and predictive analytics for efficient drug production.	Reduced R&D time, increased efficiency in drug production and quality control.	[LINK]

These real-world case studies provide tangible examples of how SMEs across various industries have successfully implemented practices such as lean manufacturing, automation, and regulatory compliance measures. The outcomes achieved—including reduced waste, improved time-to-market, and higher compliance rates—closely tie to the proposed strategies in the systematic review. For businesses looking to optimize their operations, these cases illustrate the real-world applicability of the practices outlined in this review, offering a roadmap for future improvements and operational excellence.

10. Proposed Roadmap for SMEs Businesses and Policy Recommendations

The proposed roadmap for SME adoption of best practices in various industries aims to align strategic initiatives with established policy frameworks as shown in Table 17. By linking the roadmap to national and international policies, SMEs can effectively navigate complex regulatory environments, leverage available government support, and ensure long-term sustainability. The inclusion of industries like manufacturing, automotive, textiles, electronics, food and beverage, and pharmaceuticals reflects the diverse sectors that can benefit from policy-aligned roadmaps, ensuring competitiveness and innovation.

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Table 17. Proposed Roadmap for SMEs Businesses and Policy Recommendations Linked to Policy Frameworks.

Industry	Roadmap Focus	Policy Framework	Strategic Link	Strategic Drivers	Expected Outcome	Ties to Proposed Study
Manufacturing	*Adoption of Lean Manufacturing and IoT*	South Africa's **National Industrial Policy Framework (NIPF)**	NIPF supports industrial growth through increased productivity, enabling lean manufacturing and IoT adoption for efficiency improvements.	Innovation, Tech Adoption, Operational Efficiency	Improved operational efficiency, cost savings	Aligns with lean manufacturing and IoT application findings from the review, focusing on SME growth.
Automotive	*Automation and Robotics Integration*	**Automotive Production and Development Programme (APDP)**	The APDP incentivizes the adoption of robotics and automation by providing subsidies for technology upgrades to increase productivity.	Automation, Robotics, Competitive Advantage	Increased productivity, reduced costs, improved vehicle quality	Automation links with advanced technology adoption in SMEs, particularly in highly competitive industries.
Textiles	*Digitalization and Sustainable Practices*	**Sustainable Development Goals (SDGs)**(UN) - Goal 12 (Responsible Consumption)	Aligns with SDG 12, which promotes sustainable production and the adoption of clean technology to reduce	Sustainability, Digital Transformation, Clean Production	Enhanced market positioning, reduction in waste	Supports the systematic review's focus on sustainable manufacturing in developing economies.

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			environmental impact. Supports digital and AI advancements to ensure high-quality production while maintaining compliance with environmental policies.			
Electronics	*AI-Enhanced Quality Control and Automation*	**National Development Plan (NDP)** - Chapter 5 (Environmental Sustainability)		AI Integration, Quality Control, Tech-Driven Growth	Improved product quality, compliance with environmental standards	Direct correlation with advanced manufacturing technology findings, including AI for SMEs.
Food & Beverage	*AI for Inventory and Supply Chain Optimization*	**Agriculture and Agro-Processing Master Plan (AAMP)**	AAMP promotes the use of AI and digital tools in managing supply chains to reduce food wastage and optimize production cycles.	AI, Supply Chain Management, Inventory Optimization	Reduced wastage, improved supply chain efficiency	Related to supply chain management and its impact on performance metrics in SMEs, per review findings.
Pharmaceuticals	*AI and Automation for Drug Production*	**Medicines and Related Substances Act**	The regulatory framework promotes the use of AI to enhance drug development and production efficiency, in line with compliance standards.	Automation, AI for Production, Compliance	Increased drug production efficiency, cost reductions	Reinforces findings around advanced manufacturing and regulatory alignment in pharmaceuticals.

Incorporating policy frameworks into the roadmap provides SMEs with a structured path to implementing advanced manufacturing technologies, automation, and sustainability practices. Each industry's strategic focus aligns with policy incentives, enhancing the likelihood of success. By following the roadmap, SMEs can achieve outcomes such as improved operational efficiency, cost

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savings, market positioning, and environmental compliance. This alignment with existing policy frameworks ties into the systematic review's findings, which highlight the importance of integrating technology and sustainability for SME growth and performance improvement. The roadmap is a critical tool for guiding SMEs through technological upgrades while ensuring that they adhere to national and international regulations, fostering a supportive ecosystem for long-term success.

7. Discussion

This systematic review explores the significance of manufacturing operations in enhancing the performance of Small and Medium Enterprises (SMEs), with a focus on critical aspects such as operational efficiency, sustainability, and financial outcomes. The findings reveal that SMEs benefit considerably from adopting effective manufacturing practices like lean manufacturing and digital technologies, which in turn contribute to their overall competitiveness and profitability. Incorporating sustainable practices has also led to positive impacts from both economic and environmental perspectives, aligning with global shifts toward sustainable manufacturing.

RQ1: What role do emerging technologies (AI, Industry 4.0) play in enhancing manufacturing operations in SMEs?

Emerging technologies such as Artificial Intelligence (AI) and Industry 4.0 have revolutionized manufacturing operations in SMEs by improving operational efficiency, reducing costs, and fostering innovation. These technologies assist SMEs in optimizing production schedules, managing inventory, and enhancing decision-making through predictive analytics. However, smaller SMEs often face financial and technical limitations that hinder the adoption of these technologies. While larger firms are better positioned to leverage these innovations, smaller firms may struggle without targeted support.

To overcome these challenges, it is crucial for business leaders to integrate scalable AI solutions that can evolve as their firms grow. Policymakers should also promote initiatives that provide training, funding, and resource-sharing platforms for SMEs, enabling them to maximize the potential of emerging technologies. These recommendations aim to reduce the digital divide and ensure that SMEs, regardless of size or location, can fully benefit from technological advancements, thereby contributing to a more inclusive digital economy.

RQ2: How do advanced manufacturing technologies influence SME productivity and profitability across different industry sectors?

Advanced manufacturing technologies (AMTs), including AI and Industry 4.0, have shown significant potential in enhancing productivity and profitability across various industry sectors. However, the extent of these benefits varies depending on factors such as firm size, industry type, and geographic location. Larger SMEs are often better equipped to adopt these technologies due to better financial resources and technical expertise. In contrast, smaller SMEs, especially those in underdeveloped regions, face barriers such as inadequate digital infrastructure and limited access to financial support.

This digital divide can exacerbate competitiveness disparities between larger, better-resourced SMEs and smaller ones. Policymakers should therefore focus on enhancing access to digital infrastructure, offering financial incentives, and facilitating public-private partnerships to ensure that all SMEs can adopt and benefit from AMTs. These strategies will help bridge the gap and promote more equitable growth across the SME sector.

RQ3: How does effective supply chain management influence key performance indicators (KPIs) in SME manufacturing operations, such as lead time, inventory turnover, and cost efficiency?

Effective supply chain management (SCM) plays a pivotal role in improving key performance indicators (KPIs) such as lead time, inventory turnover, and cost efficiency in SME manufacturing operations. Large firms often have the advantage of established supplier relationships and financial resources, enabling them to optimize their supply chains more effectively. In contrast, smaller SMEs face challenges such as limited financial and human capital, regional disparities in infrastructure, and reliance on outdated technologies.

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For SMEs to improve their SCM practices, managers should incorporate predictive analytics for demand forecasting, engage in long-term supply contracts, and adjust practices to their specific industry and location. Policymakers can support these efforts by subsidizing regional transport and logistics, promoting the formation of SME clusters, and offering supply chain development training. This approach can help SMEs overcome logistical challenges and improve overall supply chain performance.

RQ4: What are the quantifiable effects of lean manufacturing on the operational efficiency of SMEs in developing economies?

Lean manufacturing has proven to be an effective strategy for improving operational efficiency in SMEs, particularly in developing economies. By minimizing waste, reducing lead times, and streamlining production processes, lean practices enable SMEs to increase productivity and profitability. However, smaller firms often lack the resources to implement lean methodologies fully, leading to disparities in operational efficiency compared to larger firms.

To address these challenges, SMEs should focus on gradual lean implementation, starting with small-scale process improvements and scaling up as resources allow. Policymakers can support this by offering financial incentives for lean adoption and promoting training programs that equip SMEs with the necessary skills to implement lean methodologies. These efforts will enhance the competitiveness of SMEs in developing economies, enabling them to achieve significant gains in operational efficiency.

RQ5: What measurable effects does manufacturing process optimization have on customer satisfaction scores and product quality indicators in SMEs?

Manufacturing process optimization has a direct and measurable impact on customer satisfaction and product quality in SMEs. By eliminating inefficiencies and improving production accuracy, SMEs can enhance product reliability and customer satisfaction. However, the effectiveness of these optimizations depends on factors such as firm size, industry type, and regional market conditions. Smaller SMEs, in particular, may face challenges in accessing the necessary data and resources to fully optimize their processes.

To maximize the benefits of process optimization, SME leaders should invest in employee training, adopt advanced technologies, and seek customer feedback on product improvements. Policymakers can support these initiatives by providing incentives for technology adoption and facilitating access to best practices in manufacturing efficiency. These strategies will help SMEs improve product quality and customer satisfaction, enabling them to remain competitive in saturated markets.

8. Conclusions

This systematic review has comprehensively explored the role of manufacturing operations in enhancing the performance of Small and Medium Enterprises (SMEs), with a particular focus on operational efficiency, financial outcomes, sustainability, and customer satisfaction. It is evident that SMEs benefit significantly from implementing lean manufacturing practices, adopting advanced technologies like AI and Industry 4.0, and optimizing supply chain management. These strategies improve productivity, reduce operational costs, and enhance product quality, leading to increased customer satisfaction and competitiveness.

However, the review also highlights several challenges that SMEs face, particularly smaller firms in developing economies. These businesses often struggle with resource limitations, inadequate digital infrastructure, and limited access to emerging technologies, which can hinder their ability to fully capitalize on the benefits of process optimization and technological innovation. As a result, a digital divide is emerging, where larger and better-resourced firms are advancing more rapidly, while smaller SMEs lag behind. To bridge this gap, a concerted effort is required from both business leaders and policymakers. Business leaders should prioritize scalable, gradual implementation of advanced manufacturing technologies, coupled with workforce training and customer feedback to continuously refine their operations. Policymakers, on the other hand, need to create enabling environments through financial incentives, infrastructure development, and platforms that facilitate

knowledge-sharing among SMEs. Additionally, targeted programs that provide SMEs with access to digital tools and training are crucial for fostering inclusive growth across the sector.

Ultimately, the integration of lean practices, digital technologies, and sustainable manufacturing strategies not only enhances the operational performance of SMEs but also contributes to their long-term viability and competitiveness in a globalized market. With the right support and strategic focus, SMEs can unlock significant opportunities for growth, innovation, and sustainability, ensuring their continued relevance in the evolving industrial landscape.

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