

Integration of Lean Six Sigma and Green Productivity for Manufacturing SMEs

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Abstract: A small manufacturing company is a small entity that functions like a business. In the current era of industrial revolution, SMEs need to remain competitive in order to improve production efficiency and reduce operating costs. Continuous operations improvement efforts have motivated researchers to find a method that is suitable for SMEs. In this context, Green Lean has emerged as an integral part. The Green Lean debate in midsize manufacturing is still in its infancy and needs attention. Therefore, the main objective of this study is to use systematic data to identify and analyze the success factors, framework conditions and advantages of Green Lean in medium-sized manufacturing industry. A systematic model shows the relationships between the determinants of implementing green and lean initiatives for SME manufacturing. Lack and performance measurement are the main challenges in implementing Green-Lean. Additionally, most frameworks are designed for specific industries rather than general frameworks to reduce and eliminate various wastes. However, this framework has lost its social dimension. The main contribution of this paper is the integration framework lean six sigma - green productivity for SMEs in manufacturing. These results will help institutions, owners, and small businesses take action for improvement.

1 INTRODUCTION

Organizations are under constant pressure to improve their performance in today's competitive environment (Hang et al., 2022). One way to improve organizational performance is to implement an improvement strategy (Rehman Khan et al., 2022). Existing resources can mobilize operational problems through continuous improvement strategies (Bernal Torres et al., 2021). Moreover, the development method considers that all companies are not homogeneous. SMEs have their very own demanding situations because of a loss of size and sources compared to large companies (Albats et al., 2021). However, SMEs are dynamic and growing businesses have unique characteristics and features (Miller et al., 2021). It is widely recognized that SMEs generally differ from large companies in that they have less debt, and scale and resource constraints (both human and financial) impact core competencies and skills (Miller et al., 2021).

One of the most popular approaches to improving operational performance in manufacturing organizations is lean six sigma. Continuous improvement is believed to be a method for identifying and eliminating waste and optimizing the use of resources (Gaikwad & Sunnapwar, 2020). Current concerns about the environmental impact that has occurred in the company, changing the company's operational approach to complying with environmental regulations and responding to growth in customer demands for sustainable products and services (Siegel et al., 2019). Thus, the "green" paradigm emerged, as an operational philosophy and approach that improves an operation's ecological efficiency, reducing the negative impact of services or products on the environment while maintaining or improving financial performance (Bhattacharya et al., 2019).

Many studies have examined the natural alignment of lean and green through similar operational management approaches. Therefore, researchers suggest compatibility between lean and

green and that the two can work together effectively to positively impact the environment and operational performance (Teixeira et al., 2022). As such, researchers have proposed compatibility between lean and green so that they can work together effectively to positively impact the environment and operational performance (Inman & Green, 2018). According to (Siegel et al., 2019), both lean and green will sustainably increase the competitiveness of SMEs. Available survey data show that SMEs are responsible for most of the industrial pollution and contribute significantly to environmental degradation (Hasan et al., 2020). To achieve this, SMEs should consider economic, environmental and social issues by starting green and lean adoption. The literature extensively shows that lean practices positively impact green performance (Touriki et al., 2022). However, little research has been done on SMEs (Touriki et al., 2022). Moreover, implementation in the SME context remains challenging as it requires substantial financial resources, skills, and time (Alexander et al. 2021). Moreover, according to various experts, no clear research definition of lean green in SMEs has been established. The literature on this topic is still incomplete and needs to be reconstructed. SMEs face many obstacles in mobilizing the resources required to implement lean green strategies (Yadav and Gahlot 2022). SMEs need multiple guidelines, including identifying challenges, benefits, frameworks, and critical success factors to encourage SMEs to implement lean and green projects to improve sustainable performance. The lack of research to develop a lean-green implementation framework for SMEs is an important motivation to take up this research area (Siegel et al., 2022). This study aims to develop a conceptual framework for the application of lean green in SME manufacturing. Therefore, starting from this lack of knowledge, we propose strategies for sustainable approaches in the context of SMEs through a theoretical framework, systematically collecting and analyzing relevant lean and green areas. A literature search was conducted. Against this background, the research objectives are formulated as follows:

- (1) Identify and explore the characteristics and relationships of Lean Six Sigma with Green Productivity;
- (2) Identify operational practice gaps and opportunities to integrate Lean Six Sigma linkages with Green Productivity, focusing on SME operations in the manufacturing sector;
- (3) Propose an integrated strategy for Lean Six Sigma - green productivity in the context of SMEs through a theoretical framework.

The rest of the paper is organized as follows. Section 2 presents the research methodology. Section 3 provides detailed findings and considerations. Finally, Section 4 contains the study conclusions.

2 METHODOLOGY

This research framework uses systematic literature reviews (SLR) compiled to categorize common data and information sources examined in this study. A systematic literature review (SLR) is about lean green conducted through a structured process by reviewing selected articles from various databases and sources. SLR provides a comprehensive, transparent and explicit approach to rigorously enforcing the process (Thomé et al., 2016). SLR is a method of identifying, discovering, and synthesizing research results completed and produced by researchers and practitioners (Lima et al., 2020).

Search engines, Elsevier (www.sciencedirect.com), Emerald (http://www.emeraldinsight.com), Springer (http://www.springerlink.com), Taylor & Francis (http://www.taylorandfrancis.com) and online libraries Google Scholar database or library services such as Wiley (www.wiley.com), Ebsco (www.ebsco.com), Scopus (www.scopus.com), where relevant find Journal article for this study. Strings include (Lean), (Green), (Green and Lean), (Lean Green), (SME), (Small and Medium Business), (Manufacturing), and (Sustainability). As a result, these search terms are combined with Boolean operators (AND and OR) when searching keywords, titles, abstracts, and full article text. This approach is very important for a complete and thorough literature investigation. The search is considered complete when the same article continues to appear.

All article summaries in your search string are manually checked for maximum consistency. A final sample of 35 items was identified. As research in this area is still in its infancy, the amount of referenced literature is relatively limited, especially when compared to the vast amount of research in the lean environment field. It can therefore be argued that the literature lacks a clear and structured research definition of Greenlean. Articles with irrelevant abstracts were not used in this research report due to a strict search for terms used to identify relevant articles.

The SLR approach is shown as in figure 1. While the literature review process is shown in table 1.

Photovoltaic is a technological innovation designed to capture solar energy to convert it into

electrical energy that is greater than battery energy. Although the SCC regulates the power that comes out of the PV, the SCC is to control the voltage that will enter the battery (Setyono et al., 2022). In this research, a 100WP capacity solar panel will be explored. The PV specification data used is in table 1. When testing PV, several parameters are taken, including temperature, solar radiation, voltage, and electric current.

Table 1: Systematic literature review process.

Process	Defintion	Number of articles
Research purposes	Identify the intent and purpose of the review	
Develop research protocol	Asking research questions in advance, including evaluation scope, criteria, quality and data extraction.	
Determine the relevant criteria	Establish research criteria that are only relevant articles	
Search and collect literature	Search for relevant articles from indexed journal sources	Total 220 articles
Selection and study	The definition of criteria does not include articles that are irrelevant	95 relevant articles
Evaluate the quality of relevant studies	Depending on the research method used, rate the quality of each article. Articles that are not qualified should be removed	
Data extraction	Extract data systematically from each study in the overview. This stage can be divided into several steps, starting from finding the title of the article, abstracting it to then reviewing the article in full to analyze the content of the article topic	
Analyze (synthesize) data.	Using quantitative and/or qualitative techniques, combining the facts obtained and illustrating the main conclusions of the analysis	35 articles were analyzed
Write a review result	A detailed report on the process and results of a systematic literature search	

Process	Defintion	Number of articles
Discuss and conclude	Contribute to knowledge by publishing the results of a systematic literature review in academic scientific journals.	

In this sense, only articles published between 2002 and 2020 are included. Finally, all books, websites, conference papers, and grey literature, such as reports and working papers, were excluded from the research review, and only papers published in high-quality journals were considered

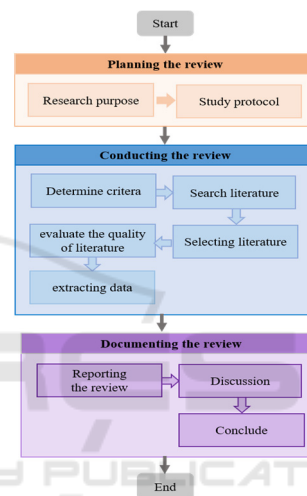


Figure 1: Research process.

3 RESULT AND DISCUSSION

Lean and Green have become very popular in recent years (Leong et al., 2019). Lean and Green are two approaches to develop in different contexts. Both are synergistic and compatible strategies as they share a common focus on waste reduction and efficient use of resources (Gaikwad and Sunnapwar 2020). As a result, the principles and tools of both approaches have been combined into an improvement approach known as “lean green” to achieve operational excellence and sustainability (Gaikwad and Sunnapwar 2020).

Green Lean is an integrated approach to achieving environmental, financial and operational improvements (Gholami et al., 2021). Integrating green and lean can be seen as a new way for companies to improve their sustainability performance. According to (Lim et al., 2022), an

organization that has implemented lean and green practices simultaneously achieves better results than an organization that focuses on just one of these initiatives.

After demonstrating the limitations of the lack of a complete and structured lean and green framework in the context of SMEs, we apply two approaches based on a combination of theoretical elements from the literature review. We propose a specific integration framework for a framework for Integrating lean six sigma - green productivity methods to increase the productivity of small and medium enterprises (SMEs) in manufacturing. The framework illustrated in Figure 2 describes the critical elements needed for SMEs to be environmentally friendly, socially conscious and ensure sustainable profitability through cost savings.

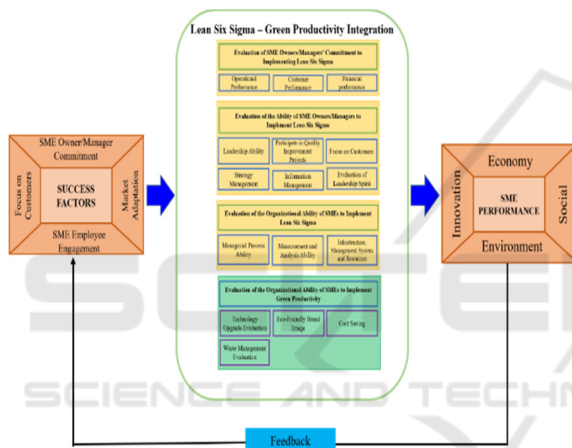


Figure 2: Lean Six Sigma - Green Productivity Integration Framework for Manufacturing SMEs

Green Lean integration is a critical phenomenon in the the framework. Success factors act as inputs to critical phenomena, and SME performance is viewed as output. Green Lean integration challenges in the context of SMEs are guided, and efforts to improve organizational performance are guided. Below is a discussion of the theoretical elements that emerge from the literature.

We describe the success factors for some areas that organizations need to pay more attention to effectively implement and sustain their Green Lean efforts (see Table 2). Small business owners or managers should encourage industry policymakers to focus on key factors for implementing integrated lean and green production in resource-constrained small businesses.

We support. SME managers can prioritize resources for the successful implementation of Lean

Green initiatives. Every article, without exception, involves SME owner/manager commitment as an essential factor for success (Baumer-Cardoso et al. 2020; Gandhi et al., 2018; Khana et al., 2020; Thanki et al., 2019; Yadav et al., 2018; Fatoki 2019; Aboelmaged & Hashem, 2019 ; Yuik et al., 2020; Aboelmaged et al., 2018).

Employee motivation is involved in integration, company goals and strategies, reviews and audits, vision and guidance by a lean, green and sustainable framework. Every article, without exception, involves employee engagement as an essential factor for success (Thanki and Thakkar 2018; Khana et al., 2020; Gandhi et al., 2018; Siegel et al., 2022; Caldera et al., 2019).

Within this group, various development processes have been identified that enable current technologies to address the unmet needs of new customers. Managers must enable cross-functional teams to discover new technologies with numerous pioneering partners.

The ideal sequence suggested to them is to achieve this by organizing the project learnings and structuring the development process to meet the changing market needs. Every article, without exception, involves market adaptation as an essential factor for success (Kasali, Ö. 2010; Mosey, S. 2005; Kumar, K. et al., 2012; Sui, S. et al., 2014; Bourletidis, K et al., 2013; Hussain et al., 2015; Fuchs et al., 2016; Neirotti et al., 2017).

The most straightforward approach is to think of lean as the activity of identifying and eliminating waste to add value to the organization and customers. Six sigma is a robust statistical methodology for reducing variation and improving quality and customer satisfaction. When lean, green, and safe are aligned, the organization, its customers and the environment all benefit. Every article, without exception, involves focus on customer as an essential factor for success (Nabhani & Shokri, 2009; Alhuraish et al., 2014; McAdam et al., 2019; Sharma et al., 2015; Amar & Davis, 2008; Nallusamy, 2016; Mustapha et al., 2018).

Table 2: Success factors for green-lean

Article	Success factor
(Baumer-Cardoso et al. 2020; Gandhi et al., 2018; Khana et al., 2020; Thanki et al., 2019; Yadav et al., 2018; Fatoki 2019; Aboelmaged & Hashem, 2019 ; Yuik et al., 2020; Aboelmaged et al., 2018)	SME owner/manager commitment. Small business owners or managers should encourage industry policymakers to focus on some key factors for implementing integrated lean and green production in resource-constrained small businesses. We support. SME managers can prioritize resources for the successful implementation of Lean Green initiatives.
(Thanki and Thakkar 2018; Khana et al., 2020; Gandhi et al., 2018; Siegel et al., 2022; Caldera et al., 2019)	SME employee engagement. Employee motivation is involved in integration, company goals and strategies, reviews and audits, vision and guidance by a lean, green and sustainable framework.
(Kasali, Ö. 2010; Mosey, S. 2005; Kumar, K. et al., 2012; Sui, S. et al., 2014; Bourletidis, K et al., 2013; Hussain et al., 2015; Fuchs et al., 2016; Neirotti et al., 2017)	To adapt to the market, managers should empower cross-functional teams to discover new technologies and systematize project learning to meet changing market needs.
(Nabhani & Shokri, 2009; Alhuraish et al., 2014; McAdam et al., 2019; Sharma et al., 2015; Amar & Davis, 2008; Nallusamy, 2016; Mustapha et al., 2018)	Focus on customer. The simplest approach is to identify and eliminate waste and think of lean as an activity that creates value for your business and your customers. Six sigma is a robust statistical methodology for reducing variation and improving quality and customer satisfaction. When lean, green, and safe are aligned, the organization, its customers and the environment all benefit.

4 CONCLUSIONS

The details of the results of the proposed integration framework for the Lean Six Sigma – Green Productivity method for SMEs are as follows:

1. Provide a positive influence on people (leaders and employees such as motivating, empowering, energizing, compensating, and educating. It will have a positive impact on the level of satisfaction and commitment of leaders/managers and employees.
2. Save time and flexibility in the production process flow, improve process management improvements, and increase customer loyalty and satisfaction.
3. Cost savings, productivity gains, increased market share, customer retention (maintaining long-term sustainable business relationships with customers), reduced cycle times, reduced errors, cultural change, and product/ Development of services.
4. The strong positive influence of SME owners/managers on employees will create an adaptive management hierarchy layer so that internal organizational communication becomes faster and more effective. It will promote more substantial and better relationships with customers.
5. Identify and reduce waste and hidden costs and eliminate the level of defective products, thereby reducing operational costs. It positively impacts profit margins, SME business growth/development, and customer value.

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