Green and Lean Paradigm Shifts in Supply Chain Management

A Literature Review-Based Approach

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Abstract

Supply chain management (SCM) promotes the inclusion of businesses and related suppliers by fostering ties and cooperation with suppliers. Incorporating the 'lean' and 'green' concepts in supply chain management is a quite well-known topic in academia and industries due to its competitive advantages. In this context, the objective of the study was to: Look up existing studies on the topic of green and lean supply chains and review them; Investigate the connections between green and lean approaches; Advance the understanding of the effects of green and lean paradigm shifts on the productivity (performance) in the supply chains; and A theoretical foundation or way forward for further research. A rigorous literature review was carried out throughout the research because the study's approach was based on a literature review. A systematic literature review and Meta-synthesis technique to analyze and interpret the findings were used in the study. The results of the study contained the current concepts of lean and green practices and their further development, current good practices of the green and lean supply chain paradigm, connections between green and lean approaches and supply chain performance, benefits and influence of the green and lean supply chain paradigm, and paradoxes of the green and lean supply chain paradigm. The common goal of the two paradigms is to fulfill consumer requirements while spending as little as possible. The main distinction between the paradigms is their explicit goals, i.e., the LSC aims to reduce waste, whereas the GSC wants to lessen its environmental effects. The feasibility of combining the lean and green paradigms within the SCM environment has also been investigated in this research. Even though green and lean practices may positively impact corporate sustainability, establishing such practices can be challenging for management. Furthermore, most green practices are strategic, while most lean practices are operational. It is, therefore, quite challenging to utilize them as a combined system. Sometimes it might be challenging to convince the stakeholders, partners, and funders to shift to a time-consuming and initially cost-increasing paradigm from a traditional one. A further study on pricing decisions for adopting GSM or LSM or their synergies can be done. Furthermore, adopting or modifying any already established system requires time, investment, positive culture, knowledge, enough data and studies, and the willingness to change and modify- abundance or lacking these may create additional benefits or challenges.

Keywords/tags (subjects)

Green, lean, supply chain, SC, green supply chain, GSCM, lean supply chain, LSCM , paradigm

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1 Introduction

Supply chain management (SCM) encourages the incorporation of businesses and associated suppliers through supplier collaborations and relationships (Azevedo et al., 2012). The set of techniques used to maintain supplier connections, known as upstream practices, is a significant issue since it affects companies and the overall supply chain efficiency (Gunasekaran et al., 2004). Bai and Sarkis (2010) identified that this significant issue has become more complicated as 'green or sustainable practices' have gained increasing attention. Furthermore, each company could be liable for its suppliers' environmental and social behavior (Seuring & Müller, 2008). Therefore, it is essential to put processes that emphasize social, economic, and environmental issues and corporate and general supply chain performance.

Moreover, another major issue affecting today's industrial and production settings is maintaining and decreasing excessive production and minimizing and eliminating wastage in their surroundings (Shah et al., 2017). Additionally, the intense market competition also prompts companies to look for effective manufacturing solutions to improve their efficiency and profitability. According to Shah et al. (2017) and Womack and Jones (1997), lean practices give businesses an advantage in managing their operational and strategic benefits and cutting waste. Previous research findings indicate that for industries to maintain a competitive advantage, they must develop suitable manufacturing processes and technological advancements, particularly those that focus on high-quality products, quick product design, demand-based manufacturing, waste minimization, and inventory control (Womack & Jones, 1997); which ultimately necessitates the importance of Lean practices within the entire supply chain.

1.1 Objectives of the Study

Issues like sustainable business practices, climate change mitigation, and adaptation create awareness among customers. Moreover, national and international regulatory bodies work effortlessly to ensure environmentally viable business practices, such as ISO 14001:2015- the International Standard for Environmental Management Systems etc. Industries are thus becoming increasingly conscious that they may sustain as networks in the market rather than as separate units. Additionally, the life cycles of products and technologies are getting shorter, competitive forces require quick changes in product and service designs, and customer demand demands increased diversity. Thus, a lean supply chain (LSC) is an integrated approach to improving processes via the decrease or elimination of waste based on cost minimization and adaptability (non-value-adding operations) (Carvalho et al., 2010) to ultimately gain efficiency, sustainability, and economic benefits in the competitive market environment.

On the other hand, green supply chain management (GSCM) is a crucial organizational paradigm that helps businesses reduce environmental consequences and risks while increasing ecological efficiency (Carvalho et al., 2010). Therefore, businesses must adapt to economically and ecologically viable business practices to sustain the rising rate of change. In this context, the objectives of the study are to-

- Look up existing studies on the topic of green and lean supply chains and review them
- Investigate the connections between green and lean approaches
- Advance the understanding of the effects of green and lean paradigm shifts on the productivity (performance) in the supply chains
- A theoretical foundation or way forward for further research

1.2 Scope of Work and Utilization of the Research Findings

As the research is planned to be a literature review-based approach, the data collection and information gathering scope will be limited to published research, journals, articles, books, or other documents. Instead of targeting a particular industry's supply chain, the study intends to look for generalized approaches and research.

The first two objectives of the research are aimed to facilitate researchers., academicians, and policy makers in further working on the issue; the compilation of previous research will be an excellent database for them. The comprehensive literature analysis, the critical characteristics of each concept, and their management and industrial significance can also be an initial guideline for understanding the concept for both students and professionals. The third objective will lead to the research findings and finally achieve the fourth objective. The last objective is expected to curve a foundation of usable and adaptable practices of green and lean supply chain concepts for industries and a way forward for further research by the researchers.

1.3 Overview of Chapters

The documentation and reporting of the study are arranged into ten chapters. The first chapter discusses the objectives and scope of the study. The next chapter narrates the methodological approach of the research. The third chapter explores the existing literature on green supply chain management and the good practices of the concept. The fourth chapter explored the literature on lean supply chain management and associated the good practices of the concept. The fifth chapter provides the linkage and differences between green and lean practices in supply chain management through a thorough literature review. The sixth chapter presents a rigorous literature review to measure the impact of green and lean paradigm shifts in supply chain management. The seventh chapter explains the paradoxes and challenges related to adopting the green and lean paradigms in the supply chain. The eighth chapter is the summary of the findings. The ninth chapter reports the reliability of the research. Finally, the last chapter concludes the research and curves a theoretical foundation or way forward for further research.

2 Methodological Approach

The study was heavily dependent on the literature review. Therefore, the methodological approach includes forming research questions to fulfill the research objectives, literature review, observation, and analysis of collected information, findings, and suggestions. The figure below illustrates the methodological approach:

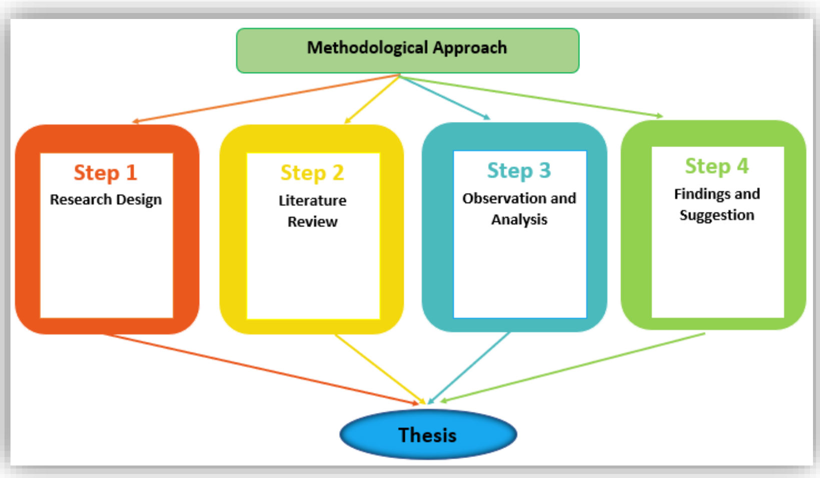

Figure 1: Methodological Approach of the Thesis

2.1 Research Design and Questions

The research design has been approved as a literature review-based approach. Since it is a literature review-based study, the research questions had chosen carefully to fulfill the objectives. Therefore, the research will seek answers to the following questions:

- What are the concepts of the green and lean supply chain?
- What are the current good practices regarding the green and lean supply chain paradigm?
- What are the connections between green and lean approaches and SC performance?
- What are the advantages and influences of the green and lean supply chain paradigms?
- What are the paradoxes of the green and lean supply chain paradigms?

2.2 Literature Review

This segment was focused on the standard existing literature review methods and the exact methods used for this study. Moreover, it also justified the reason behind choosing the methods. Although the literature review has been assigned as the second step of the methodological approach, it was started even before the topic selection. The reason behind this is to understand the topic and research scope well before writing the thesis proposal. Then, when the author was confident enough with a good literature review, she prepared the thesis topic proposal. After that, however, the literature review phase continued in parallel with all other steps until the study reached its ultimate findings, i.e., a conclusion.

The review assisted the study in gaining the most recent information. It also provided a better understanding of the existing environment, difficulties, obstacles, and projections for future advancement. The literature review directly aided in accomplishing the first three objectives of the study, while the remaining last objective was also partly influenced by it.

2.2.1 Definition and Purpose

An impartial, comprehensive synthesis and critical analysis of the available and relevant research and non-research literature on a subject can be defined as a 'literature review' (Hart, 2018). Levy and Ellis (2006) had similar findings, as they explained the purpose of a literature review more as it is a procedure to gather, understand, utilize, analyze, summarize, and assess excellent literature to contribute to creating a solid foundation for a topic and research technique. Furthermore, t objective of conducting a literature review is to update the researcher on the currently available information on the topic and lay the groundwork for other aims, such as establishing the case or justification for choosing the topic for further research (Cronin et al., 2008). Levy and Ellis (2006) described the qualities of an effective literature review as follows:

- methodologically evaluate and summarize high-quality literature
- continue providing a stable base for the choice of the research topic
- offer a stable base for the identification of a study methodology
- show how the research proposal adds something new or opens potential scopes for future advancement in the research field

The purpose of the literature review is comprehensive and critical in academic research. Some most essential purposes are mentioned below:

- to understand how much about the topic is already established.
- to make sure that the study topic is original and that there is a need for such a study
- to create a solid theoretical and conceptual basis for the research
- to support specific research methodology or strategies by knowing which techniques have been proven effective or ineffective for similar studies
- to analyze and compare the findings and recommendations with other studies
- to grasp a thorough understanding of the topic to establish the study's plausibility

2.2.2 Adopting a Suitable Type of Literature Review

There are various types of literature reviews. For example, Cronin et al. (2008) identify four main types:

- **Traditional or Narrative:** This review style analyzes, condenses, and makes recommendations for the subject matter based on a collection of literature. This review helps compile, summarize, and synthesize a large body of literature on a particular topic (Cronin et al., 2008).
- **Systematic:** Systematic reviews utilize a more well-defined methodology than conventional or narrative reviews to analyze the literature in a specified field (Cronin et al., 2008). This well-defined methodology can be selecting the search's limiting factors, choosing a publication timeframe, etc. (Parahoo, 2006). In addition, systematic reviews are used to respond to research questions with a clear emphasis (Cronin et al., 2008).

- **Meta-Analysis:** The practice of performing statistical analysis on a substantial collection of quantitative data to integrate them and further enhance knowledge on the topic is known as meta-analysis (Cronin et al., 2008). This aids in concluding, discovering trends and patterns, and drawing connections between findings (Polit & Beck, 2006).
- **Meta-Synthesis:** Meta-synthesis is a non-statistical method for combining, analyzing, and interpreting the results of many qualitative research projects (Cronin et al., 2008). Meta-synthesis entails analyzing and synthesizing crucial parts of each study. It translates the results into fresh conceptualizations and interpretations, unlike meta-analysis, where the end goal is to decrease findings.

The author found that a systematic literature review is best for this study. Therefore, the search for materials has been narrowed down to green and lean concepts and practices in the supply chain to find the answers to the research questions. Moreover, the aim was set to look for newer research studies. Therefore, a tentative timeline of studies from 1995-2022 was set. These 27 years of the timeline may seem quite long. However, given that the concepts have evolved a lot and it is essential to understand the primary concepts, the timeline was kept like this. However, some older materials have also been reviewed as they seemed important and relevant to the study. While analyzing the contrasts and similarities between the two concepts, mathematical modeling and statistical analysis have been omitted to focus mainly on these research findings, even though some previous researchers used such methodologies. This study additionally used the Meta-synthesis technique to analyze and interpret the findings, i.e., choosing the non-statistical method of analyzing and synthesizing crucial parts in each study relevant to the research questions.

2.2.3 Steps of Conducting the Literature Review

Various ways of doing a literature review can vary depending on the purpose or topic. The author Levy and Ellis (2006) described three steps of literature review through the figure below:

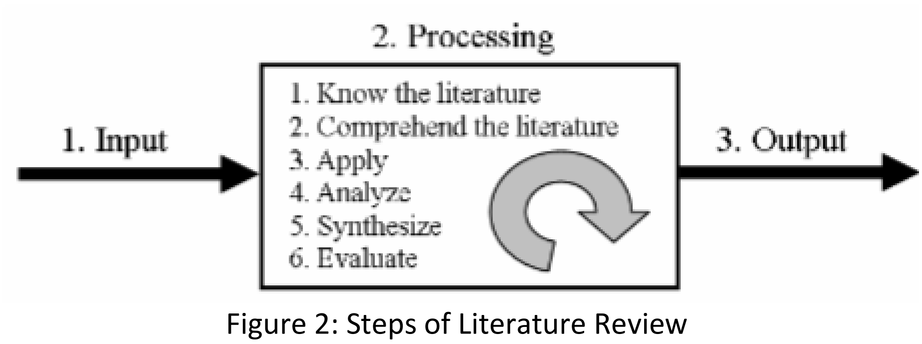

Figure 2: Steps of Literature Review

Source: adapted from (Levy & Ellis, 2006)

These steps seemed relevant to this study. Therefore, these steps were followed for the literature review.

Step 1: Input

The input for a literature review procedure is to limit the search boundaries and then search rigorously to collect relevant, acceptable, and high-quality information. No matter how well the processing step is done, a systematic method will fail if the input is either erroneous, of poor quality, or irrelevant; this is known as the garbage-in/garbage-out principle (Levy & Ellis, 2006). While finding high-caliber literature is vital, it is necessary to find pieces that apply to the intended research. Assessing the literature's relevance to the proposed study involves two essential features. The first discusses whether articles should be included in the literature review, and the second discusses the proper and improper usage of references. To guarantee a high-quality and productive literature review, both elements should be considered during the literature exploration and collection process (Levy & Ellis, 2006).

This study is a literature review-based approach; hence, it is one of the significant steps. Cronin et al. (2008) suggest collecting information and data from various sources to overview a topic comprehensively. This study has aimed for the same. It gathered information and data from sources such as conference papers, reports, articles, journals, books, and other literature reviews on a similar topic. The initial idea of what to review and where to find them came from Hart (2018). The figure below has been adapted from the same author and used as a base for finding literature:

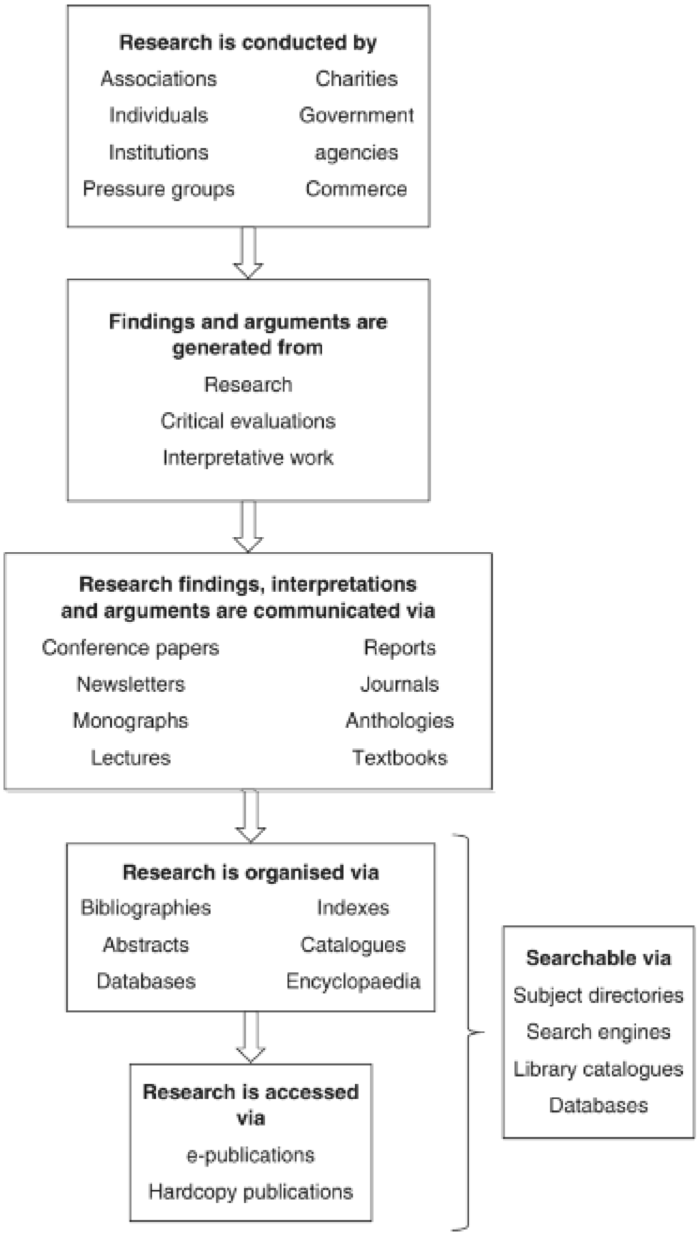

Figure 3: What to review and where to find them

Source: adapted from (Hart, 2018)

Literature databases and electronic resources are great options for searching. With the help of electronic resources, finding relevant documents is much easier. JAMK has an excellent collection resource that can be accessed physically and electronically. Moreover, this study has used scientific databases such as ScienceDirect, JSTOR, ProQuest, SciFinder, ResearchGate, Semantic Scholar, SCRIBD, Elsevier, etc. **In addition, search engines** named Google and Google Scholar have been used for this purpose.

While searching for relevant documents, **Keyword Search** can be an excellent option for saving time. It means requesting information from reputable scholarly databases using a particular term or phrase (Levy & Ellis, 2006). Green, Supply Chain, GSCM, LSC, Green Paradigm Shift, Lean Paradigm Shift, Lean Waste, Green Practices, Lean Practices, etc. are some examples of keywords used as a search term for this study.

Backward Search and **Forward Search** are two special techniques for quickly finding relevant and reliable research documents. According to Levy & Ellis (2006), backward search entails finding and analyzing the publications or references cited in an article. It is called second-level backward searching if the reader looks at the resources referenced in the first article(Levy & Ellis, 2006). Some scholars have also named this technique Chain Searching (New Jersey Institute of Technology, 2022). Second-level backward and backward searches have been done for the study. Researching additional publications that have mentioned the same article is referred to as a forward references search (Levy & Ellis, 2006). This technique too was used in the study.

Step 2: Processing

According to Levy & Ellis (2006), processing starts with **Knowing the Literature.** Then, activities like categorizing, classifying, explaining, and distinguishing are frequently used to reflect the level of knowledge. Next, the investigator must be able to review the article and glean important, relevant information from it.

The next level of processing is **Comprehending the Literature** (Levy & Ellis, 2006)**.** At this level, the researcher exhibits that they summarize the literature content accurately and understand the relevance of the presented information. Again, actions like synthesis, differentiation, interpretation, and comparing serve as comprehension indicators(Levy & Ellis, 2006).

Determining the significant ideas about the study and arranging the citation in the appropriate categorization in the literature evaluation contexts how the **Application** is most clearly visible (Levy & Ellis, 2006).

Integrating, merging, adjusting, rearrangement, redesigning, composing, summarizing, and generalizing are included in the process of **Synthesis** (Levy & Ellis, 2006). Synthesis aims to create a cohesive unit of information from the various material reviewed for a particular topic.

Evaluation includes analyzing, choosing, advising, determining, explaining, differentiating, supporting, and concluding (Levy & Ellis, 2006). In the literature review, it is crucial to distinguish between ideas, views, and facts that have been proven by actual research.

The synthesis and evaluation of the literature review have a significant influence on the success of a study. Of course, collecting relevant and vital information and reporting is necessary. However, a study cannot reach its conclusion and recommendations without proper synthesis and evaluation.

Step 3: Output

A literature review for academic purposes must be understandable, have a logical framework, and demonstrate that the author has attained the necessary knowledge, skills, and competencies (Hart, 2018). Such a review should also add something new to the current research findings. In that way, the literature review persists until the study concludes. It is crucial to keep an eye out for new, relevant studies when they are published. The review is best understood as a dynamic process continually expands and evolves as the study progresses. This is just as the same happened in this study.

2.3 Observation and Analysis

Although it has been titled as a separate step of the methodological approach, the synthesis and evaluation of the literature review have directly contributed here as this study is a literature review-based approach.

2.4 Findings and Suggestion

The findings are the answers to the research questions presented in a detailed manner. The way forward or the suggestion came from the author’s understanding and point of view, which was greatly influenced by the literature review.

3 Understanding the 'Green' in Supply Chain Management

3.1 Green Supply Chain Management

The heading of this section comprises two segments. Both segments have distinct definitions when placed as individuals, but they create a compelling concept when put together. The term "green" has evolved to represent various environmental, climatic, and sustainability-related issues and is often viewed favorably. It implies environmental compliance and is advantageous, much like "supply chain management." When combined, the two components offer a logistics and allocation mechanism of the set of materials that is both functional from the business perspective and considerate to the ecosystem. The phrase is widespread and often regarded as being highly desired nowadays.

Integrating environmentally responsible business practices into the traditional supply chain is known as "green supply chain management" (GSCM). Various conceptions of the green supply chain are available from additional research. Beamon (1999) has described it as a closed-loop supply chain. It has been described as the 'sustainable supply chain' (Linton et al., 2007; Ageron et al., 2012). Moreover, another research identifies it as an 'environmental and ethical supply chain' (Beamon, 2005).

Additionally, the term 'a socially responsible' supply chain mechanism has also been used to explain it (Salam, 2009). It has also been described as a coordinated approach that goes beyond only adopting green practices; it is an organized strategy for enhancing the environmental and organizational effectiveness and performance at every layer of administration (Zhu et al., 2007). Product design, sourcing, selection of materials, operation, manufacturing, and end-of-life management are a few examples of the 'green practices' of the supply chain (Green Supply Chain Management, n.d.). Srivastava (2007) asserted GSM as a technique of incorporating environmental issues into traditional SCM, as well as in product and service development and design, purchasing, production methods, distributing, and end-of-life operation of the product to gain sustainable competitive benefit. According to the research of Hervani et al. (2005), the definition of GSCM can be explained through the following equation using four components:

Equation 1: Definition of GSCM through its components

Green supply chain management (GSCM) = Green Purchasing + Green Manufacturing/Materials Management + Green Distribution/Marketing + Reverse Logistics (Hervani et al., 2005)

Zhu et al. (2008a) further developed a GSCM model with five components: internal environmental management, green purchasing, customer collaboration, eco-design, and investment recovery through effective use of technology and material. Finally, et al. (2013) mostly agree with both the concepts of Zhu et al. (2008a) and Hervani et al. (2005) and thus further described GSCM through the following equation:

Equation 2: Components of Green Supply Chain Management

Green supply Chain management (GSCM) = Green Purchasing + Eco-Design + Green Manufacturing + Green Distribution + Reverse Logistics (Kafa et al., 2013)

GSCM emphasizes fostering value creation within the supply chain to minimize overall environmental impacts rather than solely aiming to mitigate the environmental impacts. Carvalho et al. (2010) stressed that green supply chain management (GSCM) is a crucial organizational paradigm that helps businesses reduce environmental risks and consequences while increasing ecological efficiencies. Whereas the main objective of GSCM is primarily to lower CO_2 emissions, other substantial advantages for a business involve enhanced efficiency, reduced waste generation, improved innovation, and technology, reduced manufacturing costs, reuse of materials, greater profitability, and impression of additional value to the customer base, etc. The approach can be different for different companies. For example, IKEA went for an environmentally friendly transportation option; L'Oréal, HP, IBM, GE, and Dell—have embraced innovative energy-saving technology and made the concept "green" a significant attribute for their operations to boost their "green image" for positive public perception; BMW, Pepsi-Cola, and Kodak have employed reverse logistics that proved to be financially beneficial for them too (Kafa et al., 2013).

Following the previous research, the author also identifies that:

- It is equally important to first create the mindset of the company for adopting ’green’ practices
- Developing and strengthening the company structure, management, and professionals to adopt the practices which Zhu et al. (2008a) also acknowledge as ‘internal environmental management.’ Aslam et al. (2019) also have opinions on internal environmental management.
- Collaborating with different organizations, suppliers, and industry peers to standardize environment-friendly practices, with which Aslam et al. (2019) agree.

Therefore, equation 2 can be updated as follows:

Equation 3: Components of Green Supply Chain Updated

Green supply Chain management (GSCM) = Green Purchasing + Eco-Design + Green Manufacturing + Green Distribution + Reverse Logistics + Green Organizational Development

3.2 Component-wise Identification of Good Practices

Based on this equation 3, the following sections are dedicated to explaining these six components elaborately and detecting their existing good practices:

3.2.1 Component 1: Green Purchasing and Related Good Practices

According to Park et al. (2022), green purchasing refers to the corporate initiative to reduce environmental damage by selecting and acquiring goods and services needed for business operations. Several researchers, such as Rane and Thakker (2020), describe green purchasing as the point of view and technique of upholding an emphasis on environmental sustainability while purchasing goods and resources and maintaining the same emphasis throughout the material or goods flow. Min and Galle (1997) described green purchasing as facilitating supplies and goods purchasing to satisfy the environmental guidelines established by the purchasing enterprise. It covers the issue of purchasing sustainably (Salam, 2009) and more conventional buying factors like price, quality, and delivery (Zhu et al., 2005). According to Vachon and Klassen (2008), green purchasing is the environmental collaboration with the supplier, which is the contact between SC organizations about standard environmental management and understanding, improving delivery and flexibility performance. As a result, it improves customer satisfaction while reducing the adverse effects on the life cycle, company waste, environmental costs, and SC costs (Carvalho et al., 2010). The table below describes the Good Practices of this component, i.e., Green Purchasing in green supply chain management, and their respective benefits:

Table 1: Good Practises of Green Purchasing

<table>
<tr><th colspan="2">Good Practices</th><th>Benefits</th><th>Reference</th></tr>
<tr><td>A1</td><td>Recycling used materials, i.e., paper, packaging, waste, etc., to reduce buying</td><td rowspan="6">• Increased efficiency in resource usage
• Increased Operational Efficiency
• Enhanced Health and Safety
• Reduction of Environmental Risk
• Improved Public Image and brand value
• Increased Profitability through customer attraction and cost savings by resource and energy efficiency and reduced waste
(Kafa et al., 2013)</td><td>(Salam, 2009; Zhu, Sarkis, Cordeiro, et al., 2008; Min & Galle, 1997)</td></tr>
<tr><td>A2</td><td>Reduction of raw materials by using recycled products</td><td>(González et al., 2008)</td></tr>
<tr><td>A3</td><td>Purchasing from ethical suppliers that have environmental certification, for example, ISO 14001 certification</td><td>(Park et al., 2022; Vachon, 2010; Holt & Ghobadian, 2009; Zhu, Sarkis, Cordeiro, et al., 2008; Zhu et al., 2005)</td></tr>
<tr><td>A4</td><td>Cooperation among suppliers to minimize the environmental impacts of material flow and distribution</td><td>(Park et al., 2022; Hu & Hsu, 2006)</td></tr>
<tr><td>A5</td><td>Using pre-qualification parameters to ensure green purchasing and sourcing</td><td>(Park et al., 2022, Paulraj, 2009; Hu & Hsu, 2006)</td></tr>
<tr><td>A6</td><td>Using green Sourcing and purchasing guideline</td><td>(Park et al., 2022; Holt & Ghobadian, 2009; Paulraj, 2009; Hu & Hsu, 2006)</td></tr>
</table>

3.2.2 Component 2: Eco-Design and Related Good Practices

ECO refers to developing products to reduce environmental effects over their lifespan (Aslam et al., 2019; Eltayeb & Zailani, 2014). Product design impacts performance, consumption, manufacturing, and disposal after life, which might significantly affect manufacturing expenses. As a result, the word "eco-design" (ECO) is pertinent to sustainability (Santolaria et al., 201) and denotes an ecologically improved or developed product (Park et al., 2022). According to Park et al. (2022), the terms "design for environment" and "design for sustainability," the latter of which is regarded as an advanced level of ECO, have a similar meaning to "eco-design." To lessen a product's adverse environmental effects, ECO involves technological innovation, product redesign, and restructuring of a product's essential operation. However, at a higher level, both technological and social changes are required (Park et al., 2022). The table below describes the Good Practices of this component, i.e., Eco-Design in green supply chain management, and their respective benefits:

Table 2: Good Practises of Eco-Design

	Good Practices	Benefits	Reference
B1	Precautions and Preventive measures to address environmental emergencies, accidents, and hazards	• More options for reusing, recycling, and manufacturing • Entry to the green market • Customer attraction • Increased eco-efficiency (Zhu, Sarkis, Cordeiro, et al., 2008; Hu & Hsu, 2006; Zhu et al., 2005)	(González et al., 2008; Hu & Hsu, 2006)
B2	Reduce inventory levels		(Paulraj, 2009; González et al., 2008; Zhu et al., 2005)
B3	Reduce the usage of hazardous materials and processes in the design		(Ageron et al., 2012; Zhu, Sarkis, Cordeiro, et al., 2008; Zhu et al., 2007)
B4	Incorporate disassembly in the design procedure to better manage end of life of products		(Linton et al., 2007)
B5	Reduce energy consumption		(Park et al., 2022; Vachon, 2010; Holt & Ghobadian, 2009; Paulraj, 2009; Rao & Holt, 2005)
B6	Choosing reusable products/ raw materials		(González et al., 2008)
B7	Eco-labelling[1]		(Rao & Holt, 2005)
B8	Closely working with customers to design customized eco-friendly products and environmental collaboration		(Park et al., 2022; Vachon, 2010; Holt & Ghobadian, 2009; Zhu, Sarkis, Cordeiro, et al., 2008; Zhu et al., 2005; Lippman, 2001)
B9	Reduce material consumption		(Park et al., 2022; Kafa et al., 2013; González et al., 2008)
B10	Using Environmental and Social Management System (ESMS) for product development, design, and project implementation		(Zhu, Sarkis, Cordeiro, et al., 2008)

[1] Consumers may swiftly discover items that fulfill specified environmental performance requirements and are consequently considered "environmentally preferred" by using ecolabels, which are markings applied to product packaging or included in online catalogs.(*Introduction to Ecolabels and Standards for Greener Products | US EPA*, n.d.) https://www.epa.gov/greenerproducts/introduction-ecolabels-and-standards-greener-products

3.2.3 Component 3: Green Manufacturing and Related Good Practices

Green manufacturing is a collection of safe manufacturing techniques that use fewer resources, produce minimal to zero waste, and pollute less (Deif, 2011), ensuring a pollution-free environment (Kafa et al., 2013). Sahar et al. (2020) opine that green manufacturing aims to lessen the negative environmental consequences of the production process. According to Pal (2002), green manufacturing is not a choice but a need for well-being and sustainability in the competitive world. Using suitable materials and cutting-edge environmental technology, GM seeks to lessen the strain on the environment, resulting in lower raw material prices, manufacturing efficiency benefits, fewer environmental charges, and an enhanced reputation (Deif, 2011). The table below describes the Good Practices of this component, i.e., Green Manufacturing in green supply chain management, and their respective benefits:

Table 3: Good Practises of Green Manufacturing

	Good Practices	Benefits	Reference
C1	Reducing material usage through the improved manufacturing process	• Enhanced sustainability performances and efficiencies through cost-saving and waste reduction (Kafa et al., 2013; González et al., 2008; P. Rao & Holt, 2005)	(Deif, 2011; Rao & Holt, 2005)
C2	Minimizing waste while manufacturing		(Rao, 2014; Deif, 2011; Paulraj, 2009)
C3	Reducing Energy Consumption		(Deif, 2011; Paulraj, 2009; Holt & Ghobadian, 2009; González et al., 2008; Rao & Holt, 2005)
C4	Standardization of manufacturing requirements to support environmental sustainability – in collaboration with industrial peers		(Hu & Hsu, 2006)
C5	Improved filters, management, and controls for less emission and discharge		(González et al., 2008)
C6	Enhanced management of heating, cooling, and lighting in the production facility		(Holt & Ghobadian, 2009)
C7	Internal recycling of materials while manufacturing		(Vachon, 2010)

3.2.4 Component 4: Green Distribution and Related Good Practices

Green distribution incorporates environmental concerns into distribution operations, including packaging, shipping, and logistics (Rao & Holt, 2005). Kafa et al. (2013) and Sahar et al. (2020) also emphasized green packaging and shipping techniques for green distribution. Sahar et al. (2020) suggested optimizing routes and maximizing the volume of each transport, lowering fuel consumption and emissions as a pathway for reducing the environmental effects of the distribution process. The table below describes the Good Practices of this component, i.e., Green Distribution in green supply chain management and their respective benefits:

Table 4: Good Practises of Green Distribution

<table>
<tr><th></th><th>Good Practices</th><th>Benefits</th><th>Reference</th></tr>
<tr><td>D1</td><td>Reuse, and recycle materials and packaging</td><td rowspan="4">• Spend less on packing
• Reduced consumption of energy
• reduced congestion, pollution, emission discharge, and noise
• Better communication with the community and customers, hence a better brand image
(Ageron et al., 2012; Rao & Holt, 2005)</td><td>(Holt & Ghobadian, 2009)</td></tr>
<tr><td>D2</td><td>Using environmentally friendly packaging</td><td>(Sahar et al., 2020; Kafa et al., 2013; Holt & Ghobadian, 2009; Zhu, Sarkis, Cordeiro, et al., 2008; Rao & Holt, 2005)</td></tr>
<tr><td>D3</td><td>Using vehicles with less environmental impacts</td><td>(Sahar et al., 2020; Kafa et al., 2013; Holt & Ghobadian, 2009)</td></tr>
<tr><td>D4</td><td>Planning optimal routes for transport to reduce fuel consumption, i.e., reduce emission and other environmental impacts</td><td>(Sahar et al., 2020; Kafa et al., 2013; Holt & Ghobadian, 2009)</td></tr>
</table>

3.2.5 Component 5: Reverse Logistics and Related Good Practices

Retrieving old products from the source of consumption to the place of manufacture to potentially reuse, recycle, and remanufacture them is known as reverse logistics (Azevedo et al., 2011). A similar explanation came from Carter and Ellram (1998), that reverse logistics principally concentrates on the return of used items from the source of consumption to the subsequent supply chain for recycling, reuse, remanufacturing, repair, refurbishment, or secure disposal of the products. Kafa et al. (2013) identified that end-of-life goods could be used in the forward supply chain for three reasons, i.e., recycling, remanufacturing, and reuse. Goldsby and Stank (2000) asserted that the conventional logistics functions of inventory and transportation management are all included in reverse logistics. However, the emphasis is given to retrieving products from consumers instead of delivering the product to customers (Goldsby & Stank, 2000). The table below describes the Good Practices of this component, i.e., Reverse Logistics in green supply chain management, and their respective benefits:

Table 5: Good Practises of Reverse Logistics

<table>
<tr><th colspan="2">Good Practices</th><th>Benefits</th><th>Reference</th></tr>
<tr><td>E1</td><td>Collection of used products from customers and remanufacturing</td><td rowspan="3">• Lowering the environmental costs associated with final disposal
• Decrease in environmental expenses
• Reuse of parts from a defunct product

(Kafa et al., 2013; Ageron et al., 2012; Holt & Ghobadian, 2009; Rao & Holt, 2005)</td><td>(Vachon, 2010; Hu & Hsu, 2006; Zhu et al., 2005; Rao & Holt, 2005; Lippman, 2001)</td></tr>
<tr><td>E2</td><td>Encourage and collaborate with suppliers to return the packaging of the supplied materials</td><td>(Holt & Ghobadian, 2009; Rao & Holt, 2005)</td></tr>
<tr><td>E3</td><td>Collection of packaging material and pallets from customers for reuse</td><td>(Holt & Ghobadian, 2009; González et al., 2008)</td></tr>
</table>

3.2.6 Component 6: Green Organizational Development and Related Good Practices

Green organizational development or internal development describes creating company policies and goals to ensure environmental preservation (Çankaya & Sezen, 2019). It entails establishing a management framework for environment-friendly practices, departmental collaboration for environmental benefits, and managerial encouragement and support (Zhu et al., 2005). Aslam et al. (2019) and Zhu et al. (2008a) describe green organizational development as the emphasis on environmental aspects in operational and planning activities within an organization. Understanding goods, resources, markets, and accessible technology is required to promote the organizational structure supporting environmental sustainability (Park et al., 2022). Critical factors influencing

GSCM internal competencies include an organizational knowledge base with the required technological skillsets, a corporate culture that supports self-evaluation, and new system deployment (Hervani et al., 2005). IEM also benefits from cross-functional cooperation, comprehensive environmental quality management, and other essential environmental management methods and initiatives (Zhu et al., 2005; Zhu et al., 2008a). The table below describes the Good Practices of this component, i.e., Green Organizational Development in Green Supply Chain Management and their respective benefits:

Table 6: Good Practises of Green Organizational Development

<table>
<tr><th colspan="2">Good Practices</th><th>Benefits</th><th>Reference</th></tr>
<tr><td>F1</td><td>ISO 14001 certification</td><td rowspan="8">• Establish the essential initiatives, evaluate and promote green management, and allocate all available resources to support green practices
• Introduce and implement all the green practices
• Introduce ethical and responsible behavior within the organization and supplier tier
• Foster a moral workplace culture and a positive work ethics
• Strengthened organizational capacity and supplier capacity results in better overall performance (in terms of green practices and overall practices)
• Better brand image due to environmental certification
(Park et al., 2022; Eva et al., 2020; Hervani et al., 2005; Schwepker, 2001)</td><td>(Vachon, 2010; Holt & Ghobadian, 2009; Zhu, Sarkis, Cordeiro, et al., 2008; Rao & Holt, 2005; Zhu et al., 2005)</td></tr>
<tr><td>F2</td><td>Collaboration with local recycling facilities</td><td>(Hu & Hsu, 2006)</td></tr>
<tr><td>F3</td><td>Incorporating ‘green’ and ‘ethical’ aspects in the mission and vision of the company and use in actual practice</td><td>(Çankaya & Sezen, 2019)</td></tr>
<tr><td>F4</td><td>Integration of Total Quality Environmental Management (TQEM) into planning and operation</td><td>(Zhu, Sarkis, Cordeiro, et al., 2008; Rao & Holt, 2005; Zhu et al., 2005)</td></tr>
<tr><td>F5</td><td>Using Life Cycle Assessment (LCA) in various phases of operation</td><td>(Holt & Ghobadian, 2009; González et al., 2008; Hu & Hsu, 2006)</td></tr>
<tr><td>F6</td><td>Earning Customer approval/ brand value for ethical and green practice through providing production information</td><td>(Kafa et al., 2013; Rao & Holt, 2005)</td></tr>
<tr><td>F7</td><td>Environmental monitoring of the suppliers</td><td>(Vachon, 2010; Holt & Ghobadian, 2009; Zhu, Sarkis, Cordeiro, et al., 2008; Hu & Hsu, 2006)</td></tr>
<tr><td>F8</td><td>Strengthening organizational capacity to adopt ‘green’ practices</td><td>(Aslam et al., 2019; Passetti et al., 2018; Zhu, Sarkis, Cordeiro, et al., 2008; Zhu et al. 2008a; Hervani et al., 2005; Lippman, 2001)</td></tr>
</table>

4 Understanding the ‘Lean’ in Supply Chain Management

4.1 Lean Supply Chain Management

The basics of the lean management methodology were created by Ohno (1998). Initially, it had two fundamental pillars: "autonomation" and "just-in-time" (JIT) manufacturing to meet consumer expectations and retain profitability for the Toyota Motor Corporation, Japan. The lean strategy mainly concentrates on reducing waste to enhance the actual value provided (Womack et al., 1991). A similar conception of lean also came from much newer research- lean is the methodical elimination of waste by all employees from every aspect of a value chain (Worley & Doolen, 2006). Carvalho et al. (2010) identify this 'waste' as the 'non-value adding operations' and defines the lean supply chain (LSC) as an approach to improving processes via the minimization or elimination of all these wastes. Parveen and Rao (2009) identified that LSC focuses on removing waste or non-value operations throughout the supply line to improve internal production efficiency and set-up time reduction, facilitating the economical manufacturing of limited or smaller volumes, optimizing cost, enhancing profitability, and improving manufacturing flexibility. The fundamental goal of a lean method is to minimize waste by simultaneously lowering or limiting internal uncertainties and other uncertainties regarding the supplier, customer, etc. (Karim & Arif-Uz-Zaman, 2013).

The conceptual development of LSC can be described through five significant stages (Mc Kee R. & Ross D, 2009), which are mentioned below:

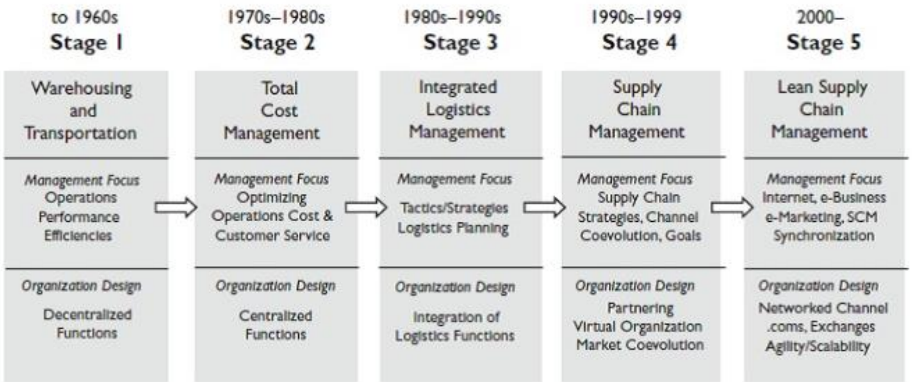

Figure 4: Conceptual Development of LSC

Sources: (Mc Kee R. & Ross D, 2009)

A variety of other conceptions of LSC are available from other research. Although there has been much research, academics are still divided on what Lean is (Shah et al., 2017). The most straightforward yet very descriptive definition came from Reichhart and Holweg (2007), i.e., lean supply chain means reducing waste downstream of the supply chain while ensuring that the end customer has access to the accurate products at the correct timing and locations. Therefore, the purpose of the lean philosophy is to eliminate waste throughout the organization, maximize core resources, and create a corporate culture that continually attempts to understand and thus enhance customer satisfaction (Karim & Arif-Uz-Zaman, 2013). Al-Balushi et al. (2014) defined lean as a 'process reengineering philosophy' containing a set of operationally focused tools and a framework of strategy-driving concepts that helps organizations to perform better by minimizing operating/ production time and resources; it also helps in minimizing accidents and errors.

According to Emiliani (2006), most leaders view lean as a rapid approach to obtain zero-sum results, which favor the business at the employees' expense. Therefore, it should be considered a management system that produces the most remarkable outcomes over the long run; however, not every utilization of the lean strategy needs to be effective in every situation (Rymaszewska, 2014). Hines et al. (2004) identified that the lean strategy looks for methods to develop performance by utilizing resources with better efficiency than typical approaches, minimizing demand variance through simplification, optimization, and streamlining, and offering additional value to the client. Therefore, LSC includes every step of a product's life cycle- from development to sale to delivery. Similar findings came from Anand and Kodali (2008, who emphasized that an LSC requires combining all upstream and downstream operations into an articulated system.

Other important lean concepts or practices, such as quality control (Brown & Mitchell, 1991), pull production (Brown & Mitchell, 1991), error-proofing (Stewart & Grout, 2001), respect for people (Treville & Antonakis, 2006), etc. have also been highlighted by sure researchers. For the most recent researchers, it is necessary to deepen the grasp of the underlying decisions and tradeoffs as the pandemics (i.e., COVID-19), geopolitical tensions, and climate change cause the attention to shift from cost reduction to resilience (Browning & Treville, 2021).

4.2 The 'Wastes' in the Lean Practice

In lean terminology, waste is any operation that adds no value to the product while costing the producer resources (money, human resources, other resources, etc.) (Browning & Heath, 2009). These wastes are so widespread in production processes that they are typically neglected, ranging from active losses to wasted prospects (Womack & Jones, 1997). The characteristics of the various forms of waste can be used to distinguish them. When producers understand and identify the seven wastes, they can rectify them and avoid wasting further resources (Shah et al., 2017).

1. **Overproduction:** In a period where productivity is the main priority, mentioning overproduction as the primary source of waste may appear contradictory. Nevertheless, overproduction can be seen in many companies. The effort put in does not necessarily determine the worth of labor. Time, labor, and resources are wasted when a product is produced earlier than required or in larger quantities than desired. If the item is seasonal, it is most likely to be discarded. If the goods are perishable, they will almost be sure to throw away. When a manufacturer produces more products than they sell, it produces volume without adding value and more significant waste (Shah et al., 2017).

2. **Waiting:** Rhythm is critical in production and distribution operations. For a seamless, continuous, and consistent flow, every essential element, i.e., tools, components, material supplies, labor, equipment, information, etc., must be available in the right form and quantity at the precise moment. Anything that disrupts or breaks the pattern at any point in the flow is the source of downstream delays. Regrettably, unexpected disruptions or delays have become so prevalent in modern industry that they are now the second most expensive source of waste. Waiting for a previous step in the production cycle to be completed; waiting for materials to be transported from another location; waiting for information, authorization, or confirmation; waiting for a missing item to complete a batch; or waiting for a missing item to complete a batch are some of the most common causes of delays (Shah et al., 2017).

3. **Transport:** Each step-by-step manufacturing process has logistical issues, from acquiring components from vendors to moving products in production from one site to another. The likelihood that transportation routes would produce wasteful and expensive waste rises with the length and complexity of such routes. If operations are not placed as close to one another or arranged in a logical working sequence, people and items must travel to complete their jobs. Traffic on the factory floor is increased as a result, particularly when employees must repeatedly traverse the same area. Over time, an excessively mobile workflow lowers efficiency and profitability.

4. **Motion:** If tools need to be moved, adjusted, or assembled before usage, they are not used effectively by the company. When equipment must be moved to and from distant storage locations, unnecessary movement is incorporated into the process. Employee injuries and tool or equipment damage are made more likely by excessive movement of people and items. While adding no value to the process or product might result in product damage or loss and increased work pressure.

5. **Overprocessing:** Overprocessing usually originates with noble intentions or extreme care and frequently commences during the design phase. Thresholds may be required in engineering that are unreasonably restrictive (Shah et al., 2017). When a less costly, more generally accessible material can suffice, designers may still specify expensive or hard-to-find materials. Salespeople may be more focused on presentation than end-user requirements, and they could thus insist on machined and polished components. In addition to the expense of meeting strict requirements, there is also the responsibility of monitoring, testing, verifying, and maintaining overzealousness. To ensure efficiency and consistency, manufacturers may employ standardized work processes. Thus, it makes 'overprocessing' probably the most complex waste to identify as a waste, not a development initiative. Discovering what the client appreciates offers perspective into enhancing manufacturing techniques, minimizing unnecessary effort, and simplifying procedures to reduce waste. Every step or element that does not offer value is a giveaway to the customer that is improperly compensated, undesired, and expensive.

6. **Inventory:** Overproduction, poor planning, process imbalances, inefficient workflow, over-ordering to qualify for bulk discounts, and various unseen variables can contribute to inventory growth (Shah et al., 2017). Dropping inventory to JIT levels might be difficult. However, the exact inventory level can reveal underlying issues that must be addressed. Manufacturers can strengthen their supply chains, reduce lead times, and optimize manufacturing processes by taking stock of their inventory methods.

7. **Defects:** When an item fails to meet the quality requirements or specifications, it is deemed faulty (Shah et al., 2017). Poor quality materials and components, poor assembly, malfunctioning equipment, and human errors are all possible reasons. Removal of defects is a wastage of time, energy, resources, tools, and materials, and replacement costs, regardless of the reason, are also expensive. Adopting proactive measures before faults can prevent much of this waste. For example, items may be designed to avoid incorrect installation or assemble. Additionally, procedures and regulations can be standardized to ensure that employees working different shifts provide reliable and correct (at least acceptable) outcomes.

According to some research, unutilized human capability or potential is one significant source of waste that is not listed in the "seven fatal wastes of lean" (*Essence of Lean – Eliminating Waste (Muda), Lean Production*, n.d.). Chances like having some creative ideas, enthusiasm, and motivation of employees may get lost due to this type of waste. Underutilized human potential frequently results from management practices that minimize workers' contributions. Boosting managerial tutoring abilities may significantly increase the participation of employees.

4.3 Existing Approaches of Lean Supply Chain: Lean Tools

Implementing lean requires choosing the right tools from the lean toolbox to obtain operational effectiveness (Pearce & Pons, 2013). Nevertheless, there is a risk of concentrating excessively on the tool's advantages and pushing for operational efficiency while ignoring the tool's durability within that particular organizational environment. An opportunity and a threat are brought to the organization every time a new approach is deployed (Pearce & Pons, 2013). Each technique has some advantages and some disadvantages. Therefore, it is required to thoroughly analyze the proposed lean approach's advantages and its associated challenges. Moreover, it is necessary to consider how the advantages might affect the longevity of the reformed intervention and whether it has long-term advantages. Below are some standard tools used in the lean practice:

- **A3 Management:** It was introduced by Toyota Motor Corporation. The idea is to thoroughly describe a particular procedure on one side of one paper. The paper size was A3- the maximum paper size used in a fax machine. A3 report can be either a problem-solving, proposal or status report (Pearce & Pons, 2013).

- **5S:** 5S is a five-step Japanese organizational system that simplifies, straightens up, scrubs, standardizes, and sustains (Cudney, 2009). It logically organizes work areas for ‘overproduction’ waste minimization (Pearce & Pons, 2013; Michalska & Szewieczek, 2007).

- **Total Preventive Measurement:** TPM was described by Nakajima (1988) as the productive maintenance performed by all employees via activities in small groups and might well be considered equipment maintenance. It is a comprehensive concept of equipment maintenance that aims for optimal output with no failures, defects, accidents, or wastage (Nakajima, 1988). The TPM implementation would speed up equipment maintenance, lowering energy and material usage and lessening the detrimental effects on the environment (Bakri et al., 2012). Shah et al. (2017) state that the TPM implementation also helps increase machinery availability boosting productivity and asset returns. This is due to a reduced rate of product flow interruptions, which also helps to lower the waste production rate and cut down on corporate wastage (Shah et al., 2017).

- **Total Quality Management:** TQM is an integrated managerial ideology and a set of techniques that place a focus on long-term planning, continuous advancement, satisfying customer demands, lowering rework, enhanced employee participation and collaboration, redesign of process, competitive benchmarking, team-based problem - solving culture, ongoing outcomes evaluation, and better supplier relationship (Anvari & Moghimi, 2012). Shah and Ward (2003) identify TQM as one of the excellent tools in lean. Furthermore, TQM enhances and preserves product and process quality to satisfy or add value to consumer expectations (Anvari & Moghimi, 2012). TQM has been supplemented in Lean contexts by unusual methods to minimize manufacturing process variation (Furlan et al., 2011).

- **KANBAN:** Kanban is a stock-controlling system using the FIFO technique. An efficient tool that helps the entire production process go smoothly. The Kanban method is said to have numerous benefits over computer technology, including lower cost of information processing, ease of obtaining and transmitting information in a dynamic environment, and adequately scaled demand for goods (Shah & Ward, 2003). Moreover, KANBAN utilizes a pull system to regulate production levels- 'overproduction' waste minimization and takes actions against overproduction- 'inventory' waste minimization (Pearce & Pons, 2013). Many other researchers, such as Kumar & Panneerselvam (2006), Akturk and Erhun (2010), and Lage Junior and Godinho Filho (2010), also identify it as a tremendous lean tool.

- **Poka-yoke:** This is a tool that aids workers in preventing mistakes. Poka-yoke aims to reduce product flaws by foreseeing, correcting, or highlighting human faults. Since this aspect of the Lean concept is rare and focuses primarily on methods for enhancing the system's performance, it is critiqued in the research from the employees' standpoint (Shah & Ward, 2003). It creates procedures that are less likely to result in faults- 'defect' waste minimization. Many other researchers, such as Pearce and Pons (2013) and Shah and Ward (2003), also identify it as a great lean tool.

- **Just in Time (JIT):** A procedure that mandates that a company generate the proper good at the right moment. Additionally, implementing JIT will help organizations lower manufacturing costs, inventories, changeover times, setup times, and maybe waste (Shah & Ward, 2003). Only take up raw materials when required- 'inventory' waste minimization. Researchers such as Browning and Treville (2021), Pearce and Pons (2013), Gurumurthy and Kodali (2011), Anand and Kodali (2008), Kumar and Panneerselvam (2006), Mahidhar (2005), Doolen and Hacker (2005), Shah and Ward (2003), Berry et al. (2002), and many more mentioned JIT as a great lean tool.

- **SMED:** One of the various lean manufacturing techniques for cutting waste in manufacturing is called SMED. It offers a quick and effective means to switch a production process from producing the present product to producing the one that will come next. This quick switchover is the key to lowering manufacturing lot sizes and thus optimizing flow. The term "single minute" refers to changeovers and startup times that should be less than ten minutes, not necessarily one minute (Ulutas, 2011). Minimize setup times to produce smaller batches more efficiently- 'overproduction' waste minimization. Take action against overproduction- inventory minimization (Pearce & Pons, 2013; Ulutas, 2011).

- **Value Map Streaming:** Value stream mapping (VSM) can create, analyze, or map out all valuable and non-valuable actions in the manufacturing process by looking at the movement of raw materials from suppliers to final consumers. According to research, organizations may smooth production, reduce waste, and enhance product quality by employing VSM to shorten lead times and production times. It helps organizations satisfy consumer demand, lowers operating costs, and increases flexibility (Shah & Ward, 2003). Create a straight, orderly flow from raw materials to completed products - 'transport' waste minimization. Consider alternative equipment configurations that minimize motion- 'motion' waste minimization (Suhardi et al., 2020; Paramawardhani & Amar, 2020; Pearce & Pons, 2013; Shah & Ward, 2003).

- **KAIZEN:** Search for possible manufacturing process simplifications by contrasting customer needs with manufacturing specifications- 'overprocessing' waste minimization (Pearce & Pons, 2013).

4.4 Existing Approaches of Lean Supply Chain: Lean Practices

Knol et al. (2018) have identified 12 success factors essential to adopting lean practices. The factors are support from top-management, a shared improvement vision, good communication, leadership, a focus on people, enough resources, development training, a performance measurement mechanism, supplier connection, customer connection, and support compatibility (Knol et al., 2018). According to Khalili et al. (2018), the relevance of completely integrating lean production and total quality management concepts is that both aim to increase the performance of organizations by decreasing waste and optimizing processes. Several researchers also use this strategy to accept and use the various tools available while using lean solutions for process development.

Several common domain or areas has been found in the literature where lean practices are used or could be used. Such as production/manufacturing, supplier management, procurement, employee management, delivery, warehousing management, and overall organizational management. The sections below will focus on those domains and their respective good lean practices.

4.4.1 Good Lean Practices in Production/ manufacturing

Lean manufacturing combines large-scale production and designing (Shah et al., 2017). It utilizes various tools and techniques, such as JIT, VSM, 5S, Kanban or pull systems, Kaizen, synchronous manufacturing, and Poka-yoke (Womack et al., 2007). According to Shah et al. (2017), lean manufacturing aims to reduce stocks, lower completion times, improve delivery performance and effectively utilize infrastructures, machinery, and resources. The table below summarizes standard good practices of LSC in Production/ manufacturing identified through the literature review:

Table 7: Good Practices of LSC in Production/ manufacturing

SL No.	Good Practices	Reference
P1.	Just in Time	(Browning & Treville, 2021; Gurumurthy & Kodali, 2011; Anand & Kodali, 2008; Mahidhar, 2005; Doolen & Hacker, 2005; Shah & Ward, 2003; Berry et al., 2002)
P2.	Cellular Manufacturing	(Gurumurthy & Kodali, 2011; Mahidhar, 2005; Doolen & Hacker, 2005; Shah & Ward, 2003)
P3.	Cycle and Set-up Time Reduction	(Shah & Ward, 2003)
P4.	Reengineered production process	(Gurumurthy & Kodali, 2011; Doolen & Hacker, 2005; Shah & Ward, 2003)
P5.	Lot/Batch Size Reduction	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008; Mahidhar, 2005; Doolen & Hacker, 2005; Shah & Ward, 2003)
P6.	Mass Customization	(Anand & Kodali, 2008)
P7.	Production Scheduling Enhancement	(Doolen & Hacker, 2005; Shah & Ward, 2003)
P8.	Product Modularity	(Anand & Kodali, 2008)
P9.	Pull System/Flow Control	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008; Mahidhar, 2005; Doolen & Hacker, 2005; Shah & Ward, 2003)
P10.	Multifunctional Parts Usage	(Anand & Kodali, 2008)

4.4.2 Good Lean Practices in Supplier Management

One of the aspects of lean that supports companies' dependability is close cooperation with suppliers (Belekoukias et al., 2014). Many other researchers such as Browning and Treville (2021), Gurumurthy and Kodali (2011), Anand and Kodali (2008), Doolen and Hacker (2005), Shah and Ward (2003), Berry et al. (2002) have also identified supplier management has a close and vital connection with lean practices implementation. The table below summarizes standard good practices of LSC in supplier management identified through the literature review:

Table 8: Good Lean Practices in Supplier Management

SL No	Good Practices	Reference
S1.	Supplier Certification	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008)
S2.	Supplier Evaluation and Classification	(Anand & Kodali, 2008; Doolen & Hacker, 2005)
S3.	Supplier Participation and Collaboration in Product Design	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008)
S4.	Supplier Relationship Management	(Browning & Treville, 2021; Gurumurthy & Kodali, 2011; Anand & Kodali, 2008; Mahidhar, 2005; Doolen & Hacker, 2005; Shah & Ward, 2003; Berry et al., 2002)
S5.	Supplier Training and Development	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008)

The practices are undoubtfully essential practices for comprehensive supplier management. However, there are contrasting findings on the relationship between 'supplier management' and adopting lean practices. For example, Bento et al. (2020) identified that incorporation with suppliers does not necessarily promote the adoption of lean approaches and has no direct impact on performance. Other researchers, such as Flynn et al. (2010) and Swink et al. (2007), also have similar findings.

Moreover, after analyzing the literature, the author of this study also concluded that supplier management is a crucial element of the supply chain. Hence, the author rejects the idea of keeping supplier management as a good practice of adopting lean ideologies in the supply chain.

4.4.3 Good Lean Practices in Procurement

From the standard definition of a 'lean' supply chain, it can be said that lean procurement practice is a purchasing strategy that focuses on enhancing value through improved efficiency and waste reduction. Purchasing has been crucial in implementing lean manufacturing (Hines, 1996). Researchers such as Azevedo et al. (2012), Gurumurthy and Kodali (2011), and Anand and Kodali (2008) highly support single sourcing as a means of lean practice to build mutual trust and enhance lean manufacturing success. Mutual trust between the manufacturer and supplier underpins this technique (Panayides & Lun, 2009). Including socially responsible providers in a company's supply chain encourages the company's dedication to maintaining connections with them, fosters a high degree of trust among partners, and works well with lean techniques such as JIT (Azevedo et al., 2012). The vendor, on the other contrary, produces a limited number of materials that are committed to a particular client (the producer); this entails a more straightforward management system, i.e., lean ideology (Anand & Kodali, 2008).

According to Hines (1996), lean manufacturing also tries to create a paradigm shift founded on integrating various value-adding companies inside the value stream, to meet high quality in finished goods and services. This shift is referred to as concurrent procurement (Hines, 1996). Concurrent procurement repositions purchasing as a crucial strategic and operational activity instead of an internal independent operation (Hines, 1996). The table below summarizes standard good practices of LSC in procurement identified through the literature review:

Table 9: Good Lean Practices in Procurement

SL No	Good Practices	Reference
PR1.	Single Sourcing	(Azevedo et al., 2012; Gurumurthy & Kodali, 2011; Anand & Kodali, 2008)
PR2.	Concurrent Purchasing	(Hines, 1996)

4.4.4 Good Lean Practices in Employee Management

Hines (1996) reported some crucial facts about the lean management system, i.e., it needs a team-playing environment with integrated divisions; all the activities are coordinated, and the overall system requires fewer human resources; all these activities are teamwork-based works, and the organizational structure is horizontal. A horizontal organizational system has a broad range of control but a limited hierarchical tier. Furthermore, it strongly emphasizes an employee-centered strategy by encouraging cooperation and teamwork. Therefore, having an efficient, coordinated, cross-functional working team and keeping them motivated and focused on work can be a great lean practice. The table below summarizes standard good practices of LSC in employee management identified through the literature review:

Table 10: Good Lean Practices in Employee Management

SL No.	Good Practices	Reference
E1.	Profit Sharing	(Anand & Kodali, 2008)
E2.	High-involvement work system	(Doolen & Hacker, 2005)
E3.	Performance Appraisal	(Doolen & Hacker, 2005)
E4.	Multifunctional Workforce	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008; Doolen & Hacker, 2005; Shah & Ward, 2003)

The practices are suitable whether the company adopts a lean technique or not. Many non-lean following companies also adopt such practices. However, the thorough literature review indicates that a multifunctional workforce is a must if a lean ideology is adopted. Therefore, only a 'Multi-functional Workforce' is a good practice in this study.

4.4.5 Good Lean Practices in Delivery and Warehouse Management

Adopting lean techniques for warehouse management assists the supply chain in gaining additional value. As a result, Dehdari (2014) defined Lean warehousing as a leadership idea, distinguishing it from a set of methods and technologies. This idea aims for long-term, quantifiable, and ongoing advances in the warehouse through employee engagement and a desire for excellence in every business action (Dehdari, 2014). However, lean warehousing focuses on leadership and culture, and applying lean principles in warehousing includes many behaviors rather than a small number of distinctive lean practices (Flinchbaugh & Carlino, 2006). Therefore, it can be said that lean warehousing practice emphasizes two goals, first, to respond rapidly to market demand (Doolen & Hacker, 2005); and second, to lower total cost by performing specific distribution activities (Azevedo et al., 2012). The table below summarizes standard good practices of LSC in delivery and warehouse management identified through the literature review:

Table 11: Good Lean Practices in Delivery and Warehouse Management

SL No.	Good Practices	Reference
W1.	Improved Demand Prediction and Stabilization	(Doolen & Hacker, 2005)
W2.	Using RFID and Barcode and/ or ERP system in the warehousing, material, and inventory management	(Anand & Kodali, 2008; Shah & Ward, 2003; Berry et al., 2002)
W3.	Cross Docking	(Anand & Kodali, 2008)
W4.	Circuit Delivery System, when applicable	(Anand & Kodali, 2008)
W5.	Vendor Managed Inventory	(Anand & Kodali, 2008)

4.4.6 Good Lean Practices in Overall Organizational Management

Specifying value, and identifying value streams, flows, pulls, and excellence are some of the fundamental tenets of lean manufacturing (Womack & Jones, 1997). Therefore, organizations should adhere to these standards to enhance their operations and achieve continuous improvement (Shah et al., 2017). In other words, lean organizational management can be productive with reduced costs and processes (Shah & Ward, 2003; Doolen & Hacker, 2005; Berry et al., 2002). The table below summarizes standard good practices of LSC in organizational management identified through the literature review:

Table 12: Good Lean Practices in Overall Organizational Management

SL No.	Good Practices	Reference
OR1.	Bottleneck Removal	(Shah & Ward, 2003)
OR2.	Competitive benchmarking	(Shah & Ward, 2003)
OR3.	Maintenance optimization	(Shah & Ward, 2003)
OR4.	Introducing new processes, technologies, or system	(Shah & Ward, 2003)
OR5.	Improved Quality Management System	(Shah & Ward, 2003)
OR6.	Improved Safety Management System	(Shah & Ward, 2003)
OR7.	Total Quality Management (TQM)	(Gurumurthy & Kodali, 2011; Mahidhar, 2005; Doolen & Hacker, 2005; Shah & Ward, 2003; Berry et al., 2002)
OR8.	Transparent Information Sharing/Flow	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008)
OR9.	Built-in Quality System	(Gurumurthy & Kodali, 2011; Anand & Kodali, 2008)
OR10.	Customer Relationship Management	(Gurumurthy & Kodali, 2011; Doolen & Hacker, 2005; Shah & Ward, 2003; Berry et al., 2002)

5 Differences, Linkages, and Synergies Between GSCM and LSCM

5.1 Comparison of Lean and Green Characteristics

The observation from the literature demonstrates that it is attainable to determine the main characteristics of both paradigms. These traits are connected to supply chain capabilities and policies (Carvalho et al., 2010). Different researchers, like Carvalho et al. (2010), Govindan et al. (2015), Garza-Reyes (2015), etc., compared GSCM and LSCM in various ways. Taking inspiration from the literature, the main characteristics of lean and green SCs are shown in the table below, and they are categorized into eight focus points:

Table 13: Comparison of Lean and Green Characteristics

Focus Point of Comparison	Lean	Green
Main Objective	Reduction of wastage of resources, time, etc. or non-value-adding components to maximize performance (Govindan et al., 2015; Carvalho et al., 2010)	Minimize the environmental risks and repercussions while boosting a company's ecological efficiency (Govindan et al., 2015; Carvalho et al., 2010)
Production	High average utilization rate (Govindan et al., 2015; Carvalho et al., 2010)	Increase the environmental efficiency through waste reduction, reuse and reuse of materials, and reverse logistics
Supplier and Customer Relationship/Collaboration	Operating level long-term relationships in a conventional manner (Govindan et al., 2015; Carvalho et al., 2010)	Collaboration with different organizations, suppliers, and customers to acquire and disseminate knowledge regarding the concept, maintaining SRM that includes training, facilitations etc., for adopting green techniques (Govindan et al., 2015; Carvalho et al., 2010; Rao & Holt, 2005)
Organizational Structure	Static and conventional (Govindan et al., 2015; Carvalho et al., 2010)	Additional units for environmental management, risk reduction etc., are added and integrated with the conventional structure (Govindan et al., 2015; Carvalho et al., 2010; Hu & Hsu, 2006)
Materials Management	Simplify the material flow to get high-quality materials at the lowest price possible (Govindan et al., 2015; Carvalho et al., 2010)	Follow green purchasing techniques, internal reuse/recycling of materials (Govindan et al., 2015; Carvalho et al., 2010; Vachon, 2010; Rao & Holt, 2005)
Inventory Management	Minimization of inventory stock level and maximization of turnover (Shah et al., 2017; Carvalho et al., 2010)	Reduce overall material consumption, introduce reusable materials/parts in the inventory, apply reverse logistics (Park et al., 2022; Kafa et al., 2013; Deif, 2011; Carvalho et al., 2010; Vachon, 2010; González et al., 2008; Rao & Holt, 2005)
Lead Time	Efforts to reduce lead times without increasing the cost (Carvalho et al., 2010)	Efforts in reducing lead time to reduce fuel and energy consumption, i.e., reduce emission and other environmental impacts (Carvalho et al., 2010) (Holt & Ghobadian, 2009), (Sahar et al., 2020), (Kafa et al., 2013)
Design of Product	Minimizing waste production and resource consumption to maximize performance (Carvalho et al., 2010)	Eco-design aims to reduce its effects on the environment over its entire lifespan (Aslam et al., 2019; Eltayeb & Zailani, 2014; Carvalho et al., 2010)

There is no specific explanation of the supply chain's lean and green paradigms that is acknowledged or accepted worldwide. Different management methods and definitions of each paradigm's overarching goal have been proposed (Pettersen, 2009; Srivastava, 2007). Therefore, it is challenging to define aspects of the lean and green paradigms (Govindan et al., 2015). However, Carvalho et al. (2011) compared the green, lean, and resilient paradigms. As this study is focused on green and lean only, the literature regarding the resilient paradigm from the article has been excluded here. Carvalho et al. (2011) asserted that while lean seeks to reduce costs and increase flexibility for items already in stock by continuously eliminating wastage or non-value-adding operations throughout the supply chain, the green paradigm emphasizes sustainable growth by minimizing the environmental effects of economic operations. Practical advice came from Sawhney et al. (2007) regarding analysis of the interrelationships between the paradigms, i.e., it is essential to bear in mind that any potential connections depend on the supply chain’s particular context, specifically on the traits of the production process, the application of lean principles, indicators of environmental performance, and the culture.

5.2 Linkage Between GSCM and LSCM

As mentioned, no specific explanation of lean and green paradigms for the supply chain is acknowledged or accepted worldwide. Different management methods and definitions of each paradigm's overarching goal have been proposed (Pettersen, 2009; Srivastava, 2007). Therefore, drawing a clear linkage between the paradigms is pretty challenging. However, t figure below is a linkage between the paradigms adapted from Govindan et al. (2015):

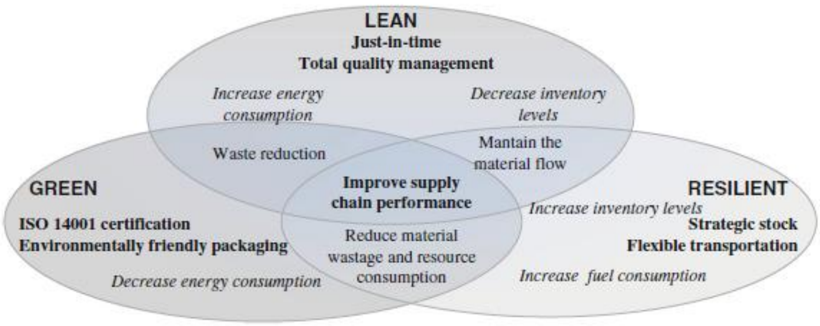

Figure 5: Linkage Between GSCM and LSCM and their practices

Source: adapted from (Govindan et al., 2015)

From the linkage of GSCM and LSCM shown in Figure 5 and the characteristics shown in table 8, it is apparent that both paradigms have some motives in common, for example, waste reduction, inventory control to avoid excess materials in stock, and improvement of performance. According to Govindan et al. (2015), lean practices such as JIT, TQM, and green practices such as ISO 14001 certification, using environmentally friendly packaging have a common motive, i.e., waste reduction and improvement of performance. The findings of other authors, such as Campos and Vazquez-Brust (2016), validate the concept of waste mitigation methods as a significant component of the linkage between lean and green practices.

5.3 Synergies Between GSCM and LSCM

Although green and lean have separate intentions and approaches, they may work together as a compatible system and have synergistic effects (Azevedo et al., 2012). Campos and Vazquez-Brust (2016) describe lean and green synergy as the added outcomes of combining lean and green techniques. The merger is called a synergy if the combined value created by adopting both lean and green techniques is greater than the values created by the lean or green techniques(Campos & Vazquez-Brust, 2016). The conceptual prerequisites for developing such synergy include the superior quality of knowledge in both lean and green concepts and their solid ties and complementary qualities (Campos & Vazquez-Brust, 2016). Compared to the studies on the influence of green or lean paradigms in SC, the studies on synergy's influence are small. The following sub-sections below summarize some conceptual models of such synergy developed by researchers.

5.3.1 Causal Loop Modeling by Carvalho et al (2010)

A conceptual model is put forward to investigate the connections between lean and green approaches and SC efficiency. To represent the SC processes, "a causal diagram" was used to create this model. Causal loop modeling is a highly successful SC system method (Carvalho et al., 2010). The Table below summarizes the green and lean practices of the model:

Table 14: Summary of Causal Loop Model of Green and Lean Synergy

Author	Green Practices Included in the Synergy	Lean Practices Included in the Synergy
(Carvalho et al., 2010)	• Environmental collaboration with suppliers • Environmentally friendly practices in purchasing • Working with designers and suppliers • Waste Minimization • Decrease the consumption of hazards and toxic materials • ISO 14001 Certification • Reverse logistics • Environmental collaboration with customers • Environmentally friendly packaging • Collaboration with customers in changing or modifying product specifications	• Supplier Relationships • JIT • Lot-size reduction • TQM • TPM • Cycle time reduction • Customer Relationships

Source: adapted from (Carvalho et al., 2010)

According to Carvalho et al. (2010), their model is the first step in establishing a comprehensive insight and knowledge of the impacts of lean and green approaches on SC performance. The second step is to examine the relationship between the two paradigms (Carvalho et al., 2010). It was apparent from the literature that connections with suppliers help reduce company waste; lean measures considered in the model hardly impact the supply chain's environmental performance(Carvalho et al., 2010). The remaining concern is whether an LSC can meet the task of going green was raised by the authors themselves, i.e., Carvalho et al. (2010). Another finding is that the model's consideration of green practices has zero impact on operational and financial performance. Most green measures lead to higher customer satisfaction, and ISO 14001 accreditation leads to higher quality (Carvalho et al., 2010). Since it could be used as an influence to compete in the marketplace and maintain and grow the market share, in this sense, it can be considered a competitive advantage for the supply chain. Nevertheless, just three green practices among the ones chosen were identified to be associated with a decrease in overall costs and an increase in efficiencies on the grounds of financial metrics by Carvalho et al. (2010).

5.3.2 Theoretical Framework' On Lean And Green Synergy By Azevedo et al. (2012)

Azevedo et al. (2012) found that although green and lean employ various motivations and strategies, they may coexist prosperously and work together in harmony. This understanding was the base of their 'theoretical framework' on lean and green synergy. The Table below summarizes the green and lean practices of the model:

Table 15: Summary of Theoretical Framework on Lean And Green Synergy

Author	Green Practices Included in the Synergy	Lean Practices Included in the Synergy
(Azevedo et al., 2012)	• The requirement for maintaining environmental management system for first-tier suppliers • Adopting ecologically friendly buying practices and guidelines and purchasing from environmentally responsible suppliers • Using reusable packaging to deliver materials	• Just-in-sequence • Deliveries directly to the point of use • Geographical concentration • Using EDI to share information • Single sourcing

Source: adapted from (Azevedo et al., 2012)

Azevedo et al. (2012) anticipated improving the sustainability of business progression using green and lean synergy. The sustainability of business progression was defined as the business's overall environmental, economic and social progression (Azevedo et al., 2012). The effectiveness of the framework was tested in the manufacturing industry context. The findings of the study show that several variables affect the environmental costings and the 'green brand image. According to Azevedo et al. (2012), such variables are energy consumption, recycling, reuse or remanufacturing rate, and the disposal of solid and liquid waste (Azevedo et al., 2012). The use of all proposed green measures reduces all these characteristics.

Additionally, the lean technique known as "geographical concentration" aids in the decrease of energy use. As a result, the collection of activities deemed green, along with the lean practice of "geographic concentration, lowered environmental costs and boosted a company's reputation for being environmentally friendly (Azevedo et al., 2012). Most of the green measures have proved to help in emission reduction. However, some lean practices are similar and help reduce energy consumption. In contrast, some practices, such as JIT, direct delivery to the point, etc., have the opposite impact on the environmental context (Azevedo et al., 2012).

5.3.3 The 'Dynamic Model of the Outcomes of Integrated Lean and Green Characteristics on Supply Chain Attributes Supply Attributes' by Alabduljabbar (2013)

According to Alabduljabbar (2013), there is a confluence of synergy when lean and green supply chain features affect specific supply chain attributes and KPIs similarly or even more. However, unlike the other researchers who studied such synergies, Alabduljabbar (2013) has identified some practices as green or lean and others as integrated lean and green, depending on the characteristics. The Table below summarizes the green, lean and integrated practices of the model:

Table 16: Summary of Dynamic Model of the Outcomes of Integrated Lean and Green Characteristics

Author	Green Practices Included in the Synergy	Lean Practices Included in the Synergy	Integrated Green and Lean Practices
(Alabduljabbar, 2013)	• Clean Production • Life Cycle Analysis	• Supplier's Ordering Flexibility • Pull Production • Optimized Production Flow	• Optimized use of resource • Preventative Supplier Maintenance and Environmentally Friendly Suppliers • Lean and Green Logistics • JIT and Minimization of redundant materials and processes

Source: adapted from (Alabduljabbar, 2013)

Lean and green paradigms call for a reduction in overcapacity and an improvement in responsible procurement practices to encourage the best possible resource use and lessen upstream waste generation. Nevertheless, it shows that the impact on several other qualities depends on the circumstances (Alabduljabbar, 2013). To improve supply chain adaptability, lean obsessively strives to lower inventory levels and transportation and production lead times. However, Green aims to decrease those qualities when doing so does not increase emissions (Alabduljabbar, 2013). Azevedo et al. (2012) has the similar findings too. Consequently, stock levels and lead times must be handled inside a green-lean synergy that does not contradict either philosophy. Lean and green adoption influence emission performance by producing distinct behaviors that lead to various turnover frequency outcomes. In particular, the lean perspective recommends increasing the turnover rate to manage stock levels and improve flexibility. In contrast, the green concept recommends decreasing the turnover rate to lower transportation-related emissions (Alabduljabbar, 2013).

5.3.4 Interpretive Structural Modeling Approach By Govindan et al. (2015)

The context of the study was the automotive supply chain in Portugal. The ISM technique determines the connections between supply chain performance metrics and lean, green, and resilient strategies (Govindan et al., 2015). This technique was selected since it encourages discovering the critical connections between particular variables that characterize an issue or problem (Charan et al., 2009). To create the contextual linkages between the variables, the ISM method advises employing expert views and management strategies like brainstorming or nominal team approaches (Talib et al., 2011). Lean, green, and resilient practices of supply chain methods were examined for their effects on performance using ten different variables, such as JIT, Total quality management (TQM), Strategic stock, Flexible transportation, environmentally friendly package, ISO 14001, Operational cost, Business wastage, Environmental cost and Customer satisfaction (Govindan et al., 2015). The variables influence each other, and the contextual relationships between them are created based on their influence or impact on each other. The Table below summarizes the green, lean and resilient practices chosen for the model:

Table 17: Summary of Interpretive Structural Modeling Approach

Author	Green Practices Included in the Synergy	Lean Practices Included in the Synergy	Resilient Practices in the Synergy
(Govindan et al., 2015)	• ISO 14001 certification • Environmentally friendly packaging	• JIT • Total quality management (TQM)	• Strategic stock • Flexible transportation

Source: adapted from (Govindan et al., 2015)

Given that it appears at the peak of the ISM hierarchies, "customer satisfaction" is a significant variable (performance metric) for the automotive supply chain. It determines the supply chain's competitiveness(Govindan et al., 2015). The ISM model further indicates that just-in-time, flexible transportation and environmentally friendly packaging are effective practices because they form the foundation of the ISM hierarchy (Govindan et al., 2015). Additionally, Govindan et al. (2015) have identified that Total quality management, strategic stock, ISO 14001, operational cost, business wastage, and environmental cost are all performance metrics and practices that contribute to "customer satisfaction" and are essential to the leanness, sustainability, and resilience of supply chains.

5.3.5 Synergic Model By Campos and Vazquez-Brust (2016)

The study was conducted at a Brazilian company, but researchers presume its implications transcend beyond a more profound comprehension of synergy in a specific corporate setting (Campos & Vazquez-Brust, 2016). The model demonstrates the key combined lean and green supply chain techniques. The research did not separately list the green and lean practices of supply; it chose from 21 publications (Campos & Vazquez-Brust, 2016). Campos and Vazquez-Brust (2016) divided the practices into three types, i.e., practices regarding the company and its consumers (C), practices regarding the suppliers (S), and practices regarding the production processes (O). The practices seem divided based on their motives or ultimate objectives. Some practices from the list can be easily identified as green or lean; however, some can act as both. Therefore, while reviewing the model, the author of this study decided to keep the division according to the original researchers to maintain authenticity. The table below summarizes the green and lean and their respective type (S, C, or O) chosen for the model:

Table 18: Summary of Synergic Model

Author	Practices Reading Company and Suppliers (S)	Practices Reading Production Processes	Practices Reading Company and Customers (C)
(Campos & Vazquez-Brust, 2016)	• Supplier network/ collaboration/ training (long-term relationship) • Supplier evaluation/certification/auditing (environmental requirements) • Use of green/fewer packages (from suppliers) • Geographic concentration • Environmental risk sharing with suppliers • Reducing the number of suppliers • JIT delivery	• Employees involvement, training, and empowerment • Continuous improvement/Kaizen • Inventory reduction • Information shared through the chain or information system • 5S • Total productive/preventive maintenance (TPM) • Six Sigma • 3Rs (Reduce, reuse and recycle) • TQM and/or TQEM • Kanban • Waste reduction • Pollution prevention • ISO systems certifications (or other systems) • Lead time and/or set-up reduction and/or total time reduction • Emissions reduction • Reduction of hazardous/materials/resources consumption • Use of green technology • Value stream map/focus or sustainable VSM • JIT philosophy	• Customer relationship/interaction • Reverse logistics • Environmental risk sharing with costumers • Environmental products and/or eco-design • Use of green/fewer packages (to customers)

Source: adapted from (Campos & Vazquez-Brust, 2016)

Only five out of the 31 integrated strategies in the study were not deemed to be synergistic for lean and green. JIT delivery, JIT philosophy, inventory reduction, and Value stream map/focus or sustainable VSM are those four non-synergic components that create trade-offs (Campos & Vazquez-Brust, 2016). The opportunity for the green with these practices was not recognized, although Campos and Vazquez-Brust (2016) identified that all four non-synergic activities are crucial for lean. However, it was also discovered that one practice, the "Use of Green Technology," had more significant potential to be green than lean and was only half applied in the organization. Moreover, the practice in this instance was not seen as fully synergic due to its meager lean advantages.

Another thing to note is that although lean and green have distinct definitions of waste reduction, many synergistic outcomes have some connection to them. According to Campos and Vazquez-Brust (2016), waste reduction would be the main focus of a lean and green synergy, and other activities might aid or boost that practice or outcome. However, t most considerable synergies arise from the supplier and customer-related processes, which has an intriguing managerial practice impact (Campos & Vazquez-Brust, 2016).

5.3.6 Remark on the Synergy

The literature explains that there are benefits to be obtained by combining lean and green paradigms in SC. However, areas of incompatibility need to be identified and controlled to counterbalance the benefits and incompatibilities. The most listed lean and green techniques were 'waste reduction. Compared to purely JIT lean and centralized circumstances, not all lean operations at the strategic SC planning level yield green advantages. The author of the study agrees with previous researchers such as Campos and Vazquez-Brust (2016) that, compared to purely JIT lean and centralized circumstances, a dynamic and flexible supply chain including good inventories is the greenest and the most efficient option.

6 Impacts of Lean And Green Paradigms Shifts In The Supply Chain Management

6.1 Identification of Measurement Criteria to Measure Impacts

Azevedo et al. (2012) have identified three significant parameters or domains of the performance measure to determine the consequences of lean and green paradigm shifts, i.e., economic, social, and environmental indicators. According to Cumbo et al. (2006), the commonly used economical and environmental indicators to assess the influence and impacts of lean practices in the long-term future business are: lead time from order to delivery, set-up and changeover times, the capacity of producing the correct quantity of products at the right time, timely shipments and reduction of inventory. Browning and Heath (2009) identified that cost measurement are the most excellent way to assess the influence of the lean concept on performance. Many other researchers have made recommendations regarding the indicators from a different point of view. For instance, social dimensions (Dakov & Novkov, 2007), risk of corruption etc. (Faisal, 2010). The following performance measurement parameters have been used to determine the consequences of lean and green supply chain paradigm shifts:

Table 19: Parameters and Indicators of Performance Measurement

Performance Measuring Parameter/Domain	Indicators of Performance Measure	References
Economic Performance	Operational Cost	(Azevedo et al., 2012; Azevedo et al., 2011; Hervani et al., 2005; Zhu et al., 2005)
	Inventory Cost	(Azevedo et al., 2012) (Zhu et al., 2005)
	Environmental Cost	(Azevedo et al., 2012) (Hervani et al., 2005)
	Return on Assets	(Carvalho et al., 2010)
	Quality	(Carvalho et al., 2010) (S. G. Azevedo et al., 2011)
	Lead Time/ Production Time	(Carvalho et al., 2010)
Environmental Performance	CO_2 Emission	(Azevedo et al., 2012)
	'Green' Image	(Azevedo et al., 2012)
	Business Wastages	(Azevedo et al., 2012; Azevedo et al., 2011; Carvalho et al., 2010)
	Life Cycle Assessment	(Carvalho et al., 2010)
Social Performance	Local Supplier Community	(Azevedo et al., 2012)
	Supplier Evaluation	(Azevedo et al., 2012)
	Customer Satisfaction	(Carvalho et al., 2010) (S. G. Azevedo et al., 2011)

A significant amount of literature and associated research identified the influence of green and/ or lean paradigm shifts in the supply chain performance in various aspects. However, the search for such literature has been limited to those that used the performance measurement indicators mentioned in table 19. The limiting boundary was created to maintain the focus of the research.

6.2 Impacts of Lean and Green Paradigms Shifts on Economic Performance

Most of the lean practices has seen to impact increased economic performance positively. However, very few green practices positively reduced the environmental cost, and only two impacted in reduced cost. Therefore, the overall economic performance of lean practices can be said to be better than green practices. The table below shows the representation of the impacts of lean and green paradigms shifts in the economic performance of supply chain management:

Table 20: Impacts of Lean And Green Paradigms Shifts on Economic Performance

		Economic Performance					
		Operational Cost	Inventory Cost	Environmental Cost	Quality	Lead Time/ Production Time	Return on Assets
Green	Cooperation among suppliers to minimize the environmental impacts of material flow and distribution	↓					
Green	Closely working with customers to design customized eco-friendly products and environmental collaboration			↓			
Green	Reduce the usage of hazardous materials and processes in the design			↓			
Green	Minimizing waste while manufacturing	↓		↓			
Green	Using environmentally friendly packaging			↑			
Green	ISO 14001 certification			↑	↑		
Green	Reverse Logistics Practices	↓		↑			
Lean	JIT Ideology	↓	↓	↓	↑	↓	↑
Lean	Customer Relationship						
Lean	Lot Size Reduction		↓				
Lean	TPM	↓					↑
Lean	TQM				↑		↑
Lean	Supplier Relationship	↓	↓		↑	↓	

Legend:

↓ Decrease

↑ Increase

Source: adapted from (Govindan et al., 2015; Susana Azevedo et al., 2014; Carvalho et al., 2010, 2014; Azevedo et al., 2010, 2011)

6.3 Impacts of Lean and Green Paradigms Shifts on Environmental Performance

Four measurement matrices, i.e., CO_2 emission, green image, business wastages, and environmental impact or life cycle assessment, have been considered to measure environmental performance. Table 21 shows that most green practices positively impact and increase overall environmental performance while lean practices only contribute to ‘reducing business wastes.

Table 21: Impacts of Lean And Green Paradigms Shifts In Environmental Performance

		Environmental Performance			
		CO2 Emission	'Green' Image	Business Wastages	Life Cycle Assessment (Environmental Impact)
Green	Cooperation among suppliers to minimize the environmental impacts of material flow and distribution	↓	↑	↓	↓
	Closely working with customers to design customized eco-friendly products and environmental collaboration	↓	↑	↓	↓
	Reduce the usage of hazardous materials and processes in the design	↓	↑	↓	↓
	Minimizing waste while manufacturing	↓	↑	↓	↓
	Using environmentally friendly packaging	↓	↑	↓	↓
	ISO 14001 certification	↓	↑	↓	↓
	Reverse Logistics Practices	↓	↑	↓	↓
Lean	JIT Ideology	↑		↓	
	Customer Relationship				
	Lot Size Reduction			↓	
	TPM				
	TQM			↓	
	Supplier Relationship			↓	
Legend:					
↓ Decrease					
↑ Increase					

Source: adapted from (Govindan et al., 2015; Susana Azevedo et al., 2014; Carvalho et al., 2010, 2014; Azevedo et al., 2010, 2011)

6.4 Impacts of Lean and Green Paradigms Shifts on Social Performance

Unlike the almost opposite relationships of lean and green practices with the two other measurement domains (economic and environmental performance), both practices positively impact social performance measures.; more precisely, in customer satisfaction. The following table summarizes the findings:

Table 22: Impacts of Lean And Green Paradigms Shifts In Social Performance

		Social Performance		
		Local Supplier Community	Supplier Evaluation	Customer Satisfaction
Green	Cooperation among suppliers to minimize the environmental impacts of material flow and distribution	↑	↑	
	Closely working with customers to design customized eco-friendly products and environmental collaboration		↑	↑
	Reduce the usage of hazardous materials and processes in the design		↑	↑
	Minimizing waste while manufacturing			↑
	Using environmentally friendly packaging			↑
	ISO 14001 certification			↑
	Reverse Logistics Practices			↑
Lean	JIT Ideology	↑	↑	↑
	Customer Relationship			↑
	Lot Size Reduction			↑
	TPM	↑	↑	
	TQM	↑	↑	↑
	Supplier Relationship	↑	↑	
Legend:				
↓ Decrease				
↑ Increase				

Source: adapted from (Govindan et al., 2015; Susana Azevedo et al., 2014; Carvalho et al., 2010, 2014; Azevedo et al., 2010, 2011)

6.5 Remark on the Overall Impacts

The common goal of the two paradigms is to fulfill consumer requirements while spending as little as possible. The main distinction between the paradigms is their explicit goals, i.e., the LSC aims to reduce waste, whereas the GSC wants to lessen its environmental effects.

7 Paradoxes and Challenges Associated With Adopting The Green And Lean Paradigms of Supply Chain

Even though green and lean practices may positively impact corporate sustainability, establishing such practices can be challenging. Furthermore, this topic can be, in fact, a separate area of research in the future. Therefore, prior internal modifications and alterations should be made for such adoptions.

7.1 Paradoxes and Challenges Associated with Adopting the Green Paradigm of Supply Chain

According to Sundarakani et al. (2010), factors such as organizational structure, organizational and business culture, strategic ideology, access to market data, innovation capacity, etc., can be vital factors in adopting a green supply chain. Azevedo et al. (2012) support the idea and identify that green SCM techniques may be challenging or unattainable to execute if some of such aspects are not considered before the operation.

Generally, adopting green practices can be expensive. Section 6.2 has explained the impact of green practices on economic performance. Adopting such practices as green purchasing, green packaging, renewable energy usage, green technology, and significant R&D initiatives may require an overall cost increase. Many consumers might not be prepared to pay a greater price for the items, which could impact profitability. Due to the higher cost of recyclable, renewable, and green technology, the first earnings will be pretty low. Green supply chain practices require significant time to be fully functional, effective, and profitable. However, sometimes it might be challenging to convince the stakeholders, partners, and funding entities to shift to a time-consuming and initially cost-increasing paradigm from a traditional one. Moreover, challenges like limited environmentally decomposable suppliers, lack of expertise, and system complexity may also hinder the shift toward green practices.

7.2 Paradoxes and Challenges Associated with Adopting the Lean Paradigm of Supply Chain

Lean deployment in the supply chain setting has been considerably more challenging than in the corporate environment (Azevedo et al., 2012). Lean tool use necessitates customization for various production settings and impacts both the social and technological systems of the businesses (Abdulmalek et al., 2006). Furthermore, understanding the connections in the broader supply chain is necessary for lean adoption (Azevedo et al., 2012). Several businesses adopt lean techniques assuming they only need to be executed once. Moreover, organizations are unwilling to invest the time and effort necessary to maintain lean operations because it may seem difficult. Another typical barrier to implementation is the idea that lean could exclusively be used in manufacturing. The advantages of implementing lean in only one department, i.e., manufacturing, might be positive at first. However, they may later decline when other departments are impacted or influenced by that department. Adopting lean only to lower inventory levels and human resources as a means of cost saving is one of the two biggest mistakes businesses make when implementing. Despite initially identifying the root causes, severely lowering inventory causes many difficulties, and ultimately a need to revert to the previous method of maintaining inventory might be required. As a result, inventory levels will decline over time. Inventory reduction should not be a company's objective; instead, it should be a method of locating waste sources and eventually eliminating them.

8 Summary of The Findings

The author prefers to summarize the research findings in the same order as the research questions, making it easier for readers to find and understand the findings.

8.1 The Concepts of The Green and Lean Supply Chain

There is no specific explanation of the supply chain's lean and green paradigms that is acknowledged or accepted worldwide. Different management methods and definitions of each paradigm's overarching goal have been proposed (Pettersen, 2009; Srivastava, 2007). However, Carvalho et al. (2011) have an insightful assertion, i.e., while lean seeks to reduce costs and increase flexibility for items that are already in stock by continuously eliminating waste or non-value-added operations throughout the supply chain, the green paradigm emphasizes sustainable growth by minimizing the environmental effects of economic operations.

Following the previous research, the author also identifies that:

- It is equally important to first create the mindset of the company for adopting 'green' practices
- Developing and strengthening the company structure, management, and professionals to adopt the practices which Zhu et al. (2008a) also acknowledge as 'internal environmental management. Aslam et al. (2019) also have similar opinions on internal environmental management.
- Collaborating with different organizations, suppliers, and industry peers to standardize environment-friendly practices, with which Aslam et al. (2019) agree.

Therefore, equation 2 regarding the concept of GSCM can be updated as follows:

Equation 4: Components of Green Supply Chain Updated

Green supply Chain management (GSCM) = Green Purchasing + Eco-Design + Green Manufacturing + Green Distribution + Reverse Logistics + Green Organizational Development

8.2 Current Good Practices of the Green and Lean Supply Chain Paradigm

8.2.1 Green Good Practices

Based on equation 3, sections 3.2.1 to 3.2.6 are explained the six components of the green supply chain elaborately and detect their existing good practices.

8.2.2 Lean Good Practices

Several common domains or areas have been found in the literature where lean practices are used or could be used, such as production/manufacturing, supplier management, procurement, employee management, delivery, warehousing management, and overall organizational management. Sections 4.4.1 to 4.4.6 has been dedicated to this purpose.

However, the author concluded that, although 'supplier management is a crucial aspect of the supply chain and hence it should be given immense importance, the identified good practices of supplier management are not exclusive to adopting lean concepts only. Therefore, the author rejects the idea of keeping supplier management as a good practice of adopting lean ideologies in the supply chain. Moreover, the ‘employee management’ domain practices are good whether the company adopts a lean technique, and many non-lean following companies also adopt such practices. However, the thorough literature review indicates that a multifunctional workforce is a must if a lean ideology is adopted. Therefore, this study chooses only the ‘Multifunctional Workforce’ as the only good practice in the ‘employee management domain.

8.3 Connections Between Green and Lean Approaches and SC Performance

Not all good practices are of the same level. For example, best green practices are strategic, while most lean practices are operational. It is, therefore, quite challenging to compare them side by side. There is no specific explanation of the supply chain's lean and green paradigms that is acknowledged or accepted worldwide. Different management methods and definitions of each paradigm's overarching goal have been proposed (Pettersen, 2009; Srivastava, 2007). Therefore, drawing clear links or differences between the paradigms is quite challenging. Some lean and green supply chain features overlap or potentially contribute to the similar impact of a particular SCM paradigm on specific attributes. For example, both paradigms advocate for reducing excess inventory and improving responsible purchasing to encourage the best possible utilization of resources and eliminate waste generation.

However, ‘waste’ in the two paradigms has two different ideas. For example: from a lean perception, waste minimization concentrates on the removal of waste throughout every operational process that comes from overproduction, waiting, transportation, incorrect processing, faults, and superfluous inventory (Shah et al., 2017; Corbett & Klassen, 2006; Womack & Jones, 1997). In contrast, the waste reduction from a green viewpoint emphasizes reducing pollution, disassembling, redesigning, segregating garbage, and using and reusing leftovers (Campos & Vazquez-Brust, 2016). The value provided by these unique catalysts can be combined in a synergic approach to waste reduction.

Integrating lean and green practices within one supply chain has been advantageous in many cases. The literature review on synergy proves this statement. However, areas of incompatibility need to be identified and controlled to counterbalance the benefits and incompatibilities. The author of the study agrees with previous researchers such as Campos and Vazquez-Brust (2016) and Fahimnia et al. (2015) that, when compared to purely lean and centralized circumstances, a dynamic and flexible supply chain including good inventories is the greenest and the most efficient option; however not all lean practices in the supply chain translate into green benefits.

8.4 The Benefits and Influence of The Green and Lean Supply Chain Paradigm

To measure the benefits or impacts, it is first necessary to identify the measuring indicators and parameters. For example, Azevedo et al. (2012) have identified three significant parameters or domains of the performance measure to identify the impacts of lean and green paradigm shifts, i.e., economic, social, and environmental indicators. Furthermore, the study created a boundary of such measurements as a significant amount of measurement matrix can be found for each domain.

Matrices such as Operational Cost, Inventory Cost, Environmental Cost, Return on Assets, Quality, and Lead Time/ Production Time were used to measure the economic performance. Table 20 represents the overall impacts on the domain. Most of the lean practices have been seen to impact economic performance positively. However, very few green practices positively reduced the environmental cost, and only two impacted reduced cost. Therefore, the overall economic performance of lean practices can be said to be better than green practices.

Four measurement matrices, i.e., CO2 emission, green image, business wastages, and environmental impact or life cycle assessment, have been considered to measure environmental performance. Table 21 shows that most green practices positively impact and increase overall environmental performance, while lean practices only contribute to reducing business waste.

Three measurement matrices, such as Local Supplier Community, Supplier Evaluation, and Customer Satisfaction, were used to evaluate the social performance of the paradigms. Unlike the almost opposite relationships of lean and green practices with the two other measurement domains (economic and environmental performance), both practices positively impact social performance measures.; more precisely, in customer satisfaction.

The common goal of the two paradigms is to fulfill consumer requirements while spending as little as possible. The main distinction between the paradigms is their explicit goals, i.e., the LSC aims to reduce waste, whereas the GSC wants to lessen its environmental effects. This finding also supports linkages and differences between lean and green concepts.

8.5 Paradoxes of the Green and Lean Supply Chain Paradigm

Even though green and lean practices may positively impact corporate sustainability, establishing such practices can be challenging. This topic can be, in fact, a separate area of research in the future. Prior internal modifications and alterations should be made for such adoptions.

The common challenges in adopting green practices are the following:

- Generally, green practices can be expensive due to cost-increasing traits of green purchasing, green packaging, renewable energy usage, green technology, and significant R&D activities.
- Many consumers might not be prepared to pay a greater price for the items, which could have an impact on the profitability
- Due to the higher cost of recyclable, renewable, and green technology, the first earnings will be pretty low since such practices require a significant amount of time to be fully functional, effective, and profitable
- Sometimes it might be challenging to convince the stakeholders, partners, and funders to shift to such a time-consuming and initially cost-increasing paradigm from a traditional one
- Moreover, challenges such as limited environmentally decomposable suppliers, lack of expertise, and system complexity may also hinder the shift toward green practices.

Lean deployment in the supply chain setting has been considerably more challenging than in the corporate environment (Azevedo et al., 2012). The common challenges are mentioned below:

- Several businesses adopt lean techniques on the assumption that they only need to be executed once
- Organizations are unwilling to invest the time and effort necessary to maintain lean operations because it may seem difficult
- Another typical barrier to implementation is the idea that lean could exclusively be used in manufacturing
- The advantages of implementing lean in only one department, i.e., manufacturing, might be positive at first, but they may later decline when other departments are impacted or influenced by that department

- Adopting lean only to lower inventory levels and human resources as a means of cost saving is one of the two biggest mistakes businesses make when implementing. Inventory reduction should not be a company's objective; instead, it should be a method of locating waste sources and eventually eliminating them.

9 Reliability of Results

The research findings are expected to facilitate researchers., academicians, and policymakers in further working on the issue; the compilation of previous research will be an excellent database for them. The comprehensive literature analysis can also be an initial guideline for understanding the concept for students and professionals. The study is also expected to curve a foundation of usable and adaptable practices of green and lean supply chain concepts for industries and a way forward for further research by the researchers. Establishing connections between diverse lean, green practices, and performance indicators is a significant accomplishment of this study. Regarding the meaningful contribution of the study, it is also necessary to recognize certain research limitations. The study was only based on literature review, but no validation activities were undertaken. Although the results can be different for different supply chains, geographical situations, etc., the study intended to work on a generalized approach to the supply chains. Therefore, the study creates an excellent background for more specialized supply chain or industry-focused future research.

10 Conclusion

Even though green and lean practices may positively impact corporate sustainability, establishing such practices can be challenging for management. Moreover, most green practices are strategic, while most lean practices are operational. It is, therefore, quite challenging to utilize them as a combined system. An organization cannot run successfully if the strategic and operational plans do not align. It is possible to change the strategic plans swiftly, although not recommended. However, the operational plans cannot adapt to changes in strategic priorities that fast and creates a complicated situation. Therefore, the management must first understand their requirements, needs, and ability to adopt the paradigms and, most importantly, whether they are going for synergy or any of them. After the target is determined, actions can be taken accordingly.

Another major challenge that needs to be taken care of is the cost situation. Sometimes, it might be challenging to convince the stakeholders, partners, and funders to shift to a time-consuming and initially cost-increasing paradigm from a traditional one. A further study on pricing decisions for adopting GSM or LSM or their synergies can be done.

Furthermore, adopting or modifying any already established system requires time, investment, positive culture, knowledge, enough data and studies, and the willingness to change and modify- abundance or lacking these may create additional benefits or challenges.

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