

A Review Study on Green Manufacturing Practices in Industries

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ABSTRACT

The increasing environmental challenges associated with industrial activities have intensified the need for sustainable manufacturing solutions. Green manufacturing practices have emerged as an effective approach for reducing environmental impacts while improving organizational performance and competitiveness. This review paper systematically examines existing literature on green manufacturing practices in industries, with a particular focus on their drivers, implementation mechanisms, and performance outcomes. The review synthesizes findings from prior empirical and conceptual studies to evaluate the effects of green manufacturing, green logistics, and green supply chain management practices on environmental, social, and financial performance. The analysis reveals that green manufacturing practices contribute positively to operational efficiency, corporate reputation, and sustainable performance, often influenced by stakeholder pressure and organizational culture. However, the literature is characterized by fragmented findings, a dominance of cross-sectional research designs, and limited attention to shop-floor-level practices and long-term impacts. This review highlights key research gaps and suggests future research directions to support the effective implementation of green manufacturing strategies and sustainable industrial development.

Keywords:- Green manufacturing practices, sustainable manufacturing, green supply chain management, green logistics, environmental performance, industrial sustainability

1. INTRODUCTION

Industrial expansion has been crucial for economic advancement worldwide, yet it has led to significant environmental issues including resource scarcity, heightened greenhouse gas emissions, and increased industrial waste. The manufacturing sector plays a significant role in environmental pollution because of its energy-consuming processes and intricate supply networks. Consequently, governments, oversight agencies, and industry participants are now demanding that companies implement sustainable business strategies. In this context, eco-friendly manufacturing techniques (EFTs) have become a pivotal approach for promoting sustainable industrial growth.

Broadly, green manufacturing encompasses the implementation of production methods, technologies, and management strategies that minimize environmental effects while preserving or enhancing economic efficiency and resource optimization as production frameworks [8]. Through gradual development, this idea encompasses green supply chain management, green logistics, eco-design, and the incorporation of sustainability into organizational ethos and planning [12], [15].

Recent empirical research demonstrates that green manufacturing strategies enhance firm outcomes significantly. Afuem et al. Research indicates that green manufacturing significantly boosts operational efficiency and corporate image, ultimately leading to enhanced environmental, social, and economic performance metrics [1]. Similarly, Agyabeng-Mensah and Tang discovered that investments in green human capital and green logistics practices markedly enhance green competitiveness, resulting in better social and financial outcomes. These results indicate that green manufacturing functions as a strategic asset rather than a mere compliance mechanism.

The significance of green logistics and supply chain strategies has garnered significant scholarly interest. Research suggests that green logistics management enhances the connection between environmental initiatives and firm performance through better market standing, environmental achievements, and social accountability [3], [11]. Furthermore, stakeholder and regulatory pressures have been recognized as major forces influencing green production and logistics strategies, especially among small and medium-sized enterprises (SMEs) [9], [10]. Successfully implemented, these strategies boost corporate reputation and sustained profitability [9].

Studies conducted in various locations underscore the increasing prevalence of green manufacturing techniques. Research in Malaysia, Thailand, India, and Indonesia indicates that green factory strategies and green production programs enhance technical effectiveness and environmental performance in manufacturing

companies [4], [7], [16]. Recent improvements in methodology, including hybrid SEM-ANN techniques, have offered greater understanding of the intricate connections between green supply chain strategies and environmental outcomes [6]. Furthermore, organizational elements like a green culture have been demonstrated to influence the effectiveness of green manufacturing initiatives in achieving sustainable corporate outcomes [5].

Although there is a growing body of research, the literature on green manufacturing practices is still divided, with studies often concentrating on particular practices, industries, or performance aspects. A significant gap exists in the comprehensive integration of drivers, implementation strategies, and outcomes of green manufacturing across various industrial and geographical settings. Consequently, this review paper intends to comprehensively examine and integrate existing research on green manufacturing techniques within various sectors, with the goal of pinpointing significant patterns, delineating research voids, and outlining future research paths to facilitate sustainable industrial evolution.

2. LITERATURE REVIEW

The reviewed literature consistently highlights the importance of green manufacturing, green logistics and green supply chain management practices in enhancing environmental, social and financial performance in manufacturing industries. Most studies employ quantitative methods, particularly structural equation modeling, and demonstrate that these practices improve operational efficiency, competitiveness, and corporate reputation, often influenced by stakeholder pressure and organizational culture. Research is primarily concentrated in developing economies, reflecting the growing acceptance of green practices in these contexts. However, the literature remains fragmented, with a limited focus on shop-floor-level practices, human capital integration, and long-term performance impacts, indicating the need for more holistic and longitudinal research on green manufacturing practices.

Ref. No.	Author(s) & Year	Country / Context	Focus Area	Methodology	Key Findings
[1]	Afum et al. (2020)	Manufacturing firms	Green manufacturing, competitiveness, reputation, sustainability	SEM	Green manufacturing positively influences operational competitiveness and firm reputation, which mediate sustainable performance outcomes.
[2]	Agyabeng-Mensah & Tang (2021)	Manufacturing sector	Green human capital, green logistics, performance	SEM	Green human capital and logistics practices enhance green competitiveness, leading to improved social and financial performance.
[3]	Agyabeng-Mensah et al. (2020)	Manufacturing firms	Green logistics and financial performance	SEM	Green logistics practices indirectly improve financial performance through market, environmental, and social performance.
[4]	Ahmad et al. (2019)	Malaysia	Green factory practices	Survey analysis	Adoption of green factory practices improves environmental performance and operational efficiency in manufacturing industries.
[5]	Al-Hakimi et al. (2022)	SMEs	Green manufacturing and sustainable performance	Moderated mediation (SEM)	Green organizational culture strengthens the impact of green manufacturing on corporate sustainable performance.
[6]	Al Karim et al. (2024)	Manufacturing industry	Green supply chain & environmental performance	SEM-ANN	Green supply chain practices significantly enhance environmental performance; ANN improves predictive accuracy.
[7]	Amornkitvikai et al. (2024)	Thailand	Green production and efficiency	DEA & regression	Green production practices improve technical efficiency among Thai manufacturers.
[8]	Atlas & Florida (1998)	Conceptual	Green manufacturing concepts	Conceptual framework	Established foundational principles of green manufacturing, emphasizing pollution prevention and resource efficiency.
[9]	Baah et al. (2021)	Manufacturing SMEs	Stakeholder pressure, green production	SEM	Stakeholder pressures drive green production practices, improving firm reputation and environmental and financial performance.
[10]	Baah et al. (2020)	Manufacturing firms	Green logistics and performance	SEM	Corporate reputation mediates the relationship between stakeholder pressure, green logistics practices, and financial performance.
[11]	Blanco & Sheffi (2017)	Supply chains	Green logistics	Conceptual / empirical	Green logistics enhances sustainability and operational resilience across supply chains.
[12]	Cankaya & Sezen (2019)	Manufacturing firms	Green supply chain management	SEM	GSCM practices positively affect environmental, social, and economic sustainability performance.
[13]	Chatzoudes & Chatzoglou	Manufacturing sector	Antecedents of GSCM	SEM	Organizational and external pressures significantly influence adoption of green supply

	(2022)				chain management practices.
[14]	Condong et al. (2012)	Malaysia (Automotive)	Green practices & innovation	Conceptual model	Proposed a green practices–green innovation framework to improve environmental and competitive performance.

3. RESEARCH GAP

The existing literature provides substantial evidence on the importance of green manufacturing practices (GMPs) in improving environmental, social, and financial performance across manufacturing industries. However, a critical analysis of prior studies reveals several theoretical, methodological, and contextual gaps that warrant further investigation.

First, although numerous studies confirm the positive impact of green manufacturing and green supply chain practices on firm performance, most research adopts cross-sectional research designs using self-reported survey data and structural equation modeling (SEM) techniques [1], [2], [3], [9], [12]. Such approaches limit the ability to capture long-term performance effects and causal relationships of green manufacturing initiatives. Longitudinal and mixed-method studies remain scarce, restricting deeper understanding of how green practices evolve over time and influence sustained competitive advantage.

Second, the literature predominantly emphasizes environmental and financial performance, while social performance and employee-related outcomes receive comparatively limited attention. Although green human capital has been recognized as an important enabler of green competitiveness [2], empirical studies integrating human, cultural, and behavioral dimensions with green manufacturing implementation are still limited. This indicates a need for research that holistically examines the role of employees, leadership, and organizational learning in driving green manufacturing success.

Third, existing studies largely focus on green logistics and green supply chain management, with relatively fewer investigations addressing shop-floor-level green manufacturing practices, such as eco-efficient production technologies, cleaner processes, energy optimization, and waste reduction techniques [4], [7], [14]. This imbalance highlights a gap in understanding the operational-level mechanisms through which green manufacturing contributes to sustainability outcomes.

Fourth, while SMEs have received increasing scholarly attention, most studies examine them within specific national or regional contexts, such as Malaysia, Thailand, Indonesia, and selected developing economies [4], [7], [17]. Comparative cross-country studies and research incorporating institutional, regulatory, and cultural differences remain limited. Consequently, the generalizability of findings across different industrial and regulatory environments is constrained.

Fifth, although stakeholder and regulatory pressures have been identified as key drivers of green manufacturing adoption [9], [10], [13], the interaction effects among stakeholder pressure, organizational culture, technological capability, and innovation remain underexplored. In particular, the mediating and moderating roles of digital technologies, Industry 4.0 tools, and green innovation capabilities in strengthening green manufacturing outcomes have not been adequately addressed.

Finally, despite recent advancements in analytical methods, such as hybrid SEM–ANN approaches [6], the application of advanced data analytics, machine learning, and optimization models to evaluate and predict green manufacturing performance is still at an early stage. There is limited research integrating quantitative efficiency measures with predictive and decision-support models to guide managerial and policy-level interventions.

4. CONCLUSIONS

This review paper amalgamates previous studies on green manufacturing techniques, emphasizing their substantial impact on enhancing environmental sustainability and organizational efficiency within manufacturing sectors. The examined studies demonstrate that green manufacturing, green logistics, and green supply chain management strategies lead to improved environmental, social, and financial benefits, alongside enhancing operational efficiency and competitiveness.

The evidence suggests that green manufacturing strategies are not just compliance efforts, but proactive strategic initiatives that enhance a company's reputation and promote long-term sustainability. Nevertheless, the critique highlights significant drawbacks, such as the predominance of cross-sectional methodologies, neglect of shop-floor operational strategies, and inadequate consideration of both human and technological elements.

To summarize, while green manufacturing practices have shown significant advantages, future studies should adopt more comprehensive and extended methodologies to fully comprehend their enduring effects. Collecting and analyzing data from various industrial settings will bolster the successful deployment of green manufacturing techniques and aid in the advancement of sustainable industrial growth.

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