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Article

Influence of green environmental management practices and supply chain integration on technological innovation performance: A conceptual review using PRISMA model

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Abstract: This conceptual review explores how supply chain integration (SCI) and green environmental management (GEM) practices affect technological innovation performance (TIP) in firms. Being based on the PRISMA methodology, the study conducts an in-depth review of related literature in various databases and highlights how the eco-design, green manufacturing, and sustainable delivery practices by GEM can directly enhance the ability of businesses to develop environmentally-friendly innovations. Also, through improved information sharing, integration within the supply chain and internal and external collaboration, supply chain integration reinforces this impact. Green practices coupled with supply chain integration have provided a synergy that has produced an ecosystem that has enabled sustainable technological progress, keeping the environment goals in line with the operational efficiencies. The results indicate that those organizations that have implemented all-inclusive green policies and enhanced supply chain relations are in a better place to realize improved innovation results, which can bring both theoretical and practical advice on the sustainable development. Further studies are needed to take on various industry settings, use wider linguistic tools, and to use quantitative designs to learn more about these associations. Altogether, the combination of green environmental management and the cooperation of suppliers chains can play a crucial role in moving the innovation forward and attaining the long-term environmental and competitive success.

Keywords: green environment; management practices; supply chain integration; technological innovation performance; PRISMA; sustainable growth

1. Introduction

The idea of sustainability has evolved recently from a side issue to a crucial strategic requirement for businesses all over the world. Green Environmental Management (GEM), which aims to incorporate environmental factors into fundamental business operations and promote ecologically conscious practices that strike a balance between economic performance and ecological preservation, is at the

heart of this change [1,2]. GEM covers a wide range of tactics, such as waste minimization, emissions reduction, resource efficiency, and eco-design, that are intended to lessen a product's environmental impact over its whole life cycle [3]. These methods, which have their origins in manufacturing, have spread to a variety of industries due to growing regulatory demands, societal norms, and the desire for a competitive edge [4,5]. The integration of GEM within supply chain management often termed Green Supply Chain Management (GSCM), has gained prominence as organizations recognize the importance of extending environmental considerations beyond internal operations to encompass upstream suppliers and downstream customers [6,7]. The idea behind this holistic approach is to streamline the whole supply chain by integrating the green supply chain practices that include green procurement, green design [8], reverse logistics, and working with supply chain partners [9]. These efforts can not only help to become environmentally sustainable but also gain better operational efficiencies, lower costs and improve the overall firm performance [10].

Although the literature on green practices and supply chain management is increasingly growing, the role of GEM and supply chain integration, jointly, in technological innovation performance (TIP) has not been studied properly [10,11]. TIP is the ability of a firm to come up with innovations that are practical for the environment, such as new products and processes that minimize environmental effects and meet the customer needs [12–15]. The development of green technologies, environmentally conscious design, and sustainable production is an important factor in the innovation agenda of the company, particularly in one of the most regulated sectors, medical devices, where adherence to strict environmental guidelines is a prerequisite [16,17]. Green innovations help companies to meet environmental goals and objectives and gain a competitive advantage in the market, as they allow the reduction of emissions, waste, and resource conservation [16–18].

Supply Chain Integration (SCI), which can be defined as the strategic coordination of the activities and information sharing between the supply chain partners, is a key factor in enhancing the impacts of green practices on the innovation results [19–21]. SCI has internal integration, which involves synchronization of work in an organization, and external integration, which is a working relationship with suppliers and customers [22,23]. Positive SCI leads to establishing trust, improving communication, and implementing green initiatives throughout the supply chain, which results in the establishment of a favorable technological innovation-friendly environment [1,24]. Nevertheless, whether the practices of GEMs can affect SCI and to what degree, and how such interaction in turn affects TIP is an issue that still needs to be explored in greater detail.

Available literature indicates that green practices and integration of supply chains have the potential to establish a favorable innovation environment, particularly for industries that encounter environmental rules and customer needs for sustainable products [25,26]. As an illustration, the adoption of sustainable innovations, including clean technologies and eco-design, in the medical device sector is not only more beneficial to a company in compliance with the regulations but also its reputation and market share [27,28]. Moreover, green practices incorporated into a supply chain can also become a competitive edge because they

allow the companies to create green products quickly and effectively [29,30].

This conceptual review employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to review the recent literature on the topic of GEM practices, supply chain integration, and technological innovation performance systematically in a way that clarifies the relationships between the three variables. This review aims to answer such research questions as Do green environmental management practices have any impact on supply chain integration? What is the joint effect of these practices and integration on the results of technological innovation of firms? Knowing these relations is important to both scholars and practitioners interested in the progressive promotion of sustainable innovation in an ever- challenging and regulated global arena.

In sum, aligning green environmental practices with effective supply chain collaboration offers a promising pathway for organizations striving to enhance their technological innovation capabilities while minimizing environmental impacts. As industries face mounting pressure from regulators, customers, and societal stakeholders, developing integrated strategies that couple environmental sustainability with innovation is not merely advantageous but essential for long-term competitiveness and resilience [1]. Therefore, this review aims to provide a comprehensive conceptual framework that advances theoretical understanding and guides managerial decision-making in the pursuit of sustainable technological innovation.

2. Literature review

Environmental issues have become a critical subject because they make a significant impact on humans' lives. The increasing number of industrial operations has increased the magnitude of environmental pollution not only at a national level but also on a global scale since the pollutants disperse throughout the earth [31,32]. This environmental pollution always creates a negative pressure on big organizations to engage in environmental management [33]. An assessment of a country's environmental performance shows that the world's level of environmental management has not improved over the past two decades, and worldwide improvements in energy efficiency have slowed within the same period [34,35]. A study of environmental management can be used to distribute to stakeholders and help them reduce environmental pollution [8]. It can be used to build a framework for the government to create a policy that will encourage organizations to produce products that are environmentally friendly; this will eventually reduce pollution [36]. According to Camarinha-Matos et al. [37], environmental challenges have inspired organizations towards sustainability models. Sustainable operations should be effective to encompass environmental issues and frequently update old-fashioned practices that are capable of managing the created impact of human activities [38]. Supply chain management is a significant area of concern to researchers, practitioners, and organizations [39,40]. It has influence on economic performance, competitiveness, and operational excellence. Supply chain management is a business model that is inspired by globalization and liberalized trade with developed economies [41]. Although the process of integration is slow, many manufacturing

firms have started to integrate their operations due to recognition of the importance of suppliers and customers in the overall development of their firms. A building block for revision studies and supports the integration of green management practices for enhancing supply chain adaptation. The green environmental management (GEM) practices and green supply chain (SC) integration-development literature demonstrate that green SC integration relationships strengthen the link between green practices and technological innovation-performance. A conceptual framework developed serves as a testable discussion on the moderating role of green SC integration on the relation between GEM practices and technological innovation performance. Ambitions for maximizing customer durability, minimizing the production of harmful waste, and overcoming resource shortages have led organizations to employ green management in their manufacturing activities. However, many uncertainties remain about how these organizations can best implement green management and take advantage of supply chains.

2.1. Theoretical framework

Extending the approaches of technological innovation and environmental management, green environmental management practices are utilized as a theoretical foundation. Supply chain integration examines the collaborative relationship between suppliers and customers [42,43], serving as an infrastructure for inter-organizational integration [44]. Technological innovation performance focuses on the output obtained from innovation activities. These three concepts form the theoretical framework guiding the investigation of their interconnections [45,46].

The concept of green environmental management practices can be defined as organizational policies, processes, and procedures that promote the minimization of the environmental impact and, at the same time, fulfill the stakeholders' expectations and other business objectives [44,47]. The rising consumer demand for environmentally friendly products has also resulted in the companies adopting green practices in all their manufacturing processes and in the development of green products, in turn [33,39,48]. Supply chain integration involves participatory and strategic cooperation between a company and its supply chain participants, which comprise both suppliers up the chain and customers down the chain [49]. It is critical in terms of maintaining competitive advantage and ensuring the maximum efficiency of relationships with customers and suppliers. Integration also allows great degrees of coordination and cooperation, which allow the exchange of information, which is essential to successful innovation.

Technological innovation performance measures a company's overall improvement in technological activities and outcomes, generally defined as the capability to develop new products or processes or to develop products and processes that are superior to those of competitors. It serves as an effective measure of the quantitative technological outputs produced through innovation activities and may be assessed directly at the industry level by examining sales derived from new products.

2.2. Green environmental management practices

Green environmental management practices are strategies integrating eco-

friendly production or operational activities with the goal of reducing environmental impact throughout a product's life cycle, such as waste, emissions, and resource use [1,8] They are an important approach for firms to sustain competitive advantage while contributing to environmental protection, and green innovation (GI) heavily depends on enterprises' green practices/capability [44,48]. To further promote the widespread adoption of green practices, previous studies already investigated the antecedents of GI and proposed that they can be categorized into internal and external factors. Internal factors are firm characteristics affecting the ability of firms to incorporate green principles across all processes. External factors mainly consist of pressures from executives, legislation, suppliers, customers, and competitors.

2.3. Supply chain integration

Supply chain integration combines the organization's processes with flows of materials, information, money, and knowledge with other members of the supply chain to achieve the communication and coordination necessary to deliver products and services to customers [50]. The practice of integrating supply chains through environmental practices, also termed green supply chain management (GSCM, which often includes considering energy, waste, pollution, and water mitigation), is a specific type of innovation. Organizations have continued to add GSCM practices, including eco-design, green purchasing, cooperation with customers and suppliers, reverse logistics, and internal environmental management [29]. GSCM continues to garner interest with the implementation of cloud computing, innovative products, and other sustainability-related measures in packaging and logistics systems for supply chains.

Extensive studies across various countries intensively support the assertion that supply chain integration positively influences innovation. The positive association between supply chain integration and firm performance represents one of the most established relationships in supply chain management. Supply chain integration can influence information sharing, agility, and innovativeness. Together, these three constructs may enhance technology innovation performance. In the framework of green supply chain management practices, performance is viewed as the final outcome of various actions and decisions throughout the supply chain.

2.4. Technological innovation performance

The technological innovation performance, which is also referred to as innovation performance, is the capacity and the performance of an enterprise in situations where it adopts technological innovation [33,39]. This idea has drawn a lot of interest from scholars, and many companies consider it as a key in acquiring a competitive edge and realizing sustainable growth. Traditionally, innovation has focused mainly on economic aspects; however, environmental considerations have become increasingly prominent due to public pressure and policy developments [1]. Consequently, both researchers and firms emphasize environmental protection, and technological innovation is a critical component of sustainability strategies due to its environmentally friendly and strategic nature.

3. Research methodology

Following the PRISMA model [51,52], data for the conceptual review was extracted between January 2024 and August 2024 from Scopus, Science Direct, Sage Publication, Web of Science, Emerald, and Google Scholar [1]. The search combined green environmental management practices, supply chain integration, technological innovation, and technological innovation performance and was refined to the title, abstract, and keywords. After removing duplicates, 606 unique records remained for screening. During screening, 164 were excluded for focusing only on either green environmental management practices or supply chain integration, addressing another outcome, or being industry-specific. The remaining 442 articles were further assessed, and 23 were removed because they were not empirical studies on the relationships of interest, were case studies, or focused on product innovation. The 419 eligible studies were complemented by 22 influential field articles obtained from backward and forward key paper citations. In total, 419 records, published between 2015 and 2024, informed the synthesis.

Following Song et al.'s [53] guidelines, a systematic review must incorporate study synthesis to summarize and integrate evidence and deliver new insights. Data collection and analysis for this study 1) clarified the conceptual bases of the work, 2) identified emerging research trends, and 3) verified contributions to theory, given theoretical inconsistencies on the clues underlying green management and supply chain integration. Data collection generated a three-part evidence base: (1) bibliographic details (author(s), year, outlet, sector, focus, theory use); (2) study focus elements (aim, time horizon, unit of analysis, sample(s), design, data collection, method, technique, key findings and contributions, underpinning theory); and (3) literature review components (theories discussed, definitions, environmental and green practices). To generate relevant insights, data analysis consisted of organizing articles into tables and grouping the most influential issues into clusters.

3.1. PRISMA model overview

The systematic reviews and meta-analysis use of the Preferred Reporting Items (PRISMA) model makes the rigorous formulation of the conceptual framework transparent and well-defined [53–55]. The increasing focus on sustainability witnessed across the world today, coupled with the awareness of the effects of the supply chain activities on the environment, has triggered the growing interest in the issue.

The overall idea of the conceptual review is that the practices of green supply chain management affect the technological performance of innovation, considering the moderating and mediating roles of green intellectual capital and green absorptive capacity.

3.2. Data collection methods

Considering the finite availability of literature, as well as cost and time constraints, the current study employs the systematic PRISMA model, developed by Song et al [53] to select, organize, and present relevant data. Several electronic databases including SCOPUS, ScienceDirect, Emerald, and Business Source

Ultimate (EBSCO) were explored using the PRISMA model. The selection process unfolded in four stages: identification, screening, eligibility, and inclusion. This is the methodical and integrative strategy involving the literature relevant to the study. This involved the researchers searching in different databases including SCOPUS, WoS, EBSCO, which produced 314 records. 292 other sources were then found and added from ResearchGate and Google scholar, resulting in a total record count of 606. Several exclusion criteria were then applied to the records before the screening process. The first record filtering process applied during this screening involved 60 publications, which were removed from the title and abstract records which were previously added from publications prior to 2015. Then, 82 sources were removed for being in areas other than business and management. Also, 51 disqualified records were removed before later stages of the process for being conference proceedings, book chapters, or other types of documents, and 8 were removed for language being a barrier, specifically, non-English publications, 23 studies were removed because they were not empirical studies. A total 419 full text publications were then left, which were manually filtered for relevance, and were thereby retained for data extraction. This is how only appropriate and relevant studies, as well as the most recent publications, were added to the study to contribute to the research. This structured process exemplifies the thoroughness of the PRISMA framework in guiding transparent and replicable data collection in systematic reviews (**Figure 1**).

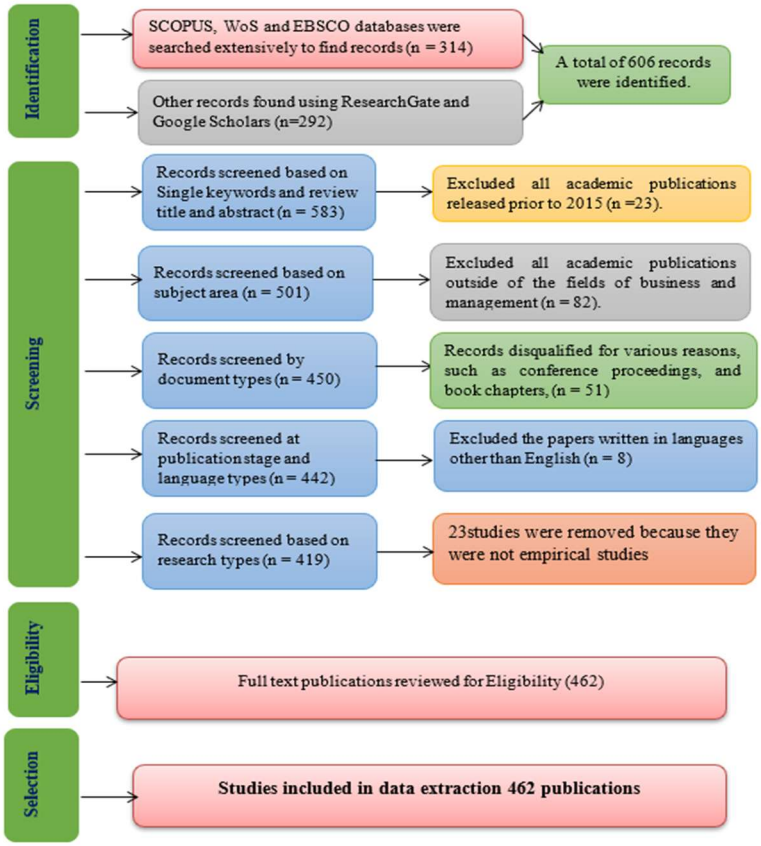

Figure 1. PRISMA model.

3.3. Data analysis techniques

Data analysis techniques serve as essential tools for systematically interpreting

quantitative and qualitative data within research frameworks [56]. Relating to the focal research components, several key approaches are commonly applied. Environmental sustainability, as the extent to which established environmental sustainability goals within sustainability frameworks have been met, can be assessed through statistical examination of measured performance indicators, enabling evaluation of sustainability achievements [25]. Green innovation initiatives receive particular attention and can be investigated by analyzing firms' engagement in various green practices. Survey data collection on green operations and technological actions, for example, coupled with structural equation modeling, offers a robust method for testing intertwined effects influencing innovation outcomes [57]. The influence of digital transformation and Industry 4.0 technologies on green supply chain management performance, particularly in the automotive sector, as well as how green manufacturing and technology adoption contribute to environmental performance, can be examined using integrated modeling strategies applied to collected industry data. Further, large-scale analyses of multiple firms with firm-level data subjected to structural modeling reveal how digitalization acts as a mediator enhancing the impact of green manufacturing on manufacturing agendas. Additional insights emerge when assessing 3PL services through surveys of enterprises and 3PL providers, whereby regression analyses elucidate the relationships between logistics outsourcing and green supply chain performance. Studies in the automotive and manufacturing industries extend the analysis by employing hierarchical regression to explore how upstream and downstream activities function as moderators in the interplay between Industry 4.0 technologies and sustainability.

3.4. Inclusion criteria

The study that come under this review are empirical research, literature review, conceptual frameworks, or meta-analyses that were published in the year 2015 to June 2024. They should be in English and have to be found in the trustworthy academic databases: Scopus, ScienceDirect, Web of Science, Emerald, Sage Publications, Google Scholar, or ResearchGate. These studies should specifically be focused on the correlations between the green environmental management practices, supply chain integration (internal and external) and the level of technological innovation performance. Moreover, the industries of the chosen research must include the manufacturing industries, healthcare (especially medical devices), automotive, or similar industries, in which green practices have an effect on the outcomes of innovation. Qualitative and quantitative studies that shed some light on the mechanisms or frameworks by which such variables are connected are both viable to consider inclusion.

3.5. Exclusion criteria

The exclusion criteria are that the studies must be non-empirical, e.g. opinion pieces, editorials or purely conceptual papers lacking empirical data. Articles that were published earlier than 2015 or those that were published after that period are not considered. The publications that are not written in English are also excluded to

ensure consistency. Literature that is centered on the green practice or supply chain management without considering the effects on the performance of technological innovation is not eligible. In addition, no conference proceedings, book chapters, non-peer-reviewed reports, and other non-research documents are included. The exclusion of studies that are industry-specific and have less generalizability or those that do not clearly analyze the connections between the green environmental management, supply chain integration and innovation are also used in order to guarantee that the review will be relevant and of quality.

3.6. Quality assessment

The quality evaluation of the chosen studies was done by an intensive screening regarding the relevance, rigor of the methods and validity. The research objectives, research design, and strengths of analytical methods were assessed in each article. Research studies with clearly defined variables, proper data collection methods and proper analytical frameworks like structural equation modeling, regression analysis or longitudinal methods were described as high. Also, the preference was given to peer-reviewed papers, which were published in reliable journals to be scholarly. The exclusion of non-empirical articles or opinion articles and studies with unclear methodological approaches was done to ensure the integrity of the review. Generally, the chosen studies were rigorous enough and relevant to offer a credible evidence base to the analysis of the relationships between green environmental management practices, supply chain integration and technological innovation performance.

4. Findings

Organizations have shown increased interest in organizational environmental responsibility activities and sustainable practices due to the increasing moves towards sustainable and green economics. The unexplored potential relationship between environmental sustainability and technical innovation performance is of increasing concern. Businesses have increasing interest in the development of formalized frameworks that allow for the comprehensive and cohesive evaluation of green environmental management practices of suppliers in the supply chain. This research will evaluate how the integration of a green supply chain influences the relationship between the green environmental management practices of green product design, green manufacturing, green customers, green delivery, and the performance of technical innovation, as well as the potential representational value of each pair of practices [58,59]. To complete the objectives, a systematic review of the literature and a meta-analysis of the data are proposed. The integration of all four environmental management practices is likely to be positively correlated and to give rise to enhanced technical innovation performance that is a consequence of the comprehensive integration of a green supply chain.

The main constructs, including those of green environmental management practices (GEM), supply chain integration (SCI), and technological innovation performance (TIP), gives a general overview, there is still a considerable gap in the inquiry of these associations. Industry comparative analysis shows that the effects of GEM and SCI on TIP differ significantly; such an industry as manufacturing,

especially the sectors with high regulation such as medical equipment and cars, are characterized by an even greater positive correlation because of the existence of stricter environmental regulations and consumer demand of green products. On the other hand, other industries like textiles or consumer electronics might experience special difficulties in establishing green practices which makes it have varying degrees of impact on TIP. In geographical terms, the geographical areas where the environmental policies are strict like the European Union or North America, are more likely to have a pronounced impact of the green practices and supply chain collaboration on the result of the innovation relative to geographical areas with less established regulatory systems like some parts of Asia or Africa. Quantitative studies (structural equation modeling, regression analysis, etc.) are more methodologically appropriate in providing more specific information about the strength and importance of these relationships, and qualitative or case-based research is not always generalizable. It would be desirable to include cross-industry and regional comparative studies, and different methodological studies to help in deepening the knowledge of contextual factors that may affect the GEM-SCI-TIP nexus and make the results of the findings stronger in terms of theoretical rigor and practical implementation.

Green regards environmental management activities as essential organization-wide environmental footprint reduction or elimination triggered by activities within the product life cycle. The partial resource-based view theory informs the examination of the interplay of green environmental management practices, green supply chain integration, and technical innovation performance [60,61]. A model for paper relevance evaluation enables the systematic review of contributions from the literature within the years 2015 and 2024. A PRISMA model extends the meta-analysis methodology aimed at assessing the degree of moderation of green supply chain integration on the nexus of green product design, green manufacturing, green customers, green delivery, and technical innovation performance.

4.1. Impact of green practices on innovation

There exist an eco-friendly practice area of green environmental management and the technology transfer process [52]. The process of sustainability is also relationally interdependent with technological development, performance, and the firm's operative functions. The implication of this association is that sustainability can enable significant operational breakthroughs in other functions that divert from the core [62]. The effort aimed at the deployment of technology across the supply chain fosters environmental practices and sustainable operations.

Greater integration boosts the growth of technical talents, skills and organizational capabilities. The green supply chain management strategies also enable interaction with outside parties, which implies that the aggregate sustainability and integration deepen the innovation process [63]. The effect of sustainable operations on complete supply chain coordination is the establishment of an ecosystem that is conducive to technological innovation. This structure is in line with resource-advantage views, which assume that integrated production plans strategically place the supply chain to provide innovative initiatives [64].

4.2. Role of supply chain integration

Several indicators determine supply chain performance: product availability, product quality, responsiveness, delivery reliability, and total supply chain costs. Innovation positively affects organizational performance and plays a major role in the implementation of green supply chain management (GSCM) practices, given the need to redesign products and processes, acquire new capabilities, and select new suppliers and logistics providers [65]. Legislative mandates aim to enforce green practices within supply chains: Australia restricts the use of fertile soil due to carbon emissions, the UK's Climate Change Act controls carbon dioxide emissions from one generation to the next to promote sustainability, and China prohibits the production and sale of products that fail to meet green standards [15,19,28]. Major multinational corporations have elaborated sustainability initiatives consistent with these principles: Walmart, for example, introduced sustainable-packaging specifications in 2006 to reduce materials, waste, and costs; Toyota announced a long-term automobile-plan initiative to develop environment-friendly vehicles, materials, and technologies. The ability to respond to environmental demands is influenced by organizational capabilities, such as resources, managerial attitudes, operations, processes, project management systems, and innovativeness [12,28,37]. Both customer integration and technological integration are based on a collaboration-oriented approach. Customer integration is a working relationship between the focal firm and customers, where the firm meets the green requirements of customers and manufactures them [66]. Customers constitute a downstream point of the supply chain: customer integration thus assists in adoption, planning, and implementation of green-management solutions to the environmental issues [55]. Customers: Firms seek to establish long-term relations with customers, as this is important to the successful projects of the environment. Customer pressure in the context of manufacturing is one of the leading forces of enhanced environmental practice when the customers' firms of the developed countries are willing to cooperate with the manufacturer in the process of achievement of environmental goals [38]. Studies have revealed that there exists a positive relationship between the customer integration and performance of green-oriented firms. Green customers give attention to product or service characteristics in assessing eco-friendliness, whereas organizational performance involves economic, environmental, and social aspects of sustainability [26,29,41]. A two-way interaction between consumers and producers is encouraging sustainable performance, and the customer cooperation level is positively linked to the environmental and social sustainability [66–68]. Technological integration is the utilization of the environmental technologies to aid in business operations, product development, process re-engineering, and technical training [69,70]. Following the fast pace of technology, environmental technology has become a crucial component of green supply chain practice in the manufacturing process. Green innovation adoption enables sustainable development and reduces the negative environmental impact of the product life cycle.

4.3. Interrelationship between practices and performance

Green environmental management practices in the internal operation as well as

the external supply chain can have a direct positive effect on technological innovation performance. The existing literature has highlighted the general adoption of green management practices in the supply chain operations. Moreover, both national and international research proves the effectiveness of such practices in the technological innovation development [70–72]. In the meantime, an extensive integration of the supply chain, upstream and downstream, is an effective way to foster the organizational ability of technological innovation [73]. Green environmental management practices are also known to promote interaction and alignment between suppliers, enterprises, and customers; therefore, the practices can intensify the acts of technological innovation by having a wider integration of upstream and downstream supply chain operations [74–76].

5. Discussion

The articles chosen are combined in the current research, which contributes to versatile theoretical and practical implications. Theoretical Foundations: The research provides a theory grounded in the overview of literature analysis and practical observations. It theorizes the underlying process through which practices of green environmental management affect the technological innovation performance with the moderating supply chain integration. Dynamics between Green and Supply Chain Management Practices: The research paper looks at the role of the upstream and downstream integration of supply chains in enhancing the effect of green practices on the outcomes of innovation [77–79]. Such relationships are put in the context of a holistic model, which provides a placement of the environmental management and supply chain alignment as concomitant agents of technological growth. Level of Analysis and Industry Focus: The analysis is made on organizational level in manufacturing companies, which will give a fine context of the operationalization of green and supply chain strategies. This point of emphasis makes the work stand out among wider or more theoretical treatments [80,81].

The theory-empirical research gap provides practitioners with practical advice on how to improve technological innovation by use of sustainable practices [82,83]. Prioritization of Green Practices Strategically: Managers obtain an insight into the direct impact of certain environmental initiatives on the possibilities to innovate [84]. The realization of contingent benefits of supply chain integration can enable the firms to utilize partnerships and information flows in an efficient manner. In the conditions of the high performance of supply chain coordination, the implementation of green practices leads to a higher output of innovation performance, which supports the importance of combined strategic approaches [85,86].

5.1. Implications for theory

The available literature provides an insight into a theoretical basis to evaluate the impact of the green environmental management practices on technological innovation. Supply chain integration is also considered as an important construct, whose synthesis of results should be conducted systematically to formulate a consistent picture and recognize the fruitful research opportunities. Considering the high level of development in these fields, it is especially deserving of a wholesome

appraisal. Green environmental practices in management of firms promote technological advancement of the firm, and integration of the supply chain is generally recognized as a key facilitator to enhance innovation capacities [87,88]. Therefore, it is necessary to establish whether supply chain integration enhances the effect of the green environmental practices on the technological innovation performance.

The review of the literature compiled shows that green environmental practices have a significant but positive impact on technological innovation, and supply chain integration alone achieves innovation improvement. The complementary nature between the supply chain integration and the green environmental management just adds weight onto the effect on technological innovation performance. The combination of these findings makes a significant contribution to theory since it explains the underlying processes that connect sustainability initiatives to the outcome of innovation [89]. In the same light, the research hypothesizes a theoretical framework, in which supply chain integration is a critical channel through which the transformation of green environmental management practices into excellent technological innovation performance can be strengthened.

The contribution and implications put the findings into the wider academic context: ‘A longitudinal analysis of the positive and negative impacts of an integrated bundle of supply chain practices is compared through a systematic literature review of existing studies in environmental and operational management. The study then comes up with conceptual propositions that capture the operational mechanisms that sustainable development practices impose on the temporal curves of supply chain performance.

5.2. Implications for practice

The paper has emphasized the need to integrate the green environmental management practices and supply chain to enhance technological innovation performance. The increasing demand of green products, production processes and specialized services can be met by the firms by focusing on green environmental management practices and creating technology that can generate long term competitive advantage. Green environmental management practices have gained advantages in form of technological, manufacturing and purchasing innovations in favor of sustainable environmental activities. The Green technological innovation is still a viable alternative to make resources more productive, create the new competitive strategies, adapt to the environmental challenges, and strengthen the social responsibility. Although significant research has been conducted on these fields, earlier studies have not carried out systematic analysis on the synergies of green environmental management and supply chain integration on technological innovation performance. Technological improvements have boosted the world supply chains, where the external and internal operations are well connected at affordable prices. A supply chain that is integrated is able to respond to the influence of the environmental contingencies and enhance innovation performance. The introduction of critical partners in both upstream and downstream supply chains is the ultimate source of simplifying and strengthening the efficacy of the

environmental initiatives and technological advancement. Green environmental management practices and integration of supply chain is thus a good way of achieving successful environment and technological goals. The study offers information that can guide managers in coming up with strategies of attaining high performance of technological innovation. An environmental management approach that is green will aid in integrating internal suppliers, customers, and suppliers of customers into the chain of supply that improves on the performance. Dealing and balancing with resources and activities at cross-border levels is a significant challenge to any supply chain-oriented company. A proper green environmental management approach and introduction of green initiatives improve the performance of supply chain partners in terms of technological innovation. [90].

6. Conclusion

Conclusively, this review points out the importance of the critical role of green environmental management (GEM) practices and supply chain integration (SCI) on technological innovation performance (TIP). According to the literature, adopting green practices like eco-design, green manufacturing, and sustainable delivery has a direct positive effect on the ability of a firm to make environmentally friendly innovations. The practices do not only serve as part of environmental goals but also as the force behind the creation of new products and processes to enhance the competitive advantage. Notably, the integration of the supply chain is an important process that increases the positive impact of green practices on TIP. Proper integration, both at the organizational level and between organizations and their supply chains, can enhance greater coordination, information exchange, and collaboration, which are needed to aid innovation. The combination of green practices and supply chain integration forms an ecosystem, which supports sustainable development of technology to meet the objectives of environment and operation efficiency. The results imply that any organization that has a holistic green approach and has good relations with the supply chain is in a better place to realize high levels of innovation. This combined strategy does not only contribute to the sustainability of the environment, but also it helps firms to have the potential of coming up with new solutions that cater to the changing market and regulatory needs. Theoretically, the review is able to expand knowledge by explaining the combined impact of green management and collaboration of the supply chain on the innovation performance. In real-life practice, it provides a strong emphasis on the strategic use of green practices and supply chain integration as strategic tools by managers towards sustainable growth. Further studies need to be conducted on various industry settings, the use of non-English materials, and quantitative methodological frameworks to gain more insight into these relationships. All in all, green environmental management is crucial to the supply chain collaboration in order to generate technological innovation and long-term sustainability objectives in the currently more environmentally conscious market.

In our review, the research gap identified in the literature is that there is no empirical data on the synergistic action of SCI and GEM practices on TIP. The gap is also overcome by analyzing the present condition of the knowledge in the field.

The proposed study would address this gap by providing an investigation of the relationships between SCI, GEM practices, and TIP, as well as the determination of the mechanisms behind the adoption of new technologies. Theoretical contribution in our study is found in supply chain management, environmental management, and innovation management. The suggested conceptual framework presents a new way of looking at the ambiguous correlations between SCI, GEM practices and TIP, and the necessity to view the interaction between the variables that may create a better innovation performance. The research results of this research can be used to influence the formulation of new strategies and policies that can help implement sustainable and innovative technologies in companies.

6.1. Limitations of the study

Many researches have been done to determine the factors which affect performance of technological innovation in corporations. The information to be used in this research was acquired by conducting the systematic literature review based on the Preferred Reporting Items to Systematic Reviews and Meta-Analyses (PRISMA) model. This method enabled the choice of articles in multiple academic databases, yet only English-written ones were taken into consideration, which may have narrowed down the research possibilities. Future studies may thus put into consideration the use of sources in other languages like Spanish and Mandarin. The articles under analysis were published in the period between January 2015 and June 2024. The number of studies included was no more than 2015 and no less than June 2024, so that may have left out some pertinent information. The research also failed to enter into the theory development and the mediating / moderating variables, and lacked the application of quantitative methods. Subsequently, these methodological restraints place the findings in perspective, and future research might attempt to investigate these points in more detail.

6.2. Future research directions

The conceptual review is based on analyzing the overlap of the green environmental management practices, supply chain integration, and technological innovation performance using the PRISMA methodology of systematic literature search. The most relevant articles are 29 written in the period of 2016–2023. Green environmental management has been established to boost the performance by technological innovation, and supply chain integration complements the former by enhancing the sharing of vital resources and information [1,4,55]. However, further investigations are necessary to discover new opportunities in the sphere of green environmental management practices. One of the opportunities involves creating a broader range of contextual settings where technological innovation performance would be viewed. Though supplies and demand are recognized as the external context of the synthesis of world philosophy by Dalai Lama, it is possible that certain political contexts are neglected [90,91,92]. Ideally, specific practice adherence under the contingency theory could be identified as the point of departure in further study.

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