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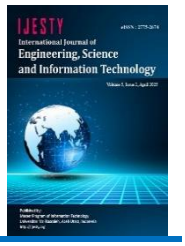

Sustainable Supply Chain Practices in Engineering-Based Manufacturing Firms

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Abstract

Sustainable Supply Chain Management (SSCM) assesses the environmental implications associated with all conventional supply chain (SC)activities to mitigate their adverse effects. This study presents a fuzzy-based methodology for examining obstacles in SSCM within the environment. Seven manufacturing companies from the electronics industry are participating. The study's findings reveal three primary challenges in engineering-based manufacturing firms. The barriers include knowledge-related factors (insufficient understanding of the adverse effects on business, absence of training programs for industry-specific training, monitoring, and mentoring, lack of technical expertise, and challenges in recognizing environmental possibilities), commitment-related issues (deficiency in corporate social accountability), and design-related challenges (complexities in designing for the reusing/recycling of used goods).The suggested research is among the first investigations undertaken within the environment regarding identifying SSCM barriers in the electrical and electronics industry. Secondly, the obstacles are examined via causation and prominent relationships, which assist decision-makers, policy developers, and organizational managers tackle the essential factors necessary to achieve SSCM activities.

Keywords: *Supply Chain, Engineering, Manufacturing Firms, Sustainability, Firms.*

1. Introduction

Since the emergence of supply chain (SC) [1] management in the 1970s, Sustainable SC management (SSCM) [9] has garnered widespread interest. Sustainability has become an essential component of any corporate organization, regardless of size or kind. GSCM has been included in all organizations' strategic planning in engineering-based manufacturing firms.

The SSCM concept entails implementing environmentally sustainable practices at several phases of the SC, including creating products, sourcing, production, distribution, and recovery of products [8]. This is a primary initiative to include environmental factors in managing SC. A prime instance of this is integrating the corporate social responsibility (CSR) [3] idea into various legal and ethical systems that regulate the operations of organizations within society. Organizations are now obligated to assume full accountability for the consequences of the conduct of every individual inside their supply network [10].

As with any radical invention, obstacles or problems are anticipated when implementing GSCM in engineering-based manufacturing firms. These impediments were encountered during the transformation from conventional to SSCM. Therefore, organizations need to identify these obstacles and implement strategies for their effective elimination.

Numerous research papers have identified challenges to SSCM. These obstacles might be categorized as structural, contextual, regulating, and cultural impediments. The regulatory hurdles pertain to governmental restrictions and policies about carbon production applicable to a company. Cultural obstacles pertain to organizational behaviour and culture, including avoidance of risk and departmental silos in engineering-based manufacturing firms. The underlying constraints are strategy, infrastructure, and technological presence inside the organization [13]. At the same time, the contextual variables are linked to the firm's working environment, including conflicting goals and a planning-oriented society[4].The literature review revealed that most research has examined SSCM constraints from an industrial viewpoint, namely within the automotive, mining, substance, textiles, and food packaging sectors in Asian nations [6]. The quantity of research is constrained to the setting of North America. Most research has emphasized the drivers and analysed their reliance on obstacles from a macro viewpoint [2]. Few studies classify obstacles by their similarities and then evaluate their interrelations. This study addresses these difficulties [12].

Seven electronic products manufacturing businesses are engaged in identifying the obstacles faced in deploying SSCM in engineering-based manufacturing firms. The obstacles are categorized based on thematic similarities. Fuzzy is selected for its capacity to evaluate the challenges based on causation and significance [5]. This study is among the first investigations undertaken inside the electronic item manufacturing industry.

2. Methods

This section offers a methodology for defining, evaluating, and prioritizing the Key Performance Indicators (KPI) [11] of success for environmentally friendly SC administration. Fig. 1 illustrates the recommended conceptual structure for the comprehensive process for evaluating and assessing KPIs in sustainable SC administration. This structure delineates the approaches used at each phase, beginning with determining KPIs. A three-tier hierarchical framework categorizes the KPIs according to the Triple Bottom Line (TBL) [7] and organizational decision-making stages in engineering-based manufacturing firms.

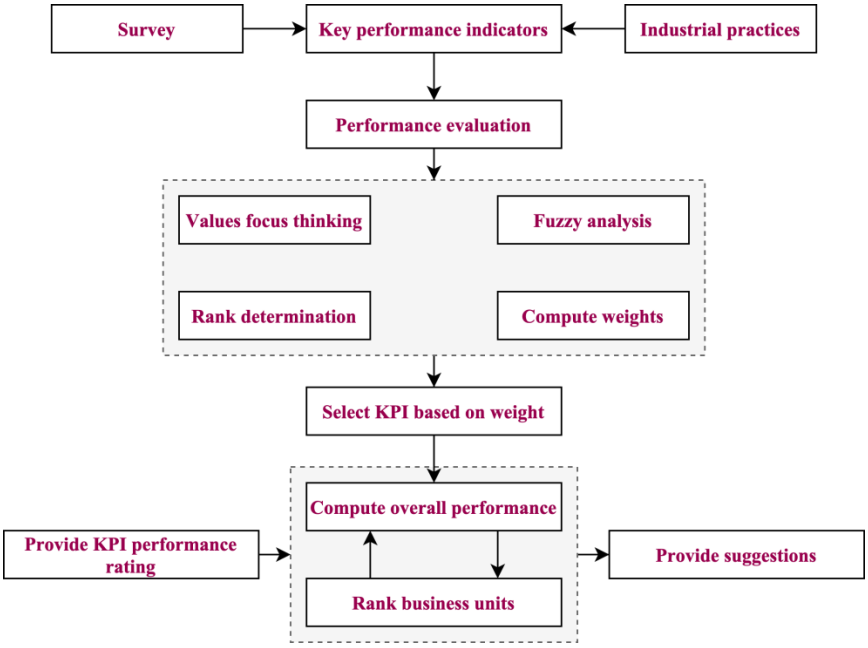

Fig 1. Workflow of the proposed model

2.1. Logistics Operations

The obstacles to SSCM are categorized according to several supply chain processes and activities, including design, procurement, manufacturing, testing and assessment, packaging, shipping, warehousing, after-sales support, and recycling. Studies offer an extensive taxonomy of SSCM procedures to enhance managers' comprehension of the interplay between inside and outside variables and GSCM procedures for operation. Research suggests using hierarchical fuzzy methodology to evaluate opportunities for enhancement in implementing SSCM activities [14].

2.2. Design

As the first phase, it has paramount significance in every SC. If organizations prioritize environmental considerations throughout planning, SC becomes more sustainable in engineering-based manufacturing firms. Research was performed to ascertain the facilitators and impediments in fluid SC design. Lowering expenses, improving delivery dependability, and the desire for agility were recognized as the primary drivers. In contrast, the main obstacles highlighted were inadequate forecasting, SC complexities, and product portfolio diversity. Research suggests a bi-objective optimization technique that concurrently addresses consumer happiness and the ecological impact in product design.

2.3. Acquisition

Procurement, sometimes called buying, sourcing, or buying, is how organizations typically pick supplies and providers. Enhancing the purchasing process via sustainable practices would result in waste reduction, cost efficiency, process optimization, improved reputation, and greater adherence to environmental rules in engineering-based manufacturing firms. Research proposes a hybrid approach to enhancing and choosing suppliers in SSCM. Research examined the relationship between ecological collaboration and environmental surveillance throughout the SC and the nature of environmental expenditure. The findings indicate that ecological cooperation with suppliers correlates favorably with higher investments in pollution-preventing technology. Still, collaboration with clients does not influence the adoption or deployment of such technology.

2.4. Production

Given the substantial environmental effects caused by production processes, it is imperative to shift the emphasis towards responsible production, encompassing advanced technology, renewable resources, secure workplaces, and reduced hazardous emissions. The research examines how varying levels of the organizational field (national and local) influence industrial ecological procedures. The study revealed that administrative ecological planning fosters market expansion, whereas technological core environmental practices enhance environmental quality. National-level demands do not result in environmentally sustainable production practices. The data indicate that institutional influences at the local market levels

affect both categories of industrial environmental policies—an assessment of current advancements in environmentally friendly SC architecture, operational decision support, and sustainable production.

2.5. Evaluation and examination

This procedure includes verifying if the product/service adheres to the requirements and rules established by the relevant authorities in engineering-based manufacturing firms. This often comes within the organization's quality control and occurs just before packing. Packaging has become a primary contributor to ecological pollution and deterioration, becoming a focal point for organizational development efforts. Clients have grown more ecologically conscious and can assess an organization's environmental consciousness.

2.6. Transportation

Since logistics activities significantly influence Greenhouse Gas (GHG) emissions and environmental degradation, the SSCM has become a crucial focus for the freight sector. Elevated client expectations and substantial fines for non-compliance with legal standards have significantly motivated this SC process.

2.7. Warehousing

It denotes any business that stores, transforms, stages, sorts, or centralizes commodities or supplies in engineering-based manufacturing firms. This procedure is significant for an organization from both financial and temporal standpoints. Organizations often refrain from adopting environmentally sustainable practices in product storage owing to obstacles such as "a36" (Risk associated with dangerous goods inventories).

2.8. After-sales services

It denotes the assistance the organization offers after purchasing its goods or services. These amenities include technical assistance, exchange offerings, prompt and efficient returns, warranties, and similar offerings.

2.9. Recycling

Reverse shipping is critical for successfully implementing SSCM. Due to heightened demands for logistics in reverse from consumers and government restrictions, organizations are encountering several obstacles associated with recycling in engineering-based manufacturing firms. The intricacy of design and fiscal limitations are among the few hurdles. Research outlines methodologies for modeling the end-of-life phase of aviation items, using environmental tools, end-of-life phase designs, and the tactical, operational, and environmental attributes of these goods.

3. Results and Discussion

The suggested research yielded numerous significant results and effects on decision-makers, policy developers, and administrators.
Three main obstacles have been recognized as obstacles to producing electronic products.The barriers encompass knowledge-related issues (insufficient awareness of the ecological effects on company, absence of training programs for industry-specific training, monitoring, and mentoring, lack of technical skills, and challenges in identifying environmental possibilities), commitment-related issues (deficiency in corporate social accountability), and design-related challenges (complexities in designing for the reuse or recycling of used goods) in engineering-based manufacturing firms.
To overcome knowledge obstacles, decision-makers must implement action plans aimed at enhancing employees' knowledge by establishing awareness programs regarding the implementation of logistical reverse logistics, offering training on recognizing potential environmental benefits, fostering eco-literacy between SC participants, alleviating apprehension towards transitioning to new systems, promoting awareness of the effects of SSCM on company performance, instituting incentive programs for vendors, and creating education programs, assistance services, or organizations to educate, observe, and mentor advancement tailored to each industry.
To overcome barriers to corporate social responsibility, supervisors must engage in environmental initiatives and conferences to shift employees' perceptions of accountability, develop programs that promote the advantages of SSCM, and offer learning and technical knowledge to empower employees in translating positive attitudes toward the environment into actionable outcomes in engineering-based manufacturing firms.
To mitigate the challenges associated with designing products for reusing and recycling capacity, vendor and consumer organizations should focus on creating goods that facilitate ease of reuse, recycling, and resource and energy efficiency. Innovative technologies, materials, and procedures aligned with ecological objectives should be utilized. Initiatives that effectively meet environmental objectives should be implemented.
The primary obstacles identified in the suggested study vary from the prevalent hurdles documented in previous studies, including the absence or unavailability of funding and federal regulations. The results are novel and logically applicable, since addressing finance and regulatory issues alone is insufficient; without staff training and upper management's dedication, the full advantages of SSCM cannot be realized.

4. Conclusion

This article uses a fuzzy-based methodology to examine the obstacles in SSCM within the environment. The suggested method consists of three stages. The first phase involves reviewing literature and engaging in expert conversations to ascertain the pertinent impediments. In the second stage, the obstacles are classified into distinct matrices according to their thematic resemblance in engineering-based manufacturing firms. The categorization areas include SC Procedures, SC Participants, Sustainable Areas, Organizational Hierarchy, and Miscellaneous. The third phase is collecting information and analyzing outcomes about the highlighted obstacles using the fuzzy approach. Seven companies are participating. Three sorts of impediments are identified as significant. The barriers encompass

knowledge-related issues (insufficient awareness of the ecological effects on business, absence of educational programs, assistance, or organizations for industry-specific training and progress tracking, lack of technical proficiency, and challenges finding ecological possibilities), commitment-related factors (deficiency in corporate social accountability), and product design challenges (complexities in designing for the reuse or recycling of used goods) in engineering-based manufacturing firms.

The strong point of the suggested investigation lies in its status as one of the initial analyses undertaken within the context of barriers to SSCM in the electronics industry. Secondly, the obstacles are examined via causation and significance, enabling organizations to focus their efforts, time, and finances on the essential hurdles necessary for the success of SSCM activities. Lastly, the study's results indicate that insufficient training and expertise, and inadequate commitment from senior management are the primary impediments. These results diverge from those often documented in research, namely, budgetary restrictions and insufficient government controls within the industrial sector of Asian nations.

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