Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 11, No. 4, November : 2023

SUPPLY CHAIN QUALITY CONTROL DURING GBWE: A STRATEGIC INNOVATION FOR BETTER ENVIRONMENTAL POLICY IN PROJECT MANAGEMENT

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Abstract
Green supply chain management (GSCM) is a multi-dimensional concept that takes care of the environmental quality of a supply chain and also reduces production cost. It controls the amount of toxic and hazardous materials at different levels of supply chain. The green bullwhip effect (GBWE) plays a pivotal role in magnifying the fluctuations in environmental demand as orders from customers progress upstream across consecutive levels of the supply chain. In an environmentally conscious project, supply chain quality control is essential to cope up with green bullwhip effect by sharing demand related information. Hence, it needs strategic innovation for better project management. In this research work, a mixed intelligent strategic framework is developed by combining 'scientific and technologically-based innovation' and 'innovation by-doing or by-using, and by-interacting'. This novel framework can share the information related to demands of toxic and hazardous materials throughout the supply chain. It will help to manufacture environment friendly with business ethics and social responsibility.

Keywords: Supply chain management, Quality control, Strategic Innovation, Project management, Green Bullwhip Effect

I. Introduction

In recent decades, as local production has transformed into worldwide supply networks, the management of eco-friendly supply chains (GSCM) is set to involve activities that bridge boundaries, centering on environmental characteristics. Changes in regulations regarding environmental qualities have subtly integrated toxic and unsafe raw materials, parts, and final products. Therefore, ensuring quality control in both the initial and final stages of a supply chain has become a daunting task for manufacturers due to rigorous environmental limitations [1, 2]. For the success of an environment friendly project, supply chain quality control (SCQC) is extremely essential as highlighted by several researchers. SCQC not only enhances sustainable environmental performance, but also helps to save energy, cost and ecological efficiency [3, 4].

The bullwhip effect stands as a significant occurrence within the supply chain, heightening the variability in demand as orders move upstream through consecutive tiers. Within this context, three distinct traits come to light: oscillation, amplification, and phase-shift. There is substantiated proof that environmental requisites undergo notable alterations akin to customer demands, traversing the supply chain to varying extents [1, 5]. This phenomenon is known as green bullwhip effect (GBWE) that is created by different environmental laws and different institutional pressure by the stakeholders [6]. Proper techniques related to SCQC are required to monitor the GBWE and meet all the environmental demands [5, 7].

Strategic innovations are required for SCQC in order to monitor GBWE. Researchers state two types of innovation methods: scientific and technologically-based innovation (STI) and innovation by-doing or by-using, and by-interacting (DUI) [8]. Mixed strategic innovation (MSI) is a combined effort of STI and DUI. MSI is a necessity to control the toxic and hazardous materials and share their requirements as it has the advantages of both technology and managerial practice. It also helps in total quality management (TQM) approach by the industries [9]. For environmentally friendly projects, a novel intelligent strategic framework is needed to share the requirements of toxic and hazardous materials. Controlling toxic and hazardous materials leads to environmentally conscious

manufacturing and it is a part of business ethics and social responsibility [10, 11].Rest of the paper is organized as follows. Literature review is discussed in section 2. Study methods and data collection is provided in section 3. Implementation of framework is elaborated in section 4. The conclusion part is given in section 5.

II. Literature Review

Researchers have concluded that quality control for a green supply chain is a multidimensional approach that requires strategic innovation for managing different projects. Intelligent or computer/software based approaches are extremely important to provide and share the requirements or demands of toxic and hazardous materials at different levels [12]. Proper strategic framework leads to develop the intelligent systems that help to convey the static and dynamic nature of information among various levels of supply chain [1, 13].

Mianabadi et al. advocate for an astute environmental management approach involving multiple stakeholders, showcasing a case study to demonstrate the model's practical application in addressing real decision-making challenges [14]. While Ruiz-Benitez et al. emphasize the ecological advantages of a streamlined, environmentally conscious, and robust supply chain, Jørgensen and Milanez showcase strategies for managing the downstream aspect, particularly concerning the export and utilization of harmful and unsafe goods [15, 16]. Pavlas et al. address the importance of considering toxic and hazardous wastes in green supply chain models [17]. Green supply chain models help to improve profit and productivity for sustainable development [18, 19].

Intelligent management in supply chain has become a key factor to gain environmental success. Burke and Gaughran propose an intelligent environmental management system, known as the 'n-tier architecture,' designed to offer a comprehensive framework suitable for small and medium-sized enterprises (SMEs) [20]. Butler (2011) creates a 'sustainable information framework' aimed at embracing eco-conscious initiatives within organizations, encompassing sense-making, decision-making, knowledge exchange, and eco-friendly design. Its purpose is to bridge information divides, pinpoint issues and prospects, and maximize learning achievements [12]. Kuo et al. (2012) focus on a procedural reference model and information framework for overseeing and regulating the volume and excellence of the supply network. They adopt an object-oriented, analytical method to depict the structure of the collaborative model, aiming to showcase its efficiency in supervising material supply networks with enhanced communication channels [13].

Researchers have considered the importance of communication to cope up with green bullwhip effect. Lee et al. observe that the ecological bullwhip effect possesses the potential to instigate beneficial shifts, catalyzing the emergence of fresh environmental competencies across various levels within a supply chain. They suggest that the timeframe for environmental criteria linked to products tends to shorten at every subsequent tier upstream. Additionally, they propose that responses within the supply chain to the environmental bullwhip effect might fluctuate, contingent upon the unique attributes of buyer-supplier connections [1]. Seles et al. examine the diverse institutional influences that foster the environmental ripple effect within an environmentally conscious supply chain. They present a Brazil-based case study illustrating the involvement of customers, suppliers, and governmental entities in this context [6].

III. Strategic Framework

In this section, the strategic framework is described. This framework basically serves as a front of pipe technology to cope up with green bullwhip effect (GBWE). This novel framework is established to develop the information technology (IT) system required in project management. It has a powerful potential to assist the manufacturing industries.

This framework is built based on seven important steps identifying (i) the end customer, (ii) the assembles (components required to make the assembly), (iii) the sub-assembles (components required to make assembles), (iv) toxic/hazardous materials, (v) tiers of upstream and downstream, (vi) regulations (or limits) of the toxic/hazardous materials for different tiers, (vii) special notes (see Fig. 1). This framework is an example of mixed strategic innovation as it captures both scientific and technologically-based innovation (STI) and innovation by-doing or by-using, and by-interacting (DUI). In any environmentally conscious project, it will help to develop the intelligent supply chain quality control to meet green bullwhip effect (GBWE).

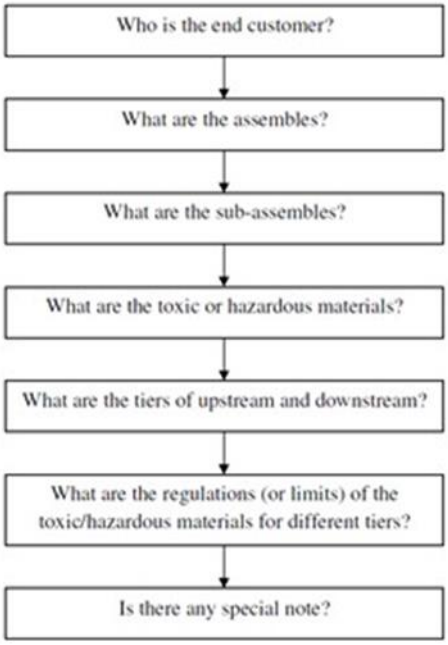

Figure 1: Strategic framework for intelligent system

IV. Implementation of Framework

In this section, the implementation of the previously mentioned framework is illustrated. Fig. 2 presents the proposed snapshot of the intelligent system. The first row shows the end customer. The second and third row state assembles (A1, A2) and sub-assembles (SA11, SA12, SA21) respectively. The fourth row presents the toxic and hazardous materials (M111, M112, M113, M121, M122, M211) for each sub-assemble along with their regulations (or limits). The toxic and hazardous materials are represented (column wise) in such a way so that it can be understood which assembles or sub-assembles they belong to even if there are common materials. The last row represents special notes or instructions, if any. The snapshot is just an example and a part of it is shown. More rows and columns can be added as per requirements. This framework basically applies the philosophy of bill of materials (BOM) and work breakdown structure (WBS).

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End Customer																	
Assembles		A1															A2
Sub-assembles		SA11									SA12						SA21
Toxic/Hazardous Materials		M111	R*1	R2	M112	R1	R2	M113	R1	R2	M121	R1	R2	M122	R1	R2	M211
Upstream	T1																
	T2																
	T3																
Downstream	T4																
	T5																
	T6																
*R indicates regulations (or limits)																	
Special Notes																	

Figure 2: Snapshot of Proposed Intelligent System

V. Conclusions

In this research work, a novel strategic framework is presented that will lead to the development of an intelligent system which is extremely important for an environmentally conscious manufacturing project management. This will help to meet the demands of stringent environmental regulations related to toxic and hazardous materials throughout the supply chain. This is a dynamic system that will share information of the green bullwhip effect among all the tiers of the supply chain. Hence, this will lead to better managerial control of the environmentally conscious projects with business ethics and social responsibility.

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