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Environmental Risks in Supply Chain: Recommendations and Directions for Future Research

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Abstract. This paper explores the environmental risks in supply chains and provides recommendations for subsequent studies. Typically, the environmental responsibility is a core part of sustainability which focuses attention directly to protecting and restoring the environment. Furthermore, environmental awareness is essential to design globally distributed supply chain networks. Therefore, the aim of this research is to explore the environmental risks and to identify the available solutions along with a projection of future trends. The basic research steps have been followed to complete this work. The Findings of this research describes the environmental risks that arises during supply chains operations. Furthermore, recommended solutions have been highlighted to address the identified risks. The Blockchain technology is regarded as a suitable solution for the environmental risks issue. The motivation for recommending this technology is its capabilities to contribute effectively towards greening the supply chain operations.

1. Introduction

Firms are continuously seeking to manage supply chain activities, in a bid to improve production processes and to gain competitive advantage [1]. Supply chain management (SCM) refers to activities related to production management, and delivery of products [2]. The process starts from raw materials suppliers through to the end consumers. However, over the years, this traditional flow has expanded thereby exposing the flow of chains to risks. Notably, the expansion factors contribute to the depletion of resources, and to the environmental pollution [3]. Specifically, environmental risk may be defined as the environmental damages which ensue from everyday supply chain operations [4]. Hence, managing this risk aims at protecting and restoring the environment's integrity. This is mainly because they have consequences on the shared ecosystem and it may also impact the natural ecosystem and corporate reputation [3]. The environmental damage is considered as one of the drivers and emerging challenges in supply chain management [4]. Furthermore, industries consider the environmental risks as the most important risk factors [3].

Nowadays, there is a growing need to deal with the challenges made by supply chain operations on the global environment and control their negative impact. Especially the context that related to complex supply chains. It is well known that both developed and developing countries are challenged with the increasing amount of CO₂ emissions. Some of the notable countries include USA, Japan, China, the European Union (EU) countries and Malaysia [5]. Till this moment, deducing appropriate means to mitigate this environmental impact have become a major issue for supply chains, especially those seeking competitive advantage for their operational performance in the marketplace [6]. Firms such as Hewlett Packard, Walmart, Patagonia, and Tesco, have benefited from considering green practices across their supply chain processes. Specifically, their approaches involve carbon control of assets and infrastructure, waste reduction through process optimization, the use of energy-efficient vehicles and recycling [7]. Therefore, this study aims to explore the environmental risks issue across supply chains



and provides recommendations and useful insights to overcome these issues in subsequent supply chain processes. In addition, possible directions for future research are also identified and presented herein.

This study is presented as follows: the next section, section 2 illustrates the research methodology while Section 3 discusses the environmental risk factors in details. Section 4 investigates the available environmental risk solutions whereas Section 5 offers recommendations and future research agenda. On the other hand, Section 6 concludes the research findings.

2. Research Methodology

This paper goal is reviewing the environmental risk factors in supply chain and provides recommendations for future researches in the area. In order to structure the literature review, the mind map has been designed to set the paper structure. To achieve the defined goal of this research, a review protocol was designed based on [8] as shown in figure 1. It is comprised of three main processes namely: determination of the target resources of search, specification of the keywords, and selection of the relevant articles. Searching the literature was achieved by using popular database sources such as Web of science, GoogleScholar and Scienedirect. Defining the search terms for data collection purposes, the following keywords were used: “supply chain”, “Environmental Risks” and “supply chain management” with combinations of these words including: Environmental AND Green Supply Chain AND Environmental Supply Chain. The initial search results in both relevant and irrelevant studies in SCM and environmental risks literature. Hence, the selection and inclusion criterion are based on the scholar’s title, keyword and abstract relevancy. In conducting the defined process, certain technologies have been used such as Endnote, which is used to search and manage the process of collecting the related studies and filtering them.

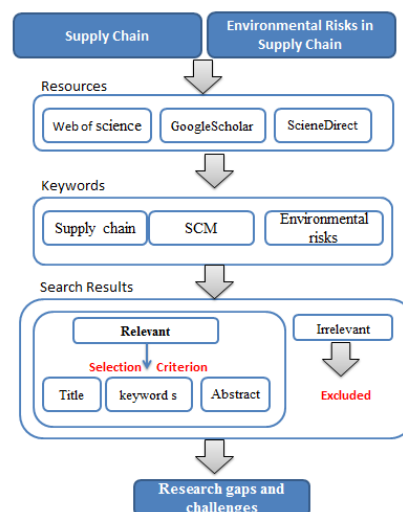


Figure 1. Review process adopted from [8].

3. The Environmental Risk Factors

Minimizing the negative effect that the supply chain has on the environment is called a green supply chain [7]. This negative effect includes the hazardous materials used during supply chain operations [4], environmental pollution [10], energy consumption [3], and carbon emissions [6]. Greening the supply chain mainly aims at integrating the environmental practices into the ordinary supply chain flow. A review of literature on green supply chain risk management reveals a list of the environmental risk factors that may be caused by supply chain operations.

Zhao [4] defined carbon emissions as the atmospheric gases spread which results in the effect of the greenhouses. However, the measurement of the carbon footprint within supply chain networks is a challenging issue for many organizations [6]. Environmental pollution is the contamination that ensues from production operations on water, soil or air due to the different production operations [11]. The risk associated with energy consumption refers to inefficient use of energy in the production processes, or during goods and services delivery [3]. On the other hand, natural disasters are considered as one of the environmental risk sources when such natural disasters cause disruptions. Examples of these are fire, earthquakes, hurricanes, flood, and storms [12]. Another potential source of risk is the environmental accident, which are accidents caused by production operations, and which affect the environment. These included fires and explosions [3]. Similarly, hazardous waste generation describes the production of

unwanted substances during operations which may harm the human health plus the environment [13]. Furthermore, water scarcity is also considered as a potential source of environmental risk and it refers to the risk caused by lack of sufficient available water resources to meet the demands of water usage (for energy production, manufacturing, and transportation) [3]. Finally, other potential risks involve the risk of heat waves and droughts which is the vulnerability caused by increase in temperature due to climatic changes [3].

4. Investigation of the Available Environmental Risk Solutions

This section reviews the current state of the art in the environmental sustainability. The authors will discuss several previous studies found in the literature that examined the environmental issues [3, 10, 14-17]. Giannakis and Papadopoulos [3] calls for integrated approaches in sustainability and risk management to enhance the supply chain sustainability. The study differentiates between the environmental risks and the other supply chain risks. The study findings revealed that the internal environmental risks may be considered as the most essential factors for many industries. Zhao [4] proposed a tool to help in identification and analysis of manufacturers strategies that reduce the materials and carbon missions. On the other hand, Urata, Yamada [5] developed a global supply chain network model for production and logistics in the Asian countries which aims at balancing of CO₂ volumes and cost. In their research, they defined a mixed integer programming (MIP) problem that determines the supplier and factory location and aims at reducing the environmental impact ratio.

In a particular study, Song, Ming [10] used a trial evaluation laboratory (DEMATEL) and decision-making method to identify the critical risk factors. Furthermore, the method assists managers of supply chains to concentrate on the most influential risk factors for SSCM performance. The results showed that the most significant risk factor for SSCM is failure in the right supplier selection. Sharfman, Shaft [14] examined the management of cooperative supply-chain environmental (CSCM) concept using an online exploratory survey and theoretical sampling. Interviews with 14 leading-edge firm were conducted to examine a model of CSCM antecedents. They reported that the consideration of the adoption CSCM is an important condition for firms to transit towards adopting more sustainable practices.

In a similar study, Yu and Solvang [15] proposed a stochastic programming model with multi-product multi-echelon for reverse logistics design. The results obtained from the sensitivity analysis showed the implications of the profit and carbon emission requirement relationship. The study also suggested that more environmental sustainability factors should be included such as land and water pollution. Mavi, Kazemi [16] studied supplier selection and evaluation in green supply chains. In their study, the fuzzy DEMATEL method was used to evaluate the logistic factors of green implementation. Observations from the study showed that environmentally friendly packaging is more influential than other factors. In another vein, the work of Rahimi and Ghezavati [17] designed a recycling construction and demolition (C&D waste) reverse logistics sustainable network to reduce the negative environmental impacts of waste. Results showed the model flexibility based on risks severity.

The subsequent section presents the risk factors as indicated by F1 to F6 to represent Environmental pollution, Natural disasters, Energy consumption, Environmental accidents, Carbon emissions, and Hazardous waste generation, respectively. Table 1 presents some studies that discussed the environmental risks issue and the proposed solution in each study along with their limitations.

5. Recommendations and future research agenda

Reviewing the literature of environmental sustainability, the following information has been derived and certain conclusions has been highlighted:

Despite the growing awareness on the need to incorporate sustainable principles into the supply chains [18], there is still the major challenge of missing implementation mechanisms for environmental integration in supply chain operations from literature [19-21]. Although Giannakis and Papadopoulos [3] pointed to the limited researches that study the topic of supply chain sustainability risks and risk management strategies, Calatayud [21] had refuted the assertion by using new technologies such as Blockchain technology for better supply chain risk management. In fact, the findings of the study conducted by Sharfman [14] revealed that Blockchain technology appears as a good solution for digital supply chain integration. Notably, due to its ledger and smart contracts, it offers tools for building more flexible and cost-effective supply chains network. In addition, Blockchain traceability offers an enhanced visibility throughout the product life cycle [22, 23]. Likewise, Price [24] stated that Blockchain is the right solution to solve core problems in supply chain transparency.

Specifically, unlike traditional centralized systems, Blockchains create decentralized networks with trust-less parties [25]. Blockchains facilitate the possibility for tracking the materials and to determine the provenance of a product from its origin to the end customers [26].

Based on the highlighted points, it is believed that Blockchain can effectively contribute to greening the supply chains. This is mainly because the practical implementation of sustainable environmental factors in new evolutionary technologies such as Blockchain presents an open research area filled with opportunities.

Table 1. The existing approaches and their limitations.

Ref.	Environmental Risks						Solution	limitation
	F1	F2	F3	F4	F5	F6		
[14]	√	√	√	√	√	√	Cooperative supply-chain environmental management (CSCEM)	Only successful CSCEM has been examined.
[4]					√		Game Theory	Consumer preference factor was not considered in the study. The manufacturers are considered as one entity.
[16]	√	√	√			√	Supplier Assessment	The shortage of study respondents. Lack of validation method such as case study
[5]					√		A mixed integer programming (MIP)	Limited number of products, countries, fixed cost (factory location), foreground data (cost and CO2 volumes) , risk types (lead time and scale).
[3]	√	√	√	√	√	√	Risk Management Framework	A small sample size. Lack of in-depth investigation in risk management related to sustainability topics.
[10]	√	√	√	√	√	√	A Novel Method Of Rough Weighted DEMATEL.	The evaluations are based on expert's judgments. No differentiate between positive and negative influences in the methodology.
[15]					√		Stochastic Programming Model	The Social consideration was not considered.
[17]	√					√	A mathematical (mixed integer linear programming) model	The social impacts are excluded. The model is not a multi-product model

6. Conclusion

The environmental damage which ensue from supply chain everyday operations is a major issue for supply chain management. Due to its impact in the natural ecosystem, managing this risk will add competitive advantage for corporate reputation and operational performance. Blockchain as a fast growing technology is able to contribute in greening the supply chains. The technology is able to track sub-standard products and identify their origin. Furthermore, the data availability removes redundancies and bottlenecks which thus decreases resource consumption. The technology is a promising approach that defines energy sources and energy storage systems, proffer solutions to environmental challenges and contribute to greenhouse gas reductions thereby boosting energy efficiency. In addition it helps to ensure that products are sold in an environmental friendly manner. Nowadays, leading-edge firms such as Oracle, SAP, Walmart and IBM are already developing Blockchain based cloud management solutions for the supply chain. Despite those successful trials, there is still the need for future supply chain applications of Blockchain technology to ensure the integration of certain factors. These include environmental considerations, enhancement in best business, and promotion of global market transformations.

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