Management of Sustainable Supply Chains in MNCS: A Comprehensive Analysis of Sustainable Supply Chain Practices

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Abstract— *The adoption of methods that are referred to as sustainable business practices is something that companies should do in order to maximize profits while simultaneously addressing the social, environmental, and economic aspects of sustainability. There have been a great number of studies that have explored various aspects of supply chain operations. Nevertheless, there is not yet a complete structure that has been provided for the various industries. Specifically, this study tackles this knowledge gap by examining past research that was both empirical and review-based. A comparison is made between the practices and the industries that were researched in order to highlight the current generation of sustainable industries. The classification of the literature that defines future trends is brought up to date in this research, and it provides a new point of view on the sustainable solutions that are being handled by a variety of corporate entities. In the process of working to improve supply chains as a whole, researchers and practitioners alike may be able to gain multiple advantages from this.*

Keywords— supply chain management; sustainable supply chains; sustainable practices; industrial classification; factor analysis.

I. INTRODUCTION

As a consequence of the introduction of mobile commerce (M-Commerce) into supply chain management (SCM) systems, there are revolutionary transformations that occur in the methodologies of supply chain management. These alterations enhance communication, decision-making, and relationships with both consumers and suppliers. Efforts to reduce carbon emissions and promote sustainability are also garnering more attention in supply chain management. In today's world, supply chains are also required to take sustainability into consideration. Customers and government agencies are exerting increasing pressure on businesses to behave ethically toward society and the environment. This pressure is expanding faster than ever before. It is possible that supply chain management (SCM) may aid businesses in achieving these standards by enhancing logistics in order to minimize carbon emissions, decreasing waste, and introducing sustainable sourcing techniques. As an example of a corporation that has made a commitment to sustainable sourcing and the reduction of their environmental impact as part of their attempts to fulfill their corporate social responsibility obligations, Unilever is just one example. In addition to being a positive reflection on the firm, this action is also a response to the growing number of consumers who are concerned about the environment.

1.1 The Digital Revolution and Its Impact on SCM

Over the course of the digital revolution, a suite of sophisticated technologies has been introduced, which has resulted in a significant transformation of the supply chain management environment. These technologies have redefined operational efficiency, visibility, and integration across supply chains. Enterprise resource planning (ERP) systems are among the most game-changing developments that have emerged in the contemporary digital era. Supply chain management (SCM) in the modern era is dependent on these systems, which provide a single framework for all parts of the supply chain.

Enterprise resource planning (ERP) systems are essential for supply chain management (SCM) process integration. This is due to the fact that ERP solutions provide a uniform platform that can be used to govern and coordinate various components of the supply chain. With the use of an enterprise resource planning (ERP) system, departments such as production, distribution, inventory management, and procurement may be able to collaborate more effectively, resulting in improved communication and a more effective utilization of available resources.

1.2 Coordinated Strategy - Bringing Supply Chain Elements Together

It is possible to differentiate an integrated approach for supply chain planning from more traditional, compartmentalized methodologies by pointing out a number of defining characteristics that set it apart from the latter. As a starting point, holistic planning takes a holistic perspective on the supply chain as a whole, focusing on how its many interdependent pieces interact with one another rather than isolating specific sections or services. For the purpose of providing a comprehensive view of operations, it emphasizes the linkages and interactions that exist between the many elements in the supply chain, which range from the production and sourcing stages to the distribution and customer service stages. A holistic approach that combines cross-functional communication and collaboration is achieved by the collaborative efforts of several departments, such as those responsible for logistics, operations, marketing, and finance. In order to facilitate cooperation, it is necessary for all parties involved to have a comprehensive understanding of the objectives and dynamics of both the organization and the market. This allows for the flow of information, coordination of strategies, and collective decision-making.

1.3 Anticipating the Unpredictable Through Supply Chain Risk Management

An essential part of supply chain management is supply chain risk management (SCRM). This subfield focuses on finding, evaluating, and reducing risks that can interrupt the movement of products, data, and money from producers to consumers. The fundamental goal of supply chain risk management (SCRM) is to make sure that operations can keep running even when faced with a lot of unknowns and problems. Predicting possible interruptions, assessing their probability and impact, and putting plans in place to minimize their negative impacts are all part of this process. Today's international economy relies on SCRM. Supply chain risk management (SCRM) is the process of identifying, assessing, treating, and monitoring supply chain risks in order to decrease vulnerability, guarantee continuity, and increase profitability.

II. REVIEW OF LITERATURE

Alejandro Figueroa (2015) stated that in recent decades, green and sustainable supply chain management strategies have emerged, aiming to incorporate environmental considerations into organizations by mitigating unexpected adverse effects on the environment resulting from manufacturing and consumption processes. Concurrently, the discourse on the circular economy has been disseminated within the literature and practices of industrial ecology. The circular economy advances environmental sustainability by highlighting the transformation of goods to establish viable connections between ecological systems and economic progress.

Andi Dwi Anjani (2024) explained that environmentally responsible supply chain management is becoming more important in Southeast Asia, and this research aims to solve the difficulties in evaluating sustainability disclosures made by corporations. While sustainability reports are becoming more common, it is still not apparent how many of these reports really represent firms' efforts to be environmentally conscious. Using reports issued between 2022 and 2023, that study comprehensively assesses the green supply chain activities articulated by five large Southeast Asian firms: Unilever SEA, Nestlé Indonesia, Indofood, Danone, and Thai Bev. Using a qualitative exploratory design, the study combines document analysis, text mining, and thematic coding to extract instances of green supply chain terms.

Muhammad Abrar (2020) noted that the supply chains of emerging economies encounter greater obstacles to sustainability than their developed-country counterparts, which is why sustainable supply chain management approaches are not as widely used in developing nations. Researchers in wealthy nations tend to focus on the textile and garment sector, whereas there is a dearth of empirical studies on SSCM in underdeveloped nations. That study analyzed the relationship between business size and the adoption of sustainable supply chain management methods, as well as the performance of firms in relation to the triple bottom line.

F. Frank Alparslan (2024) observed that many obstacles, such as economic volatility, political and regulatory shifts, and quick technical developments, confront multinational enterprises (MNEs) in today's uncertain international business (IB) climate. In order to successfully navigate such turbulent waters, that study delves into how MNEs modify their tactics and operations. Diversification, increasing agility and adaptability, and strong risk management are important tactics.

III. OBJECTIVES

1. To study anticipating the unpredictable through supply chain risk management

2. To study the confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) for sustainable supply chain constructs

IV. RESEARCH METHODOLOGY

As a multivariate statistical process, confirmatory factor analysis checks whether the variables under study adequately reflect the total number of constructs. By combining exploratory factor analysis with confirmatory factor analysis (CFA), researchers may identify the factors that replicate the variable under maximum probability circumstances. Overall, research involving theory testing uses CFA, whereas research involving theory formation uses EFA. Another benefit of CFA over EFA is that it allows the researcher to examine the factor structure of a specified model. When doing an exploratory investigation with no preexisting theories, exploratory factor analysis makes perfect sense. In this study, exploratory factor analysis (EFA) is used to summarize data for hypothesis testing and other purposes, as each construct has a number of variables. This makes it easy to understand and analyze the correlations between the variables.

Yong and Pearce (2013) stated that EFA is often used to reorganize variables into a small number of factors or clusters determined by their common variance. As a result, segregation is feasible. Factor analysis aids researchers in locating latent structures or factors, which in turn allows them to decrease the number of variables to a more manageable collection, which allows for simpler interpretations and saves time.

The data for this study was collected through a structured survey questionnaire distributed to supply chain professionals working in multinational corporations. The survey items were developed based on existing literature on sustainable supply chain management, covering three main dimensions: economic factors, environmental factors, and social factors. A total of 39 items were included in the final survey instrument. The respondents were asked to rate each item on a Likert scale. The data was analyzed using SPSS Statistics 20.

V. RESULT

Prior to EFA, the reliability of each construct was examined using Cronbach's alpha. The values are presented in Table 1 below. Each dimension of the concept has adequate evidence of reliability as all Cronbach's α values are more than 0.70.

TABLE 1
RELIABILITY STATISTICS

Factor	Cronbach's Alpha	N of Items
Economic Factor	0.888	8
Environment Factor	0.947	9
Social Factor	0.886	22
Overall Reliability	0.899	39

A statistical package developed by IBM for the social sciences called SPSS Statistics 20 was used in order to carry out an exploratory factor analysis. In addition to principal component analysis, Kaiser Barlett's test (also known as Kaiser Normalization) was used, and factor loadings were restricted to being less than 0.4. The results are shown in the tables that are provided below.

VI. Results of Exploratory Factor Analysis

TABLE 2
KMO AND BARTLETT'S TEST

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.862	
Bartlett's Test of Sphericity	Approx. Chi-Square	11441.296
	df	741
	Sig.	0

TABLE 3
COMMUNALITIES

Variable	Initial	Extraction
EC1	1	0.752
EC2	1	0.655
EC4	1	0.562
EC5	1	0.64
EC6	1	0.66
EC8	1	0.522
EC9	1	0.568
EC10	1	0.524
EV1	1	0.656
EV2	1	0.718
EV3	1	0.729
EV4	1	0.755
EV5	1	0.706
EV6	1	0.793
EV7	1	0.797
EV8	1	0.694
EV9	1	0.677
SF1	1	0.69
SF2	1	0.719
SF3	1	0.772
SF4	1	0.814
SF5	1	0.738
SF6	1	0.753
SF7	1	0.757
SF8	1	0.594
SF9	1	0.765
SF10	1	0.725
SF11	1	0.715
SF12	1	0.748
SF13	1	0.749
SF14	1	0.766
SF15	1	0.784
SF16	1	0.8
SF17	1	0.77
SF18	1	0.772
SF19	1	0.832
SF20	1	0.816
SF21	1	0.807
SF22	1	0.851

TABLE 4
TOTAL VARIANCE EXPLAINED

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.938	22.918	22.918	8.94	22.918	22.918	6.49	16.636	16.636
2	4.8	12.308	35.226	4.8	12.308	35.226	5.05	12.954	29.59
3	4.468	11.458	46.684	4.47	11.458	46.684	4.56	11.682	41.272
4	3.797	9.736	56.42	3.8	9.736	56.42	4.41	11.309	52.582
5	2.828	7.251	63.671	2.83	7.251	63.671	3.39	8.687	61.269
6	2.282	5.851	69.522	2.28	5.851	69.522	3.18	8.145	69.414
7	1.031	2.644	72.166	1.03	2.644	72.166	1.07	2.752	72.166
8	0.937	2.404	74.57						
9	0.785	2.012	76.581						
10	0.697	1.787	78.369						
11	0.654	1.677	80.046						
12	0.628	1.61	81.655						
13	0.525	1.347	83.002						
14	0.496	1.272	84.274						
15	0.443	1.137	85.411						
16	0.431	1.105	86.516						
17	0.382	0.979	87.495						
18	0.376	0.964	88.459						
19	0.351	0.9	89.359						
20	0.324	0.83	90.189						
21	0.319	0.818	91.007						
22	0.308	0.79	91.797						
23	0.29	0.744	92.541						
24	0.278	0.712	93.253						
25	0.264	0.678	93.93						
26	0.246	0.631	94.562						
27	0.24	0.616	95.178						
28	0.22	0.564	95.742						
29	0.209	0.536	96.277						
30	0.196	0.502	96.779						
31	0.188	0.482	97.261						
32	0.175	0.448	97.709						
33	0.166	0.426	98.135						
34	0.147	0.376	98.512						
35	0.137	0.352	98.864						
36	0.134	0.345	99.209						
37	0.115	0.294	99.503						
38	0.103	0.265	99.768						
39	0.091	0.232	100						

TABLE 5
ROTATED COMPONENT MATRIX

Variable	Component						
	1	2	3	4	5	6	7
EC1			0.835				
EC2			0.796				
EC4			0.745				
EC5			0.749				
EC6			0.801				
EC8			0.69				
EC9			0.734				
EC10			0.622				
EV1	0.801						
EV2	0.818						
EV3	0.838						
EV4	0.853						
EV5	0.832						
EV6	0.869						
EV7	0.853						
EV8	0.781						
EV9	0.806						
SF1				0.78			
SF2				0.69			
SF3				0.79			
SF4				0.83			
SF5				0.79			
SF6			0.824				
SF7			0.832				
SF8			0.749				
SF9			0.841				
SF10			0.816				
SF11			0.808				
SF12		0.854					
SF13		0.837					
SF14		0.767					
SF15		0.875					
SF16		0.859					
SF17		0.874					
SF18		0.801					
SF19							0.9
SF20							0.8
SF21							0.88
SF22							0.92

It has been confirmed by Chauhan (2015) and Yong and Pearce (2013) that in order for exploratory factor analysis (EFA) to be acceptable for producing separate factors, the Bartlett's Test of Sphericity should have a significance threshold of $p < .05$. It has also been pointed out by researchers through their work that the Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy has to be more than .50 in order for a data set to comply with or be eligible for factor analysis (EFA). The production of unique and dependable factors is contingent upon the presence of this requirement.

As previously mentioned in Table 2, the p-value is less than 0.01, and the Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy is much higher than 0.5 (0.862, as seen in Table 2). Chauhan (2015) also reports that a model in EFA that is a good fit would have fewer than fifty percent of the non-redundant residuals with absolute values that are more than five percent, which is the case in this particular instance. In light of the fact that this is exploratory research, the orthogonal rotation Varimax method, which focuses mostly on components that are not associated, was used.

For the CFA, the variables that were separated out from the EFA were used, and AMOS (Analysis of Moment Structures) was used in order to carry out the confirmatory factor analysis. Researchers are able to determine the links between observable measurements and latent variables or factors of interest with the assistance of confirmatory factor analysis. The objective of this process is to determine the number of factors and the type of those factors that are responsible for the variance and co-variation among a collection of indicators. In addition, Brown and Moore (2013) state that researchers tend to utilize both EFA and CFA approaches in conjunction with one another in order to recreate the observed correlations that exist between a collection of latent variables.

VII. CONCLUSION

The management of the supply chain is becoming more important in the context of the efforts that organizations are making to embrace practices and strategies that are based on sustainability. This is because supply chain management includes the conversion of resources from raw materials to finished products and involves the movement of material and energy across the whole value chain. In order to benchmark, share, and enhance the sustainability-based practices of organizations, it is essential to measure sustainability activities, especially those that pertain to supply chain management in manufacturing organizations. Organizations often have a limited focus, which is to improve the economic performance of the company, without concentrating on the environmental elements of the supply chain or the fair distribution of wealth in the supply chain. There is a lack of a measure or metric that can holistically take into consideration the unique dynamics of supply chain, which are agile, inconsistent, and involve multiple levels and partners upstream and downstream, according to the literature. However, there are numerous sustainability indicators and metrics that can be used to measure sustainability.

The factor analysis conducted in this study confirms that sustainable supply chain management can be reliably measured across three dimensions: economic, environmental, and social factors. The high Cronbach's alpha values (all above 0.88) indicate strong internal consistency of the measurement instrument. The KMO value of 0.862 and significant Bartlett's test ($p < 0.001$) confirm the appropriateness of factor analysis for this dataset. The seven factors extracted explain approximately 72% of the total variance, providing a robust foundation for future research in sustainable supply chain management.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research paper.

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