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Measuring the Environmental Maturity of the Supply Chain Finance: A Big Data-Based Multi-Criteria Perspective

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Abstract: This paper presents a strategic roadmap to handle the issue of resource allocation among the green supply chain management (GSCM) practices. This complex issue for supply chain stakeholders highlights the need for the application of supply chain finance (SCF). This paper proposes the five Vs of big data (value, volume, velocity, variety, and veracity) as a platform for determining the role of GSCM practices in improving SCF implementation. The fuzzy analytic network process (ANP) was employed to prioritize the five Vs by their roles in SCF. The fuzzy technique for order preference by similarity to ideal solution (TOPSIS) was then applied to evaluate GSCM practices on the basis of the five Vs. In addition, interpretive structural modeling (ISM) was used to visualize the optimum implementation of the GSCM practices. The outcome is a hybrid self-assessment model that measures the environmental maturity of SCF by the coherent application of three multicriteria decision-making techniques. The development of the Basic Readiness Index (BRI), Relative Readiness Index (RRI), and Strategic Matrix Tool (SMT) creates the potential for further improvements through the integration of the RRI scores and ISM results. This hybrid model presents a practical tool for decision-makers.

Keywords: GSCM; big data; SCF; fuzzy ANP; fuzzy TOPSIS; ISM

1. Introduction

In industrial economics, "Everything is worth what its purchaser will pay for it" (Publilius Syrus, 1st Century B.C., cited in [1]). Unfortunately, this is not reflected in current green supply chain management (GSCM) practices. Indeed, the cost of GSCM implementation is greater than the expected return [2,3]. The main reason for this is the cost of changing practices, including those surrounding human resources [3], and adopting new green systems [4]. Consequently, it is not surprising that financial barriers represent one of the main obstacles to GSCM implementation [2,3,5,6].

It must be noted that the costs of being green are associated with not only environmental elements but also organizational functions [7]. Hervani et al. [5] explained this viewpoint through their equation-based definition of GSCM: GSCM = [Green Purchasing (GP)] + [Green Manufacturing (GM)/Materials Management (MM)] + [Green Distribution (GD)/Marketing] + [Reverse Logistics].

Specifically, linking environmental-related strategic purchasing activities to supply chain management (SCM) practices facilitates GSCM implementation [8]. This, in turn, creates new dimensions for sophisticated networks of buyers and sellers in various industries [5,9]. This complex situation for supply chain stakeholders highlights the need for the implementation of supply chain finance (SCF), a solution developed by academicians and practitioners.

SCF has been defined as a facilitator of the physical and information flows of the financial products and services provided by financial institutions [10]. It is the ability to optimize supply chains to enable financial infrastructures and cash flows [11]. Wuttke et al. [12] defined SCF as cash flow optimization with respect to planning, management, and control to improve material flows. Other studies have offered similar definitions [13–18]. These

studies suggest that financial, physical, technological, human, and organizational resource flows are key to SCF. Thus, the definitions are centered around the concept of the "flow" (i.e., flow of information, materials, and other resources) along the supply chain. This indicates the need for a focus on the five Vs of big data: value, volume, velocity, variety, and veracity. Moreover, recent industrial economics studies have also emphasized the importance of big data as a vital dimension in such a dynamic era [19–24].

Touboulic et al. [25] emphasized that the current SC practices are still influenced by the idea that the developing countries represent a collection of suppliers to the well-established firms in the developed countries; accordingly, SCM is in need of being restructured. Indeed, for SCM, restructuring the relationships among the different stakeholders is an issue that has attracted much attention, and consequently, the field of Operations Management (OM) represents an appropriate field for decision-making (DM) and/or multicriteria decision-making (MCDM) applications [26]. For example, the variety of the variables and constraints corresponding to the vehicle routing problem (VRP) results in formulation of different algorithms in order to optimize various logistics problems [27]. Likewise, in order to decrease the environmental impacts created by the transportation fleets during transfer of goods among different logistics centers, the queuing theory has been employed [28]. Tundys and Wiśniewski [29] investigated various tools and techniques for measuring the performance of GSCM and they clearly stated that future research attempts should focus on developing "friendly" managerial tools in order to assess GSCM practices. Such interactions among environmental aspects and SCM issues create an appropriate environment in which MCDM tools, such as TOPSIS, are utilized in order to solve GSCM issues [30]. Fuzzy TOPSIS and ELECTRE have recently been applied in order to handle the issue of selecting green suppliers considering green practices [31].

On top of this, with the increasing number of the recently published GSCM research works that highlight the significance of the issue of "resources" in GSCM practices [32,33], and with consideration of the fact that promising technologies such as blockchain, Internet of Things (IoT), Artificial Intelligence (AI), and data analytics represent the most advanced platforms and/or the state-of-the-art technical facilitators for the data exchanging processes among the SCF stakeholders [34], in which the flow of big data within the interactive environment represents a cornerstone for formulating a trusted and reliable platform [35], this paper proposes a strategic roadmap to handle the issue of resource allocation among the GSCM practices. Hence, the corresponding complex hypothesis herein imposes a potential for different strategic configurations to be executed as a result of dealing with different sets of resources needed to be utilized by each GSCM practice. Consequently, three research questions can be formulated:

Research Question 1 (RQ1): How do the five Vs of big data interact with each other to improve SCF practices?

Research Question 2 (RQ2): To what extent are GSCM practice-related data accurate, valuable, big, plentiful, and fast in terms of improving the data flow to facilitate the SCF implementation?

Research Question 3 (RQ3): How do we achieve optimal resource mobilization for GSCM practices considering their different contributions to the SCF implementation?

This paper used the five Vs of big data as a platform for testing the role of GSCM practices in improving SCF implementation. Considering the fact that MCDM methods facilitate the formulation of different strategies and the creation of evaluation processes, especially in logistics [36], three MCDM methods were employed. The fuzzy analytic network process (ANP) was employed to prioritize the five Vs by their contributions to SCF. The fuzzy technique for order preference by similarity to ideal solution (TOPSIS) was used to evaluate GSCM practices on the basis of these criteria. To improve the implementation of SCF, this study also provides a roadmap for the visualization of the optimum resource mobilization of GSCM practices through interpretive structural modeling (ISM). The rest of the paper is organized as follows: Section 2 introduces the eight GSCM practices extracted from the literature. Some recent MCDM relevant applications are also presented at the

end of Section 2. The employed methods and contexts of their application are presented in Section 3. Section 4 provides the results of the proposed model. The implications, contributions, and directions for future studies are presented in Section 5. Finally, Section 6 presents the conclusion for this paper. A list of acronyms and their descriptions are presented in Table 1.

Table 1. List of acronyms and their descriptions.

Acronym	Descriptions
AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
ANP	Analytic Network Process
BPM	Business Process Modeling
BRI	Basic Readiness Index
CUST	Customer Relationship Management
DM	Decision Making
ELECTRE	Elimination Et Choice Translating Reality
EMM	Environmental Management Maturity
ENVI	Environmental Management
GD	Green Distribution
GHRM	Green Human Resource Management
GM	Green Manufacturing
GP	Green Purchasing
GSCM	Green Supply Chain Management
HRM	Human resource management
IoT	Internet of Things
ISM	Interpretive Structural Modeling
ISO 14001	The International Standard that Specifies Requirements for an Effective Environmental Management System
MCDM	Multicriteria Decision-Making
MM	Materials Management
OM	Operations Management
ORGM	Organizational Interaction Maturity
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluations
QUAL	Quality Management
RQ	Research Question
RRI	Relative Readiness Index
SCF	Supply Chain Finance
SCM	Supply Chain Management
SMT	Strategic Matrix Tool
SP&D	Smart Process and Design
SUPP	Supplier Selection
TOPM	Top Management Commitment
TOPSIS	Technique For Order Preference By Similarity To Ideal Solution
VRP	Vehicle Routing Problem
5Vs	Five Vs of big data (value, volume, velocity, variety, and veracity)

2. Background

Several research studies have identified GSCM practices. For example, Zhu et al. [37] listed 21 GSCM practices related to five main factors. Kannan et al. [38] condensed this list into 17 GSCM practices, which can be grouped into eight vital practices. This section presents the most widely accepted GSCM practices (i.e., published papers within the literature). All aspects of the supporting literature are summarized and presented in Table 2.

Table 2. Summarization of the supporting literature.

Research Gap/Aspect	Supporting Literature
Top Management Commitment (TOPM)	[37,39–48]
Organizational Interaction Maturity (ORGM)	[37,49–56]
Quality Management (QUAL)	[57–67]
Environmental Management (ENVI)	[68–73]
Customer Relationship Management (CUST)	[61,63,65,67,74–80]
Green Human Resource Management (GHRM)	[56,81–88]
Supplier Selection (SUPP)	[8,38,45,48,89–98]
Smart Process and Design (SP&D)	[38,99–104]
MCDM Applications in GSCM	[38,91,105–113]
Justifications for the Selected Methods	[106,114–122]

2.1. Top Management Commitment

Top management commitment (TOPM) is a crucial driver for greening SCM. Top and senior management commitment is required to implement environmental management systems that are in harmony with other green practices and facilitate the monitoring of the organization's environmental progress [39]. Management commitment also enhances internal cross-functional collaborations among operational units. This may include empowering employees [40], implementing effective reward systems, providing training, and promoting teamwork [41]. Therefore, management commitment is important in environmental initiatives [37,42]. For example, managers must be committed to applying GSCM to purchasing, such as the reuse and recycling potential of purchased products and materials [43–48]. Indeed, studies have emphasized the importance of top management support to the success of organizational initiatives, including those related to GSCM [37].

2.2. Organizational Interaction Maturity

Organizational theory has undergirded the exploration and elucidation of GSCM [49]. According to resource-based theory, organizational infrastructure consists of a combination of resources and capabilities that create a competitive advantage [50]. The effective utilization of these resources leads to the successful implementation of competitive strategies, including those related to the environment [37,51]. Therefore, organizational learning enhances the implementation of sophisticated systems, such as GSCM [37,52–56].

2.3. Quality Management

Quality management (QUAL) is the key to organizational performance. It also plays a significant role in organizational environmental practices [57–59], which lead to better GSCM practices [60–62]. Jabbour et al. [62] investigated the role of QUAL, environmental management maturity (EMM), and other GSCM practices in green performance. Their study of 95 Brazilian companies found that it is essential to organizational EMM, which can improve green performance, especially in purchasing. Other studies have also emphasized the significance of QUAL in improving GSCM practices [63–67].

2.4. Environmental Management

Waste and costs can be efficiently minimized, and better environmental performance can be achieved when leading companies practice GSCM [68]. Thus, ISO 14001 plays a significant role in enhancing GSCM. In a study on the effects of ISO 14001 certification in Japanese facilities, Arimura et al. [69] concluded that these standards encouraged GSCM practices. Other studies have drawn similar conclusions [70–73].

2.5. Customer Relationship Management

One of the main elements of supply chain operations is stakeholder collaboration in the development of environmental goals [61,63,74]. Thus, customer pressure plays a

significant role in GSCM [75–77]. Thun and Müller [76] found that GSCM practices in German manufacturing were driven by customer pressure; consequently, good customer relationships were considered as a competitive advantage. Currently, the application of green requirements to the supply chain constitutes a competitiveness criterion for evaluating firm performance [77]. Several studies have concluded that customer relationship management is key to the implementation of GSCM practices [65,67,78–80].

2.6. Green Human Resource Management

Human resource management (HRM) practices encourage the creation of green organizations [81]. Cantor et al. [82] developed a model to investigate the relationship between organizational environmental initiatives and HRM practices. The key features of green training related to green human resource management (GHRM) and GSCM practices in Brazilian organizations have been investigated [56]. Jabbour and de Sousa Jabbour [83] observed that GHRM and GSCM play a significant role in creating a sustainable workplace environment; however, further research is needed. Therefore, an assimilation framework for GHRM–GSCM interactions was proposed. Muduli et al. [84] used ISM to investigate the relationships among GCSM-related behaviors. To address these complex organizational environmental challenges, GHRM must be considered because of its contribution to employee environmental authorizations [85], a green organizational culture [86,87], and the enhancement of environmental groups [85,88].

2.7. Supplier Selection

Supplier environmental partnerships promote green purchasing, which improves suppliers' ecological performances [8]. Supplier environmental partnerships have been categorized as three main types of activities: supplier education, supplier support, and joint ventures [48]. Thus, the consideration of green criteria in supplier selection (SUPP) has been investigated [38,45,89–92]. Studies have also focused on green supplier selection [93–98].

2.8. Smart Process and Design

Smart process and design (SP&D) considers product eco-design and reverse logistics. Eco-design refers to the consideration of stakeholder needs in the environmental elements of product design and development [99–101], including sustainable packaging [102]. Reverse logistics describes the production activities related to the three "REs" of raw materials: reduction, reuse, and recycling [99,103,104]. SP&D covers a wide range of successful GSCM practices, such as purchasing equipment that produces clean products, selling obsolete stock, selling waste materials, and reducing energy consumption [38].

2.9. MCDM Applications in GSCM

In this regard, several MCDM studies have addressed GSCM. Although many studies noticed that the lack of MCDM applications is still considered as a research gap, specifically in the field of reverse logistics [105], Vieira et al. [106] concluded that several MCDM methods have the potential to investigate several issues related to GSCM such as the prioritizing of the reverse logistics barriers. Kechagias et al. [107] aimed at creating a process reference model and have developed an analytic hierarchy process (AHP)-based Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) model to propose a systemic methodology for selecting the best Business Process Modeling (BPM) tools. They concluded that the proposed model is capable of contributing to improvement of sustainability in the context of SCM. Büyüközkan and Çifçi [108] highlighted the importance of the environmental dimension in achieving financial success. Accordingly, they developed a fuzzy-based ANP model to evaluate GSCM practices in an evolved Turkish company. Büyüközkan and Çifçi [91] emphasized the relationship between environmental performance and internal and external factors. Thus, they developed an MCDM model that employed fuzzy ANP and TOPSIS to optimize supplier selection. Wang and Chan [109] developed a fuzzy TOPSIS model to increase practitioners' and decision-makers' under-

standing of the resources that are needed as a consequence of the greening of SCM practices. A fuzzy TOPSIS model was developed to enable a Brazilian company to optimize electronics supplier selection [38]. ISM has been employed as a research method in many fields, including GSCM [110–113]. For example, Mathiyazhagan et al. [111] used sophisticated ISM to examine 26 barriers to GSCM in Indian automobile component manufacturing. Further technical explanations of the procedures for performing fuzzy ANP, fuzzy TOPSIS, and ISM are presented in succeeding sections of the paper.

3. Methods and Applications

Three MCDM methods were employed: fuzzy ANP, fuzzy TOPSIS, and ISM. The employment of these methods can be justified by looking at the three research questions separately and collectively. RQ1 aims to investigate the interactions among the "five Vs. of big data" to improve SCF practices. Such interactions imply the existence of "dependency" and "feedback" relationships among the "five Vs". The ANP, in particular, is a best fit tool that can discover, handle, and quantify such relationships [114,115]. This point has also been discussed and validated in many ANP-based research works [116–118]. RQ2 aims to evaluate eight different GSCM practices with respect to the five criteria (i.e., the five Vs). This is a typical MCDM problem that is can be resolved by TOPSIS and, academically, TOPSIS represents the most commonly acceptable MCDM tool to handle such an issue, particularly, in the fields of SCM and the environment [119]. Note that both ANP and TOPSIS were carried out with the aid of the fuzzy set theory because the fuzzy-based ANP and TOPSIS reduce the effect of subjectivity [120,121]. Regarding RQ3, optimal resource mobilization cannot be attained unless the eight GSCM practices receive the entitled priority in terms of which practice should be implemented before the other one. Such a special configuration of a decision-making situation requires a tool that can handle the complexity amongst the investigated practices [106]. Hence, in this regard, ISM was found to be a better application because it has been widely validated as an effective decision-making method and, specifically, as a tool to handle the complexity issue [122]. Collectively, the sequence the three techniques are applied in creates a hybrid self-assessment model to measure the environmental maturity of the SCF (Figure 1).
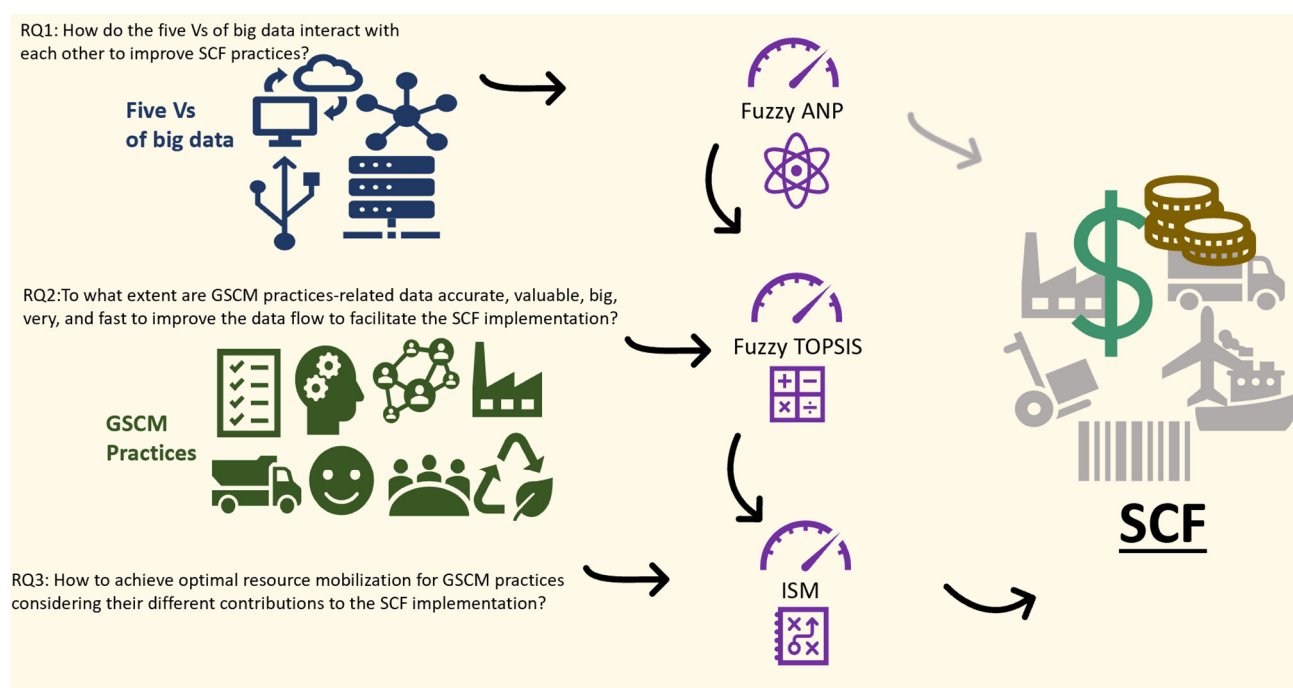

Figure 1. The perception of the proposed hybrid self-assessment model.

3.1. Fuzzy Analytic Network Process

The ANP is the generalized form of the analytic hierarchy process (AHP), a well-known MCDM technique [115]. Consequently, the AHP and fuzzy AHP can be considered special ANP and fuzzy ANP cases. Accordingly, the fuzzy ANP has been used as an extension of the traditional fuzzy AHP applications [123,124]. In AHP and fuzzy AHP, groups of elements are organized in a hierarchal structure. The application of the ANP and fuzzy ANP facilitates the formulation of more complex relationships through sets of clusters (network-based structure). These ideas have been explored in several studies [125–127].

In the ANP, a numerical scale is used to make sets of judgments, and in the fuzzy ANP, a linguistic scale is used. The MCDM literature provides several approaches to the implementation of the fuzzy AHP and ANP [128–136]. However, most of these approaches are complex. Hence, Chang's extent analysis has been considered the most accepted method because of its simplicity [124,137,138]. The present study employed Chang's extent analysis, which has been applied in previous studies [138,139].

To implement Chang's extent analysis, let $\widetilde{Q}$ symbolize the object set such that $\widetilde{Q} = \{\ddot{q}_1, \ddot{q}_2, \ldots, \ddot{q}_m\}$ and $\widetilde{R}$ symbolizes the goal set such that $\widetilde{R} = \{r_1, r_2, \ldots, r_n\}$. This application of Chang's extent analysis implies that the objects are considered independently in a sequential approach. In addition, for each independent object (i.e., $\ddot{q}_1, \ddot{q}_2, \ldots, \ddot{q}_m$), the analysis is executed for each goal, r_j. Accordingly, n numbers of extent analyses are executed as follows:

$$\widetilde{F}_{r_j}^1, \ \widetilde{F}_{r_j}^2, \ldots, \widetilde{F}_{r_j}^n, \quad j = 1, 2, \ldots, m \tag{1}$$

where $\widetilde{F}_{r_j}^i$, $(i = 1, 2, \ldots, n)$ symbolizes the triangular fuzzy numbers. $\widetilde{F}(x)$ symbolizes the membership function of the triangular fuzzy number. According to Erensal et al. [137], Chang's extent analysis can be illustrated in four steps:

Step 1: For each object j, the fuzzy synthetic extent can be expressed as:

$$C_j = \sum_{i=1}^{n} \widetilde{F}_{rj}^i \ \otimes \ \left[\sum_{j=1}^{m} \sum_{i=1}^{n} \widetilde{F}_{rj}^i \right]^{-1} \tag{2}$$

As expressed in Equation (2), $\otimes$ symbolizes the extended multiplication of two fuzzy numbers. To perform $\sum\limits_{i=1}^{n} \widetilde{F}_{rj}^i$, n extent analysis values are executed such that:

$$\sum_{i=1}^{n} \widetilde{F}_{rj}^i = \left(\sum_{i=1}^{n} k_i, \ \sum_{i=1}^{n} w_i, \ \sum_{i=1}^{n} t_i \right) \tag{3}$$

From Equation (2), $\left[\sum_{j=1}^{m} \sum_{i=1}^{n} \widetilde{F}_{rj}^i \right]^{-1}$ can be obtained by performing the fuzzy addition operation of $\widetilde{F}_{r_j}^i$, $(i = 1, 2, \ldots, n)$ as shown in Equation (4):

$$\sum_{j=1}^{m} \sum_{i=1}^{n} \widetilde{F}_{rj}^i = \left(\sum_{j=1}^{m} k_j, \ \sum_{j=1}^{m} w_j, \ \sum_{j=1}^{m} t_j \right) \tag{4}$$

The inverse of the vector can then be obtained:

$$\left[\sum_{j=1}^{m} \sum_{i=1}^{n} \widetilde{F}_{rj}^i \right]^{-1} = \left(\frac{1}{\sum_{j=1}^{m} t_j}, \ \frac{1}{\sum_{j=1}^{m} w_j}, \ \frac{1}{\sum_{j=1}^{m} k_j} \right) \tag{5}$$

where $p_j, n_j, h_j > 0$. After that, the C_j can eventually be obtained such that:

$$C_j = \sum_{i=1}^{n} \widetilde{F}_{rj}^i \otimes \left[\sum_{j=1}^{m} \sum_{i=1}^{n} \widetilde{F}_{rj}^i \right]^{-1}$$

$$= \left(\sum_{i=1}^{n} k_i \otimes \sum_{j=1}^{m} k_j , \sum_{i=1}^{n} w_i \otimes \sum_{j=1}^{m} w_j , \sum_{i=1}^{n} t_i \otimes \sum_{j=1}^{m} t_j \right) \tag{6}$$

Step 2: The opportunity that $[\widetilde{F_2} = (h_2, n_2, p_2)] \geq [\widetilde{F_1} = (h_1, n_1, p_1)]$ can be expressed as:

$$V(\widetilde{F_2} \geq \widetilde{F_1} V) = \begin{cases} 1 & if \; w_2 \geq w_1 \\ 0 & if \; k_1 \geq t_2 \\ \frac{k_1 - t_2}{(w_2 - t_2) - (w_1 - k_1)} & otherwise \end{cases} \tag{7}$$

Figure 2 illustrates all the cases of $V\left(\widetilde{F_2} \geq \widetilde{F_1} \right)$. For example, in the case of $w_2 > k_1 > t_2 > w_1$, point z represents the value that matches the highest intersection point of $\widetilde{F_2}$ and $\widetilde{F_1}$ (which is point $\ddot{Z}$). Both values, $V\left(\widetilde{F_2} \geq \widetilde{F_1} \right)$ and $V\left(\widetilde{F_1} \geq \widetilde{F_2} \right)$, are required to compare $\widetilde{F_2}$ and $\widetilde{F_1}$.
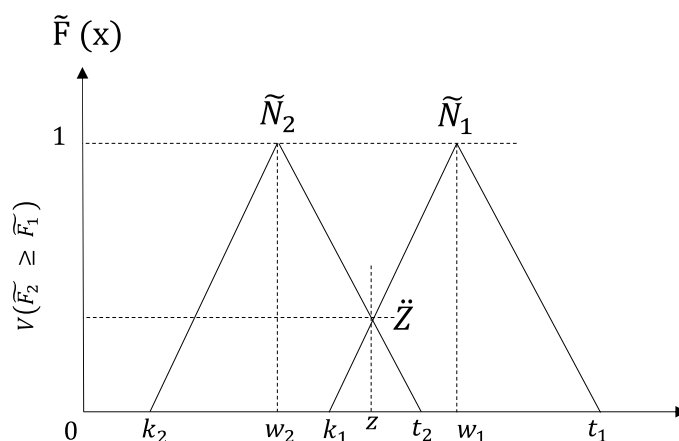
Figure 2. All possible cases of $V\left(\widetilde{F_2} \geq \widetilde{F_1} \right)$.

Step 3: The chance of the occurrence of a convex fuzzy number greater than y convex fuzzy numbers $\widetilde{F}_j$ ($j = 1, 2, \dots, y$) can be expressed as follows:

$$V\left(\widetilde{F} \geq \widetilde{F}_1 , \widetilde{F}_2, \dots, \widetilde{F}_y \right) = \min V\left(\widetilde{F} \geq \widetilde{F}_j \right), (j = 1, 2, \dots, y) \tag{8}$$

Step 4: The last step is to find the weight vector for $y = 1, 2, \dots, m$ such that:

$$W = \left(\min V \left(C_1 \geq C_y \right), \min V \left(C_2 \geq C_y \right), \dots, \min V \left(C_y \geq C_m \right) \right)^{\mathrm{T}} \tag{9}$$

3.2. Fuzzy TOPSIS

The fuzzy TOPSIS was developed by Chen [140] to address the issue of uncertainty in MCDM problems. With the fuzzy TOPSIS, decision-makers, DM_r, ($r = 1, \dots, k$) use linguistic terms to rate the criteria and alternatives. Accordingly, $\widetilde{w}_j^r$ represents the weight of the criterion j assigned by the DM_r such that C_j, ($j = 1, \dots, m$). Correspondingly, $\widetilde{x}_{ij}^r$ represents the weight of the alternative i with respect to C_j assigned by the DM_r, such that A_i, ($i = 1, \dots, n$). Several studies [38,141] have summarized the fuzzy TOPSIS as follows:

1. Aggregating the weights of the criteria and alternatives collected from k decision-makers, as shown in Equations (10) and (11):

$$\tilde{w}_j = \frac{1}{g}\left[\tilde{w}_j^1 + \tilde{w}_j^2 + \tilde{w}_j^r + \ldots + \tilde{w}_j^g\right] \tag{10}$$

$$\tilde{x}_{ij} = \frac{1}{g}\left[\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \tilde{x}_{ij}^r + \ldots + x_{ij}^g\right] \tag{11}$$

2. Constructing the fuzzy decision matrix of the criteria ($\widetilde{D}$) and the alternatives ($\widetilde{W}$), as shown in Equations (12) and (13):

$$
\widetilde{D} = \begin{array}{c} \\ A_1 \\ A_i \\ A_n \end{array}
\begin{array}{ccc} C_1 & C_j & C_m \\ \left[\begin{array}{ccc} \tilde{x}_{11} & \tilde{x}_{1j} & \tilde{x}_{1m} \\ \vdots & \vdots & \vdots \\ \tilde{x}_{n1} & \tilde{x}_{nj} & \tilde{x}_{nm} \end{array}\right] \end{array} \tag{12}
$$

$$\widetilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_m] \tag{13}$$

3. Normalizing the matrix ($\widetilde{D}$) by calculating ($\ddot{R}$). The normalized matrix ($\ddot{R}$) can be expressed as indicated in Equations (14)–(16):

$$\ddot{R} = \left[\ddot{r}_{ij}\right]_{m \times n} \tag{14}$$

$$\ddot{r}_{ij} = \left(\frac{k_{ij}}{t_j^+}, \frac{w_{ij}}{t_j^+}, \frac{t_{ij}}{t_j^+}\right)$$

$$and \ t_j^+ = max_i t_{ij} \ (for \ benefit \ criteria) \tag{15}$$

$$\ddot{r}_{ij} = \left(\frac{k_j^-}{t_{ij}}, \frac{k_j^-}{w_{ij}}, \frac{k_j^-}{k_{ij}}\right)$$

$$and \ k_j^- = max_i k_{ij} \qquad (for \ cost \ criteria) \tag{16}$$

4. Computing the weighted normalized decision matrix ($\ddot{V}$) by multiplying each $\ddot{r}_{ij}$ by the corresponding $\tilde{w}_j$, as shown in Equations (17) and (18):

$$\ddot{V} = \left[\ddot{v}_{ij}\right]_{m \times n} \tag{17}$$

$$\ddot{v}_{ij} = \tilde{x}_{ij} \times \tilde{w}_j \tag{18}$$

5. Identifying the fuzzy positive ideal solution (FPIS, $\ddot{A}^+$) and the fuzzy negative ideal solution (FNIS, $\ddot{A}^-$), as shown below:

$$\ddot{A}^+ = \left\{\ddot{v}_1^+, \ddot{v}_2^+, \ddot{v}_j^+, \ldots, \ddot{v}_m^+\right\} \tag{19}$$

$$\ddot{A}^- = \left\{\ddot{v}_1^-, \ddot{v}_2^-, \ddot{v}_j^-, \ldots, \ddot{v}_m^-\right\} \tag{20}$$

where $\ddot{v}_j^+ = (1, 1, 1)$ and $\ddot{v}_j^- = (0, 0, 0)$

6. Computing the distances $\ddot{d}_i^+$ and $\ddot{d}_i^-$ from $\ddot{v}_j^+$ and $\ddot{v}_j^-$ for each j, respectively, as shown in Equations (21)–(23):

$$\ddot{d}_i^+ = \sum_{j=1}^n \ddot{d}_v\left(\ddot{v}_{ij}, \ddot{v}_j^+\right) \tag{21}$$

$$\ddot{d}_i^- = \sum_{j=1}^n \ddot{d}_v\left(\ddot{v}_{ij}, \ddot{v}_j^-\right) \tag{22}$$

where the distances between two triangular fuzzy numbers $\widetilde{e}$ and $\widetilde{f}$ are calculated according to the vertex method shown below:

$$\ddot{d}\left(\widetilde{e}, \widetilde{f}\right) = \sqrt{\left(\frac{1}{3}\right)\left[\left(k_{\widetilde{e}} - k_{\widetilde{f}}\right)^2 + \left(w_{\widetilde{e}} - w_{\widetilde{f}}\right)^2 + \left(t_{\widetilde{e}} - t_{\widetilde{f}}\right)^2\right]} \tag{23}$$

7. Finding the closeness coefficient $\ddot{C}C_i$ using Equation (24):

$$\ddot{C}C_i = \frac{\ddot{d}_i^-}{\ddot{d}_i^+ + \ddot{d}_i^-} \tag{24}$$

8. Ranking the corresponding alternatives according to the value of $\ddot{C}C_i$.

Accordingly, the closest alternative to the FPIS is considered the best alternative.

3.3. Interpretive Structural Modeling

Several studies have discussed the mathematical foundation of ISM [142–144]. The philosophical background was presented by Warfield [145]. ISM is a mathematical technique to simplify the multifaceted relationships of any group of elements to develop a meaningful model for decision-makers [146]. It illustrates and explains the relationships among groups of entities, such as factors, elements, practices, barriers, and initiatives [111,146–150]. On the basis of applications in the literature [147,150,151], the steps in ISM are as follows:

1. Identifying the practices, such as factors, initiatives, barriers, or elements, to be examined.
2. Describing the contextual relationships among the sets of practices through four symbols:

    - V: if implementing practice $\ddot{A}$ leads to the successful implementation of practice $\ddot{E}$.
    - A: if implementing practice $\ddot{E}$ leads to the successful implementation of practice $\ddot{A}$.
    - X: if both practice $\ddot{A}$ and practice $\ddot{E}$ lead to successful reciprocal implementation.
    - O: if there is no relationship between practice $\ddot{A}$ and practice $\ddot{E}$.

3. Forming the structural self-interaction matrix (SSIM) as a result of the pair-wise contextual relationships among the examined practices.
4. Extracting the reachability matrix from the SSIM, which is converted into an initial reachability matrix in accordance with the following replacement rules:

    - If the (α, β) entry is V, then the (α, β) entry in the reachability matrix becomes 1, and the (β, α) entry becomes 0.
    - If the (α, β) entry is A, then the (α, β) entry in the reachability matrix becomes 0, and the (β, α) entry becomes 1.
    - If the (α, β) entry is X, then the (α, β) entry in the reachability matrix becomes 1, and the (β, α) entry also becomes 1.
    - If the (α, β) entry is O, then the (α, β) entry in the reachability matrix becomes 0, and the (β, α) entry also becomes 0.

5. The initial reachability matrix then has to be tested for transitivity to ensure that if practice $\ddot{A}$ leads to the implementation of practice $\ddot{E}$, and practice $\ddot{E}$ leads to the implementation of practice $\ddot{U}$, then practice $\ddot{A}$ leads to practice $\ddot{U}$. The resulting matrix is referred to as the final reachability matrix.
6. Based on the final reachability matrix, the set of practices can be classified into four categories: driving, linkage, dependent, and autonomous.
7. Based on the final reachability matrix, the set of practices can also be hierarchized. The final diagraph can then be developed in accordance with the identified levels.

3.4. The Application of Fuzzy ANP

Outer- and inner-dependence relationships were considered in the proposed fuzzy ANP model. As shown in Figure 3, the arrow from the SCF cluster to the big data cluster indicates the outer-dependence relationship in that all five Vs were weighted by their contributions to SCF practices. The arrows that connect the five Vs inside their cluster represent the inner-dependence relationships among the five Vs.
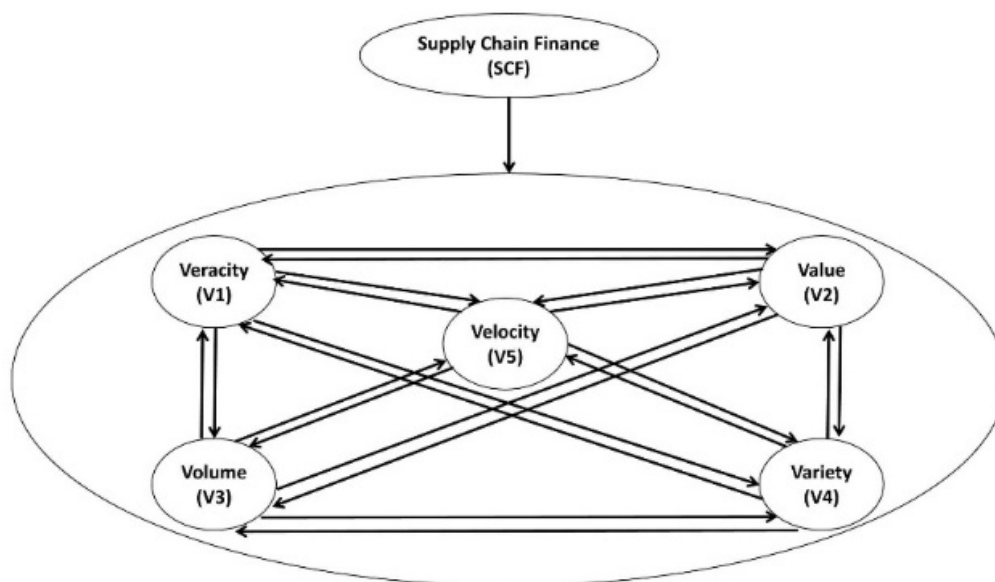
Figure 3. Conceptual fuzzy analytic network process model for supply chain finance and the 5 Vs of big data.

For the application of the fuzzy ANP model, the opinions of experts from one of the international leading food and retail holding companies were solicited. Accordingly, a group of experts in the field of SCM, including the supply and demand director, were selected. For this study, all selected experts were well-educated, holding critical managerial positions, and capable of dealing with various SCM issues concerning different contexts. To conduct fuzzy ANP and fuzzy TOPSIS, two different questionnaires were presented to the experts within several sequence sets of meetings until the consensus was reached. For fuzzy ANP, experts' views on the significance of each "V" in improving the implementation of SCF were sought. For example, they were asked about the importance of data velocity vs. data value in the improvement of SCF practices. All the Vs were compared on the fuzzy ANP linguistic scale (Table 3).

Table 3. Fuzzy analytic network process (ANP) linguistic scale.

Outer-Dependence	Inner-Dependence	Fuzzy Triangular Number			The Inverse of the Fuzzy Triangular Number		
Linguistic Expressions for Comparisons among 5Vs of Bigdata with Respect to "SCF"	Linguistic Expressions for Comparisons Among 5Vs of Bigdata						
Similar		(1,	1,	1)	(1,	1,	1)
Moderately Important		(1,	3,	5)	(1/5,	1/3,	1)
Important		(3,	5,	7)	(1/7,	1/5,	1/3)
Very Important		(5,	7,	9)	(1/9,	1/7,	1/5)
Extremely Important		(7,	9,	11)	(1/11,	1/9,	1/7)

It is worth mentioning herein that, according to Yin [152], the outcome of any case study can be validated analytically (i.e., analytical generalization) either by replication logic, in the case of having multiple case studies, or by theory development, as conducted in the current single case study (i.e., decision-making theory). Hence, Yin emphasized

that the focus should be on the case study as an "opportunity to shed empirical light on some theoretical concepts or principles ... that is, analytic genaralization" regardless of the number of cases. This is completely different from the traditional statistical validation of most quantitative research works. Further details regarding case study validation using the approach of analytical generalization can be found in [152]. Additionally, most of the ANP-based case studies have been validated and generalized analytically, not statistically, with small sample sizes [118,153].

3.5. The Application of Fuzzy TOPSIS

The extracted weights generated by the fuzzy ANP were considered in the development of the fuzzy TOPSIS model. The five Vs facilitated the rating of GSCM practices on the basis of their contributions to SCF practices. Experts used the fuzzy TOPSIS scale to evaluate each GSCM practice on each criterion (Figure 4). For example, the following question was posed to the experts: to what extent are the QUAL-related data as a GSCM practice "big" enough to improve the data flows to facilitate the SCF implementation? As indicated in Figure 4, the corresponding linguistic rates for answering the question were "big enough", "big", "normal", "partially incomplete", and "incomplete." All GSCM practices can be rated on the corresponding linguistic fuzzy TOPSIS scale (Figure 4).
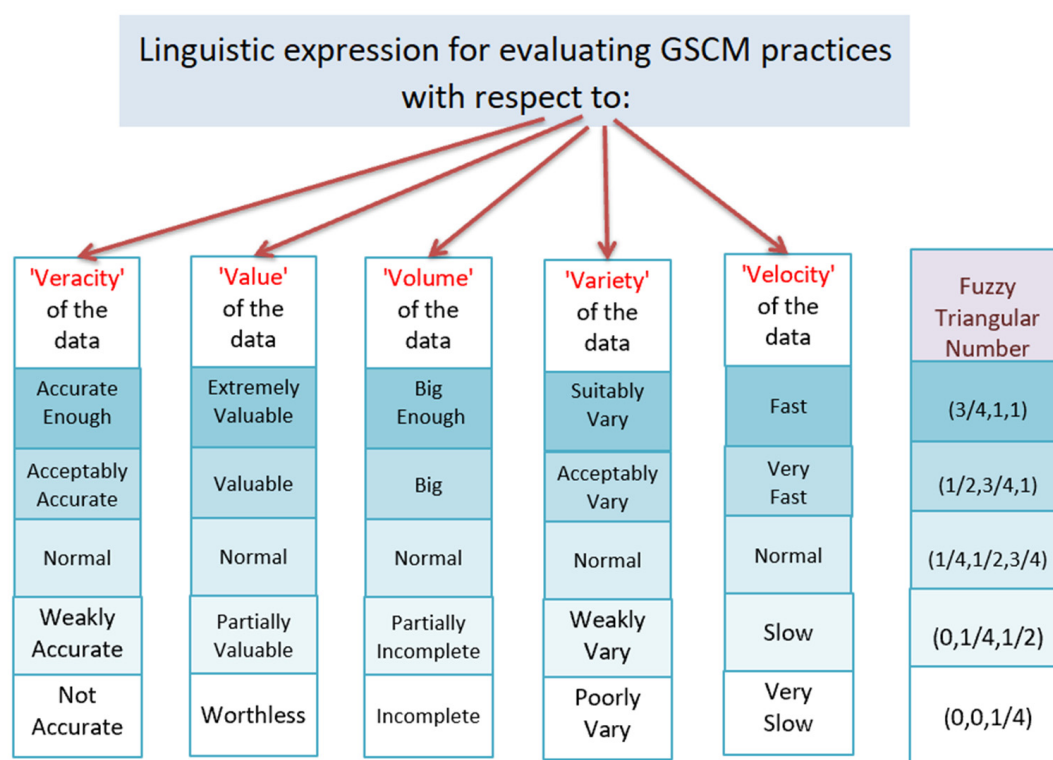

Figure 4. Fuzzy TOPSIS linguistic scale.

3.6. The Application of ISM

The ISM approach was employed to prioritize the GSCM practices by their reciprocal influence. Specifically, ISM was performed to identify the GSCM practices that should be implemented first regardless of their importance, criticality, or readiness scores. ISM achieved two significant outcomes:

1.   classification of GCSM practices into four categories: independent (drivers or driving practices), linkage, dependent, and autonomous practices;
2.   identification of the influence of each GSCM practice.

Further explanations of the proposed indices (i.e., the integration of the fuzzy TOPSIS and ISM outcomes) and key results are presented in the next section.

4. Results

4.1. Inner- and Outer-Dependence of the Five Vs of Big Data

Table 4 illustrates the contribution of each V in terms of facilitating SCF implementation. The inner-dependence relationships among the Vs, the outer-dependence linkage with SCF, and the overall significance weights that resulted from the application of the fuzzy ANP were considered. Regarding the inner-dependence relationships among the five Vs, Table 4 indicates that three (veracity, variety, and volume) of the four criteria contributed equally (31%) to the valuableness of the SCF data. However, data velocity was considered the least significant criterion (6%). Similarly, with respect to the veracity of the SCF data, all the criteria exhibited the same significance level (31%). The exception was velocity, which was considered to be relatively unimportant (6%). The velocity of the SCF data was found to be dependent mainly on the variety (40%) and volume (40%). Data veracity and value had the same low contribution level (10% on each criterion). Similarly, with respect to the volume of the data, data veracity and value were considered less important (10% on each criterion) while data velocity (40%) and variety (40%) were considered to be relatively important. Moreover, it can also be seen that the variety of the SCF data was dependent mainly on the veracity (53%) and velocity (43%). Data value and volume were considered insignificant (2% on each criterion). With respect to the outer-dependence linkage with SCF, data veracity and value were scored similarly (44%). Velocity, variety, and volume were scored as 3%, 4%, and 5%, respectively. The overall scores for the significance weighting of data veracity, value, velocity, variety, and volume were 30%, 29%, 7%, 17%, and 17%, respectively.

Table 4. Fuzzy analytic network process results.

| | Inner-Dependence | | | | | Outer-Dependence | Overall |
	Veracity	Value	Velocity	Variety	Volume	SCF	
Veracity	__	0.31	0.10	0.53	0.10	0.44	0.30
Value	0.31	__	0.10	0.02	0.10	0.44	0.29
Velocity	0.06	0.06	__	0.43	0.40	0.03	0.07
Variety	0.31	0.31	0.40	__	0.40	0.04	0.17
Volume	0.31	0.31	0.40	0.02	__	0.05	0.17

4.2. Fuzzy TOPSIS Results

4.2.1. Overall Rankings

Table 5 presents the final results for the fuzzy TOPSIS model. It can be observed that the highest score was recorded for SP&D (0.145). This indicates that it is the most mature GSCM practice for improving the implementation of SCF. The scores for the remaining GSCM practices were 0.131, 0.104, 0.101, 0.098, 0.081, 0.072, and 0.064 for QUAL, SUPP, CUTS, organizational interaction maturity (ORGM), environmental management (ENVI), TOP, and GHRM, respectively.

4.2.2. Basic Readiness and Relative Readiness Indices

All GSCM practices were rearranged by their final fuzzy TOPSIS scores (Table 6) with additional interpretations. Thus, two indices were developed: the Basic Readiness Index (BRI) and the Relative Readiness Index (RRI). The BRI measures the actual readiness of each GSCM practice to facilitate the SCF implementation by normalizing the final fuzzy TOPSIS scores (CCi). With the BRI, the final fuzzy TOPSIS score (CCi) for each GSCM practice is divided by the sum of the scores for all the GSCM practices (Table 6). The SP&D score on the BRI was 18.2% ([0.145/0.796] × 100 = 18.2%). This represented the highest normalized fuzzy TOPSIS score and, therefore, the highest BRI. GHRM had the lowest

BRI score (8.0%). The results indicate that the GSCM practices were generally not ready for SCF implementation because the BRI scores were between 8.0% and 18.2%. However, this is different from the interpretation through the RRI. The RRI measures the relative readiness of each GSCM practice to facilitate SCF implementation by benchmarking the final fuzzy TOPSIS scores (CCi). With the RRI, the final fuzzy TOPSIS score (CCi) for each GSCM practice is divided by the highest score (Table 6). For example, the RRI score of 69.4% ([0.101/0.145] × 100 = 69.4%) for customer relationship management (CUST) represents the benchmarked fuzzy TOPSIS score because it reflects the relative readiness of CUST compared with the best practice (SP&D). Accordingly, the RRI score for SP&D was 100% ([0.145/0.145] × 100 = 100%), thereby indicating that SP&D was the best practice (compared to all other practices). Consequently, GHRM had the lowest RRI score (44.1%). The outcomes of the integration of the RRI scores and ISM results are discussed in the next sections.

Table 5. Fuzzy technique for order preference by similarity to ideal solution results.

GSCM Practices	d^+	d^-	Fuzzy TOPSIS Score (CC_i)	Rank
CUST	4.534	0.507	0.101	4
SUPP	4.507	0.526	0.104	3
ENVI	4.626	0.406	0.081	6
QUAL	4.385	0.659	0.131	2
TOPM	4.695	0.366	0.072	7
GHRM	4.728	0.323	0.064	8
SP&D	4.307	0.730	0.145	1
ORGM	4.540	0.495	0.098	5

Table 6. Proposed green supply chain management practice indices: basic readiness and relative readiness.

| Ranking	GSCM Practices	TOPSIS Score	Basic Readiness Index (BRI)	Relative Readiness Index (RRI)
1	SP&D	0.145	18.2%	100%
2	QUAL	0.131	16.4%	90.1%
3	SUPP	0.104	13.1%	72.0%
4	CUST	0.101	12.6%	69.4%
5	ORGM	0.098	12.3%	67.8%
6	ENVI	0.081	10.1%	55.6%
7	TOPM	0.072	9.1%	49.8%
8	GHRM	0.064	8.0%	44.1%
		SUM = 0.796		

4.3. ISM Results

Table 7 shows the computed driving power and dependence power for each GSCM practice. It shows that SUPP, ENV, and QUAL had the same driving power (5) and a similar dependence power (8). CUST also had a similar driving power (5) but slightly different dependence power (7). Likewise, GHRM and ORGM had similar driving power (7) and similar dependence power (3). The TOPM scores indicate the highest driving power (8) and the lowest dependence power (1). In contrast, the SP&D scores indicate the lowest driving power (4) and the highest dependence power (8). On the basis of the computed driving power and dependence power, the GSCM practices were placed into three categories: driver (independent element zone), linkage, and dependent element zones (Figure 5). TOPM, GHRM, and ORGM are located in the driver zone and SP&D is considered an a dependent practice. CUST, SUPP, ENVI, and QUAL are considered linkage practices because they have relatively high driving and dependence power. The final ISM is the result of four sophisticated iterations (Figure 6). Figure 7 illustrates the final ISM in which TOPM represents the basis for the efficient implementation of the other GSCM elements.

In other words, the successful application of the GSCM-related efforts and resources are dependent on TOPM assurances and implementation. In contrast, SP&D is considered to result from the implementation of the other GSCM practices. Thus, the effort and resources needed for the implementation of SP&D cannot be technically justified. The application of the same logic and argument to all GSCM practices to improve the SCF environment (Figure 7) represents an effective initial GSCM implementation roadmap that considers the prioritized levels corresponding to each set of practices.

Table 7. Computed driving power and dependence power for each green supply chain management practice.

	CUST	SUP	ENV	QUAL	TOPMC	GHRM	SP&D	ORGM	Driving Power
CUST	1	1	1	1	0	0	1	0	5
SUP	1	1	1	1	0	0	1	0	5
ENV	1	1	1	1	0	0	1	0	5
QUAL	1	1	1	1	0	0	1	0	5
TOPMC	1	1	1	1	1	1	1	1	8
GHRM	1	1	1	1	0	1	1	1	7
SP&D	0	1	1	1	0	0	1	0	4
ORGM	1	1	1	1	0	1	1	1	7
Dependence Power	7	8	8	8	1	3	8	3	
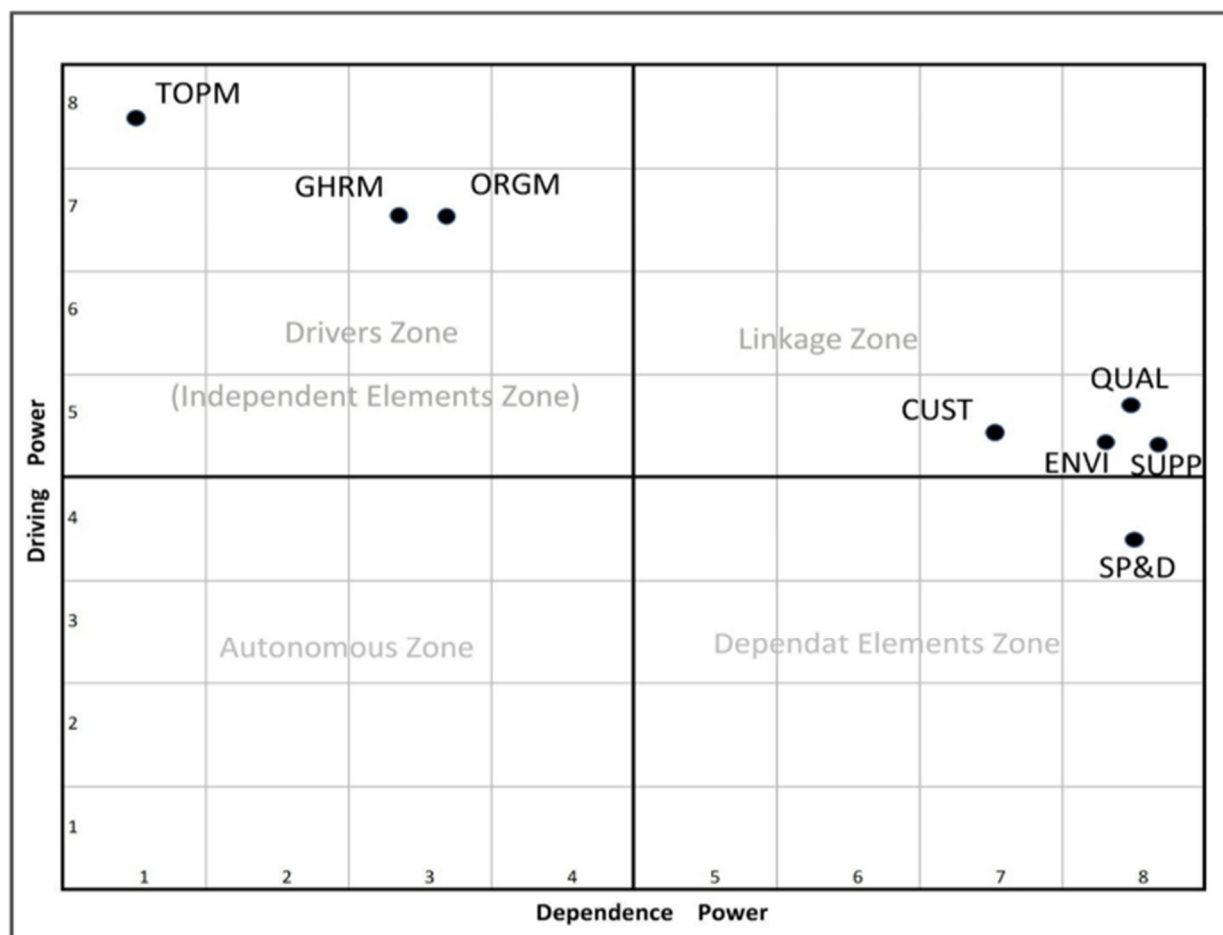
Figure 5. Location of green supply chain management (GSCM) practices in four zones.

iteration 1		Reachability Set	Antecedent Set	Intersection	Level
CUST	C	CSEQD	CSEQTGO	CSEQ	
SUPP	S	CSEQD	CSEQTGDO	CSEQD	
ENVI	E	CSEQD	CSEQTGDO	CSEQD	
QUAL	Q	CSEQD	CSEQTGDO	CSEQD	
TOPM	T	CSEQTGDO	T	T	
GHRM	G	CSEQGDO	TGO	GO	
SP&D	D	SEQD	CSEQTGDO	SEQD	I
OrgM	O	CSEQGDO	TGO	GO	

iteration 2		Reachability Set	Antecedent Set	Intersection	Level
CUST	C	CSEQ	CSEQTGO	CSEQ	II
SUPP	S	CSEQ	CSEQTGO	CSEQ	II
ENVI	E	CSEQ	CSEQTGO	CSEQ	II
QUAL	Q	CSEQ	CSEQTGO	CSEQ	II
TOPM	T	CSEQTGO	T	T	
GHRM	G	CSEQGO	TGO	GO	
SP&D	D	SEQD	CSEQTGDO	SEQD	I
OrgM	O	CSEQGO	TGO	GO	

iteration 3		Reachability Set	Antecedent Set	Intersection	Level
CUST	C	CSEQ	CSEQTGO	CSEQ	II
SUPP	S	CSEQ	CSEQTGO	CSEQ	II
ENVI	E	CSEQ	CSEQTGO	CSEQ	II
QUAL	Q	CSEQ	CSEQTGO	CSEQ	II
TOPM	T	TGO	T	T	
GHRM	G	GO	TGO	GO	III
SP&D	D	SEQD	CSEQTGDO	SEQD	I
OrgM	O	GO	TGO	GO	III

iteration 4		Reachability Set	Antecedent Set	Intersection	Level
CUST	C	CSEQ	CSEQTGO	CSEQ	II
SUPP	S	CSEQ	CSEQTGO	CSEQ	II
ENVI	E	CSEQ	CSEQTGO	CSEQ	II
QUAL	Q	CSEQ	CSEQTGO	CSEQ	II
TOPM	T	T	T	T	IIII
GHRM	G	GO	TGO	GO	III
SP&D	D	SEQD	CSEQTGDO	SEQD	I
OrgM	O	GO	TGO	GO	III

Figure 6. Identification of GSCM practice levels through four sophisticated iterations of interpretive structural modeling (ISM).
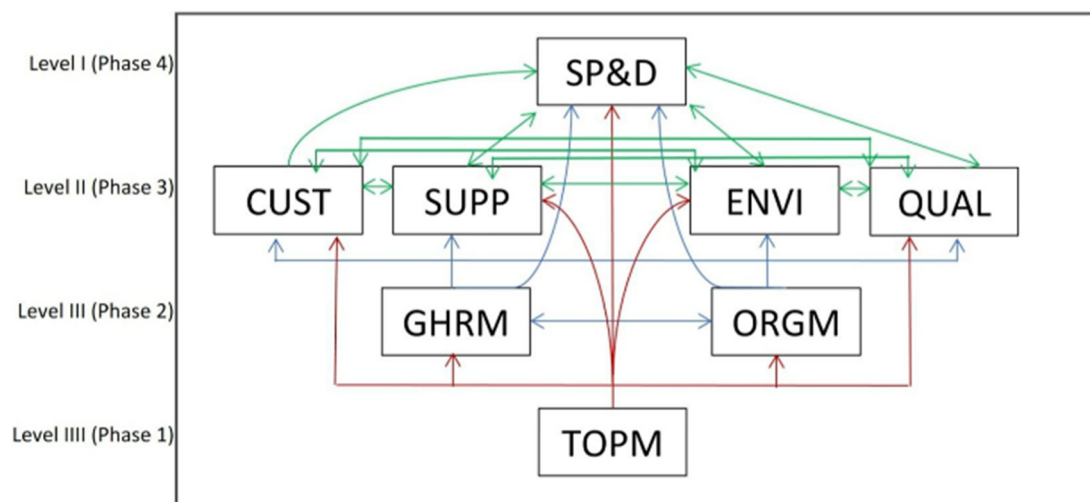
Figure 7. Final diagram of ISM.

5. Implications, Contributions, and Directions for Future Studies

Synergized outcomes can be extracted when ISM results are interpreted by RRI scores or vice versa. In Figure 8, which is an adjustment of Figure 5, the size of the bubble is a reflection of the corresponding RRI score for each GSCM practice. It indicates that the drivers (independent practices) are less ready for facilitating SCF implementation than the linkage practices or the sole dependent practice—i.e., SP&D. For example, TOPM was considered as a driver. The corresponding RRI score was very low (50%). This indicates that TOPM lacked sufficient readiness or maturity to enhance SCF. Nevertheless, it was assumed to be the most ready practice because of the corresponding results for its driving power (8—i.e., high), dependence power (1—i.e., low), and phase or priority level (Phase 1). In contrast, SP&D was considered a dependent practice. The corresponding RRI score was the highest (100%). This indicates that SP&D was the readiest practice. However, this was counter to its corresponding driving power (4), which was the lowest; dependence power (8), which was the highest (i.e., = 8); and phase or priority level, which was the lowest (Phase 4).
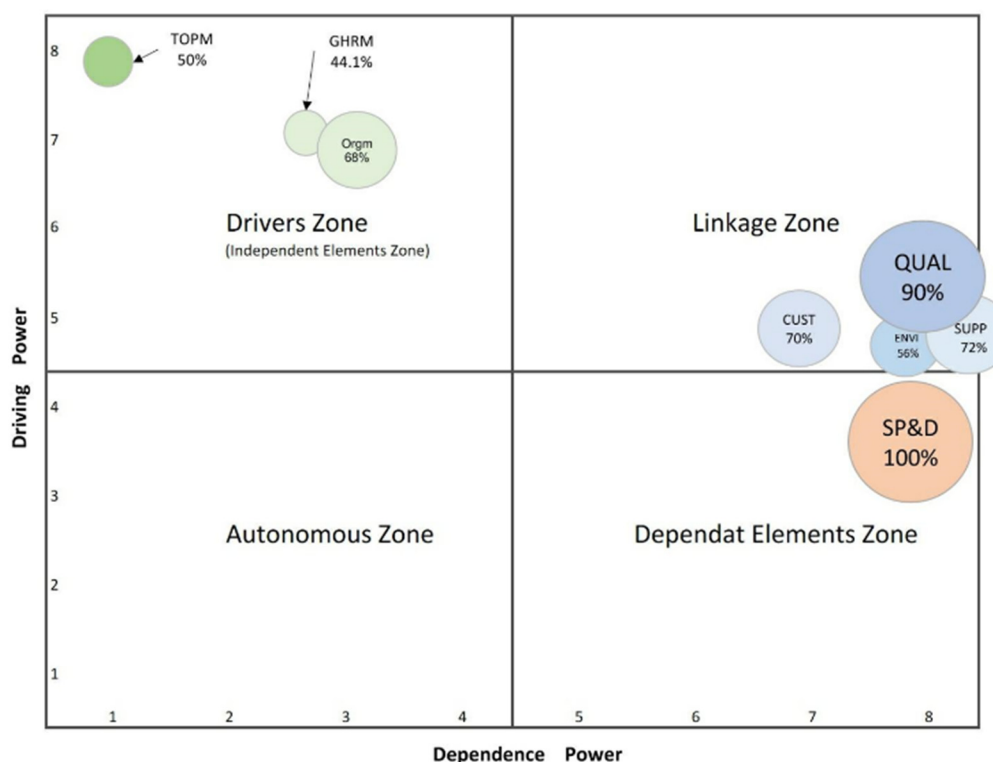
Figure 8. Integration of Relative Readiness Index scores and categorized GSCM practices.

To overcome this issue, the present study developed a strategic matrix tool (SMT), which is important for the reorganization and remobilization of the available resources. In Figure 9, the prioritized phases are listed vertically by the corresponding GSCM practice categories (zones). This also illustrates the horizontal classification of the RRI scores into three categories: 1, RRI score ≤ 50%; 2, RRI score ≥ 50% up to 90%; and 3, RRI score = 90% up to 100%. Therefore, three strategies were developed. The first (Strategy 1) refers to the process of increasing the allocated resources for each GSCM practice located in any square labeled "very high", "high", or "normal" attention in Phases 1 and 2 (Figure 9). The second (Strategy 2) refers to the decrease in the allocated resources for each GSCM practice located in any square labeled "very high", "high", or "normal" attention in Phases 3 or 4. The third (Strategy 3) is the maintenance of the same level of resources for each GSCM practice located in any square labeled "low" attention in Phases 1, 2, 3, or 4. The strategies for each practice are assigned on the basis of their location in the SMT (Figure 9).

Figure 9. Proposed strategic matrix tool.

This study contributes to the context of MCDM and its applications in GSCM from different angles. From a technical point of view, in order to evaluate the eight GSCM practices, fuzzy TOPSIS was conducted innovatively by using the relevant linguistic expression corresponding to to each V of big data (i.e., each criterion), as shown in Figure 4, which is a relatively more appropriate and accurate application compared to several traditional applications of fuzzy TOPSIS. Additionally, the study succeeded in visualizing the resources throughout a developed version of the ISM's final structure as shown in Figure 8. Such an innovative representation facilitates the resource allocation adjustment process to ensure better utilization of resources by each GSCM practice. Specifically, note that the size of the bubble is a reflection of the dedicated resources for each GSCM practice, which is a developed and unique form of ISM results representation.

Such technical contributions lead the talk to the practical/managerial contributions of the developed model. With such innovative tools proposed herein (i.e., BRI, RRI, and SMT), decision-makers can precisely allocate the required resources for the "demanding" GSCM practices with respect to the appropriate phase (i.e., timing). This can be performed by reducing the amount of resources dedicated to the GSCM practices in which resources are overutilized (i.e., saturated practices). Such strategic managerial actions can be executed with the aid of the three proposed strategies, as illustrated in the proposed SMT (Figure 9). By following such an approach, practitioners can allocate more resources confidently to the independent GSCM practices (drivers) such as TOPM, GHRM, and ORGM because the current dedicated resources for these practices are below their requirements as "drivers". Similarly, resources can be deducted confidently from the dependent GSCM practices such as QUAL, SP&D, ENVI, CUST, and SUPP. Such MCDM-driven practical/managerial approaches for resource allocation and/or strategy creation are applicable in many fields including sustainability [154–157].

In this study, opinion-based measures for big data were employed when carrying out fuzzy ANP and fuzzy TOPSIS. However, the employment of a data-driven approach would provide more accurate interpretations. To illustrate this, instead of using linguistic terms in measuring the GSCM practices with respect to the five Vs (Figure 4), the volume of data, for example, can be measured in Terabytes (TB) or even Petabytes (PB), the velocity of the data

can also be measured, for example, in TB per second (TB/s), and so. Another direction for future research can be investigated within the context of resource utilization. Specifically, the required resources for each GSCM practice can be cascaded into a further levels of details such as the types of resources to be utilized (human, technical, organizational, physical, or financial), as discussed and illustrated in [118].

6. Conclusions

This study proposes a hybrid self-assessment model to measure the maturity of SCF considering the environmental dimension by the coherent application of three MCDM techniques: fuzzy ANP, fuzzy TOPSIS, and ISM. The five Vs of big data were found to provide a template for assessing of GSCM practices. The fuzzy ANP illustrates the quantification of the five Vs by considering their inner- and outer-dependence. The fuzzy TOPSIS measures the contribution of each GSCM practice to supply chain financial performance. Moreover, rather than extracting the final GSCM practice scores, as is typical of traditional fuzzy TOPSIS applications, the study developed two indices: the BRI and RRI. The BRI scores indicated that the GSCM practices in the investigated company were not mature enough to improve the implementation of SCF. However, the proposed RRI index facilitated the benchmarking of GSCM practices to create the initial improvement guidelines. Consequently, the application of ISM creates a roadmap for the improvement of each practice through the categorization by driver, linkage, and dependent practices. ISM also allows for additional interpretations through the computation of the driving and dependence power for each practice and the identification of the corresponding level for each set of practices. In sum, the proposed SMT creates the potential for further improvements through the integration of the RRI scores and ISM results. Hence, the proposed hybrid model offers a practical tool for decision-makers.

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