Evaluating the Sustainability of Fashion Brands Using a Neutrosophical ORESTE Approach

Article *in* Sustainability · September 2023
DOI: 10.3390/su151914406

Saliha Karadayi-Usta
Istinye Universitesi

sustainability

MDPI

Article

Evaluating the Sustainability of Fashion Brands Using a Neutrosophical ORESTE Approach

Saliha Karadayi-Usta [1] and Erfan Babaee Tirkolaee [1,2,*]

[1] Department of Industrial Engineering, Istinye University, Istanbul 34396, Turkey; saliha.usta@istinye.edu.tr
[2] Department of Industrial Engineering and Management, Yuan Ze University, Taoyuan 320315, Taiwan
* Correspondence: erfan.babaee@istinye.edu.tr

Abstract: The fashion industry represents a significant source of consumerism within the global economy and requires substantial funding, eco-friendly practices, and ethical attitudes towards human capital, which are the triple bottom line of sustainability. Conscious customers are the key to reshaping the fashion industry by shopping and supporting fashion brands that adopt sustainable practices. Thus, the purpose of this study is to extract the factors affecting the decision-making process of conscious customers in selecting fashion brands adopting ethical and sustainable implementations, to present a case study covering alternative fashion brands, and to evaluate them in terms of sustainability measures. A bibliometric analysis is conducted within the scope of this research to address the most suitable and original decision-making technique; hence, a novel neutrosophic set-based ORESTE approach is proposed to rank the alternative brands. Next, after reaching the case study findings, a sensitivity analysis is conducted to illustrate the parameter changes' impact on the result in order to validate the findings' outcomes. Thus, this paper contributes to the literature by proposing a novel approach as an alternative to Besson ranking, extracting sustainable and ethical fashion practices of brands, and identifying the related reports and websites as references to measure sustainability in the fashion industry. The practitioners and managers can comprehend the factors to be taken into consideration by assessing the sustainability status of the particular fashion enterprises and can examine their positions in the global market within their competitors.

Keywords: neutrosophic sets; bibliometric analysis; ORESTE; sustainability; fashion industry

Citation: Karadayi-Usta, S.; Tirkolaee, E.B. Evaluating the Sustainability of Fashion Brands Using a Neutrosophical ORESTE Approach. *Sustainability* **2023**, *15*, 14406. https://doi.org/10.3390/su151914406

Academic Editor: Hong-Youl Ha

Received: 1 September 2023
Revised: 25 September 2023
Accepted: 27 September 2023
Published: 30 September 2023

1. Introduction

Sustainable fashion includes slow, ethical, and eco-friendly fashion but is a relatively new term in the consumer lexicon of green words because the media has not popularized it [1]. Slow fashion is the slowing of the manufacturing-consumption loop by enhancing sustainability and conserving local resources; it requires longer lead times, reduced workloads, and processes producing high-quality apparel to prolong product life [2]. Ethical fashion entails conscious sourcing, production, and consumption by transparency in economic interactions, living wages for workers, attentiveness to animal welfare, and ethical business practices [3]. To curtail clothing going to landfills, eco-friendly fashion chooses natural-content biodegradable products and recycled, vintage, or second-hand apparel to increase the life cycle of the product and minimize clothing purchases [4].

With over GBP 1 trillion in revenue, the fashion industry plays a major role in the global economy, and fashion brands compete at the highest level. The fashion industry is one of the largest consumers of resources in the global economy, and sustainability efforts depend on fashion firms' financial footing, eco-friendliness, and ethics. External sustainability incentives exist. London Fashion Week prohibited designers from using animal fur on the catwalks, encouraging companies like Burberry, Gucci, and Versace to go fur-free; Adidas developed clothing salvaged from ocean plastic [5]. Meanwhile, H&M

created a "conscious" collection in 2011, and Intimissimi focused on buying back used apparel from customers and reusing it to create new clothing [1].

In creating demand for products, consumers shape the fashion industry [6]. Because customers pay attention to many factors in selecting fashion brands [7], multi-criteria decision-making (MCDM) is a requirement for ranking fashion brands and identifying the best ones [8]. Because there are many MCDM techniques, the methodology must fit the subject. Bibliometric analysis is a powerful tool for identifying which technique to study by highlighting the literature details.

Among MCDM techniques, neutrosophy enhances opinion mining [9,10]. Neutrosophic sets are general forms of fuzzy sets and intuitive fuzzy sets, which are frequently employed to cope with indeterminate, incomplete, and inconsistent information in real-world applications. Because the neutrosophic sets have the advantage of measuring truth, indeterminacy, and falsity memberships independently, this study concentrates on neutrosophic MCDM methodologies.

This study addresses the absence in the literature of comprehensive studies about fashion brands' sustainable and ethical attitudes towards both producing the garments and satisfying customer needs. As represented in Section 2, this study aims to develop a novel methodological procedure in order to enhance the theoretical backdrop of related literature. Further, with little research addressing both fashion sustainability and ethics [11,12], this study both builds a theory and advances a practice.

The related literature involves the issues of sustainable materials for the circular economy [13], fashion design education for sustainability [14], ethics and conscious textile consumption [11], greenwashing [15], upcycled fashion purchases [16], waste management [17], and challenges of sustainable ventures in the fashion industry [18]. The most up-to-date theories in this field include mostly the theory of planned behavior [11,15,16] and the implementation of the structural equation modeling (SEM) technique. There is an obvious gap in the literature conducting multi-criteria decision-making analysis.

Hence, the purpose of the study is to construct sustainability and ethics assessments with specific factors for fashion brands, conducting a bibliometric analysis to decide on which MCDM technique to apply. Since the bibliometric analysis points out that a neutrosophic approach is new for organísation, rangement et synthèse de données relarionnelles (ORESTE) technique, this research aims to present the novelty of a neutrosophic set-based approach in ORESTE and propose a novel neutrosophic ORESTE technique to rank the alternative fashion brands in terms of sustainability. Therefore, by addressing the current studies in the literature, this paper fills the gap in this research field and makes both theoretical and practical contributions.

In order to realize the purpose, the research questions of this research are as follows: (*i*) What is the current theoretical background in sustainable and ethical attitudes of fashion brands? (*ii*) What are the existing methodologies applied in this field? (*iii*) What is the research gap? (*iv*) What are the criteria to evaluate fashion brands in sustainable and ethical ways? (*v*) What would be the alternative fashion brands? (*vi*) How do the parameters change by conducting a sensitivity analysis? The motivation behind developing such an extended methodology is based on the fact that there is no approach in the existing literature (cf. Section 2).

In the case of alternatives that can be prioritized for various factors, and when the factors themselves can be ranked in accordance with their importance levels, the ORESTE technique is applicable. Based on the advantages of the methodology, ORESTE is useful in the absence of numerical evaluations to obtain meaningful interpretations of the technical parameters. It is possible to rank the candidate alternatives with a complete rank, and then after an in-detail conflictual situation analysis, it provides better insides about the alternatives' relationship. In addition, there are several parameters enabling a sensitivity analysis in order to gather different scenario results for the outranking relation [19–22].

All in all, our work contributes to the literature by (*i*) proposing a novel neutrosophic ORESTE approach, (*ii*) presenting a neutrosophical approach instead of the Besson ranking procedure, (*iii*) conducting bibliometric analysis to justify the novelty of the neutrosophy for ORESTE, (*iv*) isolating and identifying the factors producing sustainable and ethical brands in the fashion industry, (*v*) identifying web content that provides references to measure sustainability, and (*vi*) emphasizing the ethical attitudes companies must develop to be sustainable in the fashion industry.

In the following sections, bibliometric analysis determines the proper MCDM technique as ORESTE by addressing the neutrosophic approaches' novelty to the technique. Next, preliminaries for the neutrosophic sets are presented, and then a novel neutrosophic ORESTE approach is proposed. The application, findings, sensitivity analysis, discussion, and conclusion sections are provided, respectively.

2. Bibliometric Analysis

Knowledge and experience exchange among academicians are dependent on technological progress, information dissemination speed, and the ease of scientific communication [23]. Hence, bibliometrics serves as a significant tool for assessing and analyzing academic research manuscripts. Bibliometrics stands for the mathematical and statistical techniques that can be executed in reviewing books, journals, proceedings, and articles [24].

Bibliometric analysis involves the quantitative examination and categorization of bibliographic information for reporting purposes [25]. Bibliometric analysis observes a field of study comprehensively [26] and can be applied to determine the historical progression of a field, pinpoint research inquiries, and generate fresh publication strategies, contributing significantly to those being studied in related fields [27,28]. Bibliometric analysis conducted for MCDM techniques identifies an MCDM methodology that is new for a neutrosophic approach.

Bibliometric Analysis for Neutrosophic MCDM

MCDM bibliometric analysis reveals a few papers applying MCDM techniques to sustainable fashion. On 3 June 2023, neutrosophy/neutrosophic/neutrosophical and multi-criteria keywords were searched in the Scopus database title-abstract-keyword field; only 534 documents resulted.

Based on the bibliometric analysis with 5 minimum numbers of occurrences, 81 of them meet the threshold, and TOPSIS and AHP [29,30], DEMATEL [31], EDAS [32,33], VIKOR [34], MULTIMOORA [35,36], CRITIC [37,38], MABAC [39], SWARA [40], WASPAS [41], COPRAS [42], CoCoSo [43], CODAS [44], QUALIFLEX and TODIM [45], PROMETHEE [46], ELECTRE [47], ANP [48,49], and MARCOS [50] are the most frequently-appeared MCDM methods for neutrosophic approach.

As it is clear from the existing literature, there are plenty of MCDM techniques in the energy, transportation, logistics, robotics, aviation, and healthcare industries. The neutrosophy-focused papers in textile/garment/apparel/clothing/outfit/fashion are limited and address the circular supply chain enablers [51,52], stakeholder analysis [12], performance evaluation [35], workplace analysis [53], and risk evaluation [54]. Therefore, there is a gap in the literature in discussing the neutrosophy for "sustainability of fashion brands".

It appears that there is no paper available on neutrosophic ORESTE in order to rank the alternatives in terms of a set of criteria. A comprehensive internet and electronic academic source search has been conducted, extending beyond the use of Scopus, and a neutrosophic ORESTE cannot be identified. Therefore, this research offers a neutrosophic ORESTE to rank the sustainability factors. The subsequent section provides an introduction to the foundational concepts and background information for neutrosophic sets.

3. Methodology

3.1. Foundational Concepts of Neutrosophic Sets

Smarandache (1998) [55] introduced neutrosophic sets as a comprehensive extension of fuzzy sets and intuitionistic fuzzy sets. This versatile approach is widely adopted for handling incomplete, uncertain, and inconsistent information in real-world applications [56–58].

One of the notable advantages of neutrosophic sets lies in their capacity to independently assess three aspects: truth, indeterminacy, and falsity memberships, illuminating their interplay in decision-making. In contrast, intuitionistic fuzzy sets exhibit an inverse relationship between membership and the sum of the other two measures: as membership increases, the sum decreases. Furthermore, intuitionistic fuzzy sets entail interdependence between membership and non-membership degrees, with their sum constrained to be less than or equal to 1. In neutrosophic sets, each source operates autonomously, devoid of interaction or knowledge about the responses from other sources [59,60].

There are three fundamental definitions of neutrosophic sets.

Definition 1. *A neutrosophic set A in E (the universe) is denoted by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$, where $x \in E$. Here, A is notated by $A = \{\langle x, T_A(x), I_A(x), F_A(x), |x \in E\rangle\}$ where $T_A(x)$, $I_A(x)$, $F_A(x) \in [0, 1]$ such that $0 \leq T_A(x), I_A(x), F_A(x) \leq 3$.*

Definition 2. *A single-valued neutrosophic set A is a subclass of neutrosophic sets and is displayed by $A = \{\langle x, T_A(x), I_A(x), F_A(x), \mid x \in E\rangle\}$, where T_A, I_A, F_A: $X \to [0, 1]$ such that $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$. Particularly, if E has only 1 element, A is defined as a simplified neutrosophic number (SNN), which is shown by $A = \langle T_A, I_A, F_A\rangle$ [61].*

Definition 3. *Let $A = \langle T_A, I_A, F_A\rangle$ be an SNN, and the score function $s(A) = (2 + T_A - I_A - F_A)/3$ is utilized to rank SNNs [56]. This function is applied to convert the fuzzy neutrosophic sets into crisp ones.*

All these definitions will find practical application in the methodology presented in the subsequent sections.

3.2. Proposed Neutrosophic ORESTE Approach

First introduced by Roubens in 1980 [62], the ORESTE technique uses ordinal information to rank alternatives [30]. A compensatory method with attributes that must be independent, ORESTE differs from other decision-making methodologies in not requiring the conversion of qualitative to quantitative processes [63]. It is based on several parameters and thresholds and is widely used when a decision-maker provides an initial ranking of criteria [19].

A traditional ORESTE technique (*i*) defines the decision problem; (*ii*) identifies a pre-ranking of relative importance, ranking the criteria in descending order; (*iii*) calculates Besson rank values in order to obtain numerical values from the previous qualitative rank; and (*iv*) computes projection distances DR_i as follows:

$DR_j\,(a_i) = \left[\frac{1}{2}\, rc_j^R + \frac{1}{2}\, rc_j^R\,(a_i)^R\right]^{\frac{1}{R}}$, where a_j is alternative i, rc_i stands for the (Besson-) rank of criterion j, and $R \in \mathbf{R_0}$ denotes a constant value used for more flexibility. Here, $R = 1$ stands for the weighted arithmetic mean, $R = -1$ is the harmonic mean rank, and $R = 2$ is the quadratic mean rank. Furthermore, in the case of $R = -\infty$: min $(rc_i, rc_i\,(a))$ and in case of $R = -\infty$: max $(rc_i, rc_i\,(a))$, formulas are utilized, where rc_i is the alternatives' values in terms of Besson rank values [19,64]. In fact, R is a parameter selected by the decision-makers. A larger R value represents greater relative importance in comparing two criteria [65].

Traditional ORESTE methodology does not refer to a pre-defined linguistic variable table; instead, it generates a weak order of alternatives for each criterion and then calculates

Besson rank values to obtain quantitative tables of decision matrices. In the neutrosophic expert evaluation process, experts present their opinions using truth, indeterminacy, and falsity values as inputs. Hence, the first two steps of ORESTE are valid for the neutrosophic approach, while the third step is not needed in this part of the study.

The traditional ORESTE approach continues by (*v*) determining global ranks by ranking the projection distances DR_i in a descending order and (*vi*) specifying average ranks by calculating the sum of global rank values from the previous step for each alternative via $r(a_j) = \sum_{i=1}^{m} r_i(a_j)$, where m is the set of alternatives [64]. The proposed neutrosophic ORESTE approach steps [62,65,66] then follow.

Phase I: Complete ranking

1. Define the research questions, factors affecting decision-making, and alternatives.
2. Identify the decision-makers, apply the Delphi technique to gather their mutual opinions, obtain a pre-ranking in terms of relative importance values (rank the factors in a descending sort according to the importance values), use neutrosophic sets as input values, and calculate score functions via Definition 3 instead of the Besson ranking procedure.
3. Compute projection distances DR_i with the equation $DR_j\ (a_i) = \left[\frac{1}{2}\, rc_j^R + \frac{1}{2}\, rc_j^R\ (a_i)^R\right]^{\frac{1}{R}}$.
4. Determine global ranks by prioritizing the projection distances DR_i in descending order by specifying average ranks by getting the sum of the obtained global rank values for each alternative via $r(a_i) = \sum_{j=1}^{k} r_j(a_i)$, where k is the number of criteria.

Phase II: Indifference and conflict analysis, followed by partial ranking

5. Compute normalized preference intensities. For each pair of alternatives, compute the preference intensity via $C(a_i,\ a_{i'}) = \sum_j max\left(r_j(a_{i'}) - r_j(a_i),\ 0\right)$, and similarly compute $C(a_{i'},\ a_i)$. These preferences can be normalized by dividing them to their upper bound $k^2(m-1)$, where k is the number of criteria and m stands for the number of alternatives; therefore, normalization is fulfilled via $C^n(a_i,\ a_{i'}) = \frac{C(a_i,\ a_{i'})}{k^2(m-1)}$; repeat for $C^n(a_{i'},\ a_i)$.
6. Conduct indifference and conflict analysis by using the following rules using three thresholds of β, C^*, and γ. Then, obtain the final outranking relation matrix as the normalized preference intensities.

```
if |C^n(a_i, a_i') − C^n(a_i', a_i)| ≤ β
then if C^n(a_i, a_i') ≤ C* and C^n(a_i', a_i) ≤ C*
    then a_i I a_i'
    else a_i R a_i'
else if |C^n(a_i, a_i') − C^n(a_i', a_i)| > β
   then if C^n(a_i, a_i') / |C^n(a_i, a_i') − C^n(a_i', a_i)| ≥ γ
        then a_i R a_i'
      else a_i P a_i'
else if C^n(a_i, a_i') / |C^n(a_i', a_i) − C^n(a_i, a_i')| ≥ γ
   then a_i' R a_i
else a_i' P a_i
```

Here, $a_iRa_{i'}$ stands for a_i and is incomparable with $a_{i'}$. Moreover, P means "still transitive", and I is the indifference.

Thresholds β, C^*, and γ should be determined, and β is defined as the "indifference threshold" and is formulated by $\beta < \frac{1}{k\ (m-1)}$ as an upper limit. Practitioners may opt to take lower values for β [66], where k denotes the number of criteria and m shows the number of alternatives [19].

Threshold C^* is a reference for conflict and candidate pairs and corresponds to the normalized preference intensity. A practitioner can identify them interactively, either as indifferences or incomparabilities. This is calculated via $C^* < \frac{d}{2(m-1)}$ with $d = 1, \ldots, (m-1)$, where d is the "perfect conflict degree" assessed by decision-makers. It is a terminology threshold separating indifferences and incomparability and taken 1 in general.

Threshold γ is the "incomparability threshold" and represents the perturbation by switching pairs of positions in conflict, known as the "iso-perturbation" parameter [19], and the $\frac{1}{\gamma}$ value corresponds to the net relative preference intensity [66], which is limited by the formula $\gamma > \frac{k-2}{4}$ in case of comparing two alternatives [19].

Figure 1 presents the flow chart of this process.

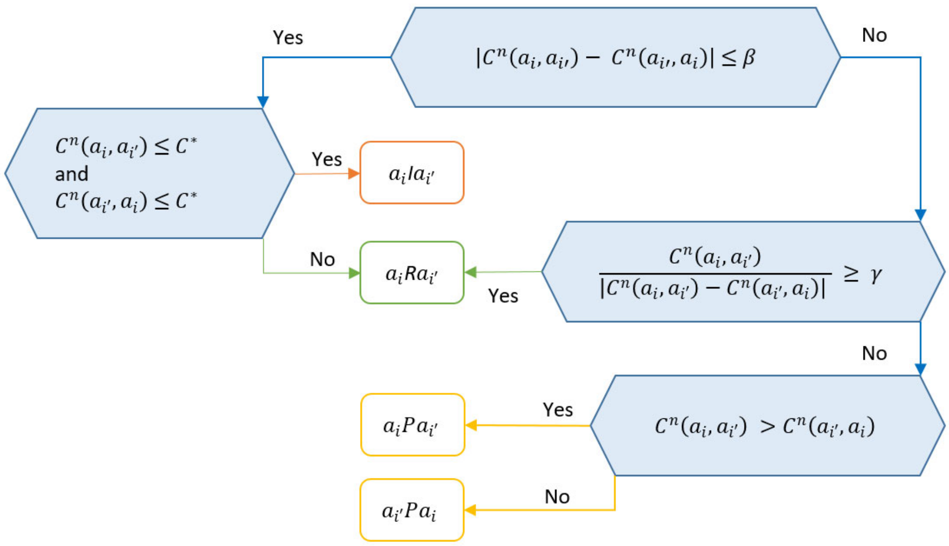

Figure 1. Flow chart of the indifference and conflict analysis step [19].

7. Generate a graph of the preference structure.

Figure 1 represents that after getting the sum of the obtained global rank values r_i for each alternative, a matrix is generated, and the partial ranking process follows. Accordingly, preference intensities (C^n) are calculated, and then indifference and conflict analysis by using thresholds of β, C^*, and γ is conducted. For example, in the $|C^n(a_i, a_{i'}) - C^n(a_{i'}, a_i)| \leq \beta$ case, particular C^n values are subtracted, the absolute value of this subtraction is obtained, and it is compared with the β threshold. Here, there are 2 options. (*i*) The first one examines the $\leq C^*$ case. If both of the C^n values are lower than C^*, then we can say these alternatives are indifferent (I is the indifference). Otherwise, they are incomparable (R is the incomparability). (*ii*) The second option again computes C^n values, and compares them with the γ threshold. If the division calculation is higher than γ threshold, then the alternatives are incomparable. Otherwise, there is the third step to follow. (*iii*) The symmetric C^n values are compared, and which alternative is preferred is determined.

4. Case Study

A detailed literature review and bibliometric analysis deal with the first step, "defining the research question, the factors affecting decision-making, and the alternatives". The defined sustainability factors are:

F1. Applying the health and safety laws at work [67];
F2. Employing qualified personnel and paying workers a living wage [68];
F3. Using biodegradable natural fabrics [69];
F4. Practicing reverse logistics and recycling [70];
F5. Utilizing animal welfare and cruelty-free applications [71];
F6. Manufacturing durable-quality products [72];

F7. Ensuring traceability and transparency [73].

To identify the alternatives, a detailed internet search was conducted. Key data sources included brand and company reports, third-party indices (such as Fashion Transparency Index FTI and CDP Climate Change and Water Security projects), and independent certifications, accreditations, and other standards-based systems (e.g., Cradle to Cradle, Fair Trade, Global Organic TextileStandard, and OEKO-TEX STeP) [74–78]. The Goodonyou website provided sustainable and ethical fashion brand ratings that were also considered [79]. According to Goodonyou, the ratings are as follows:

- "Brand G (Japan) does not give adequate details regarding its environmental and labor policies, as well as its efforts to minimize its impact on the environment, society, and/or wildlife."
- "Brand H (Sweden) utilized some eco-friendly materials including recycled ones while it has rapid fashion traits such as "on trend styles" and regular "new arrivals". Almost none of Branh H's supply chain is officially authenticated by labor standards that guarantee worker health and safety, living wages or other labor rights. It also gets a score of 71–80% in the Fashion Transparency Index FTI."
- "Brand I (New Zealand) has commendable animal welfare policies in place but falls short in guaranteeing fair wages for its workers. The brand incorporates eco-friendly materials, including recycled ones. While it has established a concrete goal to reduce greenhouse gas emissions from both its operations and supply chain, there is a lack of evidence indicating it is making satisfactory progress toward achieving this target. Furthermore, none of its supply chain partners hold certifications in labor standards, which encompass worker health, safety, living wages, and other labor rights. Its FTI score ranges between 51–60%. The company maintains a formal animal welfare policy aligned with the principles of the Five Freedoms."
- "Brand F (Canada) specializes in producing essential clothing items, offering a versatile wardrobe centered around timeless pieces. A substantial portion of its materials, including Tencel fibers [80], are eco-friendly. The brand prioritizes local manufacturing to minimize its carbon footprint, with the final production stages taking place in Canada, a region considered low-risk for labor exploitation. While there is no documented Code of Conduct [81], the company does have an official statement addressing workers' rights. It demonstrates supply chain traceability. Although it ensures the payment of a living wage in some segments of its supply chain, the specific percentage is not disclosed. Regular supplier visits are part of its documented practices. Additionally, Brand F refrains from using animal-based products, but it does not explicitly claim to be vegan."
- "Brand U (Denmark), headquartered in Copenhagen, is dedicated to crafting undergarments that inspire confidence, loungewear designed for everyday comfort, and swimwear that evokes dreams of vacations and summers. The company's products hold Oeko-Tex Standard 100 certification, signifying their adherence to strict safety and sustainability standards. A significant portion of its materials is eco-friendly, including recycled resources. While there is no documented Code of Conduct, the brand does have an official statement addressing workers' rights. It procures its final production stages from countries categorized as having a high risk of labor abuse. There is no available evidence indicating that it guarantees a living wage throughout its supply chain. The company demonstrates substantial supply chain traceability and conducts audits for all final production stages. Furthermore, Brand U does not use fur, leather, down, exotic animal skin, exotic animal hair, or angora. It explicitly mentions sourcing wool from non-mulesed sheep."
- "Brand O (Australia) is a distinguished denim label specializing in premium denim pieces crafted from organic materials. The brand prominently features eco-friendly materials, including Global Organic Textile Standard [82] certified cotton. In all of its product lines, it employs low-impact, non-toxic dyes. This commitment to eco-friendly materials reduces the use of chemicals, minimizes water consumption, and decreases

wastewater output during production. Furthermore, Brand O operates as a social enterprise, actively involved in creating employment opportunities for women who have been victims of trafficking in Cambodia. The company demonstrates complete supply chain traceability and ensures the payment of a living wage in most of its supply chain, including all stages of the final production. Although it abstains from using animal-based products, it does not explicitly label itself as vegan."

- "Brand Y (UK) is dedicated to crafting clothing that is both sustainable, ethical, and accessible to all. The brand extensively incorporates eco-friendly materials, prominently featuring GOTS cotton. To mitigate its environmental footprint, it relies on renewable energy throughout its supply chain. This eco-conscious approach minimizes the use of chemicals, reduces water consumption, and mitigates wastewater generation during production. Furthermore, Brand Y's commitment to ethical practices is validated by its certification from Fairtrade International—Small Producers Organizations. The company boasts complete supply chain transparency, guarantees the payment of a living wage across most of its supply chain, and has received recognition from [83] for its vegan-friendly products [74–79,84]."

Next, in May 2023, the decision-makers for decision matrices were contacted via LinkedIn for possible assessments and were briefed on the aim and scope of the study. Fifty-six people were asked to join the evaluation; seven participated. The participants (cf. Table 1) engaged in Turkish for two hours online in May 2023. The most challenging aspect of coordinating the meeting was identifying a convenient time for all participants, resulting in the scheduling of a daytime session. Since the attendees had been previously apprised of the meeting's scope, individual assessments were readily available at the outset of the session.

Table 1. Profiles of the participants.

#	Institution	Role in the Institution	Country
1	A Textile	Sustainable Fashion Designer	Turkey
2	B Group	Sustainable Procurement Expert	Turkey
3	C Consultancy	Sustainable Textile Consultant	Turkey
4	D Textile	Sustainable Fashion Entrepreneur	Turkey
5	E Fashion	Sustainability Coordinator	Turkey
6	Freelance	Sustainable Brand Designer and Stylist	Turkey
7	G Fashion	Sustainable Buying Manager	Turkey

The Delphi method was employed to collect insights on specified factor relationships. It operates as a predictive model involving multiple rounds of interviews where a panel of experts is provided with a consolidated summary of evaluations. This allows each expert to revise their responses based on the collective input from the group. This approach amalgamates the advantages of expert analysis with the collective wisdom of the panel [85].

Table 2 illustrates the consensus reached among participants regarding the sustainability levels of fashion brands using input values based on neutrosophic sets. In this context, the truth-membership (T_A) signifies the likelihood of a statement being true, the indeterminacy-membership (I_A) indicates the degree of uncertainty, and the falsity-membership (F_A) signifies the statement's falsehood [86]. In simpler terms, participants assert that stakeholder 1 impacts stakeholder 8 with a power degree of 0.2, and they are 90% certain that this statement is accurate. For instance, participants unanimously agree that stakeholder 3 exerts influence on stakeholder 1 with a power degree of 0.9, and they are 90% certain that this statement holds true.

Table 2. Brand ratings in terms of sustainable implementations as neutrosophic sets.

	Brand G	Brand H	Brand I	Brand F	Brand U	Brand O	Brand Y
F1	<.4 .15 .6>	<.65 .1 .35>	<.7 .1 .3>	<.8 .1 .2>	< 1 .1 0 >	<.95 .1 .05>	< 1 .1 0 >
F2	<.4 .15 .6>	<.65 .1 .35>	<.7 .1 .3>	<.8 .1 .2>	< 1 .1 0 >	<.95 .1 .05>	< 1 .1 0 >
F3	<.2 .1 .8>	<.6 .1 .4>	<.4 .2 .6>	<.8 .1 .2>	<.7 .1 .3>	< 1 .15 0 >	< 1 .1 0 >
F4	<.2 .1 .8>	<.6 .1 .4>	<.4 .2 .6>	<.8 .1 .2>	<.7 .1 .3>	< 1 .15 0 >	< 1 .1 0 >
F5	< 0 0 0 >	<.4 .1 .6>	<.8 .1 .2>	<.8 .1 .2>	<.8 .1 .2>	<.9 .1 .1>	< 1 .1 0 >
F6	<.6 .1 .4>	<.6 .15 .4>	<.65 .1 .35>	< 1 .15 0 >	<.8 .1 .2>	<.9 .1 .1>	< 1 .1 0 >
F7	<.6 .1 .4>	<.6 .15 .4>	<.65 .1 .35>	< 1 .15 0 >	<.8 .1 .2>	<.7 .1 .3>	<.9 .1 .1>

In addition to the brand review, a detailed literature review determined the factors affecting sustainability in the fashion industry (cf. Table 2), and the listed factors are rated in the Delphi session via neutrosophic sets, then converted into score function values by applying Definition 3 (cf. Table 3). The experts presented varying indeterminacy levels according to the information provided by the companies. In the second step, a pre-ranking of relative importance values is obtained in the Delphi session.

Table 3. Initial decision matrix with calculated score function values for fashion brands.

	Brand G	Brand H	Brand I	Brand F	Brand U	Brand O	Brand Y
F1	0.55	0.73	0.77	0.83	0.97	0.93	0.97
F2	0.55	0.73	0.77	0.83	0.97	0.93	0.97
F3	0.43	0.7	0.53	0.83	0.77	0.95	0.97
F4	0.43	0.7	0.53	0.83	0.77	0.95	0.97
F5	0	0.57	0.83	0.83	0.83	0.9	0.97
F6	0.7	0.68	0.73	0.95	0.83	0.9	0.97
F7	0.7	0.68	0.73	0.95	0.83	0.77	0.9

The projection distances and global rank values are computed, and a final ranking is obtained (cf. Table 4). Here, when the R value is 1, the ranking is 7, 6, 5, 3, 4, 2, 1; when $R = -1$, the final ranking is 7, 6, 5, 2, 4, 3, 1; when $R = 2$, the ranking is 7, 6, 5, 4, 3, 2, 1; and when $R = 3$, the ranking is again 7, 6, 5, 4, 3, 2, 1. As mentioned earlier, R is a parameter that is chosen by the decision-makers, and a larger R value represents more relative importance in comparison with two criteria [65]. Since the outranking is similar in these cases and the highest R values yield the same final ranking, this study follows reference studies [62,66,87,88] in adopting R as three.

Table 4. Projection distances, global rank values, and ranking.

	F1	F2	F3	F4	F5	F6	F7	Global Rank	Rank
Brand G	5.56	5.60	5.70	5.88	6.16	6.00	6.54	5.88	7
Brand H	4.77	4.82	4.24	4.55	5.55	6.54	7.00	5.32	6
Brand I	3.98	4.05	4.95	5.19	4.55	5.55	6.16	4.89	5
Brand F	3.19	3.30	3.00	3.57	4.55	4.82	5.56	3.98	4
Brand U	1.30	1.79	3.57	4.00	4.55	5.19	5.70	3.71	3
Brand O	2.41	2.60	2.60	3.30	4.05	4.95	5.88	3.66	2
Brand Y	1.30	1.79	2.41	3.19	3.98	4.77	5.60	3.27	1

In Phase II of the proposed methodology, normalized preference intensities are computed (cf. Table 5).

Table 5. Normalized preference intensities.

	Brand G	Brand H	Brand I	Brand F	Brand U	Brand O	Brand Y
Brand G	0	0.003401	0	0	0	0	0
Brand H	0.016927	0	0.004608	0	0	0	0
Brand I	0.023818	0.014900	0	0	0	0	0
Brand F	0.045717	0.032191	0.021899	0	0.005132	0.001542	0.000127
Brand U	0.052184	0.038657	0.028366	0.011599	0	0.007167	0
Brand O	0.053230	0.039704	0.029412	0.009055	0.008214	0	0
Brand Y	0.062614	0.049088	0.038797	0.017025	0.010431	0.009384	0

Next, indifference and conflict analysis were conducted by calculating β, C^*, and γ thresholds. According to the previously defined equations, the maximum value of β is 0.0238, the maximum value of C^* is 0.0833, and the minimum value of γ is 1.25, where m = 7, k = 7, and d = 1. As an example, from the literature, [66] took β as 0.008, the C^* as 0.045, and γ as 2, while [65] considered β as 0.02, the C^* as 0.05, and γ as 2.5.

In this study, β is taken as 0.02, C^* is taken as 0.08, and γ is taken as 1.25. By following the indifference and conflict analysis step that is illustrated in Figure 1, the final outranking relation matrix is generated as it is stated in Table 6. For instance, in comparing Brand G and Brand H, the computational β value is lower than the identified β = 0.02 threshold, so C^* is used to compare the two. Because $C^n(a_i, a_{i'}) \leq C^*$ and $C^n(a_{i'}, a_i) \leq C^*$ conditions are fulfilled at the same time, the relationship is determined as indifference I. Another example compares Brand G to Brand I, in which the computational β value is higher than the identified β = 0.02 threshold, so γ is required to maintain the rules, and since the computational γ value is lower than the threshold γ value, pairwise comparisons follow. In this part, two related pairwise cells are compared, and the matrix reflects the lower or higher status.

Table 6. Final outranking relation matrix.

	Brand G	Brand H	Brand I	Brand F	Brand U	Brand O	Brand Y
Brand G	*I*	*I*	<	<	<	<	<
Brand H	*I*	*I*	*I*	<	<	<	<
Brand I	>	*I*	*I*	<	<	<	<
Brand F	>	>	>	*I*	*I*	*I*	*I*
Brand U	>	>	>	*I*	*I*	*I*	*I*
Brand O	>	>	>	*I*	*I*	*I*	*I*
Brand Y	>	>	>	*I*	*I*	*I*	*I*

Finally, a graph of the preference structure is generated by considering the outranking relation matrix (cf. Figure 2).

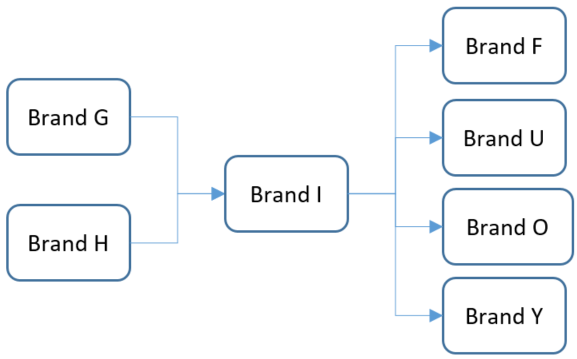

Figure 2. Graph of the preference structure.

According to the implemented proposed methodology, the fashion brands in this study are three-fold in terms of sustainability and ethics. Brand G and H are indifferent; Brand I is better at sustainability; and the last four brands, F, U, O, and Y, are indifferent, with the best performance in sustainability among these fashion brands.

By comparing the initial decision matrix with the final outranking relation matrix, one can conclude that although there are slight differences in factor values, an overall evaluation is required to result in an outranking of the alternatives.

According to the results of this study, "applying the health and safety law properly at work", "employing qualified personnel and paying workers a living wage", and "enabling animal-welfare, cruelty-free applications" are the least attention-shown factors. "Biodegradable natural fabrics usage", "reverse logistics and recycling", "manufacturing durable quality products" and "ensuring traceability and transparency" are relatively more widely adopted by fashion brands, with more implication areas.

5. Sensitivity Analysis and Discussion

Variable threshold values have possible effects on the findings. For example, when $\beta = 0.01$, there is an outranking $G = H = I = F < U < O < Y$, which means the first four brands are indifferent and there is an order for the remaining brands in terms of sustainability. Therefore, one can infer from this sensitivity analysis result that reducing the β value leads to a desensitization among the alternatives by considering that the brands are indifferent.

When the C^* threshold value is less than 0.05, brands U, O, and Y are labeled *R incomparable*, while the rest of the analysis results remain the same. The inference is that reducing C^* renders the alternatives incomparable. Moreover, when the γ threshold value is more than 1.5, the outranking $G < H < I < F <$ U'R'O $< Y$ constitutes an order such that U and O brand alternatives are incomparable. It is clear that the higher γ threshold values provide better visible orders, but incomparability may be observed in this case.

To compare this study with other sustainable and ethical fashion papers applying MCDM techniques in the literature, the others are listed by the issues they address: performance evaluation using sustainability index [89], sustainable supplier selection [90–93], corporate culture in textile manufacturing [94], sustainable practices in textile production [95], traceability and capacity building for improving sustainability [96], textile and apparel sustainability challenges [97], and sustainable textile manufacturing decision-making [98].

Of these studies, only [92] focus on ethics in fashion industry research. The MCDM literature emphasizes sustainable partner selection, and many studies are concerned with the financial sustainment of businesses. According to these, suppliers' eco-friendly applications remain unsatisfactory, and, casting aside ethics and transparency, companies conceal reports and other documents or do not communicate on this issue. These papers apply to AHP, TOPSIS, and DEMATEL in general.

The current customer-centric research papers examining the sustainability and ethics of fashion brands adopt the theory of planned behavior, survey customers, and implement SEM. Our research offers more, contributing both to theory and practice.

Furthermore, the impact of the fashion brands' attributes literature reveals that they have a significant positive impact on various aspects of the industry and society in terms of mitigating the environmental footprint [99], using eco-friendly materials [100], lowering energy and resource consumption [101,102], fair and ethical labor practices [103], safe working conditions [104], protecting workers' rights [105], providing transparency about sourcing and manufacturing [106], producing durable high-quality timeless garments [107], reducing over-consumption and waste [108], innovativeness [109], initiating the circular economy practices such as repairing [110], recycling [111], second-hand shopping [112], training the consumers [113], cooperating with the competitors to make an industry-wide shift to change the market [114], and engaging with the community to disseminate the local craftspeople [115] to contribute to sustainable practice.

There is a gap in the literature to bring the whole sustainability dimension into a single comprehensive study. Although the ethics and sustainability-focused papers of the fashion industry are underlying performance evaluations, sustainable supplier selections, corporate culture, sustainable production practices, traceability, challenges, etc., they are generally qualitative papers, and only a few of them use MCDM (multi-criteria decision-making) techniques. Indeed, there are only AHP, TOPSIS, and DEMATEL applications as a part of the MCDM literature. Here, the ORESTE technique is extracted as a result of the bibliometric analysis in order to identify the most suitable and original methodology. In conclusion, while the previous studies are not exhaustive and the number of MCDM applications is limited, this study utilizes these separate papers to provide a more generic framework and presents a comprehensive approach with a novel proposed methodology.

6. Conclusions and Outlook

The fashion industry generates over GBP 1 trillion in revenue for the global economy; it is also one of the largest consumers of resources. Well-financed, eco-friendly, and ethical sustainability in the fashion industry is a must, and conscientious customers are the key to reshaping the fashion industry. They are required to pay attention to several sustainability factors when selecting fashion brands for garment shopping. Hence, MCDM is a requirement for ranking the alternative fashion brands and preferring the best one. Furthermore, since neutrosophy is utilized to enrich opinion mining by dealing with incomplete, indeterminate, and inconsistent information from real-world applications, a neutrosophic MCDM approach is adopted in this study.

The main goal of this study was to construct sustainability and ethics, measure specific factors for fashion brands, present the novelty of a neutrosophic set-based approach in ORESTE, which was an MCDM technique, and propose a novel neutrosophic ORESTE technique to rank the alternative fashion brands in terms of sustainability. A bibliometric analysis was conducted to highlight the novelty of the neutrosophical ORESTE method; next, the literature was reviewed in detail to extract the factors that are sustainable and ethical in the fashion industry; key data sources were identified to understand the position of a brand; and finally, a novel neutrosophic technique was developed to rank the alternative fashion firms.

According to the results of the study, although there are slight differences in factor values, an overall evaluation is a major requirement to result in an outranking of the alternatives. According to the results of this study, the factors "applying the health and safety law properly at work", "employing qualified personnel and paying workers a living wage", and "enabling animal-welfare, cruelty-free applications" draw the least attention. "Biodegradable natural fabrics usage", "reverse logistics and recycling", "manufacturing durable quality products", and "ensuring traceability and transparency" are relatively more widely adopted by fashion brands, with more implication areas. The evaluation procedure addresses both the order and indifference situations of the alternatives.

Variable threshold values have possible effects on the findings of the ORESTE. For example, reducing β values leads to the desensitization of alternatives by assuming brands to be indifferent. When C^* threshold takes a lower value, it causes an incomparability of the alternatives. Moreover, when γ thresholds are taken at a higher value, they provide better detectable orders, but at the same time, incomparability may be observed in this case.

A practitioner can grasp the factors to consider in evaluating the fashion firms' sustainability condition, and the listed data source organizations are a reference for analysis of other fashion companies to determine sustainability dynamics. Moreover, managers can interpret the results and figure out which factors should be performed to achieve sustainability in their fashion enterprises. Accordingly, the indexes and the responsible institutions are highlighted in detail to guide the practitioners so that they can determine the short-, medium-, and long-term strategies to reach and maintain sustainable attitudes.

Local experts' participation in just one country can be considered a research limitation. However, to eliminate bias, key data sources like the Fashion Transparency Index, Climate

Change, and Water Security projects; standards-based systems like Fair Trade, Cradle to Cradle, OEKO-TEX STeP, Global Organic Textile Standard, and Code of Conduct; and related websites like Goodonyou and PETA were utilized to arrive at an unbiased assessment of the sustainability of fashion brands. The proposed approach is limited in its coding process and adherence to the predefined iterative steps, but careful implementation yields successful results and reflects customer reality. As another limitation, the proposed methodology does not require any weight for the decision-makers' evaluations. However, it could be dealt with by utilizing a supportive methodology such as AHP, SWARA, or MACBETH.

Future research may apply different MCDM methodologies like TOPSIS, AHP, VIKOR, DEMATEL, EDAS, MULTIMOOR, CRITIC, etc., which are aforementioned in the bibliometric analysis as the most frequently appearing MCDM methods of neutrosophic approach. Different factors affecting customers' preferences in apparel purchases supporting sustainability initiatives might be extracted to enhance this comprehensive study. In addition, the neutrosophic approach might be changed to plithogenic sets, hyper soft sets, intuitionistic fuzzy sets, hesitant fuzzy sets, Fermatean fuzzy sets, picture fuzzy sets, etc. to propose original approaches to further enrich the literature. The study can be generalized by including more industry representatives from different countries in the fashion industry.

Author Contributions: Conceptualization, S.K.-U.; Software, S.K.-U.; Validation, E.B.T.; Formal analysis, E.B.T.; Resources, S.K.-U.; Data curation, E.B.T.; Writing—original draft, S.K.-U.; Writing—review & editing, E.B.T.; Visualization, S.K.-U.; Supervision, E.B.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data will be available upon request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Evans, S.; Peirson-Smith, A. The sustainability word challenge: Exploring consumer interpretations of frequently used words to promote sustainable fashion brand behaviors and imagery. *J. Fash. Mark. Manag.* **2018**, *22*, 252–269. [CrossRef]
2. Jung, S.; Jin, B.E. Slow fashion branding: Understanding what consumers value most. *J. Brand Manag.* **2022**, *29*, 141–149. [CrossRef]
3. Liu, Y.; Liu, M.T.; Pérez, A.; Chan, W.; Collado, J.; Mo, Z. The importance of knowledge and trust for ethical fashion consumption. *Asia Pac. J. Mark. Logist.* **2021**, *33*, 1175–1194. [CrossRef]
4. Munir, S. Eco-Fashion Adoption in the UAE: Understanding Consumer Barriers and Motivational Factors. *Fash. Pract.* **2020**, *12*, 371–393. [CrossRef]
5. Bhardwaj, G.; Ditty, S. Understanding Sustainable Fashion. 2018. Available online: https://www.chathamhouse.org/2018/10/understanding-sustainable-fashion?gclid=Cj0KCQjwuMuRBhCJARIsAHXdnqOghXyU9Oaf3Rqw46OTgYfDtn5TGJvfCbbShnlEXZ-rm1mh249jyOYaAlqFEALw_wcB (accessed on 5 September 2022).
6. Pereira, L.; Carvalho, R.; Dias, Á.; Costa, R.; António, N. How Does Sustainability Affect Consumer Choices in the Fashion Industry? *Resources* **2021**, *10*, 38. [CrossRef]
7. Ünal, S.; Deniz, E.; Akın, N. Determınıng the Factors that Influence the Intentıon to Purchase Luxury Fashıon Brands of Young Consumers. *Ege Acad. Rev.* **2019**, *19*, 221–236. [CrossRef]
8. Fares, N.; Lloret, J. An integrated SWOT-AHP-fuzzy TOPSIS approach for maturity management following the COVID-19 outbreak: Lessons learned from fast fashion. *J. Glob. Oper. Strateg. Sourc.* **2022**, *15*, 510–533. [CrossRef]
9. Núñez, W.E.C.; Maldonado, P.A.C.; Valencia, D.X.C.; Ibarra, D.S.A.; León, A.R.S. Neutrosophy to Enrich Legal Opinion Mining. *Neutrosophic Sets Syst.* **2021**, *44*, 315–323.
10. Das, M.; Mohanty, D.; Parida, K.C. On the neutrosophic soft set with rough set theory. *Soft Comput.* **2021**, *25*, 13365–13376. [CrossRef]
11. Lira, J.S.; Costa, M.F. Theory of planned behavior, ethics and intention of conscious consumption in Slow Fashion Consumption. *J. Fash. Mark. Manag.* **2022**, *26*, 905–925. [CrossRef]
12. Karadayi-Usta, S. A novel neutrosophical approach in stakeholder analysis for sustainable fashion supply chains. *J. Fash. Mark. Manag.* **2023**, *27*, 370–394. [CrossRef]

13. Costa, J.; Broega, A.C. New Sustainable Materials for the Fashion Industry: The Button in the Circular Economy. *Springer Ser. Des. Innov.* **2023**, *25*, 342–356. [CrossRef]
14. Schulz, F.E.; Freire, L.H.; da Cunha, J.L.F.L. The 7 Complex Lessons from Edgar Morin Applied in Fashion Design Education for Sustainability. *Springer Ser. Des. Innov.* **2023**, *25*, 193–208. [CrossRef]
15. Adamkiewicz, J.; Kochańska, E.; Adamkiewicz, I.; Łukasik, R.M. Greenwashing and sustainable fashion industry. *Curr. Opin. Green Sustain. Chem.* **2022**, *38*, 100710. [CrossRef]
16. Hasbullah, N.N.; Riyard Kiflee, A.K.; Roni, M.; Idris, N.H.; Malan IN, B.; Jayeola, O.; Jamil, M.F.; Arham, A.F. Parasocial relationship influence on the upcycled fashion purchase intention among igeneration in Malaysia post-COVID-19: An empirical study. *J. Theor. Appl. Inf. Technol.* **2022**, *100*, 5813–5829.
17. Dominguez, M.F.O.; Bhatti, Y.A. From Waste to Luxury Fashion at Elvis & Kresse: A Business Model for Sustainable and Social Innovation in the Circular Economy. *Sustainability* **2022**, *14*, 11805. [CrossRef]
18. Hofmann, K.H.; Jacob, A.; Pizzingrilli, M. Overcoming Growth Challenges of Sustainable Ventures in the Fashion Industry: A Multinational Exploration. *Sustainability* **2022**, *14*, 10275. [CrossRef]
19. Pastijn, H.; Leysen, J. Constructing an outranking relation with ORESTE. *Math. Comput. Model.* **1989**, *12*, 1255–1268. [CrossRef]
20. Wu, X.; Liao, H. An approach to quality function deployment based on probabilistic linguistic term sets and ORESTE method for multi-expert multi-criteria decision making. *Inf. Fusion* **2018**, *43*, 13–26. [CrossRef]
21. Liao, H.; Wu, X.; Liang, X.; Xu, J.; Herrera, F. A New Hesitant Fuzzy Linguistic ORESTE Method for Hybrid Multicriteria Decision Making. *IEEE Trans. Fuzzy Syst.* **2018**, *26*, 3793–3807. [CrossRef]
22. Torkayesh, A.E.; Deveci, M.; Torkayesh, S.E.; Tirkolaee, E.B. Analyzing failures in adoption of smart technologies for medical waste management systems: A type-2 neutrosophic-based approach. *Environ. Sci. Pollut. Res.* **2022**, *29*, 79688–79701. [CrossRef]
23. Serdarasan, Ş.; Yılmaz, H.; Doğan, E.; Koç, B.; Kayır, M.H.; Çatalyürek, M. Lojistik ve Tedarik Zinciri Alanında TR Dizin'de İndekslenen Çalışmaların Bibliyometrik Analizi. *Dumlupınar Üniversitesi Sos. Bilim. Derg.* **2021**, *68*, 164–184. [CrossRef]
24. Pritchard, A. Statistical Bibliography or Bibliometrics. *J. Doc.* **1969**, *25*, 348–349. [CrossRef]
25. Cancino, C.A.; Amirbagheri, K.; Merigó, J.M.; ve Dessouky, Y. A bibliometric analysis of supply chain analytical techniques. *Comput. Ind. Eng.* **2019**, *137*, 106015. [CrossRef]
26. entürk, F.; ve Fındık, H. Türkiye'deki akademik araştırma dergilerinde 2005-2014 döneminde muhasebe alanında yazılmış makalelerin literatür taraması ve içerik analizi. *World Account. Sci.* **2015**, *17*, 413–436.
27. Kazemi, N.; Modak, N.M.; ve Govindan, K. A review of reverse logistics and closed loop supply chain management studies published in IJPR: A bibliometric and content analysis. *Int. J. Prod. Res.* **2019**, *57*, 4937–4960. [CrossRef]
28. Duran, G.; ve Çelikkaya, S. Türkiye'de lojistik üzerine yapılmış lisansüstü tezlerin bibliyometrik analizi. *GÜ İslahiye İİBF Uluslararası E-Dergi* **2019**, *3*, 152–167.
29. Atassi, R.; Yang, K. An Integrated Neutrosophic AHP and TOPSIS Methods for Assessment Renewable Energy Barriers for Sustainable Development. *Int. J. Neutrosophic Sci.* **2022**, *18*, 158–173. [CrossRef]
30. Jablonsky, J. MS Excel based software support tools for decision problems with multiple criteria. *Procedia Econ. Financ.* **2014**, *12*, 251–258. [CrossRef]
31. Ghag, N.; Acharya, P.; Khanapuri, V. Analyzing the sustainable international competitiveness factors of SMEs by Fuzzy Delphi and Neutrosophic DEMATEL. *Bus. Strategy Dev.* **2023**, *6*, 447–463. [CrossRef]
32. Cakmak, E.; Guney, E. Spare parts inventory classification using Neutrosophic Fuzzy EDAS method in the aviation industry. *Expert Syst. Appl.* **2023**, *224*, 120008. [CrossRef]
33. Simić, V.; Milovanović, B.; Pantelić, S.; Pamučar, D.; Tirkolaee, E.B. Sustainable route selection of petroleum transportation using a type-2 neutrosophic number based ITARA-EDAS model. *Inf. Sci.* **2023**, *622*, 732–754. [CrossRef]
34. Deveci, M.; Gokasar, I.; Pamucar, D.; Zaidan, A.A.; Wen, X.; Gupta, B.B. Evaluation of Cooperative Intelligent Transportation System scenarios for resilience in transportation using type-2 neutrosophic fuzzy VIKOR. *Transp. Res. Part A Policy Pract.* **2023**, *172*, 103666. [CrossRef]
35. Aytekin, A.; Okoth, B.O.; Korucuk, S.; Karamaşa, Ç.; Tirkolaee, E.B. A neutrosophic approach to evaluate the factors affecting performance and theory of sustainable supply chain management: Application to textile industry. *Manag. Decis.* **2023**, *61*, 506–529. [CrossRef]
36. Zavadskas, E.K.; Bausys, R.; Lescauskiene, I.; Usovaite, A. MULTIMOORA under Interval-Valued Neutrosophic Sets as the Basis for the Quantitative Heuristic Evaluation Methodology HEBIN. *Mathematics* **2021**, *9*, 66. [CrossRef]
37. Simic, V.; Gokasar, I.; Deveci, M.; Karakurt, A. An integrated CRITIC and MABAC based type-2 neutrosophic model for public transportation pricing system selection. *Socio-Econ. Plan. Sci.* **2022**, *80*, 101157. [CrossRef]
38. Krishnan, A.R.; Kasim, M.M.; Hamid, R.; Ghazali, M.F. A Modified CRITIC Method to Estimate the Objective Weights of Decision Criteria. *Symmetry* **2021**, *13*, 973. [CrossRef]
39. Pamučar, D.; Petrović, I.; Ćirović, G.; Stević, Ž. An extension of the MABAC and OS model using linguistic neutrosophic numbers: Selection of unmanned aircraft for fighting forest fires. *Transport* **2022**, *37*, 73–97. [CrossRef]
40. Korucuk, S.; Tirkolaee, E.B.; Aytekin, A.; Karabasevic, D.; Karamaşa, Ç. Agile supply chain management based on critical success factors and most ideal risk reduction strategy in the era of industry 4.0: Application to plastic industry. *Oper. Manag. Res.* **2023**. [CrossRef]

41. Görçün, Ö.F.; Pamucar, D.; Krishankumar, R.; Küçükönder, H. The selection of appropriate Ro-Ro Vessel in the second-hand market using the WASPAS' Bonferroni approach in type 2 neutrosophic fuzzy environment. *Eng. Appl. Artif. Intell.* **2023**, *117*, 105531. [CrossRef]
42. Hezam, I.M.; Mishra, A.R.; Krishankumar, R.; Ravichandran, K.S.; Kar, S.; Pamucar, D.S. A single-valued neutrosophic decision framework for the assessment of sustainable transport investment projects based on discrimination measure. *Manag. Decis.* **2023**, *61*, 443–471. [CrossRef]
43. Deveci, M.; Pamucar, D.; Gokasar, I.; Delen, D.; Wu, Q.; Simic, V. An analytics approach to decision alternative prioritization for zero-emission zone logistics. *J. Bus. Res.* **2022**, *146*, 554–570. [CrossRef]
44. Pamučar, D.; Badi, I.; Sanja, K.; Obradović, R. A novel approach for the selection of power-generation technology using a linguistic neutrosophic CODAS method: A case study in Libya. *Energies* **2018**, *11*, 2489. [CrossRef]
45. Ji, P.; Zhang, H.-Y.; Wang, J.-Q. Fuzzy decision-making framework for treatment selection based on the combined QUALIFLEX–TODIM method. *Int. J. Syst. Sci.* **2017**, *48*, 3072–3086. [CrossRef]
46. Bausys, R.; Zavadskas, E.K.; Semenas, R. Path Selection for the Inspection Robot by m-Generalized q-Neutrosophic PROMETHEE Approach. *Energies* **2022**, *15*, 223. [CrossRef]
47. Tian, Z.-P.; Nie, R.-X.; Wang, X.-K.; Wang, J.-Q. Single-valued neutrosophic ELECTRE II for multi-criteria group decision-making with unknown weight information. *Comput. Appl. Math.* **2020**, *39*, 224. [CrossRef]
48. Kahraman, C.; Çebi, S.; Onar, S.Ç.; Öztayşi, B. Recent Developments on Fuzzy AHP and ANP Under Vague and Imprecise Data: Evidence from INFUS Conferences. *Int. J. Anal. Hierarchy Process* **2022**, *14*, 1–17. [CrossRef]
49. Osintsev, N.; Rakhmangulov, A.; Baginova, V. Evaluation of logistic flows in green supply chains based on the combined DEMATEL-ANP method. *Facta Univ. Ser. Mech. Eng.* **2021**, *19*, 473–498. [CrossRef]
50. Pamucar, D.; Ecer, F.; Deveci, M. Assessment of alternative fuel vehicles for sustainable road transportation of United States using integrated fuzzy FUCOM and neutrosophic fuzzy MARCOS methodology. *Sci. Total Environ.* **2021**, *788*, 147763. [CrossRef]
51. Ghufran, M.; Khan KI, A.; Ullah, F.; Alaloul, W.S.; Musarat, M.A. Key Enablers of Resilient and Sustainable Construction Supply Chains: A Systems Thinking Approach. *Sustainability* **2022**, *14*, 11815. [CrossRef]
52. Dohale, V.; Ambilkar, P.; Kumar, A.; Mangla, S.K.; Bilolikar, V. Analyzing the enablers of circular supply chain using Neutrosophic-ISM method: Lessons from the Indian apparel industry. *Int. J. Logist. Manag.* **2023**, *34*, 611–643. [CrossRef]
53. Rahman, M.A.; Karmaker, C.L.; Ahmed, T.; Khan, M.I.; Morshed AK, M.M.; Ali, S.M. Modelling the causes of boiler accidents: Implications for economic and social sustainability at the workplace. *Heliyon* **2022**, *8*, e09601. [CrossRef]
54. Yucesan, M.; Gul, M. Failure modes and effects analysis based on neutrosophic analytic hierarchy process: Method and application. *Soft Comput.* **2021**, *25*, 11035–11052. [CrossRef]
55. Smarandache, F. *A Unifying Field in Logics. Neutrosophy: Neutrosophic Probability, Set and Logic*; American Research Press: Rehoboth, DE, USA, 1998.
56. Broumi, S.; Bakali, A.; Talea, M.; Smarandache, F.; Uluçay, V.; Sahin, M.; Dey, A.; Dhar, M.; Tan, R.-P.; Bahnasse, A.; et al. *Neutrosophic Sets: An Overview, New Trends in Neutrosophic Theory and Applications*; Smarandache, F., Pramanik, S., Eds.; Pons Editions: Brussels, Belgium, 2018; Volume 2, pp. 388–418.
57. Karadayi-Usta, S. A novel neutrosophic set based hierarchical challenge analysis approach for servicizing business models: A case study of car share service network. *Comput. Ind. Eng.* **2022**, *163*, 107795. [CrossRef]
58. Yilmaz, H.; Karadayi-Usta, S.; Yanık, S. A novel neutrosophic AHP-Copeland approach for distance education: Towards sustainability. *Interact. Learn. Environ.* 2022; *Article in Press*. [CrossRef]
59. Smarandache, F.; Pramanik, S. *New Trends in Neutrosophic Theory and Applications*; hal-01408066; Pons Editions: Brussels, Belgium, 2016.
60. Smarandache, F. Neutrosophy, Neutrosophic Theories and Applications. 2021. Available online: http://fs.unm.edu/neutrosophy.htm (accessed on 5 September 2022).
61. Wang, X.; Gou, X.; Xu, Z. Assessment of traffic congestion with ORESTE method under double hierarchy hesitant fuzzy linguistic environment. *Appl. Soft Comput. J.* **2020**, *86*, 105864. [CrossRef]
62. Roubens, M. Preference relations on actions and criteria in multicriteria decision making. *Eur. J. Oper. Res.* **1982**, *10*, 51–55. [CrossRef]
63. Baldini, F. ORESTE. 2021. Available online: https://fabiobaldini.com.br/oreste-excel/ (accessed on 3 September 2022).
64. Eroglu, E.; Yıldırım, B.; Yıldırım, B.F.; Özdemir, M.; Özdemir, M. Çok Kriterli Karar Vermede "ORESTE" Yöntemi ve Personel Seçiminde Uygulanması. *İstanbul Üniversitesi İşletme Fakültesi İşletme İktisadı Enstitüsü Yönetim Dergisi* **2014**, *25*, 1–19.
65. Adalı, E.A.; Işık, A.T. Ranking Web Design Firms with the ORESTE Method. *Ege Acad. Rev.* **2017**, *17*, 243–254.
66. Mercier, P.; Teghem, J.; Pastijn, H. Assignment of available products to orders with the MCDM software ORESTE. *Appl. Math. Comput.* **1993**, *54*, 183–196. [CrossRef]
67. Moretto, A.; Macchion, L.; Lion, A.; Caniato, F.; Danese, P.; Vinelli, A. Designing a roadmap towards a sustainable supply chain: A focus on the fashion industry. *J. Clean. Prod.* **2018**, *193*, 169–184. [CrossRef]
68. Nayak, R.; Akbari, M.; Maleki Far, S. Recent sustainable trends in Vietnam's fashion supply chain. *J. Clean. Prod.* **2019**, *225*, 291–303. [CrossRef]
69. Nagurney, A.; Yu, M.; Floden, J. Fashion Supply Chain Network Competition with Ecolabeling. In *Sustainable Fashion Supply Chain Management*; Choi, T.M., Cheng, T., Eds.; Springer: Cham, Switzerland, 2015; Volume 1. [CrossRef]

70. Bouzon, M.; Govindan, K. Reverse Logistics as a Sustainable Supply Chain Practice for the Fashion Industry: An Analysis of Drivers and the Brazilian Case. In *Sustainable Fashion Supply Chain Management: From Sourcing to Retailing*; Choi, T.-M., Cheng, T.C.E., Eds.; Springer Series in Supply Chain Management; Springer: Berlin/Heidelberg, Germany, 2015; pp. 85–104. [CrossRef]
71. Molderez, I.; De Landtsheer, P. Sustainable Fashion and Animal Welfare: Non-Violence as a Business Strategy, Contributions to Conflict Management. *Peace Econ. Dev.* **2015**, *24*, 351–370. [CrossRef]
72. Fung, Y.-N.; Chan, H.-L.; Choi, T.-M.; Liu, R. Sustainable product development processes in fashion: Supply chains structures and classifications. *Int. J. Prod. Econ.* **2021**, *231*, 107911. [CrossRef]
73. Lee, Y.K. Transformation of the Innovative and Sustainable Supply Chain with Upcoming Real-Time Fashion Systems. *Sustainability* **2021**, *13*, 1081. [CrossRef]
74. CDP. CDP Climate Change and Water Security. 2022. Available online: https://www.cdp.net/en/water (accessed on 4 December 2022).
75. Cradle to Cradle. Cradle to Cradle Products Innnovation Institute. 2022. Available online: https://www.c2ccertified.org/ (accessed on 3 September 2022).
76. Fair Trade. Fair Trade International. 2022. Available online: https://www.fairtrade.net/ (accessed on 10 December 2022).
77. FTI. Fashion Transparency Index. 2021. Available online: https://www.fashionrevolution.org/about/transparency/ (accessed on 10 December 2022).
78. OEKO-TEX. Standard 100. 2022. Available online: https://www.oeko-tex.com/en/our-standards/standard-100-by-oeko-tex (accessed on 11 December 2022).
79. GY. Sustainable and Ethical Fashion Brand Ratings. 2022. Available online: https://goodonyou.eco/ (accessed on 10 December 2022).
80. Tencel. Cellulosic Fibers of Botanic Origin Define a New Standard of Sustainability. 2022. Available online: https://www.tencel.com/ (accessed on 15 December 2022).
81. CoC. Ethics and Compliance Initiative. 2022. Available online: https://www.ethics.org/resources/free-toolkit/code-of-conduct/ (accessed on 6 December 2022).
82. GOTS. Global Organic Textile Standard. 2022. Available online: https://global-standard.org/ (accessed on 10 December 2022).
83. PETA. People for the Ethical Treatment of Animals. 2022. Available online: https://www.peta.org/international/ (accessed on 15 December 2022).
84. Karadayi-Usta, S.; Serdarasan, S. Defining and modeling risks in service supply chains. *Int. J. Ind. Eng. Theory Appl. Pract.* **2021**, *28*, 52–74. [CrossRef]
85. Twin, A. Delphi Method. 2021. Available online: https://www.investopedia.com/terms/d/delphi-method.asp (accessed on 11 December 2022).
86. Ye, J. Some aggregation operators of interval neutrosophic linguistic numbers for multiple attribute decision making. *J. Intell. Fuzzy Syst.* **2014**, *27*, 2231–2241. [CrossRef]
87. Chatterjee, P.; Chakraborty, S. Material selection using preferential ranking methods. *Mater. Des.* **2012**, *35*, 384–393. [CrossRef]
88. Isik, A.T. QUALIFLEX and ORESTE methods for the insurance company selection problem. *Alphanumeric J.* **2016**, *4*, 55–68.
89. Agarwal, S.; Singh, A.P. Performance evaluation of textile wastewater treatment techniques using sustainability index: An integrated fuzzy approach of assessment. *J. Clean. Prod.* **2022**, *337*, 130384. [CrossRef]
90. Acar, E.; Kiliç, M.; Güner, M. Measurement of sustainability performance in textile industry by using a multi-criteria decision making method. *Tekstil Konfeksiyon* **2015**, *25*, 3–9.
91. Bhattacharya, R.; Raut, R.D.; Gardas, B.B.; Kamble, S.S. Sustainable partner selection: An integrated AHP-TOPSIS approach. *Int. J. Oper. Res.* **2020**, *39*, 205–236. [CrossRef]
92. Guarnieri, P.; Trojan, F. Decision making on supplier selection based on social, ethical, and environmental criteria: A study in the textile industry. *Resour. Conserv. Recycl.* **2019**, *141*, 347–361. [CrossRef]
93. Kusi-Sarpong, S.; Gupta, H.; Khan, S.A.; Chiappetta Jabbour, C.J.; Rehman, S.T.; Kusi-Sarpong, H. Sustainable supplier selection based on industry 4.0 initiatives within the context of circular economy implementation in supply chain operations. *Prod. Plan. Control.* **2023**, *34*, 999–1019. [CrossRef]
94. Miletić, S.; Stanojević, Š.Z.; Jovanović, I.; Radivojević, M.; Conić, V. AHP analysis of organizational culture in textile companies in Serbia. *Ind. Textila* **2020**, *71*, 124–131. [CrossRef]
95. Naqvi, S.A.; Arshad, M.; Farooq, A.; Nadeem, F. Implementation of sustainable practices in textile processing mills of Lahore Pakistan. *Pol. J. Environ. Stud.* **2020**, *29*, 1–9. [CrossRef] [PubMed]
96. Mejías, A.M.; Bellas, R.; Pardo, J.E.; Paz, E. Traceability management systems and capacity building as new approaches for improving sustainability in the fashion multi-tier supply chain. *Int. J. Prod. Econ.* **2019**, *217*, 143–158. [CrossRef]
97. Gardas, B.B.; Raut, R.D.; Narkhede, B. Modelling the challenges to sustainability in the textile and apparel (T&A) sector: A Delphi-DEMATEL approach. *Sustain. Prod. Consum.* **2018**, *15*, 96–108. [CrossRef]
98. Hack-Polay, D.; Rahman, M.; Billah, M.M.; Al-Sabbahy, H.Z. Big data analytics and sustainable textile manufacturing: Decision-making about the applications of biotechnologies in developing countries. *Manag. Decis.* **2020**, *58*, 1699–1714. [CrossRef]
99. Ekanayake, B.J.; Sandanayake, Y.G. Applicability of ecological footprint for environmental sustainability evaluation in Sri Lankan apparel sector built environments. *Int. J. Appl. Eng. Res.* **2017**, *12*, 12707–12715.

100. Abo El-Naga, H.T.E.S.; Abd El-Aziz, M.Y.I. Eco-friendly materials knitting by different yarn ply for high-performance garments. *Res. J. Text. Appar.* **2023**. [CrossRef]
101. Kousar, S.; Shafqat, U.; Kausar, N.; Pamucar, D.; Karaca, Y.; Salman, M.A. Sustainable Energy Consumption Model for Textile Industry Using Fully Intuitionistic Fuzzy Optimization Approach. *Comput. Intell. Neurosci.* **2022**, *2022*, 5724825. [CrossRef] [PubMed]
102. Li, Y.; Wang, Y.; Ding, L.; Ke, L.; Ma, W.; Yang, Y. Dynamic response analysis among environmental regulation, technological progress and water resource consumption in China's textile industry. *Pol. J. Environ. Stud.* **2020**, *29*, 2709–2719. [CrossRef]
103. Bhaduri, G.; Ha-Brookshire, J.E.; Leshner, G. Too Good To Be True? Effect of Consumers' Brand Schemas on Apparel Brands' Fair Labor Marketing Messages. *Cloth. Text. Res. J.* **2017**, *35*, 187–203. [CrossRef]
104. Eom, R.-I.; Lee, Y. Working environments and clothing conditions in the construction industry. *Fash. Text.* **2020**, *7*, 9. [CrossRef]
105. Uddin, S.; Ahmed, M.S.; Shahadat, K. Supply chain accountability, COVID-19, and violations of workers' rights in the global clothing supply chain. *Supply Chain. Manag.* **2023**, *28*, 859–873. [CrossRef]
106. Guo, S.; Sun, X.; Lam, H.K.S. Applications of Blockchain Technology in Sustainable Fashion Supply Chains: Operational Transparency and Environmental Efforts. *IEEE Trans. Eng. Manag.* **2023**, *70*, 1312–1328. [CrossRef]
107. Wakes, S.; Dunn, L.; Penty, D.; Kitson, K.; Jowett, T. Is price an indicator of garment durability and longevity? *Sustainability* **2020**, *12*, 8906. [CrossRef]
108. Lee, H. The Dual Strategy for Textile and Fashion Production Using Clothing Waste. *Sustainability* **2023**, *15*, 11509. [CrossRef]
109. Carfora, V.; Catellani, P. Advertising Innovative Sustainable Fashion: Informational, Transformational, or Sustainability Appeal? *Sustainability* **2022**, *14*, 16148. [CrossRef]
110. Zhang, L.; Hale, J. Extending the Lifetime of Clothing through Repair and Repurpose: An Investigation of Barriers and Enablers in UK Citizens. *Sustainability* **2022**, *14*, 10821. [CrossRef]
111. Bin Hamdan, N.I. A Survey of the Role of Charity Societies in Recycling Clothing Waste and the Extent of Their Societal Impact in Saudi Arabia. *Sustainability* **2023**, *15*, 11380. [CrossRef]
112. Usta, S.K.; Kadaifçi, Ç. An integrated methodology proposal for sustainable fashion: Understanding and examining criteria affecting the second-hand clothes shopping. *J. Fac. Eng. Archit. Gazi Univ.* **2022**, *37*, 873–887. [CrossRef]
113. Risley, J. Reusable textiles: Educate your customers. *Text. Rent.* **2012**, *96*, 22–24.
114. Gautam, S.; Lal, M. Analysing competitiveness and trade performance: Evidence from Indian textile industry and its select competitors. *Transnatl. Corp. Rev.* **2020**, *12*, 420–438. [CrossRef]
115. Ramsamy-Iranah, S.; Kistamah, N. Supporting Local Craftsmanship through Fashion. In *Fashion and Its Multi-Cultural Facets*; BRILL: Leiden, The Netherlands, 2019; pp. 311–321. [CrossRef]