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Assessing Green Approaches and Digital Marketing Strategies for Twin Transition via Fermatean Fuzzy SWARA-COPRAS

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Abstract: Integrating green approaches and digital marketing strategies for Information and Communication Technologies (ICTs), which reduce environmental risks to desired levels by eliminating emissions and pollution, is considered one of the most promising solutions for logistics companies. The study strives to bring a practical and applicable solution to the decision problem involving the selection of indicators for green approaches and digital marketing strategies for ICTs in the logistics sector. An integrated Fermatean Fuzzy Step-wise Weight Assessment Ratio Analysis (FF–SWARA) and Fermatean Fuzzy Complex Proportional Assessment (FF–COPRAS) methodology is applied to evaluate green approaches and digital marketing strategies. Concerning the findings, the foremost criterion is "data management," whereas the best strategy is "programmatic advertising." To the best of the authors' knowledge, there is no other study that both offers a strategy selection for the logistics industry and considers environmental protection, sustainability, digital transformation, energy costs, and social and economic factors. The study is a part of ongoing research on productivity, sustainability, the environment, digitization, recycling and estimating levels of waste reduction, as well as business practices, competitiveness and ensuring employee satisfaction and resource efficiency. Also, it investigates the similarities and dissimilarities in the green approach practices of business in logistics and determines the extent to which these practices could be reflected. It is expected to ensure a roadmap for green approach practices and to support sustainable and ecological awareness efforts for ICTs in the logistics sector. Logistics companies can select an integrated digital strategy based on green informatics that suits them using the decision model employed in this study, which can handle uncertainties effectively. In this regard, the study's findings, which focus on reaching customers and the most precise target audience in digital applications for businesses, are critical for developing strategy, plan and process.

Keywords: twin transition; green transition; digital transition; fermatean fuzzy sets; sustainability; information and communication technology

MSC: 03B52; 03E72; 90B06; 90B50

Citation: Korucuk, S.; Aytekin, A.; Ecer, F.; Karamaşa, Ç.; Zavadskas, E.K. Assessing Green Approaches and Digital Marketing Strategies for Twin Transition via Fermatean Fuzzy SWARA-COPRAS. *Axioms* **2022**, *11*, 709. https://doi.org/10.3390/axioms11120709

Academic Editor: Joao Paulo Carvalho

Received: 8 November 2022
Accepted: 3 December 2022
Published: 8 December 2022

1. Introduction

The service and manufacturing sectors are becoming increasingly digitalized as the concept of sustainability gains importance. Businesses use green approaches to ensure the survival of future generations while continuing to use Information and Communication

Technologies (ICTs). Besides, marketing strategies have emerged as critical components for gaining a cost advantage, increasing competitiveness and satisfying customers. As a result, while online marketing efforts are vital factors, digital marketing strategies and selection, along with green transformation and digitalization, are considered critical instruments for businesses. Supporting sustainability with technology has led to the development of the twin transition paradigm [1]. The twin transition advocates not ignoring the circular economy while modernizing the industry with the latest technologies [2]. In this context, the twin transition includes planning processes that are deeply intertwined to cognitive tool renewal and the need to develop "zero impact" strategies for ecological transition and digital transformation [3].

The majority of current scientific works focuses on the drivers that influence twin transition and its economic effects. According to Matarazzo et al. [4], sensing and learning skills are significant drivers of digital transformation, and enhancing these skills will allow businesses to realize the value of digital transformation.

Regarding the effects of the twin transition on the economy and the environment, it was stated that digitalizing energy firms could help them lower operating costs and increase productivity, enhance the safety, effectiveness and durability of energy structures in response to market demand, and accelerate growth and quick adaptation [5]. Green digital transformation, in this sense, means the constructive use of digitalization and green technology in the connection of business processes, activities, products and models, with the purpose of making companies more ecologically sustainable [6].

Green approaches to ICTs are defined as practices and studies that involve the efficient manufacture, design use and destruction of computers, servers and linked subsystems like storage devices, printers and monitors [7] or the use of computers and computer-related resources with an awareness of environmental responsibility [8]. Recently, green information technology approaches have been identified to address environmental issues and create new market opportunities. Kiruthiga and Vinoth [9] emphasized the significance of transitioning to green information technology to enhance energy efficiency and reduce electronic waste. As per Mines [10], cloud computing reduces the waste of resources and energy while increasing resource efficiency. In this context, the importance of environmentally sustainable practices in logistics, as in all sectors, is expanding [11,12]. In fact, environmentalist approaches have been adopted by public institutions and commercial businesses as significant sustainable goals in environmental preservation, energy consumption reduction, manufacturing and recycling because of economic, social and legal pressures. The United Nations and the European Commission emphasized the use of green technology strategies, such as using natural energy resources, monitoring climate change, biological diversity protection and encouraging the adoption of sustainable development values [13].

On the other hand, Moon and Millision [14] defined digital marketing as "the entire set of activities undertaken to acquire new customers via the internet". The Internet provides a platform for reaching many people at the lowest possible cost, completely altering marketing strategies [15]. Through the online channel, digital marketing strategies enable businesses to collect large amounts of data, including user opinions and comments. In this case, businesses see the digital ecosystem as an effective element of today and the future [16]. The digital marketing strategies are necessary to build good relationships with other social media users [17]. Digital marketing strategy entails the steps and activities related to customer access, acquisition, conversion and retention.

However, despite the major advances in marketing and sustainability, significant gaps still exist between the capacity of businesses to understand and confront this trend [18]. Digital technologies are gradually employed to protect the environment. Also, sustainability transforms various fields of environmental protection. Examples of these domains include waste management, pollution control, sustainable production and urban sustainability [19]. Because digital technologies make it possible to combine sustainability's triple bottom line in value propositions [20], the convergence of digitalization and environmental sustainability has a nationwide impact that extends beyond organizational and industry boundaries. For example, ElMassah and Mohieldin [21] revealed how different countries around the world achieved their sustainability targets and how digital transformation assisted them.

However, companies will need to form and capture value for customers and assess changes to the existing business model in light of environmental sustainability criteria. Although the literature shows that including sustainability and implementing environmental protection policies can increase customer loyalty, the question of whether digitizing environmental sustainability will change the firm's overall performance remains unanswered. Businesses continue to prefer digitalization because they believe it will benefit them in the digitalizing world [22]. As a result, implementing sustainability practices should provide businesses with the same expectations. Otherwise, authorities will not consider it an essential component of the digital transformation process [19]. In this case, this research offers a framework for a practical solution to the stated problem.

The researchers in this study have been prompted by various reasons to investigate the problem. When it comes to ensuring sustainability and securing a place for future generations, the decision-makers' expertise, experience and knowledge point to green approaches for ICTs as a significant area. The widespread use of ecological awareness and its adoption in ICTs has enabled new models that have revealed a new relationship between digital indicators and green approaches. The integration of digital marketing strategies with green approaches for ICTs, which minimize environmental risks to desired levels through eliminating emissions and pollution, is considered, by governments and the private sector, as one of the most promising solutions for logistics companies. The study also strives to bring a practical and applicable solution to the decision-making issue involving the selection of indicators for green approaches and digital marketing strategies for ICTs in a vital area such as the logistics sector.

The study may encourage more research into the role played by the connection between environmentally friendly approaches to information and communication technology and modern digital marketing strategies. Analyzing the contribution to environmentally friendly practices and digital marketing strategies is particularly beneficial. Moreover, the study will give decision-makers and individuals interested in the subject a new viewpoint by emphasizing the twin transition within the context of sustainability. To enable digital technologies to provide competitiveness with green applications, the study expands on the concept of leaving a better living environment to future generations.

The research—which is expected to ensure a roadmap for green approach practices and, subsequently, supports sustainable and ecological awareness efforts for ICTs in the logistics sector—also examines the similarities and differences in the green approach practices of business in logistics and determines the extent to which these practices could be reflected. Thus, it provides a practical roadmap related to green approaches for ICTs and the logistics industry's digital marketing strategy process selection.

Furthermore, the study aims to present an overview of the twin transition's role in the logistics sector, going beyond simply providing a theoretical or conceptual under-standing or presenting single technological components that provide the structure. The contributions of the present research are as below. The development of environmental, social and digital awareness has created a need in businesses for new alternatives and strategies to solve nature's sustainability problems. The selection of green approach indicators and digital marketing strategies for ICTs is, undoubtedly, one of the crucial components in solving these problems. Another contribution of the study is that it helps to deal with current uncertainties by proposing a strong, practical and sensible decision-making model. While contributing to the finding of a permanent and reasonable solution to the relevant decision-making issue in the logistics sector, this study tries to fill some crucial gaps in the literature with a strong and robust methodological framework by making use of the benefits of the methods used. In this way, the study can contribute to the solution of similar problems in different fields.

In this context, the study's criteria are evaluated by considering green approaches for ICTs in logistics enterprises, and the best digital marketing strategy is chosen. The goal of this study, conducted in logistics companies with a corporate identity that conducts international transportation activities in Istanbul, is to rank green approaches for ICTs and to select the best digital marketing strategy. To evaluate the drivers obtained from the literature review, the Fermatean Fuzzy Step-wise Weight Assessment Ratio Analysis (FF–SWARA) and Fermatean Fuzzy Complex Proportional Assessment (FF–COPRAS) methodology is performed.

Fermatean Fuzzy Sets (FFSs), FF–SWARA and FF–COPRAS are preferred for various reasons in this study. FFSs enable decision-makers to independently determine the degree of uncertainty over a wide range [23,24]. As a result, the problem can be addressed in a more flexible and effective way. Linguistic expressions used by decision-makers in making evaluations can be translated into mathematical equations and successfully processed by using FFSs [25–30]. On the other hand, experts are rarely aware of how problems are solved. In such cases, simple methods ensure that assessments are completed correctly for experts. As a result, FF–SWARA is employed in this study to determine the weight values of the criteria due to its practical and easy framework, whereas FF–COPRAS is used to proportionally analyze the performance of alternatives using cost and benefit structured criteria.

The remaining sections of the study can be summed up as below: Literature survey related to green approaches for ICTs and digital marketing strategies are presented in Section 2. Preliminaries for FFSs, FF–SWARA and FF–COPRAS are given in Section 3. The case study is explained, and findings are given in Section 4. Section 5 includes discussions related to the findings. Conclusions, limitations, managerial and practical implications, and future investigations are revealed in Section 6.

2. Literature Review

Today, having a more sustainable, clever and current digital technology-based marketing application is an inevitable requirement for moving toward a globalized market [31]. Dao et al. [32] contend that, although the concept of sustainability in the field of information technologies has been chiefly confined to energy consumption, the idea of green computing has a far wider reach than this. Recently, green approaches to ICTs have been identified as a path to address ecological matters and to create fresh market opportunities. Businesses with the vision and technology to offer services and products that solve ecological issues can complete a sustainable competitive advantage through decreasing their energy costs [33]. According to Belkhir and Elmeligi [34], studies on green informatics are considered to be very crucial. While the world's population has more than doubled in the last 50 years, the use of electronic devices has increased sixfold.

In this context, a literature review related to green approaches for ICTs and digital marketing strategies is given in Table 1.

Table 1. Green approaches for ICTs and digital marketing strategies.

Authors(s)	Year	Applications	Method(s)
Jenkin et al. [35]	2011	Conducting a system analysis of green information technologies.	Descriptive analysis
Smith [36]	2012	Investigating which digital marketing options are adopted by the Y generation and effective in influencing their behaviors.	Descriptive analysis
Loeser et al. [37]	2012	Examining ICTs for sustainable production.	Sustainability balanced scorecard
Bai and Sarkis [38]	2013	Carrying out strategic justification and evaluation in the context of green information technology.	Grey systems, fuzzy sets, and TOPSIS
Kumar and Kiruthiga [9]	2014	Investigating green information technology to increase energy efficiency and reduce electronic waste.	Descriptive Analysis

Table 1. *Cont.*

Authors(s)	Year	Applications	Method(s)
Wang et al. [39]	2014	Using Data Mining Technology to evaluate the Digital Marketing Strategy in a methodical way.	Data Mining, RFM, Apriori algorithm
Khan et al. [40]	2015	Examining the motivators for outsourcing green information technology from the vendor's standpoint.	Systematic literature review
Dasgupta and Ghatge [41]	2015	Investigating the Indian multinational automobile corporation's internet marketing strategies.	Descriptive analysis
Asımgil [42]	2016	Evaluating how sustainable architectural form affects resource conservation.	Descriptive analysis
Kamal [43]	2016	Examining the evolution of digital marketing strategies.	Descriptive analysis
Muhammad et al. [44]	2017	Examining 50 papers between 2008 and 2015 on green ICT.	Systematic literature review
Bakhtieva [45]	2017	Studying B2B digital marketing strategies in Austria.	Literature review
Damar and Gökşen [46]	2018	Investigating user and institution-oriented energy management systems employing green informatics approaches.	Descriptive analysis
Ilyas et al. [47]	2018	Developing a new digital marketing strategy in the retail industry.	SWOT–ANP
Suryawanshi [48]	2019	Assessing green ICT techniques in higher education institutions in terms of future generations.	Qualitative methodological approach
Zare and Vilys [49]	2019	Determining pharmaceutical companies' digital marketing strategies.	AHP–TOPSIS
Diez-Martin et al. [50]	2019	Reviewing literature on digital marketing and sustainability for the years 2009 to 2018.	Bibliometric literature analysis
Mukonza and Swarts [51]	2020	Examining the impact of green marketing tactics corporate image on and business performance in the retail sector.	Path Analysis and Content Analysis
Dewi [52]	2020	Investigating digital marketing strategy in travel tourism businesses in the age of Marketing 4.0.	Data Analysis
Jnr [53]	2020	Examining green information technology and systems in the context of innovation.	Regression analyses
Önaçan [54]	2020	Studying green informatics in Turkey.	Systematic literature review
Fidan and Yıldırım [55]	2020	Carrying out a qualitative study on digital marketing strategies.	Descriptive analysis
Chen et al. [56]	2021	Defining parameters to assess the quality of marketing communication channels based on a company's green competitiveness.	Entropy
Yousaf et al. [57]	2021	Investigating the alignment of green motives with green business strategies for the long-term hotel development and tourism industries within the context of green environmental policies.	Quantitative Analysis
Saçan and Eren [58]	2021	Studying the digital marketing strategy selection problem.	SWOT, ANP, PROMETHEE
Wang et al. [59]	2021	Examining how digital technology research may help with green development.	KPWW method and multiple panel regression
Çayırağası and Sakıcı [60]	2021	Investigating sustainable digital marketing strategies in the context of the SDGs of the UN.	Bibliometric Literature analysis
Denga et al. [61]	2022	Focused on understanding digital marketing concepts and how organizations may gain a competitive advantage by using multiple examples.	Literature Review
Trung and Thanh [62]	2022	Assessing digital marketing technology via fuzzy linguistic MCDM methodologies.	Fuzzy Linguistic MCDM Methods
Adebisi and Babatunde [63]	2022	Investigating green ICTs in the textile industry.	Fuzzy–TOPSIS
Sutedjo [64]	2022	Investigating various digital marketing strategies for increasing sales.	Qualitative research with a case study approach.

Table 1. *Cont.*

Authors(s)	Year	Applications	Method(s)
Reza-Gharehbagh et al. [65]	2022	Examining the problem of green technology development.	Three-level game Theory model
Piranda et al. [66]	2022	Looking at digital marketing as an online marketing approach on the Facebook marketplace.	Library method

Since we propose a model based on FFSs information, some studies related to FFSs are given in Table 2.

Table 2. FFSs related studies.

Authors(s)	Year	Objective(s)	Method(s)
Senapati and Yager [23]	2019	Picking the specific spots for home construction	FF-weighted averaging/geometric operators
Keshavarz-Ghorabaee et al. [67]	2020	Green construction supplier selection	FF–WASPAS
Rani and Mishra [68]	2021	Selecting electric vehicle charging station	FF–MULTIMOORA
Mishra and Rani [28]	2021	Healthcare waste disposal site determination	FF–WASPAS
Gül [27]	2021	Solving COVID-19 testing laboratory selection problem	FF–SAW–ARAS–VIKOR
Gül et al. [27]	2021	Ranking potential hazards in manufacturing	FF–TOPSIS
Simic et al. [69]	2021	Suitable tax scheme identification for financing public transit investments	FF–CODAS
Rani et al. [70]	2022	Food waste treatment technology assessment	FF–MEREC–ARAS
Zhou et al. [71]	2022	Location selection of fangcang shelter hospitals for COVID-19 patients	FF–ELECTRE
Kirişçi et al. [72]	2022	Most suitable biomedical material selection	FF–ELECTRE I
Aytekin [73]	2022	Selecting school for a middle-school student.	FF–CRTIC–WASPAS
Mishra et al. [74]	2022	Evaluating the adaptation of IoT barriers	FF–CoCoSo
Tan et al. [75]	2022	For Belt on One Road (B&R), they evaluated the investment risk of the countries on the route.	FF–MABAC–CRITIC
Simic et al. [76]	2022	Serbia is considering how the city of Belgrade will adapt its transport plans in a real-world context in relation to COVID-19 developed decision-making guidelines.	FF–MEREC–CoCoSo
Aytekin et al. [26]	2022	Pharmaceutical distribution and warehousing companies' assessment	FF–Entropy–WASPAS
Mishra et al. [30]	2022	Selecting sustainable third-party reverse logistics providers	FF–CRITIC–EDAS

Since its introduction into the literature, the SWARA method and its uncertain extensions have been successfully applied in many studies to decide factor importance weights. Some studies related to SWARA are depicted in Table 3.

Table 3. Studies related to SWARA.

Authors(s)	Year	Objective(s)	Method(s)
Shukla et al. [77]	2016	Evaluating ERP systems	SWARA–PROMETHEE
Tuş Işık and Aytaç Adalı [78]	2016	Solving a hotel selection problem	SWARA–OCRA

Table 3. *Cont.*

Authors(s)	Year	Objective(s)	Method(s)
Radovic and Stevic [79]	2018	Assessment and selection of key performance factors for transport field in Serbia and Bosnia and Herzegovina	SWARA
Akcan and Taş [80]	2019	Green supplier evaluation for reducing ecological risk factors in Turkey	SWARA–TOPSIS
Ren et al. [81]	2019	Electric vehicle charging station site selection	Hesitant fuzzy SWARA–WASPAS
Zolfani and Chatterjee [82]	2019	Prioritizing the criteria for home furniture materials	SWARA–BWM
Ghenai et al. [83]	2020	Assessment of sustainability indicators for renewable energy systems	SWARA–ARAS
Balki et al. [84]	2020	Optimization of engine operating parameters	SWARA–ARAS
Rani et al. [85]	2020	Evaluating sustainable suppliers	Hesitant fuzzy SWARA–COPRAS
Rani et al. [86]	2020	Performance evaluation of solar panel selection	Pythagorean fuzzy SWARA–VIKOR
Khalesi et al. [87]	2020	Identification and reduction of delays caused by restructuring within the scope of construction projects.	SWARA–Building Information Modelling (BIM)
Aytekin and Gündoğdu [88]	2021	Assessing sustainable governance levels of OECD and EU member countries	SWARA–TOPSIS Sort B–WASPAS
Ulutaş et al. [89]	2021	Evaluation and assessment of collaboration-based and non-collaboration-based logistics risks.	Plithogenic SWARA
Vrtagic et al. [90]	2021	Determining the degrees of safety in the observed road sections.	DEA–IMF SWARA–Fuzzy MARCOS
Torkashvand et al. [91]	2021	DRASTIC framework improvement in Iran.	SWARA–Genetic Algorithm– Entropy
Yücenur and İpekçi [92]	2021	Solving a marine current energy production plant location problem in Turkey	SWARA–WASPAS
Balali et al. [93]	2022	Determining cost overrun for mega hospital construction projects	Delphi–SWARA
Kumar et al. [94]	2022	Identifying the best apposite spray-painting robot	SWARA–CoCoSo
Tripathi et al. [95]	2022	Food waste treatment technology selection	IF–SWARA–COPRAS

Finally, some of the studies performed with COPRAS are given in Table 4.

Table 4. Studies related to COPRAS.

Authors(s)	Year	Objective(s)	Method(s)
Ecer [96]	2014	Assessing website quality of banks	Grey COPRAS
Ecer [97]	2015	Assessing internet banking branches	Grey COPRAS
Mishra et al. [98]	2019	Service quality selection	Shapley COPRAS under hesitant fuzzy sets
Korucuk [12]	2019	Competitive Strategy Selection	SWARA–ARAS–COPRAS
Kumari and Mishra [99]	2020	Green supplier selection	Intuitionistic fuzzy COPRAS
Roozbahani et al. [100]	2020	Assessing inter-basin water transfer projects in Iran	AHP–DEMATEL–Shannon entropy–COPRAS (deterministic, fuzzy and grey)
Gündoğdu and Aytekin [101]	2020	Evaluation of countries in terms of citizens' trust in public administration	ARAT–COPRAS

Table 4. *Cont.*

Authors(s)	Year	Objective(s)	Method(s)
Lu et al. [102]	2021	Green supplier selection	CRITIC–Picture fuzzy COPRAS
Hezer et al. [103]	2021	Analyzing some regions' safety levels in terms of COVID-19	TOPSIS–VIKOR–COPRAS
Narayanamoorthy et al. [104]	2021	Examining alternative fuel for controlling the impact of GHGs.	DEMATEL–COPRAS
Balali et al. [105]	2021	Evaluating the risks in urban natural gas projects in Shiraz	ANP–COPRAS
Saraji et al. [106]	2021	Identifying the barriers to the adoption of Industry 4.0 in fintech companies.	FF–CRITIC–COPRAS
Saraji et al. [107]	2021	Evaluating the barriers to developing the sustainable business model innovation	Pythagorean fuzzy SWARA–CRITIC–COPRAS
Ecer [108]	2021	Assessing battery electric vehicles	COPRAS and four MCDM methods
Rajareega and Vimala [109]	2021	Equipment selection process	CIFS–COPRAS
Mishra et al. [29]	2022	Studying the selection of desalination technology for the treatment of feedwater.	Interval-valued hesitant FF–COPRAS
Tripathi et al. [95]	2022	Food waste treatment technology selection	IF–SWARA–COPRAS

In this study, the comprehensive literature review aims to understand sustainability in logistics businesses better and to look at the digital marketing drivers for the problem of selecting green approaches and digital marketing strategies for real-world ICTs. Consequently, no other study that considers environmental protection, sustainability, digital transformation, energy cost reduction, and social and economic factors has been found, based on the studies in Table 1. Further, there is no research in the literature that uses quantitative research methodologies in terms of green approaches in general for the province of Istanbul, green approaches for ICTs in particular, or digital marketing strategies. The mathematical model developed in this study (SWARA–COPRAS framework under FFSs) is thought to help reveal the study's significance since it can provide solutions to green approaches and digital marketing strategies for ICTs at various levels of importance, which decision-makers should determine for each criterion and alternative.

3. Methodology

In contrast to the traditional fuzzy set, the FFS includes both membership and non-membership degrees. FFSs are a subset of q-Rung Orthopair Fuzzy Sets (q-ROFSs) with q = 3. Similar expressions can be used for q = 1 Intuitionistic Fuzzy Sets (IFSs) and q = 2 Pythagorean Fuzzy Sets (PFSs). The advantage of creating FFSs apart from q-ROFSs is that the q = 3 operation gives enough breadth to solve most decision problems. There are some recent studies in which IFSs [95,110], PFSs [111,112] and q-ROFSs [113,114] were used. On the other hand, FFS enables for more general uncertainty modeling than IFS and PFS because the sum of the IFS membership and non-membership degrees must equal one. Similarly, the sum of the squares of the membership and non-membership degrees must be 1 in PFSs. In addition, the total of the cubes of FFS membership and non-membership must equal 1. As a result, FFS can address a number of critical concerns that IFS and PFS cannot. When it comes to dealing with uncertainty in imprecise information, FFS has proven to be one of the strongest sets [25]. FFS enables decision-makers to independently determine the degree of uncertainty over a large range. As a result, the problem can be addressed in a more flexible and effective manner. Linguistic expressions used by decision-makers to make evaluations can be translated into mathematical equations and successfully processed by implementing FFS [25–30]. Experts or decision-makers have a comprehensive understanding of the problem. Experts, on the other hand, are rarely aware of how problems with uncertainties and conflicting criteria are handled. In such cases, methods that are simple to understand and apply ensure that assessments are done properly. Because of its simple and practical structure, FF–SWARA will be employed to calculate the weight values of the criteria in this context. Some of the criteria in the problem are cost-oriented, while others are benefit-oriented. FF–COPRAS is a good method for assessing the performance of alternatives proportionally using cost and benefit structured criteria. For these reasons, we used the FF–SWARA–COPRAS methodology in this study. The preliminaries related to FFSs, FF–SWARA and FF–COPRAS are clarified under this section.

3.1. Fermatean Fuzzy Sets

FFS was developed by Senapati and Yager [24] as a generalization of intuitionistic and Pythagorean fuzzy sets for better explaining unreliable, inconsistent, vague and inexact information under fuzzy environments [25].

A fermatean fuzzy (FF) number F on finite discourse set X is defined as Equation (1):

$$F = \{x, \mu_F(x), v_F(x); x \in X\} \tag{1}$$

where $\mu_F(x) : X \to [0,1]$ and $v_F(x) : X \to [0,1]$ show membership and non-membership degree of the object $x \in X$ to F with a condition of

$$0 \leq \mu_F(x)^3 + v_F(x)^3 \leq 1 \tag{2}$$

The indeterminacy degree is computed as below:

$$\pi_F(x) = \sqrt[3]{1 - (\mu_F(x))^3 - (v_F(x))^3} \tag{3}$$

A Fermatean Fuzzy Number (FFN) was defined by Senapati and Yager [24] as $\alpha = (\mu_\alpha, v_\alpha)$ that satisfying $\mu_\alpha, v_\alpha \in [0,1]$ and $0 \leq (\mu_\alpha)^3 + (v_\alpha)^3 \leq 1$.

Consider that $\alpha = (\mu_\alpha, v_\alpha)$, $\alpha_1 = (\mu_{\alpha_1}, v_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, v_{\alpha_2})$ are three FFNs. The operations related to FFNs are shown as follows [25,26,30,106]:

(i) $\lambda\alpha = \left(\sqrt[3]{1 - (1 - \mu_\alpha^3)^\lambda}, (v_\alpha)^\lambda\right), \lambda > 0;$
(ii) $\alpha^\lambda = \left((\mu_\alpha)^\lambda, \sqrt[3]{1 - (1 - v_\alpha^3)^\lambda}\right), \lambda > 0;$
(iii) $\alpha_1 \cap \alpha_2 = (\min\{\mu_{\alpha_1}, \mu_{\alpha_2}\}, \max\{v_{\alpha_1}, v_{\alpha_2}\});$
(iv) $\alpha_1 \cup \alpha_2 = (\max\{\mu_{\alpha_1}, \mu_{\alpha_2}\}, \min\{v_{\alpha_1}, v_{\alpha_2}\});$
(v) $\alpha_1 \oplus \alpha_2 = \left(\sqrt[3]{\mu_{\alpha_1}^3 + \mu_{\alpha_2}^3 - \mu_{\alpha_1}^3\mu_{\alpha_2}^3}, v_{\alpha_1}v_{\alpha_2}\right);$
(vi) $\alpha_1 \otimes \alpha_2 = \left(\mu_{\alpha_1}\mu_{\alpha_2}, \sqrt[3]{v_{\alpha_1}^3 + v_{\alpha_2}^3 - v_{\alpha_1}^3 v_{\alpha_2}^3}\right);$
(vii) $\alpha^C = (v_\alpha, \mu_\alpha)$.

The score value for a FFN $\alpha = (\mu_\alpha, v_\alpha)$ can be written as follows:

$$S(\alpha) = \mu_\alpha^3 - v_\alpha^3 | -1 \leq S(\alpha) \leq 1 \tag{4}$$

The positive score value for a FFN $\alpha = (\mu_\alpha, v_\alpha)$ can be calculated as Equation (5):

$$S^+(\alpha) = 1 + S(\alpha) = 1 + \mu_\alpha^3 - v_\alpha^3 \tag{5}$$

The accuracy value for a FFN $\alpha = (\mu_\alpha, v_\alpha)$ can be computed by $A(\alpha) = \mu_\alpha^3 + v_\alpha^3 | 0 \leq A(\alpha) \leq 1$.

Additionally, the following comparative schemes are considered to rank $\alpha_1 = (\mu_{\alpha_1}, v_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, v_{\alpha_2})$ as two FFNs.

(i) If $S(\alpha_1) > S(\alpha_2)$, *then* $\alpha_1 > \alpha_2$.
(ii) If $S(\alpha_1) < S(\alpha_2)$, *then* $\alpha_1 < \alpha_2$.

(iii) If $S(\alpha_1) = S(\alpha_2)$, *then*
   (a) If $A(\alpha_1) > A(\alpha_2)$, *then* $\alpha_1 > \alpha_2$.
   (b) If $A(\alpha_1) < A(\alpha_2)$, *then* $\alpha_1 < \alpha_2$.
   (c) If $S(\alpha_1) = S(\alpha_2)$, *then* $\alpha_1 = \alpha_2$.

3.2. FF-SWARA

SWARA as a subjective criteria weighting-based method was proposed by Kersuliene et al. [115]. Using SWARA, decision-makers or experts have a chance to determine their own priorities by taking current conditions into account [25,116,117]. The procedure of the FF–SWARA can be identified as below [25]:

Step 1. A decision matrix is formed by considering the judgments of decision-makers related to each driver via linguistic terms seen in Table 5. Consider $B_{jk} = \left(\mu_{jk}, v_{jk}\right)$ as an evaluation of driver *j* from the decision-maker. Linguistic terms have been converted to FF numbers by making use of Table 5 given below [25].

Table 5. Linguistic terms for assessing criteria.

Linguistic Terms	Codes	FFNs
Extremely Important	E	(0.975,0.10)
Very Important	V	(0.85,0.20)
Important	I	(0.70,0.35)
Moderately Important	M	(0.55,0.50)
Slightly Important	S	(0.35,0.70)
Not Important	N	(0.20,0.85)
Extremely Unimportant	U	(0.10,0.975)

Step 2. Judgments of decision-makers related to criteria are aggregated via the Fermatean Fuzzy Weighted Averaging (FFWA) operator given as Equation (6). Aggregation is obtained by taking the weight of each decision-maker (ω_k) into the account. In this study equal weights are assigned to each decision-maker.

$$z_j = Z\left(\mu_j, v_j\right) = \left(\sqrt[3]{1 - \prod_{k=1}^{r}\left(1 - \left(\mu_{jk}\right)^3\right)^{\omega_k}}, \prod_{k=1}^{r}\left(v_{jk}\right)^{\omega_k}\right), \ j = 1, \ldots, n \tag{6}$$

Step 3. The positive score value $S^+(j)$ for each criterion is computed concerning Equation (7):

$$S^+(j) = 1 + \mu_j^3 - v_j^3 \tag{7}$$

Step 4. Criteria are ranked according to the descending positive score values.

Step 5. Comparative significance of $\left(cs_j\right)$ positive score value related to each criterion is obtained thanks to differentiation from the second preferred criterion $S^+(j)$ of criterion (j) and (j−1).

Step 6. Comparative coefficient $\left(cc_j\right)$ related to each criterion is computed per Equation (8):

$$cc_j = \begin{cases} 1, & j = 1 \\ S^+(j) + 1, & j > 1 \end{cases} \tag{8}$$

Step 7. Recalculated weights $\left(rw_j\right)$ are forecasted as below:

$$rw_j = \begin{cases} 1, & j = 1 \\ \frac{rw_{(j-1)}}{cc_j}, & i > 1 \end{cases} \tag{9}$$

Step 8. Final criteria weights $\left(w_j\right)$ are acquired via Equation (10):

$$w_j = \frac{rw_j}{\sum_{j=1}^{n} rw_j} \tag{10}$$

where the number of criteria is shown by n.

3.3. FF–COPRAS

The procedure of FF–COPRAS can be clarified as below [106,118]:

Step 1. Decision matrix is formed. Consider $\{A_1, A_2, \ldots, A_m\}$ as a set of alternatives, $\{C_1, C_2, \ldots, C_n\}$ as a set of criteria and $\{DM_1, DM_2, \ldots, DM_r\}$ as a group of decision-makers who evaluate each alternative A_i with regard to criterion C_j via Fermatean linguistic variables as seen in Table 6 [106]. The decision matrix (O) is stated by $O = \left(t_{ij}^k\right)$, for $i = 1, \ldots, m; j = 1, \ldots, n$; while t_{ij}^k shows the given value to the alternative (i) with regard to the criterion (j) by the kth decision-maker.

Table 6. Linguistic Terms for Evaluating Options.

Linguistic Terms	Codes	FFNs
Extremely High	EH	(0.90,0.10)
Very High	VH	(0.80,0.10)
High	H	(0.70,0.20)
Medium High	MH	(0.60,0.30)
Medium	M	(0.50,0.40)
Medium Low	ML	(0.40,0.50)
Low	L	(0.25,0.60)
Very Low	VL	(0.10,0.75)
Extremely Low	EL	(0.10,0.90)

Step 2. FF–decision matrix is aggregated. For this purpose, the individual decision-making matrices are aggregated via FFWA operator given as Equation (6).

Step 3. The solution in COPRAS is based on the weighted values of the alternatives in the cost and benefit criteria. To that end, the values of the criteria are summed via Equation (11) for benefit-based criteria and Equation (12) for cost-based criteria.

$$\alpha_i = \left(\sqrt[3]{1 - \prod_{j=1}^{n}\left(1 - \left(\mu_{ij}\right)^3\right)^{w_j}}, \prod_{j=1}^{n}\left(v_{ij}\right)^{w_j} \right), \; for\; beneficial\; criteria \tag{11}$$

$$\beta_i = \left(\sqrt[3]{1 - \prod_{j=1}^{n}\left(1 - \left(\mu_{ij}\right)^3\right)^{w_j}}, \prod_{j=1}^{n}\left(v_{ij}\right)^{w_j} \right), \; for\; non-beneficial\; criteria \tag{12}$$

Step 4. The degree of criteria is computed via Equation (13).

$$C_i = S(\alpha_i) + \frac{\sum_{i=1}^{m} S(\beta_i)}{S(\beta_i)\sum_{i=1}^{m} \frac{1}{S(\beta_i)}} \tag{13}$$

where $S(\alpha_i)$ and $S(\beta_i)$ represent the score functions of the benefit- and cost-based criteria, respectively.

Step 5. The utility degree of the options is estimated via Equation (14). The alternative with the highest utility degree is the best choice.

$$U_i = \frac{C_i}{C_{max}} * 100 \; for\; i = 1, \ldots, m \tag{14}$$

4. Application and Findings

Explanations for the criteria and alternatives considered in the study are given in Table 7.

Table 7. The criteria and alternatives for evaluating the green approaches and digital marketing strategies.

Codes	Criteria	Explanation	References
C1	Environmentally friendly products	They are products made using renewable energy and materials that do not contain hazardous elements to the environment.	Suki [119]
C2	Energy use in informatics	It is the accumulation of energy through the more intelligent application of ICTs.	Damar and Gökşen [46]
C3	Virtualization	It is the usage of more than one machine, server or other software with a same system at the same time.	O'Connor [120]
C4	Data centers	It involves the administration of important computing resources, such as web and application servers, file messaging servers, storage and backup systems, and network infrastructure.	Arregoces and Portolani [121]
C5	Data management	It is the collecting, storage and processing of data in a secure and efficient manner.	Aydınoğlu et al. [122]
C6	Recycling of IT sector waste	These are studies for the reuse of IT sector wastes.	Mobbs [123]
C7	Cloud computing	They are internet-based applications for facilitating and providing services.	Mell and Grance [124]
C8	Green offices	It refers to situations like removing unwanted office items and preventing unnecessary use in the workplace.	Damar and Gökşen [46]
C9	Climate-sensitive alternative technologies	They are climate-focused alternative technical solutions.	Korucuk and Memiş [125]
Codes	**Alternatives**	**Explanation**	**References**
A1	Search engine optimization	It refers to the efforts done to get a website's content at the top of search engines.	Saçan and Eren [58]
A2	Search engine marketing	It is the work that contributes to a product's increased popularity on the current website.	Saura et al. [16]
A3	Social media marketing	Marketing strategies made via social media.	Weinberg [126]
A4	Programmatic advertising	Graphic technologies are expressed as the processing of big data in business information systems by making use of data mining artificial intelligence.	Zeren and Keşlikli [127]
A5	Influencer marketing	It is one of the most essential digital marketing applications.	Young [128]

The experts whose opinions are gathered for the study are those with at least 10 years of managerial and practical experience. A total of seven experts provided assessments, including personnel (5), a business manager (1), and an academician (1), all of whom are experts in the field. While determining the study's criteria and alternatives, a preliminary study was done with the production personnel (1) and the business manager (1). As a result, the problem's criteria and alternatives were defined. The experts' assessments of the importance of the criteria are shown in Table 8.

Table 8. The linguistic assessments of the experts on the criteria.

Experts	C1	C2	C3	C4	C5	C6	C7	C8	C9
DM1	I	V	V	V	V	E	I	V	V
DM2	V	V	V	V	V	V	V	V	V
DM3	E	V	E	E	E	E	E	E	E
DM4	V	I	I	V	V	M	S	S	I
DM5	I	V	S	I	I	I	I	I	M
DM6	E	E	E	E	E	E	E	E	E
DM7	V	E	M	S	E	V	E	I	I

The aggregated evaluations of DMs and results of FF–SWARA are presented in Table 9.

Table 9. The results of FF–SWARA.

Criteria	μ	N	Score	cs_j	cc_j	rw_j	w_j	Rank
C5	0.927	0.161	1.792		1.000	1.000	0.120	1
C6	0.917	0.183	1.766	0.026	1.026	0.975	0.117	2
C7	0.908	0.209	1.740	0.026	1.026	0.950	0.114	3
C2	0.905	0.178	1.736	0.005	1.005	0.946	0.113	4
C1	0.897	0.193	1.714	0.022	1.022	0.926	0.111	5
C4	0.890	0.213	1.696	0.018	1.018	0.909	0.109	6
C9	0.883	0.219	1.678	0.018	1.018	0.893	0.107	7
C8	0.880	0.230	1.670	0.008	1.008	0.886	0.106	8
C3	0.875	0.242	1.657	0.013	1.013	0.875	0.105	9

The foremost driver is C5 (data management). The criteria are ranked in order of importance: C5 > C6 > C7 > C2 > C1 > C4 > C9 > C8 > C3.

The integrated decision matrix is depicted in Table 10.

Table 10. The integrated decision matrix.

	C1		C2		C3		C4		C5		C6		C7		C8		C9	
Integrated	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν	μ	ν
A1	0.730	0.258	0.756	0.179	0.590	0.336	0.742	0.192	0.725	0.212	0.439	0.479	0.665	0.294	0.575	0.365	0.538	0.410
A2	0.595	0.312	0.748	0.232	0.619	0.304	0.761	0.203	0.750	0.149	0.601	0.333	0.664	0.299	0.391	0.537	0.532	0.414
A3	0.561	0.367	0.536	0.389	0.601	0.430	0.663	0.305	0.554	0.399	0.776	0.239	0.669	0.294	0.446	0.503	0.519	0.417
A4	0.460	0.462	0.424	0.487	0.665	0.256	0.579	0.334	0.694	0.212	0.433	0.490	0.770	0.242	0.659	0.331	0.668	0.260
A5	0.687	0.225	0.629	0.358	0.779	0.232	0.751	0.184	0.603	0.312	0.606	0.322	0.645	0.328	0.697	0.341	0.681	0.246

The result obtained using FF–COPRAS is shown in Table 11.

Table 11. The results of FF–COPRAS.

Alternatives	$S(\alpha)_i$	$S(\beta)_i$	C_i	U_i	Rank
A1	0.206	0.273	6.163	77.485	4
A2	0.170	0.294	5.687	71.510	5
A3	0.161	0.236	7.033	88.423	2
A4	0.214	0.210	7.953	100.000	1
A5	0.245	0.261	6.456	81.170	3

The alternatives are ranked in the descending order as A4 > A3 > A5 > A1 > A2. Concerning these findings, programmatic advertising takes first place.

5. Robustness Test

Sensitivity and comparison analyses play an essential role to gain confidence in the results obtained [129–132]. In this context, to assess the suggested model, a comprehensive three-stage sensitivity analysis has been carried out. In the initial stage, we looked at the effects of changing the criteria weights on the overall ranking results. The second step assesses the rank reversal problem-handling capability of the proposed model. In the final phase, we compared the proposed models with some well-known FF methodologies.

5.1. Assessing the Impacts of Changing Criteria Weights

In this section, the consistency and stability of the model were examined by changing criteria weights. For this purpose, it has formed 90 different scenarios and the original weight of each criterion was reduced at the rate of 10% in each scenario until the weight of a criterion is equal to zero. The reduced value of a criterion in each scenario is added to the others' weights equally to provide the condition that the sum of criteria weights should be equal to 1. In literature, there are different approaches applied. Some authors proposed changing the first or third influential criteria [133]. The authors decided to follow the basic algorithm of an approach proposed by Görçün et al. [134]. In this context, the mathematical expressions of the proposed model are given below [134].

$$w_{fv}^{1} = w_{pv}^{1} - \left(w_{pv}^{1} \cdot m_v\right) \tag{15}$$

$$w_{nv}^{2} = \frac{\left(1 - w_{fv}^{1}\right)}{n-1} + w_{pv}^{2} \tag{16}$$

$$w_{fv}^{1} + \sum w_{nv}^{2} = 1 \tag{17}$$

By applying the proposed approach, the impacts of the criteria changing on the overall ranking results are examined. In Figure 1, the obtained results for 90 scenarios are presented.

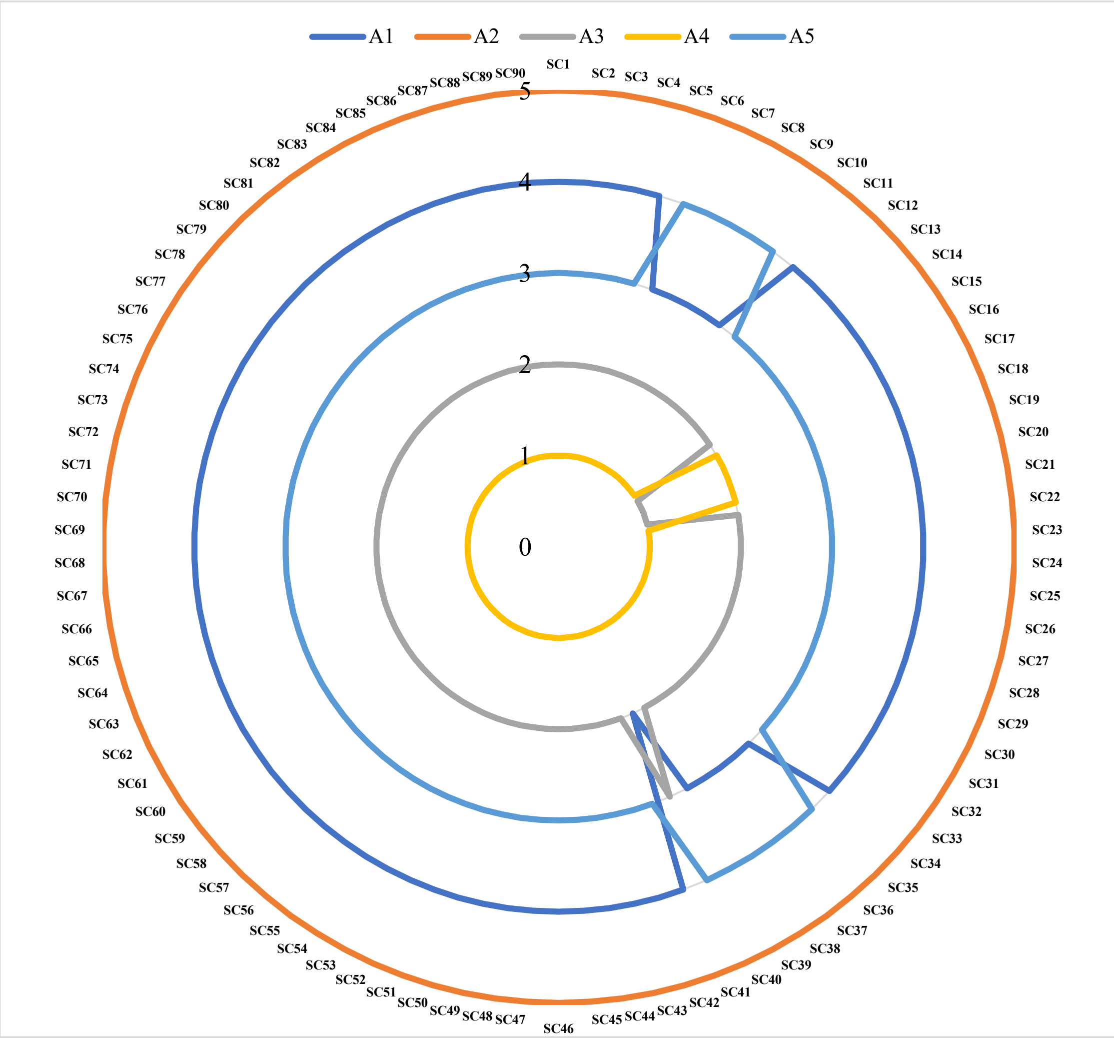

Figure 1. Impacts of the changing criteria weights concerning 90 scenarios.

As seen in Figure 1, the worst alternative (A2) has kept its place in all scenarios. When the weight of the C2 criterion is changed by more than 60%, the ranking position of the A4, the best alternative, changes only in five scenarios. Furthermore, like A4, the ranking performance of A3, the second-best alternative, has varied in six scenarios. When the average similarity coefficient of the alternatives was analyzed, it was found to be 0.9267. Although the result is regarded as high, it also shows that the proposed methodology has a stable and consistent mathematical model. The similarity ratio and the average similarity coefficient are presented in Table 12.

Table 12. The similarity ratio and the average similarity coefficient.

Alternatives	The Same with Original Rank	Similarity Ratio
A1	79	0.878
A2	90	1.000
A3	84	0.933
A4	85	0.944
A5	79	0.878
Average similarity coefficient		0.9267

5.2. Assessing the Resistance of the Model to the Rank Reversal Problem

The rank reversal problem is the most significant challenge for decision-making approaches. If any change occurs in indexes, i.e., adding or eliminating an alternative or criterion, the ranking results may dramatically change. We removed the worst alternative in each scenario to evaluate the model's resistance. The obtained results are presented in Table 13.

Table 13. The results for testing the model to the rank reversal problem.

Scenarios	Rank
Original	A4 > A3 > A5 > A1 > A2
S1	A4 > A3 > A5 > A1
S2	A4 > A3 > A5
S3	A4 > A3
S4	A4

As seen in Table 13, the ranking performances of all alternatives have not been changed, and with A4, in all scenarios, it was determined that the best alternative remained at the same level. As it can be understood from the results obtained, it can be said that the presented approach is an indicator of maximum resistance to the order inversion problem. It is also an indication that the proposed model provides decision-makers with a reliable decision-making environment and can be applied to solve extremely difficult and complex decision-making problems.

The proposed model has remained consistent and stable when the results are evaluated in general. Also, the average similarity coefficient is high, proving that the proposed model provides a reliable methodological frame for practitioners. In addition, the results obtained in the second stage of sensitivity analysis show that the model is maximally stable and resistant to the rank reversal problem.

5.3. Comparatative Analysis

We applied four prominent MCDM methodologies based on the FFSs such as FFS–WPM [26], FFS–ARAS [27], FFS–TOPSIS [135,136] and FFS–WASPAS [26,73] to compare the results of the proposed model. The ranking results obtained via these methods are shown in Figure 2.

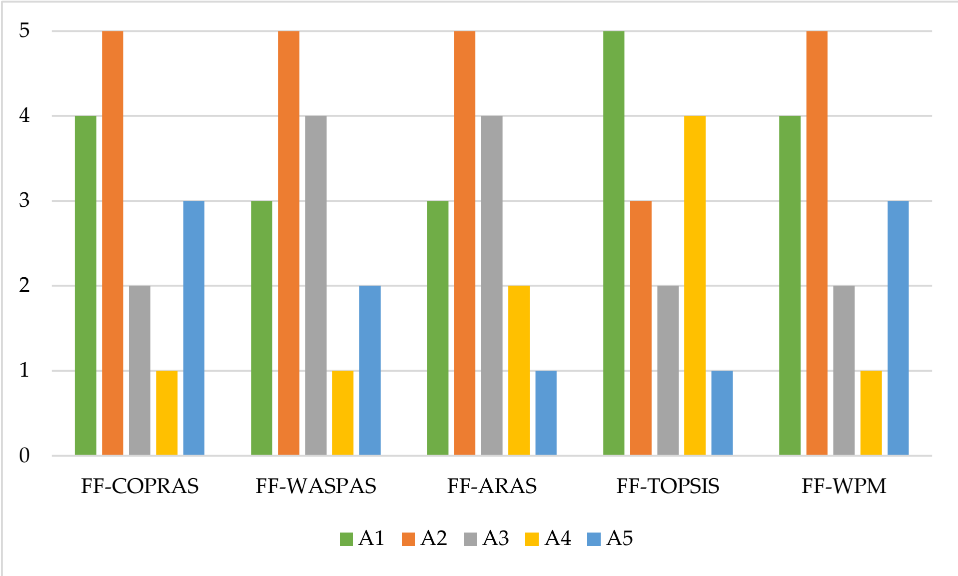

Figure 2. The ranking results obtained via different methods.

The ranking results of FF–COPRAS are the same as those of FF–WPM, as seen in Figure 2. A4 is also placed in the first place according to the solutions of the three methods. However, A5 was ranked first place by FF–ARAS and FF–TOPSIS. Different results might be obtained when other MCDM methods are used to solve the same decision problem [137–139]. As a result, it is reasonable to conclude that the model used in the study gives a stable and validated solution to the problem.

6. Discussion

The stimulation of new ideas and consumer behavior can explain modern society's growing awareness of the importance of sustainable development. Digitalization and advancements have an impact on all aspects of human life. The marketing function is currently expected to bridge the gap between the adverse effects of digitalization on environmental concerns and customers' emphasis on social and environmental issues [140]. After the concept of sustainable development became a globally accepted phenomenon, its requirements were discussed, and various criteria were defined in this regard. One of the necessary conditions for sustainable development, regarding the Brundtland Report, is to "establish a production system that respects the preservation of the ecological base required for development" [141]. At this point, consumers' growing environmental awareness and responsibility in the green information and communication movement have increased the pressure on businesses. Consumer pressure on manufacturers, as well as an increase in the preference and consumption of environmentally friendly products, has driven them to make more environmentally friendly and sustainable products [142].

This requires an assessment of the research findings in this context. Once the obtained results are compared to the literature, the similarities and differences can be revealed, and critical conclusions can be drawn. The final weights of green approaches to ICTs are shown in Table 5. The most crucial weight has been determined to be "data management". It is consistent with Çavdar and Alagöz [143] and Saura et al.'s [16] previous research. Because, according to research on rapidly developing digital technologies, the digital transformation process with models, such as business analytics and big data ecosystems, has expanded the horizon even further [144]. Developing an effective data management strategy, especially in businesses, significantly benefits its users. When it comes to data management, processing information documents, legal processes and technological issues and converting them to data is extremely useful to businesses.

"Recycling of IT sector waste" is another essential criterion. This result is in line with the results of Mobbs [123], Kumar and Kiruthiga [9], and Topçu [145]. Whereas most of these wastes are hazardous, their disposal or storage harms the ecological balance. So, it poses serious environmental and public health risks. In this regard, recycling and disposing of hazardous waste are critical.

According to the FF–SWARA results, "cloud computing" is the third most vital driver. The findings support those of Furht and Escalant [146], Yang and Tate [147], and Paşaoğlu and Cevheroğlu [148]. Storage capacity has been reduced due to the widespread adoption of cloud computing in businesses. It is now possible to quickly access relevant data over the internet without needing physical evidence. Cloud computing applications boost energy efficiency by saving money and supporting process innovation.

Moreover, regarding the study's findings, the best alternative is "programmatic advertising". This result is consistent with the findings of Jung et al. [149], Malthouse et al. [150], and Zeren and Keşlikli [127]. Programmatic advertising enables businesses to manage activities such as finding customers, presenting their products, and much more efficiently and quickly. It can be considered a smart solution that helps deliver products to customers more effectively by processing data. Also, it allows for close recognizing, tracking and analysis of business segments. Thus, it is to define appropriate targets and ensure they reach the most accurate target audience.

7. Conclusions, Future Works, Limitations, and Implications

This section is divided into four subsections: conclusions, future works, limitations and implications.

7.1. Conclusions

Although most recent studies want to activate the technologies specific to industrial transformation using green approaches, they have not focused enough on twin transformation. The importance of the increase in green strategies in manufacturing processes notwithstanding, an overview of the building process of a twin transition that includes technologies, new skills requirements, markets, standards, business models and policy is still lacking.

The industrial strategy of the European Union mentions the importance of the twin transition by emphasizing that it provides a unique opportunity to fight for the protection of values and identical conditions [151].

Montalvo and Leijten [152], on the other hand, stated that the twin transition model expresses a new logic for innovation and industrial policy that has been created, directed and legitimized through great effort. In fact, according to Deng et al. [153], the twin transition is the inevitable goal of digital transformation. With twin transition, different scenarios can be developed from different conditions; thus, all activities in the supply chain can be modified by considering various strategies to improve performance [154].

The industrial policy of the European Union has directed and analyzed different initiatives aimed at improving the knowledge of managers and employees on the green and digital capabilities necessary for a successful twin transition and has made different emphases on the subject [151].

The study focused on green approaches for ICTs in logistics companies with international transportation activities and corporate identity in Istanbul. It was based on the best digital marketing strategy selection. As there are few studies on the use of green approaches in digital marketing strategy for ICTs, this study is valuable for future research and allows for comparison with other studies. Besides, the methods used in the relevant research are thought to contribute to the logistics sector, digital marketing and literature.

Using digital systems with green strategies requires integrating these systems to accrue the maximum benefit in terms of increasing market share and cost advantage in enterprises. It is critical to choose green approaches and a digital marketing strategy for ICTs. The fact that the current study's findings reveal this situation is another contribution of the study. At the same time, decision-makers and practitioners face many uncertainties and complexities when selecting green approaches and digital marketing strategies for ICTs. As a result, this situation may pose challenges for logistics companies in terms of cost, marketing, recycling, waste, energy, environment, performance and digitalization/digitalization application levels. At this point, the study's findings serve as a road map for overcoming the difficulties listed.

It is also vital to establish new strategic policies and plans to promote twin transition and green approaches in energy, electrical and electronics, manufacturing, transportation and mobility industries and to identify new special financing programs for these sectors.

After a comprehensive literature review, we discovered major and significant gaps in the existing literature. The first theoretical gap concerns past studies' decision-making frameworks. The authors evaluated green approaches and digital marketing strategies for information and communication technology using classic objective and subjective decision-making methodologies as well as fuzzy techniques. The lack of articles focused on green methods and digital marketing strategy evaluation and selection using fuzzy MCDM methods has been identified as a research gap in this context. Second, most past studies have concentrated on a specific subset of green strategies for information and communication technologies. Still, to develop a comprehensive and long-term solution, this problem must be addressed holistically. The next gap is a clear understanding of the benefits and opportunities of employing digital marketing strategies. The benefits and limitations for diverse industries are not well-stated. As a result, additional research and studies addressing the benefits of digital marketing strategies can provide a knowledge of their significance and critical role for industries.

Fourth, previous studies have failed to demonstrate the interdependence and linkages between digital marketing strategies and green approaches. Furthermore, to understand the main problem and solve it quickly, the interdependencies and relationships between them must be determined. Many previous studies in the literature, however, have disregarded this. As a result, because the authors only gave partial solutions to the literature, it is difficult to evaluate this decision-making problem holistically. The fifth gap is connected to the criteria employed in previous research. It is unclear how these criteria are defined in these studies, and no explanation of the methodological framework used to describe them is provided. This could reduce the reliability of the findings acquired. It also makes determining the relationships between criteria and alternatives more difficult.

7.2. Future Works

A decision-making model should be able to evaluate complex alternatives and criteria to produce results that are reliable, reasonable and logical. These requirements and motives are considered in the decision-making model included in the current study. The methodology, including the FF–SWARA and FF–COPRAS methods, can also be applied to various logistics and digital marketing problems. Similarly, the study's methodology can be applied to a wide range of problems in various fields, such as engineering, business, health, etc. Future research could compare different decision-making environments, such as spherical and T-spherical fuzzy sets [155,156], picture fuzzy sets [132,157], hesitant fuzzy sets [158,159], neutrosphic sets [160,161], optimization problems modeling with fuzzy logic [162,163] and methods, such as MACBETH, MAIRCA, REF, PROMETHEE and SAW. The limitations and practical and managerial implications are discussed in the subheadings following.

7.3. Limitations

One of the study's main limitations is that it is only conducted in the specified province and sector. Another limitation of the study is its emphasis on green approaches and digital marketing strategies for ICTs, which means that other studies on green practices and digital marketing are not sufficiently examined and focused on at the desired level. Further, some of the subject categorizations used in the studies are subjective. Last, no criteria are found in the literature review for the theme of selecting green approaches and digital marketing strategies for ICTs.

7.4. Practical and Managerial Implications

The study is part of ongoing research on determining the levels of efficiency, sustainability, environment and digital transformation in enterprises, digitalization, recycling and waste reduction, ensuring employee satisfaction and resource efficiency, business practices and competitiveness. Aside from theoretical contributions, the study gives critical insights for logistics decision-makers and practitioners, as well as individuals interested in the subject. These offer the opportunity to evaluate environmentally friendly approaches to ICTs. The study also pioneers a fundamental model for selecting the best green method and a digital marketing strategy selection process for ICTs. Also, the study allows for a flexible and structured decision-making environment in which different points of view can be considered.

This work can assist decision-makers in charting a new course and developing plans considering the globalizing market conditions for green approaches to ICTs and the selection of digital marketing strategies using the proposed model. Further, the related study addresses critical areas, such as green approaches and digitalization transformation in logistics. It presents a new set of drivers suitable for real-world decision-making problems, another superiority of the study that will inspire future researchers and various sectors and industries. Finally, using the methods in the study to evaluate green approaches for ICTs and digital marketing strategy selection processes enabled logistics decision-makers to convey their practical approaches in a scientific context and contribute to the interaction of theoretical and practical applications.

Author Contributions: Conceptualization, S.K. and A.A.; methodology, A.A., E.K.Z., Ç.K. and F.E.; software, A.A.; validation, Ç.K., F.E. and E.K.Z.; formal analysis, A.A.; investigation, S.K.; resources, S.K.; data curation, S.K.; writing—original draft preparation, A.A.; writing—review and editing, F.E and E.K.Z.; visualization, Ç.K.; supervision, F.E and E.K.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article.

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

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