

2-Tuple Representation Model Integrated Optimization Procedure for Strategy Selection in Sustainable Marketing

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Abstract: - This study presents an integrated decision-making approach combining the 2-tuple linguistic representation model with a common-weight data envelopment analysis (DEA) method to identify the most effective sustainable marketing strategy. The proposed framework processes linguistic and numerical data from multiple sources without information loss. The common-weight DEA model enables a unified performance evaluation and ranking of decision-making units through a single mixed-integer linear programming formulation. A case study in the Turkish fast-moving consumer goods sector illustrates the method's applicability in selecting the optimal strategy. The main contributions include the first integration of the 2-tuple model into sustainable marketing, the initial application of DEA in this domain, and the novel combination of linguistic modeling with mixed-integer programming. The proposed approach provides marketing executives with a robust, objective tool for strategic decision-making to advance sustainability.

Key-Words: - 2-tuple representation model, data envelopment analysis, common weights, sustainable marketing, strategy selection, mixed-integer linear programming, multi-criteria decision-making.

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1 Introduction

The principal objective of sustainable marketing is to synchronize company strategy with environmental and social accountability while ensuring economic sustainability [1]. Companies implementing sustainable marketing aim to reduce the environmental effects of their activities by producing eco-friendly products, promoting responsible consumption, and reducing resource waste [2]. The objectives extend beyond profit generation, incorporating the development of strong relationships with environmentally conscious consumers, improving corporate social responsibility (CSR), and promoting long-term sustainability in business processes [3], [4]. These objectives become increasingly crucial as customers demand greater transparency and accountability from the brands they support. Businesses that implement sustainable practices are better positioned to meet the increasing demand for sustainable products, keep ahead of legislative changes, and meet the evolving expectations of the market regarding environmental stewardship [5]. Ultimately, sustainable marketing seeks to establish a win-win situation where companies can thrive financially while making beneficial contributions to society and the

environment, improving brand loyalty and reputation in the marketplace.

Sustainable marketing offers organizations several benefits that can strengthen their competitive edge. Customer loyalty and brand reputation are enhanced, especially when people pick more carefully the businesses they support that align with their moral and environmental principles [6]. Additionally, businesses can save operating expenses and increase profitability over time by increasing resource efficiency [7]. Sustainable marketing can also stimulate innovation and provide new market opportunities, enabling businesses to create distinctive goods and services that appeal to the growing number of environmentally concerned customers. However, sustainable marketing also comes with certain risks. One key challenge is the potential for higher upfront costs, as transitioning to eco-friendly practices and products often requires significant investment [8]. Another potential threat is greenwashing, which is the practice of misleading customers about a product's environmental benefits. If such practices are revealed, they can seriously harm a company's reputation [9]. To avoid these problems and benefit in the long run from sustainable marketing, companies must carefully combine their sustainability goals with transparency and authenticity [10]. Businesses may protect their

brand and increase the benefits of their sustainable marketing initiatives by taking proactive measures to mitigate these risks.

The objective of the paper is to develop a 2-tuple representation model integrated with common weight data envelopment analysis (DEA) based mathematical programming framework to rank the efficiencies of sustainable marketing strategy alternatives according to their performance ratings and obtain the most suitable one. The proposed combined decision-making methodology copes with information obtained from linguistic as well as numerical scales with multiple information sources. Moreover, it enables the marketing managers to handle heterogeneous data without loss of information. In the selection procedure, a common weight DEA-based model [11], which provides performance ranking of the decision-making units (DMU) without a priori information and full ranking of the alternatives, is employed. The employed framework ensures the identification of the best-performing DMU by solving a single mixed-integer linear programming model. A case study, which aims to obtain the most suitable sustainable marketing strategy, is conducted in the Turkish fast-moving consumer goods (FMCG) sector.

The contributions of the proposed integrated decision methodology to the literature can be summarized as follows. First, one can conclude that there is no work that integrates a 2-tuple representation model in the sustainable marketing field. Second, this paper provides novelty by employing DEA in the sustainable marketing strategy selection problem. Third, the proposed DEA-based framework guarantees to yield the best-performing sustainable marketing strategy without requiring any information about the weights of the evaluation criteria and using common importance weights for all inputs and outputs; hence, a common and non-subjective assessment is provided. Fourth, no other paper in the literature combines 2-tuple representation and mixed-integer linear programming models. Fifth, this integrated approach supports companies in determining which marketing strategies to prioritize in order to achieve sustainability in their marketing management procedures. Thus, the paper functions as a strategic management guide for marketing executives during their transition toward sustainable practices.

The rest of the paper is organized as follows. Section 2 outlines a literature review on sustainable marketing. The following section presents the materials and methods, along with the proposed mathematical programming-based decision-making support. Section 4 gives the case study. Section 5 mentions discussion and managerial implications. The

final section outlines conclusions along with future research.

2 Literature Review

In recent years, the literature on marketing strategies has been significantly enriched by numerous studies using various methodologies to address the dynamic needs of consumers and environmental challenges. Some researchers have focused on sustainable and green marketing while others have examined different marketing approaches. [12] investigated Slovak companies' perspectives on the link between marketing strategy and sustainability using binary logistic regression and gathering data from 896 companies in the Slovak Republic. [13] investigated the impacts of marketing activities on achieving sustainable products and increased obedience to environmental regulations by conducting a theoretical review and gathering data from 110 manufacturing companies. [14] created a framework for sustainable marketing that synchronizes corporate aims with social and ecological objectives, highlighting the fact that a well-coordinated approach can lead to both environmental impact and profitability. [15] examined the relationship between greenwashing and customer skepticism and found that misleading sustainability promises undermine consumer loyalty and brand trust.

On the other hand, using quantitative analysis, [16] looked into how the green marketing mix affected Bangladeshi consumers' purchasing decisions. Regression analysis, frequency, mean, and standard deviation were used to examine the data from 200 respondents that were gathered by Convenient and Judgmental Sampling. [17] aimed to measure the value of green food labels in online and offline markets of China by using a hedonic price analysis. [18] investigated the current state of digital marketing in the Malaysian property development industry and the principles and practices used by conducting an online questionnaire survey with 279 Malaysian property development sector representatives. [19] investigated the elements that impact the purchase decision of green consumers while buying organic agriculture products by conducting a survey with 559 green consumers. [20] conducted a questionnaire with 230 samples to reveal that the value-satisfaction-trust-WOM context was remarkably impacted by emotional and rational appeals.

Alternatively, [21] revealed that sustainable profits and creating market demand could be achieved with efficient energy usage and low waste by carrying out a survey with 500 respondents in Bangladesh. [22] revealed that sustainability marketing can help change

consumer behavior to a more sustainability-oriented one and that it can play a part in reaching a sustainable bioeconomy by investigating the literature and conducting a focus group accordingly. [23] investigated how green marketing affected the meal choices of students in Ho Chi Minh City, Vietnam. SPSS was used to evaluate data from a sample of 400 students using a combination of qualitative and quantitative research approaches. [24] explored the strategies of sustainable fashion brands on Instagram during the Black Friday event and the anticipated consumer response to them by analyzing Instagram content and conducting an online survey.

Moreover, the following scholars have focused on customer behavior and buying decisions of consumers. [25] discovered that sustainable brands perform like all other brands when it comes to the behavior or loyalty of consumers towards them by processing 22 sets of continuous data from the UK. [26] investigated the effects of sustainable marketing strategies on the consumer's interpretation of fit by conducting an experiment with 185 consumers, an online survey with 546 respondents, and also a qualitative pretest with 88 MBA students. [27] aimed to generate insights on impacting buying decisions of consumers in order to encourage a more sustainable society by conducting a comprehensive analytical review of relevant literature. [28] discovered that the impact of green innovation culture on market and product innovation was positive, which then amplified market performance by conducting an online survey with 564 small and medium-sized enterprises (SME) employees in China.

Apart from these studies, several researchers employed structural equation modeling (SEM). [29] look into how sustainable marketing affects consumer engagement and sustainable purchasing intentions, specifically in the Chinese market for electric vehicles. The study looks at brand image and corporate social responsibility (CSR) as important moderators using SEM and a survey of 393 participants. It finds that CSR, brand image, and sustainable marketing all significantly increase customer engagement and sustainable purchase intentions. Using the same modeling, [30] investigated the influence of sustainable marketing on customer loyalty within India's consumer electronics sector. After examining survey data from 302 respondents, they discovered that sustainable marketing has a beneficial effect on brand image, which in turn influences consumer loyalty. To promote environmentally conscious consumer behavior, fashion businesses are implementing sustainable marketing strategies [31]. By establishing a favorable brand image and trust, companies can

reinforce sustainable activities and eventually encourage long-term sustainable buying behavior. These findings, which were derived from a survey that was analyzed using PLS-SEM, emphasize the mediating function of brand perception in encouraging brand loyalty.

In addition, researchers have also examined the psychological factors that shape consumer responses to marketing strategies. [32] investigated how cues such as limited-edition products and brand heritage influence perceived brand value and consumers' willingness to pay a premium.

More recently, [33] investigated the perception and application of sustainable marketing by agri-food exporting companies by conducting interviews with sector experts and company managers. [34] explored the main factors of green marketing that affect the purchasing decisions of young Portuguese consumers regarding eco-friendly products, along with their interrelationships. The study gathered data from 708 young Portuguese consumers through an online survey and analyzed it using the partial least squares (PLS) technique. [35] analyzed data from 320 marketing experts in Greece to investigate the impact of emerging technologies on smart sustainable marketing. The efficiency of smart sustainable marketing is improved by developments in business informatics and related technologies, according to the findings, which also encourage managers to use complementary technologies for market shaping and innovation. [36] investigated how green marketing factors affect the business performance of electronics manufacturers in India. Using a stakeholder-driven empirical framework and analyzing survey data from 160 industry managers through the Smart PLS model, the study finds that green marketing significantly enhances business success while promoting sustainability efforts.

Although researchers have focused on sustainability concepts in the marketing area by proposing several approaches throughout the literature, there is no research paper that provides an evaluation of sustainable marketing strategies. To the best of our knowledge, no existing study in the literature integrates the 2-tuple representation with mixed-integer linear programming models. Moreover, this comprehensive approach helps companies identify the most critical marketing strategies to pursue to achieve sustainability in their marketing management processes. As such, the paper serves as a strategic resource for marketing executives undergoing the shift toward sustainable practices.

3 Materials and Methods

3.1 The 2-Tuple Representation Model

[37] developed the two-tuple linguistic representation model to overcome the limitations of traditional linguistic decision-making methods. One of its key advantages is preventing information loss when converting numerical values into linguistic expressions. The two-tuple model represents linguistic data using a pair (s, α) . Here, s is a linguistic term, while α indicates the deviation from the closest linguistic term. This approach ensures greater accuracy in linguistic assessments. It also enhances the precision of calculations and aggregations in fuzzy logic. As a result, the model significantly improves decision-making processes [38].

The two-tuple linguistic representation model provides a structured method for managing linguistic data. It ensures accuracy in fuzzy decision-making. Below is a step-by-step breakdown of the model:

4 Define the Linguistic Term Set

A collection of ordered linguistic terms is represented as $S = \{s_0, s_1, \dots, s_g\}$, where g denotes the granularity of the linguistic scale.

1. Convert a Numerical Value into a Linguistic Term Index

Given a numerical evaluation $\beta \in [0, g]$, the closest linguistic term s_i is determined by rounding β to i , where $i = \text{round}(\beta)$. The deviation $\alpha = \beta - i$ represents the fine-tuned difference between the exact numerical value and the nearest linguistic term.

5 Represent the Two-Tuple

The two-tuple representation is denoted as (s_i, α) , where s_i represents the selected linguistic term and α is the deviation, a real value within the range $[-0.5, 0.5]$, reflecting the closeness of the value to the next or previous term.

6 Perform Computational Operations

Arithmetic operations, such as addition or averaging, can be directly applied to two-tuple values through the use of transformation functions.

7 Reverse Transformation

If needed, the two-tuple representation can be converted back to a numerical value using

$\beta = i + \alpha$. This ensures precise calculations while maintaining the linguistic meaning.

The two-tuple linguistic model enhanced fuzzy information fusion [37]. This model made a significant contribution by preserving the accuracy of linguistic terms in decision-making processes.

The transformation function can be expressed as follows:

Consider two linguistic term sets, $A = \{l_0, l_1, \dots, l_p\}$ and $S_T = \{s_0, s_1, \dots, s_g\}$, where $g \geq p$.

$F(S_T)$ and $F(S_G)$ denote the fuzzy sets associated with the source and target linguistic term sets, respectively. The transformation function τ_{AS_T} maps the fuzzy representation of one linguistic term set into another while preserving the semantic information. The transformation function, τ_{AS_T} , is defined as:

$$\tau_{AS_T}: A \rightarrow F(S_T), (1)$$

$$\tau_{AS_T}(l_i) = \{(s_k, \gamma_k^i) / k \in \{0, 1, \dots, g\}\}, \forall l_i \in A, (2)$$

$$\gamma_k^i = \max_y \min\{\mu_{l_i}(y), \mu_{s_k}(y)\}, (3)$$

where $\mu_{l_i}(y)$ and $\mu_{s_k}(y)$ represent the membership functions of the fuzzy sets linked to the terms l_i and s_k , respectively.

3.2 Data Envelopment Analysis

A decision-making tool based on mathematical programming, data envelopment analysis (DEA) addresses decision problems that require the consideration of multiple inputs and multiple outputs in order to assess the relative effectiveness of decision-making units (DMUs) without knowing beforehand the weights of inputs and outputs [39]. Conventional DEA models have a number of drawbacks, notwithstanding their usefulness in performance evaluation by providing data on the effectiveness of assessed DMUs. To get the efficiency ratings of all DMUs, these models must first be solved n times, where n is the number of DMUs that need to be assessed.

Furthermore, they don't use common attribute weights to measure DMU performance, which allows the examined DMUs to choose input and output weights that maximize their own efficiency scores. This could lead to conclusions that are far from useful. In addition, conventional DEA models designate as "efficient" all DMUs with an efficiency score of 1 and "inefficient" all DMUs with an efficiency score below 1. Put differently, efficient DMUs with an efficiency score of 1 are likely to lack the discriminating power that traditional DEA models may offer. Many academics have suggested common weight DEA-based models as a way to get around these restrictions.

[11] proposed a mixed-integer linear programming model and reached the single best performing DMU for cases with multiple inputs and outputs. Initially, they developed the following programming model for indicating the maximum value for non-Archimedean infinitesimal ε .

$$z = \max \varepsilon(4)$$

subject to

$$\begin{aligned} \sum_{i=1}^m v_i x_{ij} &\leq 1 \quad \forall j, \\ \sum_{r=1}^s u_r y_{rj} - u_0 - \sum_{i=1}^m v_i x_{ij} + d_j &= 0 \quad \forall j, \\ \sum_{j=1}^n \theta_j &= n - 1 \\ d_j &\leq M\theta_j \quad \forall j, \\ \theta_j &\leq Md_j \quad \forall j, \\ d_j &\geq 0 \quad \forall j, \\ \theta_j &\in \{0,1\} \quad \forall j, \\ v_i, u_r &\geq \varepsilon \quad \forall i, r, \end{aligned}$$

where u_r is the weight assigned to output r , v_i is the weight assigned to input i , y_{rj} denotes the quantity of output r produced by DMU j , x_{ij} denotes the amount of input i consumed by DMU j , and ε is a small positive scalar. Second, they proposed the following mixed-integer linear programming model to provide a complete ranking of the DMUs.

$$z = \min d_{\max}(5)$$

subject to

$$\begin{aligned} d_{\max} - d_j &\geq 0, \quad \forall j, \\ \sum_{i=1}^m v_i x_{ij} &\leq 1 \quad \forall j, \\ \sum_{r=1}^s u_r y_{rj} - u_0 - \sum_{i=1}^m v_i x_{ij} + d_j &= 0 \quad \forall j, \\ \sum_{j=1}^n \theta_j &= n - 1 \\ d_j &\leq M\theta_j \quad \forall j, \\ \theta_j &\leq Nd_j \quad \forall j, \\ d_j &\geq 0 \quad \forall j, \\ \theta_j &\in \{0,1\} \quad \forall j, \\ v_i, u_r &\geq \varepsilon \quad \forall i, r, \end{aligned}$$

where M and N are large positive numbers, $d_{\max}$ refers to the maximum value for deviation from efficiency, and u_0 denotes a free variable. The model ensures to obtain the most efficient DMU by solving one mixed-integer linear programming model. However, the authors guarantee to identify the best efficient DMU by adding some constraints that restrict obtaining more than one efficient DMU. Additionally,

including the binary variable θ_j , and the penalty value M to the model are required to solve it.

4 Case Study

Sustainable marketing strategy selection focuses on creating long-term value for both businesses and society by integrating environmental, social, and economic considerations into marketing practices. This approach encourages brands to prioritize ethical sourcing, eco-friendly production, and transparent communication, ensuring their actions align with sustainable values. A successful strategy involves understanding the target market's growing preference for sustainable products and services, while also recognizing the competitive advantage that eco-consciousness can bring. Marketers must also consider the product lifecycle, minimize waste, and leverage digital platforms to reduce carbon footprints. By adopting a sustainable marketing strategy, businesses not only build customer loyalty but also contribute to the broader goal of sustainable development.

This paper develops an integrated methodology for identifying the most suitable sustainable marketing strategy alternative among 5 alternatives, namely "life cycle assessment (A_1)", "environmental management systems (A_2)", "green supply chain management (A_3)", "sustainable product design (A_4)", "waste management and recycling (A_5)", respectively. The case study is carried out in the Turkish fast-moving consumer goods sector. The case company aims to manage a sustainable marketing process, and thus wants to select an appropriate strategy among these five sustainable marketing strategy alternatives.

Sustainable marketing strategy selection criteria, given in Table 1, are determined by reviewing the literature and experts' opinions. These criteria, as mentioned in Table 1, are obtained by reviewing the related literature and interviewing experts. The first six factors are referred to as cost criteria, while the other seven factors are benefit criteria.

Table 1. Sustainable marketing strategy selection factors

Label	Factor	Cost	Benefit
C ₁	High startup costs	*	
C ₂	Training requirements	*	
C ₃	Market uncertainties	*	
C ₄	Technological limitations	*	
C ₅	Management challenges	*	
C ₆	Green certification costs	*	
C ₇	Environmental awareness		*
C ₈	Brand image		*
C ₉	Customer loyalty		*

C_{10}	Competitive advantage	*
C_{11}	Cost savings	*
C_{12}	Innovation	*
C_{13}	Research and development incentives	*

Source: created by the authors

One marketing manager, two marketing specialists, and a sustainability responsible who have been working for at least two years in the case company have come together and conducted the assessment. A survey document, which involves the evaluation of sustainable marketing strategies according to evaluation factors along with interrelationships between the pair of factors, is implemented. Experts 1 and 3 utilized the linguistic term set very low (VL), low (L), medium (M), high (H), and very high (VH) as given in Figure 1, whereas experts 2 and 4 used the linguistic term set definitely low (DL), very low (VL), low (L), medium (M), high (H), very high (VH), and definitely high (DH), as provided in Figure 2 [40].

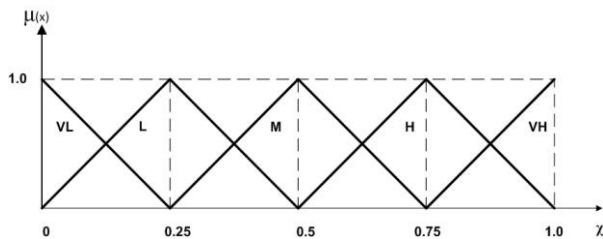


Fig. 1: A linguistic term set where VL: (0, 0, 0.25), L: (0, 0.25, 0.5), M: (0.25, 0.5, 0.75), H: (0.5, 0.75, 1), VH: (0.75, 1, 1)

Source: [40]

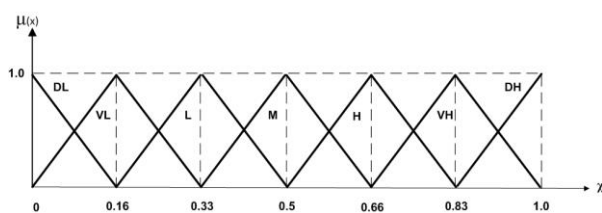


Fig. 2: A linguistic term set where DL: (0, 0, 0.16), VL: (0, 0.16, 0.33), L: (0.16, 0.33, 0.50), M: (0.33, 0.50, 0.66), H: (0.50, 0.66, 0.83), VH: (0.66, 0.83, 1), DH: (0.83, 1, 1)

Source: [40]

The assessments of cost criteria provided by four experts are given in Table 2. The assessments of benefit criteria provided by four experts are given in Table 3.

The fuzzy data are transformed into the BLTS employing Eqs. (1-3) and then the data are aggregated using the arithmetic mean operator. The β values of the ratings are calculated and converted into a linguistic 2-tuple, and the results are given in Table 4 and Table 5.

Table 2. The assessments of the four experts according to cost criteria

Alternative	C_1	C_2	C_3	C_4	C_5	C_6
A_1	(M,V H,L, DH)	(VH, DH,H ,DH)	(M,H ,VL, H)	(L,M, M,H)	(L,H, VL,D H)	(H, M,M ,M)
A_2	(VH, VH, M,H)	(H,V H,M, VH)	(H,M ,L,H)	(H,H, M,DH)	(L,V H,VL ,VH)	(VH, M,M ,M)
A_3	(H,H, M,H)	(VH, DH,V H,H)	(H,V H,M, M)	(VL, VL,V L,VL)	(VH, H,H, H)	(M, H,M, H)
A_4	(M,H ,M,H)	(M,V H,L, VH)	(VL, M,V L,H)	(M,M ,L,M)	(M,V L,M, M)	(H,H ,M,H)
A_5	(VL, DL,V L,L)	(M,H, M,D H)	(M,H ,L,H)	(L,DL ,L,DL)	(M,M ,VL, H)	(H, M,H, H)

Source: created by the authors

Table 3. The assessments of the four experts according to benefit criteria

Alternative	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
A_1	(H,H ,M,H)	(H, M, L,H)	(M, VH, VL, DH)	(H,L ,VH, M)	(H,L ,H, M)	(M, VH, L,V H)	(M, H, M, H)
A_2	(H,M ,M, M)	(M, L,L, M)	(L,L ,L,M)	(M, M,L ,M)	(M, DL, VL, DL)	(H, VH, H,V H)	(M, DH, H,H)
A_3	(L,V L,VL ,VL)	(L, M, L, M)	(VL, M, M,L)	(H, VH, H,V H)	(VH ,VH, H,V H)	(VL ,M, VL, L)	(M, H,L ,H)
A_4	(VH, DH, VH, DH)	(H, DH, L,D H)	(M, M, M,L)	(VH ,VH, H,V H)	(M, VL, M,L)	(H, M, M, M)	(M, VH, L,V H)
A_5	(H,H ,M,H)	(H, M, H,H)	(VH ,M, M,H)	(L, M,L ,VH)	(M, DH, L,D H)	(VL ,L, VL, L)	(L, VL, M, M)

Source: created by the authors

Table 4. The results of cost criteria

Alternative	C_1	C_2	C_3	C_4	C_5	C_6
A1	$(s_5, -)$	$(s_7, -)$	$(s_4, -)$	$(s_4, -)$	$(s_4, -)$	$(s_5, -)$
A2	$(s_6, -)$	$(s_6, -)$	$(s_4, 0)$	$(s_6, -)$	$(s_4, -)$	$(s_5, -)$
A3	$(s_5, 0)$	$(s_7, -)$	$(s_5, 0)$	$(s_1, 0)$	$(s_6, -)$	$(s_5, -)$
A4	$(s_5, -)$	$(s_5, -)$	$(s_3, -)$	$(s_3, 0)$	$(s_3, 0)$	$(s_5, 0)$
A5	$(s_1, 0)$	$(s_5, -)$	$(s_4, 0)$	$(s_1, 0)$	$(s_4, -)$	$(s_5, 0)$

Source: created by the authors

Table 5. The results of benefit criteria

Alternative	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
A1	$(s_5, 0)$	$(s_4, 0)$	$(s_5, -)$	$(s_5, -)$	$(s_5, -)$	$(s_5, -)$	$(s_5, -)$
A2	$(s_5, -)$	$(s_3, 0)$	$(s_3, -)$	$(s_3, 0)$	$(s_2, -)$	$(s_6, 0)$	$(s_6, -)$
A3	$(s_1, 0)$	$(s_3, -)$	$(s_3, -)$	$(s_6, 0)$	$(s_7, -)$	$(s_2, 0)$	$(s_4, 0)$
A4	$(s_7, 0)$	$(s_5, 0)$	$(s_4, -)$	$(s_7, -)$	$(s_3, 0)$	$(s_5, -)$	$(s_5, -)$
A5	$(s_5, 0)$	$(s_5, 0)$	$(s_5, 0)$	$(s_3, 0)$	$(s_5, -)$	$(s_2, -)$	$(s_3, -)$

Source: created by the authors

The results of the 2-tuple representation model are utilized as input to the DEA methodology. First, the maximum value for non-Archimedean infinitesimal ε is indicated as 0.0322 by solving Model (4). Second, Model (5) is employed, and the DMUs are ranked according to their deviation scores in descending order. The resulting rankings are mentioned in Table 6.

Table 6. Ranking results

Alternative	$d(j)$	Rank
A1	0.3419	3
A2	0	1
A3	0.3419	3
A4	0.3419	3
A5	0.0767	2

Source: created by the authors

The deviation score $d(j)$ represents the deviation of each DMU from the efficiency frontier obtained by the common-weight DEA model. A deviation score of zero indicates that the corresponding DMU is identified as the most efficient alternative, whereas larger deviation scores indicate lower relative efficiency.

According to Table 6, the environmental management system is the best-performing sustainable marketing strategy, followed by waste management and recycling. The other strategy alternatives, namely life cycle assessment, green supply chain management, and sustainable product design, have the same efficiency scores and are ranked as third.

5 Managerial Implication and Discussion

Sustainable marketing has become an essential strategy in today's competitive industry for businesses looking to differentiate themselves from the competition and satisfy consumers' increasing demands for social and environmental responsibility. Businesses that prioritize sustainability first not only improve their market positioning but also establish long-lasting competitive advantages as consumers increasingly seek out brands that share their values. Businesses can include social, environmental, and economic factors into their strategy through sustainable marketing, which also encourages innovation and improves relationships with consumers. Companies might remain ahead of the competition by responding to market trends that support eco-friendly practices, customer expectations, and legislative changes by focusing on long-term value creation rather than short-term profit.

In the context of sustainable marketing, integrating various key drivers is essential for companies seeking to maintain a competitive edge. Businesses can improve their brand image and cultivate customer loyalty by focusing on environmental awareness and aligning their operations with growing consumer demand for sustainability. In addition to increasing consumer trust, a solid dedication to sustainability promotes customer retention and improves brand loyalty. Additionally, businesses that adopt sustainable practices frequently achieve significant cost savings by reducing waste and improving resource efficiency, which eventually raises profitability. By placing a strong emphasis on innovation, businesses can embrace new practices and technology that set them apart from competitors and establish them as industry leaders in sustainability. Furthermore, the availability of R&D incentives pushes businesses to explore green technology, strengthening their market position. These strategies establish a strong foundation that allows businesses to succeed in an increasingly environmentally conscious market while fostering positive social and environmental impacts. By using this multidimensional approach, firms can secure long-term success in the changing market landscape by meeting present consumer expectations and anticipating future trends.

According to the outcomes obtained from the proposed decision framework, the environmental management system is the best-performing sustainable marketing strategy, which is a very significant strategy in the FMCG sector, which requires high-volume manufacturing and short life

cycles of the products, and tries to deal with high pressure to achieve sustainable operations. Environmental management systems, named as ISO 14001, have a vital position in allowing FMCG firms to sustain their operations with sustainability goals, while efficiently marketing their commitment to environmental responsibility. From the point of view of sustainable marketing, an environmental management system provides a structured approach that enables companies to align their environmental performance with marketing strategies, enhancing brand value as well as ecological responsibility.

On the other hand, waste management and recycling are ranked second, and thus it is a significant alternative strategy. The FMCG sector is one of the biggest contributors to packaging waste and resource consumption throughout the world. Since environmental concerns are increasing, effective waste management and recycling practices have become significant and strategic not only for regulatory compliance, but also as key pillars of sustainable marketing processes. Incorporating these practices into the marketing process enables FMCG firms to meet consumer expectations, enhance brand loyalty, and obtain a competitive advantage.

6 Concluding Remarks

This paper integrates a 2-tuple representation model into the common weight DEA framework. Ranking of the efficiencies of sustainable marketing strategy alternatives according to their performance ratings and obtaining the most suitable alternative are provided. The proposed combined decision-making methodology deals with information obtained from linguistic as well as numerical scales with multiple information sources. In the selection process, a common weight DEA-based model [11], which provides performance ranking of the decision-making units (DMU) without a priori information and full ranking of the alternatives, is employed. The proposed framework guarantees obtaining the best-performing DMU via solving a single mixed-integer linear programming model.

The contributions of the modeling framework are listed as follows;

1. There is no paper that integrates a 2-tuple representation model in the sustainable marketing field.
2. This paper is novel since it employs DEA in the sustainable marketing strategy selection problem.
3. The proposed DEA-based framework guarantees to yield the best-performing sustainable marketing strategy without requiring any information about the weights of the evaluation criteria and using

common importance weights for all inputs and outputs; hence, a common and non-subjective assessment is provided.

4. There is no other study that integrates a 2-tuple representation model into the mixed-integer linear programming model.

5. The proposed approach helps companies determine marketing strategies prioritizing sustainability in their marketing management processes.

6. This paper has been a guide for marketing managers during sustainability transformation in marketing practices.

The objective of future research will be decision-making approaches in different sectors requiring dealing with hesitation in evaluating data.

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