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Evaluation of Digital Marketing Technologies with Fuzzy Linguistic MCDM Methods

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Abstract: Technology is becoming the tool that changes how people live every day, and the marketing strategies of businesses are also gradually shifting to the industry 4.0 mindset of constant growth and development. Digital marketing has changed human habits of information accessibility, determined their interactions, and witnessed the birth of a variety of new marketing technologies. Marketers are creating digital marketing products and services that enhance the experience for consumers, products, and services that are also delivered through high digital marketing networks. As a result, data sources become more abundant and allow consumers to have more choices. All products, services, technologies, and data are increasingly meeting the needs of consumers, thereby confirming the effectiveness of digital marketing in today's market. However, the evaluation and selection of digital marketing technology is very complex since it has many conflicting criteria and goals. The multi-criteria decision-making model (MCDM) is a powerful technique widely used for solving this type of problem. Thus, the author proposed a fuzzy linguistic MCDM method for evaluation of digital marketing technologies. After determining the evaluation criteria and alternatives, two MCDM methods, including Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), are used in the evaluation and selection of digital marketing technologies procedure. Finally, an application is present to demonstrate the potential use of the proposed methodology. The main contribution of this study is to propose a Spherical fuzzy MCDM model to support planners and decision makers in the digital marketing technology evaluation and selection processes. A case study is also performed to showcase the feasibility of the proposed approach.

Keywords: digital marketing; MCDM; fuzzy theory; SF-AHP; TOPSIS; industry 4.0

MSC: 03E72; 90B50; 90C70; 00A69

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1. Introduction

In late 2019, a new coronavirus was identified as the cause of human illness in Wuhan, China, and given the name "novel coronavirus" (2019-nCoV). Individuals of all ages are at risk of SARS-CoV-2 infection and severe disease. However, the probability of serious COVID-19 disease is higher in people aged ≥60 years, such as those living in a nursing home or long-term care facility and those with chronic medical conditions. In the context of the complicated development of the COVID-19 pandemic, the trend of users accessing the Internet and social networking sites is still developing strongly. As a result, Digital Marketing in Vietnam is becoming more and more popular, gradually occupying an important position in an overall marketing strategy [1].

Looking back at the general development trend of the whole world, with the help of technology, communication activities are also gradually shifting and adapting to the needs of interacting and understanding customers, thereby significantly contributing to promotion and accelerating the sales process of businesses, opening a new development step for the media field in Vietnam today [2]. Many years ago, the marketing industry transitioned from a traditional paradigm to a digital one, resulting in a more sophisticated marketing approach. The previous Marketing model's core was behavioral-based customer targeting, which led to the development of automation. As a result, digital commerce and customer service in cyberspace are possible. Additionally, this can serve as a springboard to fresh demand.

To be more effective, digital marketing must now be supported by digital technology. The following technologies are utilized in digital marketing:

Artificial Intelligence (AI): AI is a branch of computer science; an intelligence created by humans with the goal of helping computers to automate intelligent behaviors like humans. Artificial intelligence has been used in a variety of industries, including labor, health care, security, transportation, and marketing, as technology has advanced. The application of AI in marketing is connected to researching consumer behavior, collecting customer information, and answering customers about the company's offerings [3]. The future of digital marketing will be shaped by artificial intelligence. The power of AI creates new opportunities for digital marketing in the near future. Lots of other productivity techniques, strategies, and levers will be made possible by artificial intelligence [4].

Big data: Big Data is a discipline that deals with methods for analyzing, methodically extracting information, and generally dealing with data volumes that are too big or complicated for typical data-processing application software to handle [5]. Currently, customers are becoming increasingly "fastidious" when making decisions to buy products or use services in any field. With the application of Big Data, businesses can easily approach customers and answer their questions, enabling them to understand the "Insight" of customers in a better way [6].

Machine learning (ML): ML is the study of computer algorithms that may improve automatically via experience and the usage of data. Machine learning will likely have a huge influence on the application of digital marketing in the future. To lead in the technology race, the use of machine learning will improve the effectiveness of Digital Marketing strategy. Machine learning supports collect information about target customers to best serve marketing campaigns. Machine learning can help collect user data, including their behavior, and marketing automation supports the arrangement and grouping of data in the most logical way. The information collected is used to develop strategies to attract and improve customer satisfaction. At the same time, it also helps companies create personalized content suitable for each audience [7].

Augmented/Virtual Reality (AR): With the potential to create a breakthrough in customer experience, from product discovery to purchase decision, Augmented Reality has quickly captured the attention of marketers [8]. AR application brings a new dimension to the online retailer catalog, allowing interaction on online features. Using an AR application allows you to view the product from any angle and can project the product in the three-dimensional space that the customer wants. In other words, AR brings a wide range of shopping options to catalogs and online retailers, providing an effective visual view of the product, leading to a seamless customer shopping experience [9].

Internet of Things (IoT): The IoT accelerates marketing processes and provides businesses with real-time marketing. The time spent on marketing and sales has been decreased as a result of altering marketing methods using the Internet of Things, and the sales process has been faster and easier.

Because there are so many competing criteria and aims, evaluating and selecting digital marketing technologies is quite difficult. The multi criterion decision-making model (MCDM) is a sophisticated approach that is extensively used to solve issues of this nature. Thus, the author proposed a fuzzy linguistic MCDM method, including SF-AHP and TOPSIS models, for evaluation of digital marketing technologies in this research.

Science, technology, and innovation represent a bigger category of activities that are highly interrelated but separate [10]. The primary goal of this study is to propose a fuzzy MCDM model for digital marketing technologies. The evaluation of digital marketing technology alternatives requires several linguistic criteria to be included in the decision process.

The numerical definitions of these criteria are realized by spherical fuzzy sets, incorporating a new point of view to decision making under fuzziness. The independent assignment of membership parameters with larger domains brings novelty to the evaluation process of digital marketing technology alternatives. After determining the evaluation criteria and alternatives, SF-AHP is used for determining the weights of criteria, where the spherical fuzzy sets theory is applied in order to deal with uncertainty in this decision-making environment, and the TOPSIS model is applied for ranking digital marketing technologies.

2. Literature Review

The MCDM model is a study area that involves the examination of numerous accessible options in a circumstance or research topics that include everyday life, social sciences, engineering, medicine, and many other fields. The term MCDM refers to the process of selecting the best opinion from among all viable possibilities. Figure 1 depicts a MCDM process model.

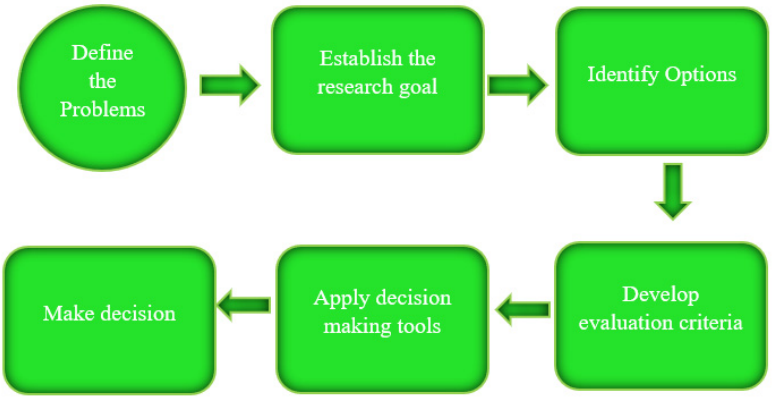

Figure 1. The MCDM model's processes.

Mukul et al. [11] proposed a MCDM model for evaluation and selection of a suitable digital marketing technology. In this research, they applied the AHP model and Complex Proportional Assessment (COPRAS) for ranking digital marketing technologies. Erdoğan et al. [12] presented a fuzzy MCDM model to determine the best cyber security technology. Via fuzzy MCDM process, the author also discussed risk factors in the selection processes.

Chang et al. [13] used a hybrid MCDM framework for evaluating industry 4.0 technology application in SMEs. In this study, the author applied MCDM models, such as the DEMATEL—INRD—VIKOR technique. The results of their research show that the technology aspect is the most influential factor. Samanlioglu et al. [14] proposed MCDM models, including fuzzy FBWM and Fuzzy TOPSIS, for evaluation of a hotel website and digital solutions provider firms.

Imanova and Gunel [15] proposed a framework under Z-environment for the evaluation and selection of optimal digital marketing technologies. The author also presented a numerical example in order to check the validity of the considered framework. Mahdiraji et al. [16] showed marketing strategies' evaluation based on big data analysis. The author applied Best/Worst Method Complex Proportional Assessment methods in this study. Hsieh [17] applied MCDM methodology to verify the co-relationship between social media and service quality in the dynamic m-commerce era. In this study, the fuzzy-set qualitative comparative analysis (FSQCA) approach was hierarchically cross-employed in the compared assessable statistics and measurements of QFD-HOQ model.

Tang et al. [18] proposed the Fuzzy MCDM method for evaluating the propagating Electronic Commerce market strategies. Ajripour [19] used the MCDM Technique in analyzing the effect of promotion items based on online shopping factors. The author applied PROMETHEE II in analyzing the effect of promotion items based on online shopping criteria. Khatwani and Das [20] used the hybrid fuzzy MCDM technique for evaluating the combination of individual pre-purchase internet information channels. The author applied Fuzzy AHP and was employed to identify the weight criteria, and then Fuzzy TOPSIS was used to rank different combinations of pre-purchase channels according to the same demographic parameters.

Joshi et al. [21] did research into enhanced selling on digital space via matching buyer and seller preferences using the fuzzy MCDM method. Büyüközkan et al. [22] introduced a decision framework based on the HFLTS, Hesitant Fuzzy Linguistic (HFL), AHP, and ARAS methods for analysis of companies' digital maturity. Kwak et al. [23] applied the integer goal programming model and the analytic hierarchy process for media selection in the dual consumer/industrial market. The satisfying solution is identified and analyzed, and sensitivity analyses are performed for model flexibility. Kaltenrieder et al. [24] introduced the fuzzy analytical network process (FANP) as a potential multi-criteria-decision-making (MCDM) method to improve digital marketing management endeavors. Lu et al. [25] demonstrated the effectiveness of the hybrid MCDM model for Improving RFID adoption in Taiwan's healthcare industry. In this research, the author applied the DEMATEL model for solving the problems of interdependence and feedback and applied the DEMATEL-based ANP (DANP) and VIKOR models for identify influential weights and gaps based on the TOEC framework. Boopathy et al. [26] presented decision analysis framework in financial marketing using multi-criteria decision-making methods.

3. Methodology

In the past few years, marketing has become a rapidly growing industry. The current trend of Digital Marketing is gradually replacing traditional marketing. Marketing activities are deployed mainly on the Internet and social networks. The MCDM is one of the most popular treaties in the literature among scholars. The term MCDM refers to the process of determining the best opinion from among all possible alternatives. This study's recommended approach consists of three key steps, and the research graph is shown in Figure 2.

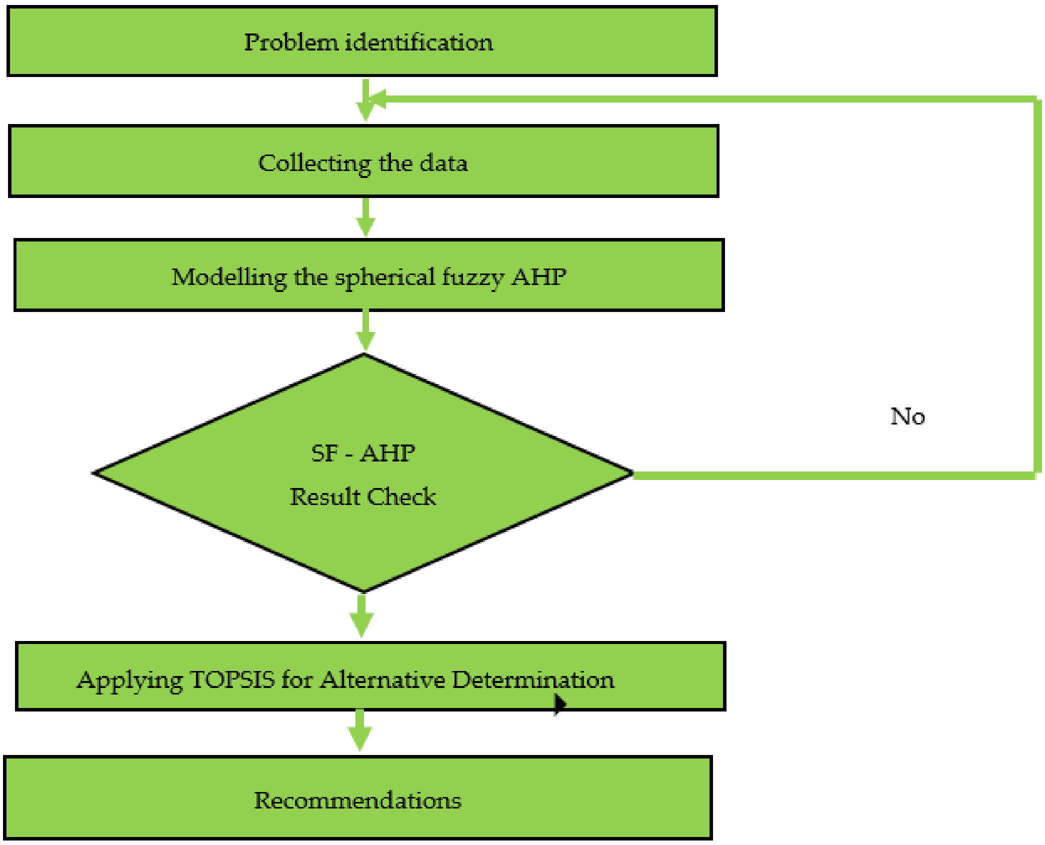

Figure 2. Research Graph.

Step 1. Determining the criteria to evaluate and select digital marketing technology processes.

Step 2. Identifying the weight of criteria via the Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) model.

Step 3. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is based on the idea that the preferred alternative should be the one with the shortest geometric distance from the positive ideal solution (PIS) and the one with the greatest geometric distance from the negative ideal solution (NIS). In the last stage, the TOPSIS approach is used to evaluate digital marketing technologies based on the criteria.

3.1. Theory of Spherical Fuzzy Sets

The Spherical Fuzzy Sets Theory was initially mentioned by Gundogdu and Kahraman [27] as a subset of Neutrosophic Sets Theories [28]. Since its recent inception, the spherical fuzzy sets theory has been used in various researches to construct MCDM models to handle a wide range of decision-making concerns and problems [29]. A spherical fuzzy set's $\widetilde{B}_S$. membership matrix is determined by its membership ($m_{\widetilde{B}_S}(x).$), non-membership ($n_{\widetilde{B}_S}(x)$), and hesitation (($h_{\widetilde{B}_S}(x)$). Each of these parameters can separately have a value between 0 and 1, and the aggregate of their squared values can only be 1.

Within a universe U_1, a spherical fuzzy set $\widetilde{B}_S$ is defined as:

$$\widetilde{B}_S = \left\{ x,\ (m_{\widetilde{B}_S}(x),\ n_{\widetilde{B}_S}(x)\ ,\ h_{\widetilde{B}_S}(x)) | x \epsilon U_1 \right\} \quad (1)$$

with:

$$m_{\widetilde{B}_S}(x)\ :\ U_1 \to [0,1],\ n_{\widetilde{B}_S}(x)\ :U_1 \to [0,1],\ \text{and } h_{\widetilde{B}_S}(x)\ :U_1 \to [0,1]$$

and

$$0 \le\ m^2_{\widetilde{B}_S}(x) + n^2_{\widetilde{B}_S}(x) + h^2_{\widetilde{B}_S}(x) \le 1 \quad (2)$$

with $\forall x \in U_1$.

3.2. Model of the Spherical Fuzzy Analytic Hierarchy Process (SF-AHP)

The SF-AHP approach extends the AHP with spherical fuzzy sets. The SF-AHP approach consists of five stages:

Stage 1: Create the model's hierarchical structure.

The model's hierarchical structure is divided into three tiers. Level 1 is the model's goal, which is derived using a performance index. The score index is determined with n criteria, which is represented in Level 2 of the structure. A set of m alternative B (m $\geq$ 2) is defined in Level 3 of the structure.

Stage 2: As stated in Table 1, create a pairwise comparison matrix of the criteria using spherical fuzzy judgement based on qualitative words and the linguistics measure of importance established by Gundogdu and Kahraman.

Table 1. Linguistic measures of significance.

	(μ, v, π)	**Score Index (PI)**
Absolute high significance (AH)	(0.9, 0.1, 0.0)	9
Very high significance (VH)	(0.8, 0.2, 0.1)	7
High significance (HS)	(0.7, 0.3, 0.2)	5
Slightly high significance (SM)	(0.6, 0.4, 0.3)	3
Equally significance (ES)	(0.5, 0.4, 0.4)	1
Slightly low significance (SL)	(0.4, 0.6, 0.3)	1/3
Low significance (LS)	(0.3, 0.7, 0.2)	1/5
Very low significance (VL)	(0.2, 0.8, 0.1)	1/7
Absolutely low significance (AL)	(0.1, 0.9, 0.0)	1/9

The performance index (PI) of each equation is then calculated using Equations (3) and (4):

$$\mathrm{PI} = \sqrt{\left|100 * \left[\left(\mu_{\widetilde{B}_s} - \pi_{\widetilde{B}_s}\right)^2 - \left(v_{\widetilde{B}_s} - \pi_{\widetilde{B}_s}\right)^2\right]\right|} \quad (3)$$

for absolute high significance, very high significance, high significance, slightly high significance, and equally significance and

$$\frac{1}{\mathrm{PI}} = \frac{1}{\sqrt{\left|100 * \left[\left(\mu_{\widetilde{B}_s} - \pi_{\widetilde{B}_s}\right)^2 - \left(v_{\widetilde{B}_s} - \pi_{\widetilde{B}_s}\right)^2\right]\right|}} \quad (4)$$

for slightly low significance, low significance, very low significance, and absolutely low significance.

Stage 3: Conduct a proper consistency check for each pairwise comparison matrix.

The Consistency Ratio (CR) has a 10% threshold:

$$CR = \frac{CI}{RI} \quad (5)$$

The Random Index (RI) is computed using the number of criteria, and the Consistency Index (CI) is calculated as follows:

$$CI = \frac{\lambda_{max} - N}{N - 1} \quad (6)$$

with λ_{max}. as the matrix's maximum value.

Stage 4: Determine the fuzzy weights of the criteria and choices.

The fuzzy weightings of each choice with regard to each criterion are determined as follows:

$$SWM_w\left(\widetilde{B}_{S1},\ \ldots,\ \widetilde{B}_{SN}\right) = w_1\widetilde{B}_{S1} + \cdots + w_N\widetilde{B}_{SN} =$$
$$\langle\left[1-\prod_{i=1}^{n}\left(1-\mu^2_{\widetilde{B}_{Si}}\right)^{w_i}\right]^{\frac{1}{2}},\ \prod_{i=1}^{n} v^{w_i}_{\widetilde{B}_{Si}},\ \left[\prod_{i=1}^{N}\left(1-\mu^2_{\widetilde{B}_{Si}}\right)^{w_i} - \prod_{i=1}^{n}\left(1-\mu^2_{\widetilde{A}_{Si}} - \pi^2_{\widetilde{A}_{Si}}\right)^{w_i}\right]^{1/2}\rangle \tag{7}$$

with $w = 1/N$.

Stage 5: To determine the total weights, use layer sequencing from highest to lowest.

The choices performance index is computed by adding the fuzzy weights at each level of the model's hierarchical structure. There are two approaches to this:

The first option is to use Equation (8) to de-fuzzify the criterion weights:

$$S\left(\widetilde{w}_j^S\right) = \sqrt{\left|100 * \left[\left(3\mu_{\widetilde{B}_s} - \frac{\pi_{\widetilde{B}_s}}{2}\right)^2 - \left(\frac{v_{\widetilde{B}_s}}{2} - \mu_{\widetilde{B}_s}\right)^2\right]\right|} \tag{8}$$

Then, using Equation (9), normalize the criterion weights as follows:

$$\overline{w}_j^s = \frac{S\left(\widetilde{w}_j^s\right)}{\sum_{j=1}^{n} S\left(\widetilde{w}_j^s\right)} \tag{9}$$

In Equation (10), use spherical fuzzy multiplication:

$$\widetilde{B}_{S_{ij}} = \overline{w}_j^s * \widetilde{B}_{S_i} = \langle\left(1-\left(1-m^2_{\widetilde{B}_S}\right)^{\overline{w}_j^s}\right)^{\frac{1}{2}},\ n^{\overline{w}_j^s}_{\widetilde{B}_S},\ \left(\left(1-m^2_{\widetilde{B}_S}\right)^{\overline{w}_j^s} - \left(1-m^2_{\widetilde{B}_S} - h^2_{\widetilde{B}_S}\right)^{\overline{w}_j^s}\right)^{\frac{1}{2}}\rangle \tag{10}$$

For each choice B_i, the final performance index ($\widetilde{P}$) is calculated:

$$\widetilde{P} = \sum_{j=1}^{N} \widetilde{B}_{S_{ij}} = \widetilde{B}_{S_{i1}} + \widetilde{B}_{S_{i2}} + \cdots + \widetilde{B}_{S_{iN}} \quad . \tag{11}$$

The second method is to execute the computation without de-fuzzifying the weights of the criterion. The spherical fuzzy global weights are computed as follows:

$$\prod_{j=1}^{N} \widetilde{B}_{S_{ij}} = \widetilde{B}_{S_{i1}} * \widetilde{B}_{S_{i2}} * \ldots * \widetilde{B}_{S_{iN}} \tag{12}$$

The final performance index ($\widetilde{P}$) for each option B_i is determined using Equation (11).

3.3. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS was initially suggested by Hwang et al. in 1981. A typical TOPSIS procedure consists of the five phases shown below [30]:

Stage 1: Create the normalized choice matrix:

$$g_{ij} = \frac{\mathrm{X_{ij}}}{\sqrt{\sum_{\mathrm{i=1}}^{\mathrm{m}} \mathrm{X_{ij}^2}}} \tag{13}$$

where $\mathrm{X_{ij}}$. is the decision matrix's original score and g_{ij} is the decision matrix's normalized score.

Stage 2: Calculate the normalized weight matrix:

$$o_{ij} = h_j g_{ij} \tag{14}$$

where the weight of the j^{th} criteria is represented by h_j.

Stage 3: Positive ideal solution (PIS) and Negative ideal solution (NIS) matrices are defined as follows:

$$\begin{aligned} O^{+} &= o_1^{+},\ o_2^{+}, \ldots, o_n^{+} \\ O^{-} &= o_1^{-},\ o_2^{-}, \ldots, o_n^{-} \end{aligned} \quad (15)$$

Stage 4: Using the PIS and NIS matrices, compute the performance difference between the values of each option.

Each option's distance to PIS is computed as follows:

$$\begin{aligned} &D_i^{+} = \sqrt{\sum_{j=1}^{m} \left(o_i^{+} - o_{ij}\right)^2}\ ; \\ &i = 1,\ 2,\ \ldots,\ m \end{aligned} \quad (16)$$

Each option's distance to NIS is computed as follows:

$$D_i^{-} = \sqrt{\sum_{j=1}^{m} \left(o_{ij} - o_i^{-}\right)^2}\ ;\ i = 1,\ 2,\ \ldots,\ m \quad (17)$$

using the i^{th} option, with D_i^{+} as the distance to the PIS and D_i^{-} as the distance to the NIS

Additionally, with D_i^{+} as the distance to the PIS and D_i^{-} as the distance to the NIS for the i^{th} option.

Stage 5: Each option's preference value (V_i) is determined as follows:

$$V_i = \frac{D_i^{-}}{D_i^{-} + D_i^{+}} \qquad i = 1,\ 2,\ \ldots,\ m \quad (18)$$

Finally, the V_i values are utilized to rank and analyze the various options.

4. Case Study

In this research, a fuzzy linguistic MCDM method for evaluation of digital marketing technologies included Artificial Intelligence (A1), Big Data (A2), Machine Learning (A3), Augmented/Virtual Reality (A4), and the Internet of Things (A5). Based on experts opinions and literature reviews, there are three sub-criteria of this, and each main criterion is shown in Figure 3.

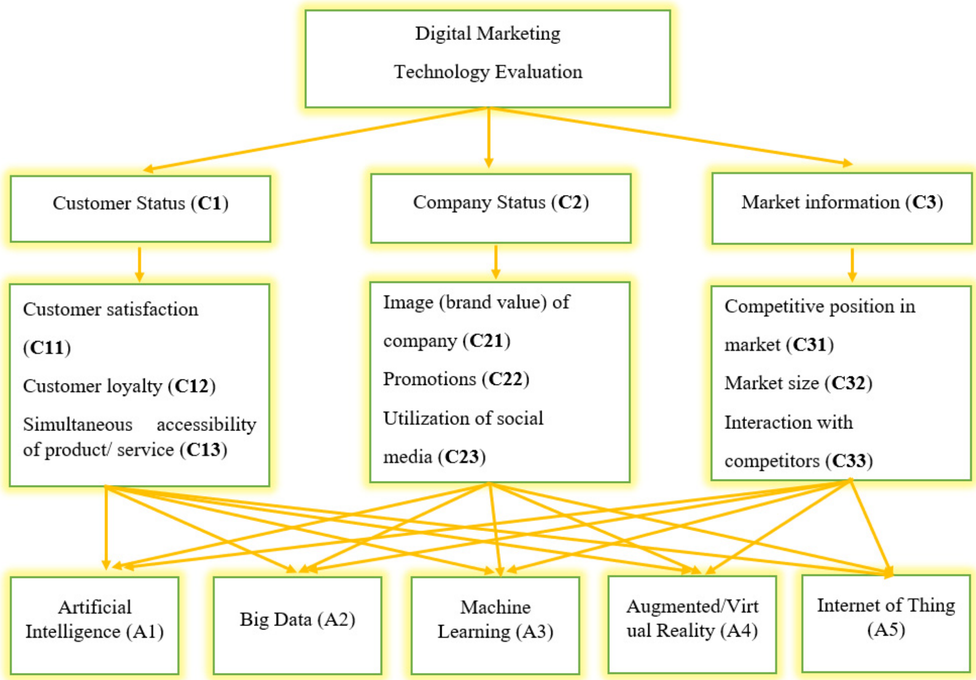

Figure 3. The devised AHP model for the evaluation process.

The Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) method was introduced by Gundogdu and Kahraman and is an extension of AHP with spherical fuzzy sets. In this paper, SF-AHP was employed to determine the DC selection criteria weights. All inputs data were defined by 15 experts (Marketing manager, IT manager, . . .). Based on linguistic measures of significance (Table 1), some information about the experts is shown in Table 2. Input data and results from the SF-AHP model is shown in Tables 3 and 4.

TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the PIS and the longest geometric distance from the NIS. In this stage, the TOPSIS model is applied for evaluation and ranking of digital marketing technologies. Normalized matrix and normalized weighted matrix are shown in Tables 5 and 6.

Table 2. The professionals interviewed.

Category	Profile	No. of Experts
Education level	BSc in Marketing/BSc in Information technology/Business administration	9
	MSc in Marketing/BSc in Information technology/Business administration	4
	PhD in Marketing/BSc in Information technology/Business administration	2
Work Experience	Between five to ten years	3
	More than ten years	12
Age	Between 20- to 30-year-old	1
	More than 30-year-old	14

Table 3. Initial comparison matrices.

	Left Criteria Is Greater				Right Criteria Is Greater				
Dimension	**AH**	**VH**	**HS**	**SM**	**ES**	**SL**	**LS**	**VL**	**AL**	**Dimension**
C11		4	3	2	1	3	1	1		C12
C11				4	3	2	1	5		C13
C11			3	2	1	4	5			C21
C11		3	4	1	1	3	2	1		C22
C11			3	4	4	2	1	1		C23
C11			3	3	3	4	1	1		C31
C11			2	3	4	1	2	3		C32
C11			3	4	1	1	3	3		C33
C12			3	4	3	3	2			C13
C12		1	3	4	5	1	1			C21
C12		2	3	4	5	1				C22
C12				2	3	4	5	1		C23
C12		3	4	5	2	1				C31
C12				3	4	5	2	1		C32
C12			3	4	2	5	1			C33
C13				3	4	5	2	1		C21
C13			2	4	2	1	5	1		C22
C13		3	4	3	2	2	1			C23
C13			1	3	4	4	3			C31
C13			1	4	3	3	4			C32
C13		3	2	2	4	2	2			C33
C21				4	5	4	1	1		C22
C21		3	3	4	2	1	1	1		C23
C21			4	2	3	1	1	4		C31
C21		3	3	4	2	2	1			C32
C21		4	5	1	3	2				C33
C22			4	3	3	1	1	3		C23
C22		2	2	2	4	2	3			C31
C22			3	4	3	3	2			C32
C22		2	2	3	4	3	1			C33
C23				4	3	4	2	2		C31
C23			4	5	1	1	2	2		C32
C23				3	4	4	1	3		C33
C31		3	4	3	2	3				C32
C31			2	3	4	5	1			C33
C32			3	4	5	2	1			C33

Table 4. Results from the SF-AHP model.

Criteria	Spherical Fuzzy Weights			Crisp Weights
C11	0.439	0.533	0.324	0.092
C12	0.425	0.545	0.319	0.089
C13	0.395	0.597	0.281	0.084
C21	0.462	0.532	0.288	0.099
C22	0.487	0.499	0.296	0.105
C23	0.538	0.455	0.293	0.117
C31	0.574	0.414	0.282	0.126
C32	0.616	0.379	0.267	0.137
C33	0.667	0.330	0.253	0.150

Table 5. Normalized matrix.

	A1	A2	A3	A4	A5
C11	0.54976	0.42759	0.30542	0.48868	0.42759
C12	0.61667	0.34259	0.47963	0.20556	0.47963
C13	0.44630	0.25503	0.57382	0.51006	0.38255
C21	0.53692	0.20135	0.53692	0.13423	0.60404
C22	0.52489	0.40825	0.46657	0.34993	0.46657
C23	0.44540	0.50903	0.44540	0.38177	0.44540
C31	0.53882	0.47895	0.41908	0.41908	0.35921
C32	0.48242	0.42212	0.48242	0.42212	0.42212
C33	0.53882	0.41908	0.41908	0.47895	0.35921

Table 6. Normalized weighted matrix.

	A1	A2	A3	A4	A5
C11	0.05073	0.03946	0.02818	0.04509	0.03946
C12	0.05504	0.03058	0.04281	0.01835	0.04281
C13	0.03728	0.02130	0.04793	0.04260	0.03195
C21	0.05330	0.01999	0.05330	0.01332	0.05996
C22	0.05514	0.04288	0.04901	0.03676	0.04901
C23	0.05228	0.05975	0.05228	0.04481	0.05228
C31	0.06814	0.06057	0.05300	0.05300	0.04543
C32	0.06610	0.05784	0.06610	0.05784	0.05784
C33	0.08069	0.06276	0.06276	0.07172	0.05379

The 4.0 technology revolution opens a new era for the marketing industry: moving from traditional to digital technology. It means that consumers have become more powerful and have more choices, so businesses need to change their sales and marketing thinking accordingly. Marketing technology 4.0 is a form of marketing with interaction between online and offline businesses and customers. In today's digital age, businesses must completely change the way they approach customers, specifically analyzing needs, sales, marketing, customer care, and so on, to match the modern day. Digital Marketing offers fair competition opportunities for all types of businesses, allowing them o advertise their brands in an online environment. No longer the same as before, when there were only large companies; new multinationals are able to grasp and apply Digital Marketing in business. Currently, the role of Digital Marketing for small and medium businesses is very important because it helps businesses achieve efficiency and improve business results.

In this study, the author proposed a fuzzy linguistic MCDM method for evaluation of digital marketing technologies, including Artificial Intelligence, Big data, Machine learning, Augmented/Virtual Reality, and Internet of Things. As shown in Table 7 and Figure 4, Artificial Intelligence (A1) has become the most appropriate digital marketing technology among five alternatives, with a final score value of 0.8342. To compare results obtained using traditional TOPSIS with equal weights and the proposed MCDM model, we have shown the result in Table 8.

Table 7. Ranking score.

Alternatives	Si+	Si-	Ci
A1	0.0146	0.0735	0.8342
A2	0.0602	0.0299	0.3314
A3	0.0367	0.0576	0.6108
A4	0.0672	0.0334	0.3322
A5	0.0440	0.0567	0.5635

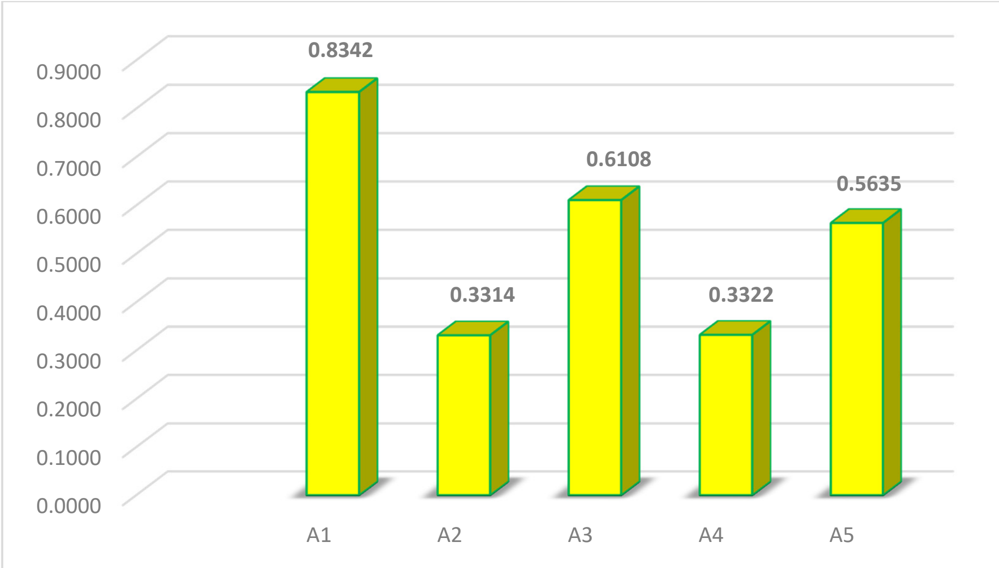

Figure 4. Digital marketing technologies ranking list.

Table 8. Comparing results with TOPSIS with equal weights Ci value.

Alternatives	TOPSIS with Equal Weights Ci Value	Rank	Proposed MCDM Model Ci Value	Rank
A1	0.8222	1	0.8342	1
A2	0.3061	5	0.3314	5
A3	0.6372	2	0.6108	2
A4	0.3334	4	0.3322	4
A5	0.6058	3	0.5635	3

As shown in Table 8, the ranking of alternatives is the same between traditional TOPSIS with equal weights and the proposed MCDM model. However, the traditional TOPSIS model has some disadvantages, such as correlations between criteria, uncertainty in obtaining the weights only by objective methods or subjective methods, and the possibility of alternative closed to ideal point and nadir point concurrently. This is one of the reasons why the author integrated the SF-AHP and TOPSIS models in this paper: to assist corporates in decision making due to its flexibility in analytical ranking, especially for the digital marketing industry.

5. Conclusions

Today, there are many technologies applied in the field of digital marketing, and businesses must choose a technology that is suitable for their organization. However, the evaluation and selection of digital marketing technologies is very complex since it has many conflicting criteria and goals. Therefore, the author proposed a fuzzy linguistic MCDM method for evaluation of digital marketing technologies. After determining the evaluation criteria and alternatives, two MCDM methods, including SF-AHP and TOPSIS models, were used in the evaluation and selection of digital marketing technologies. Finally, an application is presented to demonstrate the potential use of the proposed methodology. The most significant contributions in this study can be described as follows:

- ✓ The proposed fuzzy MCDM model is the first digital marketing technology selection model in Vietnam. We discovered this by interviewing experts and reviewing the literature.
- ✓ Second, this is the first study to provide a case study on evaluating marketing technology utilizing the approach proposed by the combination of SF-AHP and TOPSIS models.

✓ The results of this study can be valuable guidance in the alternatives assessment and selection sector, not only for the marketing sector but also for decision-makers and investors in other industries.

For future research, the digital marketing technology evaluation model can be improved by increasing the number of criteria and alternatives or by using different decision-making methods, such as MAIRCA, COPRAS, and LINMAP models, for comparing the results.

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