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A new ranking approach for E-commerce websites based on fuzzy TOPSIS algorithm

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ABSTRACT

With the gigantic growth of the E-commerce market, E-commerce websites are becoming more and more numerous. Customers of E-commerce websites are spoiled for choice and have encountered several problems in choosing not only the right products but also the E-commerce website from which they want to purchase the desired products. E-commerce websites ranking is recognized as a complex multi-criteria decision-making (MCDM) problem. In practice, clients of E-commerce websites generally have difficulty expressing their judgments in precise numbers because the criteria are sometimes imprecise and sometimes uncertain and ambiguous. In this context, we propose to use fuzzy logic to allow clients to express their ratings in natural language and propose an approach based fuzzy technique for order preference by similarity to the ideal solution (TOPSIS) for E-commerce websites ranking. A numerical experimentation was conducted for validate the effectiveness of the proposed approach.

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1. INTRODUCTION

Multi-criteria decision-making (MCDM) is an operations research sub-discipline that allows for the explicit assessment of several conflicting criteria in decision-making. It leads to better considered, justifiable, explainable and transparent decisions, because it allows to deal simultaneously and in a transparent way of often contradictory and contradictory points of view [1]. Structuring a complex problem well and considering multiple criteria explicitly leads to more informed and better decisions. The actual application of multicriteria decision making requires the processing of imprecise, uncertain, and qualitative or fuzzy data. An efficient way to model uncertainty and imprecision is to use fuzzy logic and more specifically fuzzy set theory. Fuzzy sets provide the flexibility to represent and manage uncertainty and imprecision resulting from a lack of knowledge or ill-defined information [2]. Ranking E-commerce websites and providing customers with the best fit for them automatically comes down to solving an MCDM problem (several alternatives with several common criteria). The ranking of E-commerce websites is considered as a complex MCDM problem. Several works such as [3] have addressed this problem by relying on MCDM methods.

On another side, it is sometimes difficult to define with precision the criteria of quality of service because the qualities of the services related to a set of E-commerce websites are imprecise and sometimes uncertain and ambiguous, therefore, it is therefore preferable that quality of service (QoS) properties are in linguistic terms (bad, average good, and excellent). This presentation makes it easier for customers and experts to evaluate different alternatives. Fuzzy logic comes to enable this presentation as it supports the representation of imprecise QoS constraints. In this study, we present a new ranking approach for E-commerce websites based on fuzzy technique for order preference by similarity to the ideal solution (TOPSIS) algorithm. More precisely, we focus on the fuzzy TOPSIS method to assess and rank E-commerce websites.

This paper is organized is being as: section 2 presents some related work. Section 3 describes web sites E-commerce criteria evaluation. In the sections 4 and 5 we present successively membership function and fuzzy TOPSIS method. In section 6, we present our proposed approach. Before concluding we detail in section 7, a numerical illustration with the obtained experimentation results. Finally, section 9 presents a conclusion and future directions of this work.

2. RELATED WORK

Awasthi *et al*. [4], tackled the problem of environmental performance of suppliers, to resolve it they propose an evaluation using an approach based on fuzzy multi-criteria. The mentioned solution composed by three steps: (i) involves the identification of criteria for assessing environmental performance of suppliers; (ii) the experts evaluate each of the selected criteria using linguistic assessments then evaluate the different alternatives according to each criterion evaluated previously; (iii) through fuzzy TOPSIS method they combine the resulted alternatives to generate an overall performance score, then the authors select the best alternative with the highest score.

Order to achieve the high level of durable security in web applications, the authors propose the fuzzy analytic hierarchy process (AHP) method to assess the effectiveness of overall durable security and its characteristics [5]. Bire *et al*. [6] presented research that aims to create a decision support system for selecting tourist attractions using the fuzzy AHP method. Sahu *et al*. [7] proposed a method based on the two fuzzy MCDM method AHP and TOPSIS to ensure the sustainability of web applications.

Pattnaik *et al*. [8] proposed a method of selection of the best insurance company for buy a term plan online. They opted for the fuzzy TOPSIS method to make the selection. In their experiments, they test their approach for twelve (alternative) companies characterized by ten criteria, each of which is expressed in linguistic terms (very low, low, medium, high, and very high).

Kumar *et al*. in [9] focussed on the security and usability of web applications to satisfy the end user. They propose a fuzzy AHP-TOPSIS based method to assess the usability and security of the web application and also identify the attribute with the highest priority in building the usable security of the web application. Fuzzy AHP is used to calculate the weights of each criterion while fuzzy TOPSIS is used to assigning scores.

Zhao and Bose [10] confirmed that it is possible to apply MCDM methods with fuzzy logic in order to deal with imprecision in decision-making problems. The authors describe the famous methods MCDM such as fuzzy AHP, fuzzy analytic network process (ANP), fuzzy TOPSIS, fuzzy preference ranking organization method for enrichment evaluation (PROMETHEE), and combined fuzzy MCDM methods. The authors focus on the application of these methods in the field of energy. Rouyendegh *et al*. [11] proposed a new framework which combine two methods analytic hierarchy process (AHP) and fuzzy TOPSIS technique. The authors invent this solution to asses and evaluate E-commerce web site (EWS) performance. The proposed idea composed by five steps. In their case study, they test the model with three E-commerce websites, each of which is characterized by four criteria which are: system quality, information quality, service quality, and attractiveness.

3. E-COMMERCE WEBSITES CRITERIA EVALUATION

Sulova [12] presented two basic types for evaluating E-commerce websites. The functionality of E-commerce website and the E-commerce website as a marketing tool. The first family includes several criteria such as structure and design of the catalog of products or services, registration system and data transfer security while the second family presents a lot of criteria such as site content, graphic design of the website, and organization and navigation of the site.

Merwe and Bekker [13] proposed a framework for evaluating E-commerce websites. It consists of five categories of criteria that serve as an evaluation framework covering all relevant aspects of the E-commerce website. These categories of criteria are; Interface: it contains graphic design principles, graphic and multimedia, style and text and flexibility and computability. Navigation: it contains logical structure, ease to use, search engine, and navigational necessities. Content: it contains product/service-related information, company and contact information, information quality, and interactivity. Reliability: it contains stored consumer profile, order process, after-order to order receipt, and consumerservice. Technical: it contains speed, security, software and dataset and system design.

Zo and Ramamurthy [14] proposed a consumer selection model of websites in a business to consumer (B2C) environment the in which the author offers three of the criteria for choosing B2C E-commerce websites. The author classify factors for choosing B2C E-commerce web sites in three major categories: products characteristics, website characteristics and user (consumer) characteristics. Huizingh in [15], the author distinguishes between the content and the design of an E-commerce website, content includes: information content, since the main purpose of the site is to provide commercial information on both thecompany and the product, as well as other information. Transactional content including ordering and tendering, the size of which is directly related to the size ofthe website.

As for website design, it includes navigation tree, hyperlinks and search functions. Liang *et al*. [16] described another criteria for E-commerce website evaluation. It details four criteria efficiency, system availability, fulfilment, and privacy. Each one is described by a set of information. For example system availability criterion has got four sub-criteria which are: the website is always available; the website launches and runs immediately; the website does not crash; pages in this website do not freeze after the entry of order information.

4. MEMBERSHIP FUNCTION

In fuzzy logic, to present the variables in linguistic terms, we use membership functions. In practice, membership functions can have several different types, such as [10]: triangular, trapezoidal, gaussian, two-sided gaussian, bell-shaped, sigmoid-right, sigmoid-left, and polynominal-Z. The exact type depends on the actual applications. In this paper, we focus much more on the triangular fuzzy number function since this type is close to human reasoning.

4.1. Fuzzy triangular number

The rating of criteria, weights and alternatives are represented in linguistic values such as: very low, low, medium, high, and very high. To manage the imprecision of such an assessment, we use fuzzy logic and more precisely triangular fuzzy sets. The use of this presentation is justified by the fact that the translation of human expertise to this type of fuzzy number is easier.

A triangular fuzzy number $\widetilde{N}$ is defined by a triplet (l, m, u) and the membership function $\mu_{\widetilde{N}}(x)$ is defined by is defined as [17]:

$$\widetilde{N} = \begin{cases} 0 \; if \; x < a \\ \dfrac{x-a}{b-a} \; if \; a \leq x \leq b \\ \dfrac{c-x}{c-b} \; if \; b \leq x \leq c \\ 0 \; if \; x > c. \end{cases}$$

Where a, b, c are real numbers and $(a < b < c)$.
A fuzzy triangular membership function has the following form Figure 1:

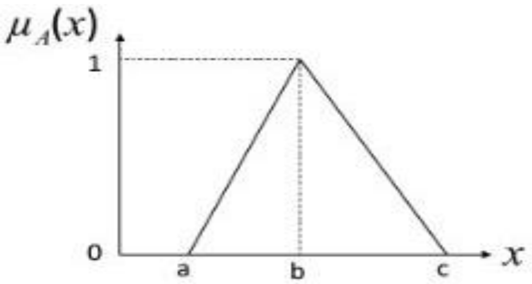

Figure 1. Fuzzy triangular membership function

5. FUZZY TOPSIS METHOD

The technique called fuzzy TOPSIS can be used to assess multiple alternatives against multiple conflicting criteria. The TOPSIS technique is an MCDM method that was initially proposed by [18], [19] subsequently introduced a fuzzy TOPSIS. Fuzzy TOPSIS is used when we want to solve an MCDM problem whose criteria and alternatives are evaluated with linguistic values. The optimal solution in classical TOPSIS approach is close to the fuzzy positive ideal solution (FPIS) and extreme from the fuzzy negative ideal solution (FNIS) [20], [21].

Using fuzzy TOPSIS gives a profit to evaluate human opinion which consist of distinguishes between the interest (the better) and the cost (the less is the better) category criteria then chose the solutions close to the positive ones and far from the negative ones [4]. The previous version of TOPSIS stand on numerical values for both criteria weights and the alternatives. This presentation lead to ambiguity of understanding the human opinions which are vague and cannot be evaluated with exact numbers. To resolve the mention problem in TOPSIS, the experts combine it with fuzzy which is a set of MCDM approaches [22]. Fuzzy TOPSIS method has shown its powers in several areas and almost present in the majority of real world applications. Fuzzy TOPSIS is used in many real life applications [23]: energy, health, performance evaluation, personal selection, networks, health care, construction, business, manufacturing, and stock exchange.

6. PROPOSED APPROACH

The proposed approach is described is being as: before applying fuzzy TOPSIS method to choose the best web site E-commerce, it is important to follow the following steps; Form a committee of experts: we assume that we are a group of k experts (E_1, E_2, .., E_k) with $m$possible E-commerce websites which are evaluated against n criteria (C_1, C_2, .., C_n). These experts can be decision-makers just as they can be experts in the field of E-commerce. Identification of linguistic terms to assess criteria and websites E-commerce by the experts. Linguistic evaluation of E-commerce websites by customers. Application the fuzzy TOPSIS method. Final ranking. The following Figure 2 shows the detail of our proposed approach:

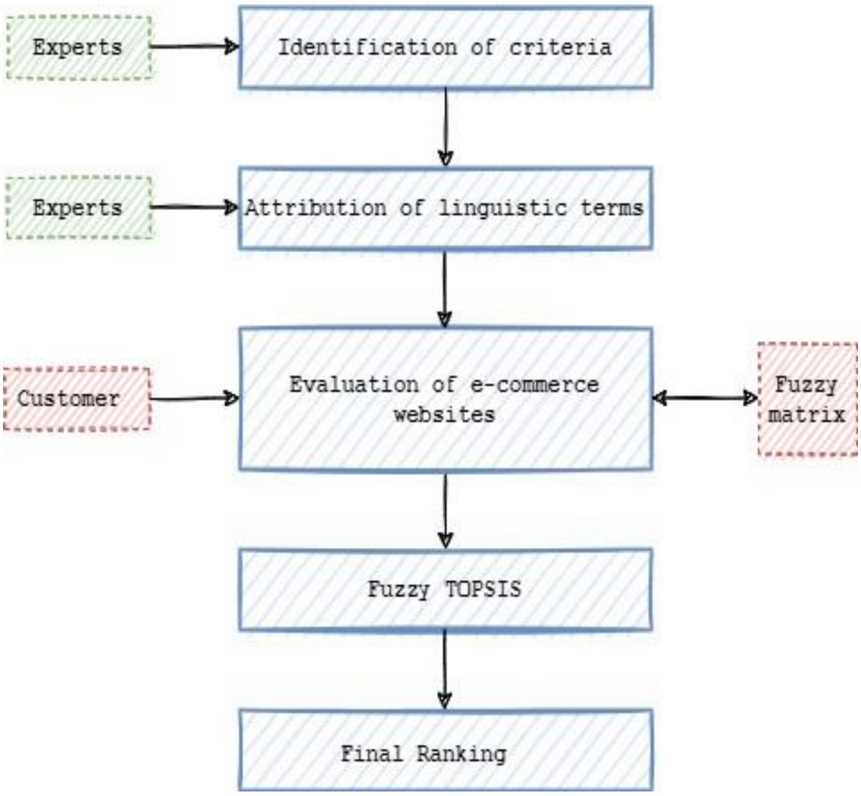

Figure 2. Proposed approach

6.1. Identification criteria

This step makes it possible to identify the set of criteria to be used to evaluate the SWEs. This task is principal. it is attributed to the experts since they are the ones who know the field of E-commerce. For this, it is important to choose the most influential criteria on the ranking of E-commerce websites.

6.2. Attribution of linguistic terms

This task is developed by the experts, it makes it possible, on the one hand, to identify the possible linguistic values for the quality of service criteria. These values will help the experts to assign weights for each criteria. On the other hand, to identify the possible linguistic values that can be used by consumers to evaluate E-commerce websites according to each criterion.

6.3. Evaluation of E-commerce websites

This step allows consumers to evaluate E-commerce websites. Each consumer evaluates each site according to all the criteria initially defined by the experts.

6.4. Fuzzy technique for order preference by similarity to the ideal solution for E-commerce websites ranking

The fuzzy TOPSIS method is mainly based on the work of Chen [24], the steps of fuzzy TOPSIS as presented as shown in, [25]-[27]:

- Step 1: construct the decision matrix

We suppose that we have a group of k experts and n E-commerce websites which are evaluated according to the criteria cj(j=1,2..,3). The evaluation of expert kth for the E-commerce website Ai according to the criterion Cj is noted:

$$\tilde{X}_{ij}^{k} = \left(a_{ij}^{k}, b_{ij}^{k}, c_{ij}^{k}\right).$$

The weigths of the criterion is C_j is noted. $\widetilde{W}_{ij}^{k} = \left(w_{j1}^{k}, w_{j2}^{k}, w_{j3}^{k}\right)$. The aggregated fuzzy values x_{ij} of the E-commerce websites for each criterion are given by: $X_{ij} = (a_{ij}, b_{ij}, c_{ij})$ where $a_{ij} = \min_{k}\{a_{ij}^{k}\}$, $b_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ij}$ and $c_{ij} = \max_{k} c_{ij}^{k}$. The aggregated fuzzy weights w_{ij} for each criterion is calculated by:

$$w_{ij} = \min_{k}\{w_{j1}^{k}\},\ w_{j2} = \frac{1}{k}\sum_{k=1}^{k} w_{j1}\ and\ w_{3j} = \max_{k} w_{j1}^{k}$$

- Step 2: construct the normalized matrix

The normalized fuzzy matrix $\tilde{R}$ is given by:

For positive criteria: $\tilde{r}_{ij} = (\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*})\ and\ c_j^* = \max_{i}\{c_{ij}\}$

For negative criteria criteria: $\tilde{r}_{ij} = (\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{c_{ij}})\ and\ c_j^* = \min_{i}\{a_{ij}\}$

- Step 3: construct the weighted normalized matrix

The weighted normalized matrix is given by:

$\tilde{V} = [\tilde{v}_{ij}]_{mxn}$ where $\tilde{v}_{ij} = \tilde{r}_{ij}.w_{ij}$

– Step 4: calculate the fuzzy ideal and fuzzy negative ideal solution

The FPIS is calculated by: $A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \tilde{v}_3^*)$ where $\tilde{v}_j^* = \max_{i}\{v_{ij3}\}$

The FNIS is calculated by: $A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \tilde{v}_3^-)$ where $\tilde{v}_j^* = \min_{i}\{v_{ij1}\}$

- Step 5: calculate the fuzzy distance for each E-commerce website

$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*)$ where $i = 1,2,3, \dots, m$

$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-)$ where $i = 1,2,3, \dots, m$

- Step 6: calculate the relative closeness to the ideal solution

This coefficient represents the distance of the positive ideal solution A^* and the negative ideal solution A^-:

$$CC_i = \frac{d_i^*}{d_i^- + d_i^*}$$

- Step 7: rank the alternatives

7. NUMERICAL ILLUSTRATION

To demonstrate the feasibility of our approach, we provide an illustrative example. The example is described in Table 1, we have four imaginary E-commerce websites: wse1, wse2, wse3, and wse4. These E-commerce websites are evaluated according to ten criteria (c1 to c10) whose the criteria from c1 to c8 are positive criteria, while the two criteria c9 and c10 are negative criteria. This operation passes with several steps: (i) linguistic term for criteria ratings : According to the different experts, each criterion can take one of the linguistic values presented in Table 1, the linguistic terms and the triangular fuzzy numbers are values are taken from the work [28]; (ii) linguistic assessment of criteria : each expert gives the importance of each criterion. The aim of this step is to calculate the weight of each criterion Table 2; (iii) criteria weights: the weight of each criterion is given by Table 3; (iv) linguistic assessment of the E-commerce websites: each customer (cus) assesses with a linguistic value each E-commerce website according to all the criteria. We obtain the linguistic assessment of the E-commerce websites Table 4; (v) in this step the previous table (see Table 5) presents the Aggregate Fuzzy matrix which explains the translation of calculated values from previous Tables; (vi) next step normalized fuzzy matrix, we give a meaning to each value by defining an interval for each criterion (Table 6); (vii) then we pass directly to step 7 which will calculate the weighted normalized matrix given in Table 7; (viii) the ideal positive fuzzy solution and the ideal negative fuzzy negative solution are illustrated in Table 8. After preparting the above mentioned tables, we pass directly to the last satges which consists of the fuzzy distance for each E-commerce website. The final step shows the closeness coefficient to classify the web site according to their respective distance.

Table 1. Linguistic term for criteria ratings

Linguistic term	Triangular fuzzy number
Very low (VL)	(1,1,3)
Low (L)	(1,3,5)
Medium (M)	(3,5,7)
High (H)	(5,7,9)
Very high (VH)	(7,9,9)

Table 2. Linguistic assessment of criteria

Criteria	Expert		
	E1		E1
C_1	H	C_1	H
C_2	VL	C_2	VL
C_3	H	C_3	H
C_4	VH	C_4	VH
C_5	VL	C_5	VL
C_6	VH	C_6	VH
C_7	VH	C_7	VH
C_8	L	C_8	L
C_9	VL	C_9	VL
C_{10}	M	C_{10}	M

Table 3. Criteria weights

Criteria	Fuzzy weight
C_1	(5,7,0000,9)
C_2	(1,4,3333,9
C_3	(1,6,3333,9)
C_4	(5,8,3333,9)
C_5	(1,3,6667,9)
C_6	(1,6,3333,9)
C_7	(1,5,6667,9)
C_8	(1,5,6667,9)
C_9	(1,5,0000,9)
C_{10}	(1,4,3333,9)

Table 4. E-commerce websites linguistic assessment

Criteria		wse_1			wse_2			wse_3			wse_4	
	Cus_1	Cus_2	Cus_3	Cus_1		Cus_1	Cus_2	Cus_3	Cus_1		Cus_1	Cus_2
C_1	P	F	P	VP	C_1	P	F	P	VP	C_1	P	F
C_2	VG	VG	G	VG	C_2	VG	VG	G	VG	C_2	VG	VG
C_3	F	G	VG	VP	C_3	F	G	VG	VP	C_3	F	G
C_4	VP	VG	VG	G	C_4	VP	VG	VG	G	C_4	VP	VG
C_5	VG	G	VG	P	C_5	VG	G	VG	P	C_5	VG	G
C_6	P	VP	F	G	C_6	P	VP	F	G	C_6	P	VP

Table 5. Fuzzy matrix

	wse_1	wse_2	wse_3	wse_4
C_1	(1, 3.66667, 7)	(1,5,9)	(5, 8.3333,9)	(1, 6.3333,9)
C_2	(5, 8.33333,9)	(1, 5.6667,9)	(1, 1.6667,5)	(1,3,5)
C_3	(3,7,9)	(1,2.3333,5)	(1, 4.3333,9)	(1,7,9)
C_4	(1,7,9)	(1, 4.33333,9)	(3,7,9)	(1,1,3)
C_5	(5, 8.33333,9)	(1,5,9)	(1,1,3)	(1, 6.3333,9)
C_6	(1,3,7)	(1, 4.33333,9)	(3, 6.3333,9)	(1,3,7)
C_7	(1, 4.33333,9)	(1, 6.3333,9)	(1, 5.6667,9)	(1,5,9)
C_8	(1,3,9)	(1,8.3333,9)	(1,5,9)	(1,5,9)
C_9	(1, 6.33333,9)	(1, 4.33333,9)	(1, 3.6667,7)	(1, 6.3333,9)
C_{10}	(7,9,9)	(1, 5,6667,9)	(1, 5,6667,9)	(1, 3.6667,9)

Table 6. Normalized fuzzy matrix

	wse_1	wse_2	wse_3	wse_4
C_1	(0.111,0.407,0.778)	(0.111,0.556,1)	(0.556, 01926,1)	(0.111,0.704,1)
C_2	(0.556, 0.926,1)	(0.111,0.630,1)	(0.111, 01185, 0,556)	(0.111,0.333,0.556)
C_3	(0.333, 0.778,1)	(0.111,0.259,0.556)	(0.111, 0.481,1)	(0.333,0.778,1)
C_4	(0.333, 0.778,1)	(0.111,0.481,1)	(0.333, 0.778,1)	(0.111,0.111,0.333)
C_5	(0.556, 0.926,1)	(0.111,0.556,1)	(0.111, 0.111, 0,333)	(0.111,0.407,1)
C_6	(0.111, 0.333,0.778)	(0.111,0.481,1)	(0.333, 0.704,1)	(0.111,0.333,0.778)
C_7	(0.111, 0.481,1)	(0.111,0.704,1)	(0.111, 0.630,1)	(0.111,0.556,1)
C_8	(0.111, 0.333,1)	(0.556,0.926,1)	(0.111, 0.556,1)	(0.111,0.556,1)
C_9	(0.111, 0.158,0.333	(0.111,0.231,1	(0.143, 0.273,1)	(0.111,0.158,1)
C_{10}	0.111,0.111,0.143	(0.111,0.176,1	(0.111, 0.176,1)	(0.111,0.273,1)

Table 7. Weighted normalized fuzzy matrix

	wse_1	wse_2	wse_3	wse_4
C_1	(0.556, 4.926,7)	(0.556, 3.889,9)	(2.778, 6.481,9)	(0.556, 4.926,9)
C_2	(0.556, 4.012,9)	(0.111, 2.728,9)	(0.111, 0.802,5)	(0.111, 1.444,5)
C_3	(0.333, 4.926,9)	(0.111, 1.642,9)	(0.111, 3.049,9)	(0.333, 4.926,9)
C_4	(0.556, 6.481,9)	(0.556, 4.012,9)	(1.667, 6.481,9)	(0.556, 0.926,3)
C_5	(0.556, 6.481,9)	(0.111, 2.037,9)	(0.111, 0.407,3)	(0.111, 1.494,9)
C_6	(0.111, 2.111,7)	(0.111, 3.049,9)	(0.333, 4.457,9)	(0.111, 2.111,7)
C_7	(0.111, 2.728,9)	(0.111, 3.988,9)	(0.111, 3.568,9)	(0.111, 3.148,9)
C_8	(0.111, 1.889,9)	(0.556,5.247,9)	(0.111, 3.148,9)	(0.111, 3.148,9)
C_9	(0.111, 0.789,3)	(0.111, 1.154,9)	(0.143, 1.364,9)	(0.111, 0.789,9)
C_{10}	(0.111, 0.481,1.286)	(0.111, 0.765,9)	(0.111, 0.765,9)	(0.111, 1.182,9)

Table 8. Fuzzy positive ideal solution and fuzzy negative ideal solution

A^*	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000
A^-	0.556	0.111	0.111	0.556	0.111	0.111	0.111	0.111	0.111	0.111

7.1. Fuzzy distance for each E-commerce website

After preparting the above mentioned tables we pass directly to the last satges which consists of the fuzzy distance for each E-commerce website is given by Table 9. In Table 10, the wse2 E-commerce website is ranked as the best because it has the highest coefficient. The wse3 E-commerce website is in the next rank. Finally the E-commerce website wse1 and wse4 are in the last positions. Analyzing the numerical illustration, we can conclude that fuzzy logic and more precisely the fuzzy TOPSIS method can be heavily used to rank E-commerce websites. Again, this approach can be broadened in application in several application areas.

7.2. Criteria weights with fuzzy analytical hierarchy process

Analytical hierarchy process (AHP) is a multi-criteria decision-making approach introduced by Saaty in 1980 [29]. It is characterized by its ability to manage different classes of qualitative and quantitative criteria. The fuzzy AHP technique is the extension of the traditional AHP method which supports linguistic data [30]. The MCDM method fuzzy AHP is widely used in the field of selection of alternatives sharing contradictory criteria. It also shows its power to assign weights to criteria. In this study we use fuzzy analytical hierarchy process (FAHP) to determine the weights of the criteria. Table 11 provides the weights of the qualitative criteria using the FAHP method [31].

Table 9. Fuzzy distance

	wse_1	wse_2	wse_3	wse_4
C_1	3.9498	5.2415	6.0927	5.4897
C_2	5.6104	5.3498	2.8507	2.9257
C_3	5.8379	2.9577	5.4051	5.8379
C_4	5.9561	5.2681	5.9905	1.4274
C_5	5.477	5.2511	1.6767	5.1937
C_6	4.1415	5.4051	5.7139	4.1415
C_7	5.3498	5.5988	5.5064	5.4233
C_8	5.2336	5.9326	5.4233	5.4233
C_9	1.7133	5.1672	5.1827	5.1469
C_{10}	0.7111	5.1459	5.1459	5.1691
d_i^-	43.981	51.318	48.988	46.179

	wse_1	wse_2	wse_3	wse_4
C_1	6,140	5,699	3,876	5,413
C_2	5,662	6,281	7,353	7,120
C_3	5,529	7,051	6,176	5,529
C_4	5,088	5,662	4,477	7,583
C_5	5,852	6,519	7,934	6,717
C_6	6,595	6,176	5,650	6,595
C_7	6,281	5,892	6,014	6,144
C_8	6,572	5,335	6,144	6,144
C_9	7,798	6,845	6,752	6,986
C_{10}	8,388	6,996	6,996	6,835
d_i^*	63,905	62,456	61,371	65,067

Table 10. Closeness coefficient with FuzzyTOPSIS

	wse1	wse2	wse3	wse4
d_i^-	43,981	51,318	48,988	46,179
d_i^*	63,905	62,456	61,371	65,067
CC_i	0,408	0,451	0,444	0,415

Table 11. Criteria weights with FAHP

Criteria	Fuzzy weight
C_1	(0.15 0.23 0.35)
C_2	(0.13 0.23 0.36)
C_3	(0.1 0.15 0.24)
C_4	(0.04 0.06 0.1)
C_5	(0.06 0.1 0.15)
C_6	(0.05 0.09 0.14)
C_7	(0.03 0.04 0.08)
C_8	(0.03 0.04 0.08)
C_9	(0.02 0.03 0.05)
C_{10}	(0.01 0.02 0.03)

By applying the same algorithm with the same data only changing the weights of the criteria by applying the FAHP method. We obtain the following scores (Table 12): as we see in the previous table, the wse1 E-commerce website is ranked as the best because it has the highest coefficient. The wse2 E-commerce website is in the next rank. Finally, the E-commerce website wse3 and wse4 are in the last positions.

Table 12. Closeness coefficient with FAHP

	wse1	wse2	wse3	wse4
d_i^-	0,850	0,851	0,776	0,766
d_i^*	0,993	1,072	1,062	1,092
CC_i	0,461	0,443	0,422	0,412

8. RESULTS AND DISCUSSION

By analyzing Figure 3 which compares the two variants of scores: score with fuzzy TOPSIS whose weights are directly attributed by the experts and scores whose criteria weights are calculated through fuzzy AHP. We can quickly conclude that the scores assigned to the different E-commerce websites are not the same and this is due more precisely to the importance of the weights relative to the criteria in the ranking of the E-commerce websites.

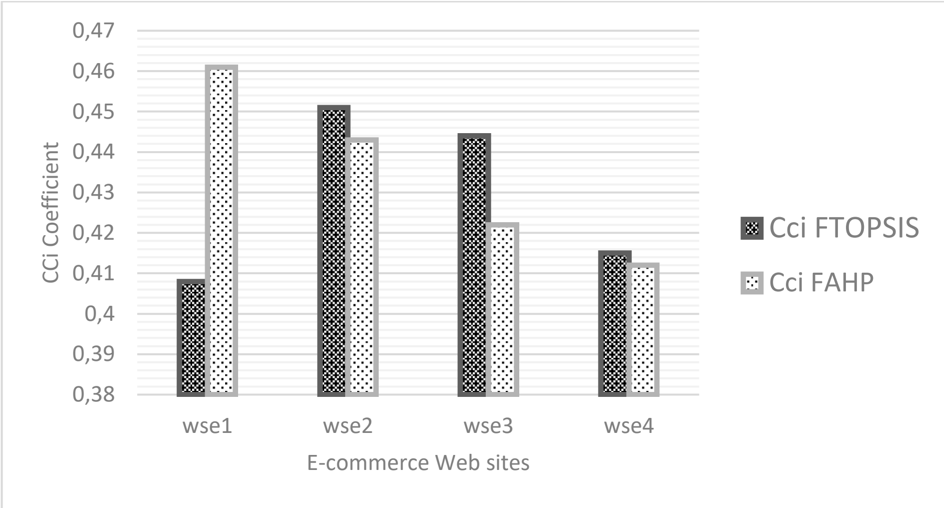

Figure 3. Score comparison

9. CONCLUSION

In this study, we have presented a fuzzy logic based fuzzy TOPSIS algorithm for E-commerce websites ranking. The proposed approach is centered on the evaluation of consumers of E-commerce websites by linguistic values using fuzzy logic. The approach was illustrated with an example of E-commerce websites consisting of four E-commerce websites and ten criteria. The evaluation of E-commerce sites by consumers as well as the criteria and weights were presented in linguistic terms with the presentation of fuzzy triangular numbers. As the weights of the criteria play an essential role in the final result (scoring), we established a comparison of our proposal with data for which the weights of the criteria were calculated using the fuzzy AHP method. In the future and as work prospects, we will consider the following extensions: in order to improve the ranking process, we will introduce other quality of service measures; Develop another solution based on fuzzy inference engine and make a comparison with the current proposal; As the weights have a great influence on the ranking, we try to propose an MCDM method which performs the calculation of the weights of the criteria and then propose a hybrid solution of ranking.

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