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BHARAT Decision Making Model: Harness an Innovative MCDM Methodology for Recommending Beneficial E-Commerce Website

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Abstract

The electronic commerce (e-commerce) business has become increasingly important due to the recent hoopla around online shopping. This is due to the volatility of the situation and disasters such as the COVID-19 pandemic. In order to keep customers loyal and avoid customer attrition, service and product suppliers were compelled to adjust to the latest developments in digital marketing. Business-to-consumer (B2C) is a key market niche in this market, as companies utilize their websites to offer goods and services directly to customers. That's why B2C wants to be shaped in a way that helps companies and customers establish a reliable, long-lasting connection. As a result, this study showcases the essential criteria that contribute to constructing a profitable B2C e-commerce website. These criteria are leveraged to prioritize and evaluate e-commerce websites (E-WSs). This is a crucial phase in this study to recommend effective E-WSs amongst a set of competitors for customers. This study achieved this phase by constructing a decision-making model. This model can deal with conflicting criteria for preferring E-WSs over each other. The best Holistic Adaptable Ranking of Attributes Technique (BHARAT) is a novel methodology of Multi-Criteria Decision Making (MCDM). This methodology is proposed in the constructed decision-making model to evaluate and rank E-WSs. Ultimately, we applied this model to real E-WSs, and the findings indicated that E-WS2 is optimal; otherwise, E-WS4 is the worst one.

Keywords: E-Commerce; B2C; BHARAT; MCDM; E-Commerce Eebsites.

1 | Introduction

Online services are becoming more and more important as a result of growing technology and the digital revolution, which is having a greater impact on our lives. This revolution and study of [1] have made it easier for businesses and commercial sectors to contact consumers and users. These sectors may now see the possibility presented by electronic shopping and showcase their products in digital arenas and electronic channels. Hence, the scholars in [2] clarified the online shopping site as a type of e-commerce (electronic commerce) platform that lets customers buy products or services without physically visiting a business by using a web browser or a mobile application. While [3] stipulated e-commerce as generally pertaining to online purchasing and selling or any transaction involving the transfer of ownership or the right to make use of

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products or services over a computer-mediated network. In another context, e-commerce is the practice of businesses, factories, enterprises, industrial undertakings, and consumers purchasing and/or selling goods electronically or moving payments and/or data over the internet [1].

Generally, The business activities of e-commerce may be broadly categorized into five primary categories: business-to-business (B2B), customer-to-customer (C2C), business-to-government (B2G), and lastly business-to-customer (B2C)[4]

E-commerce websites are used by many people, since it has become more and more common for businesses and consumers to sell goods and/or services in this manner [3]. Confirmation of this may be found in, where statistics gathered by Oberlo [1] show that 2.64 billion people will be digital purchasers in 2023, meaning that about one in four people will shop online, and this figure will likely rise annually. In confirmation of this statistic, others, as in [5], underlined how the COVID-19 epidemic directly and favourably impacted people's perceptions of value, online buying habits, and desire to make an online purchase. Additionally, it concluded that most individuals don't endanger their lives in the internet environment by leaving their houses to make this transaction.

This is due to the benefits that online shopping or e-commerce provides, as mentioned in [6], which include: (1) the convenience of shopping at any time of day; (2) the simplicity of comparing the features and costs of different brands and items; (3) the prospect of saving money by purchasing the same item online rather than in-store; and (4) the opportunity to browse without getting bored or wasting time.

As a result, it's imperative that any enterprise or commercial agency boost and advance its e-commerce or online shopping websites. From the perspective of [7] given that a large number of people utilize online shopping, the issue of quickly and practically measuring the quality of a shopping website is crucial. As a result, several researchers have looked at a variety of criteria in this field that will enhance the effectiveness of e-commerce sites by fostering the development of client connections.

The previous prospective study [7] considered incentives for preparing this study, where the objective of this study is to measure and evaluate the quality of e-commerce site competitors in the digital economic market based on a set of criteria. Hence, for conducting the evaluation process for competitors, we constructed a decision-making model based on a novel technique of MCDM, where this technique has been leveraged for the first time to serve our objective.

This technique, the Best Holistic Adaptable Ranking of Attributes Technique (BHARAT), was introduced by Rao in [8], who described it as a straightforward and efficient MCDM technique. Thus, the innovative technique's objective is to encourage decision makers (DMs) to rank the criteria in order of perceived importance; these ranks are then converted into the appropriate weights. The criteria's weights are multiplied with the corresponding normalized values of the criteria for each alternative to determine the total scores of the alternatives.

2 | Illustrative Foundations

The objective of this section is to illustrate and exemplify the concepts utilized in this study and in our decision-making model. Also, this section covers two important pillars. The first pillar is conducting surveys for the prior studies, which embraced our study's notion. Thus, the pillar's objective is to examine the previous methodologies that contributed to evaluating and selecting the optimal e-commerce site competitor with the highest quality. The second pillar demonstrates and explains the main concept of the novel methodology of MCDM, BHRATA, which has been incorporated into our decision-making model.

2.1 | First Pillar: Prior Methodologies for Evaluation E-Commerce Sites

Herein, we attempt to reveal and gather prior studies concerning previous methodologies that are applied in evaluating e-commerce sites and selecting the optimal one. One of the famous methodologies that is employed for ranking e-commerce sites and showing clients which ones are most appropriate for them is

MCDM techniques. There is strong evidence of this [9] which puts forward the weighted sum approach and entropy as MCDM techniques under the supervision of the Single Value Neutrosophic (SVN) Scale for selecting the optimal web service provider based on a set of quality of services (QoS) parameters. In addition, [9] suggested a fuzzy approach based on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for evaluating e-commerce websites. Also, the security issue is an important factor in web applications and e-commerce sites for securing customer information and gaining customer satisfaction. Hence, [10] provided a fuzzy analytical hierarchy process (AHP)-TOPSIS-based approach to evaluate the web application's security and usability, as well as to choose which feature should be given the greatest priority when creating a workable security framework. To assess and evaluate the performance of e-commerce websites, the authors of [11] developed a system that combined two methodologies: the fuzzy TOPSIS approach and AHP. In the Western Balkans region, the researchers of [12] incorporated AHP with triangular fuzzy numbers to investigate the necessary elements for designing effective e-commerce platforms.

The authors in previous studies incorporated uncertainty theory as fuzzy with MCDM techniques to bolster these techniques in ambiguous situations.

Nonetheless, Rao introduced the novel methodology of BHARAT, which is highlighted in [8]. This methodology of MCDM dispenses with the use of fuzzy theory.

Hence, we are leveraging the ability of this methodology to achieve the study's objective. Moreover, we are clarifying the basic concepts of the utilized methodology, BHARAT.

2.2 | Second Pillar: BHARTA MCDM Methodology

The objective of this methodology is to prioritize alternatives based on the influence criteria/attributes and select best and worst one. The selection and prioritizing processes require ranking alternatives according to certain criteria. In BHARAT, ranking process for criteria is conducting through adherence to the following sequences of [8].

(i). When DMs rank alternatives based on three influenced criteria:

- Reciprocal of reciprocal of rank 1: 1/ (1/1) = 1.0
- Reciprocal of reciprocals of ranks up to 2: 1/(1/1 + 1/2) = 0.67
- Reciprocal of reciprocals of ranks up to 3: 1/(1/1 + 1/2 + 1/3) = 0.55

Moreover, Summation of three criteria' rank =1.0+0.67+0.55=2.22. criteria's summation employed by dividing each value of rank by criteria's summation to obtain criteria's average weights. For instance:

- Rank 1 is assigned Average Weight value as: value of reciprocal of reciprocal of rank / Summation of three criteria'srank = 1.0/2.22=0.45.
- Rank 2 is assigned Average Weight value as: value of reciprocal of reciprocal of rank / Summation of three criteria's rank = 0.67 /2.22=0.302.
- Rank 3 is assigned Average Weight value as: value of reciprocal of reciprocal of rank / Summation of three criteria's rank = 0.55/2.22=0.248.

(ii). When DMs rank alternatives based on N of influenced criteria:

- Reciprocal of reciprocals of ranks up to X: 1/(1/1 + 1/2 + 1/3+…..+1/X) = Value of reciprocal of reciprocals of X.

Hence, Summation of N criteria's rank =1.0+0.67+0.55+…. +Z= Total summation of rank N criteria. Where, Z= Value of reciprocal of reciprocals X.

- Rank X is assigned Average Weight value as: Value of reciprocal of reciprocals of X/ Total summation of rank N criteria.

(iii). The "best" alternative for each attribute—beneficial or non-beneficial is used to normalize the Average quantitative value assigned.

(iv). Total scores of the alternative are computing through multiplying alternative's normalized value by Average weight value assigned to the attributes (w_i).

3 | Methodology: BHARAT Decision-Making Model

Herein, we constructed our decision-making model based on a novelty technique of BHARAT deciding on the best e-commerce website amongst a set of e-commerce websites. This evaluation process for determined e-commerce websites is performed by rating these websites according to various criteria. Hence, the objective of BHARAT is achieved through executing the following several steps. Figure 1 summarizes BHARAT decision steps.

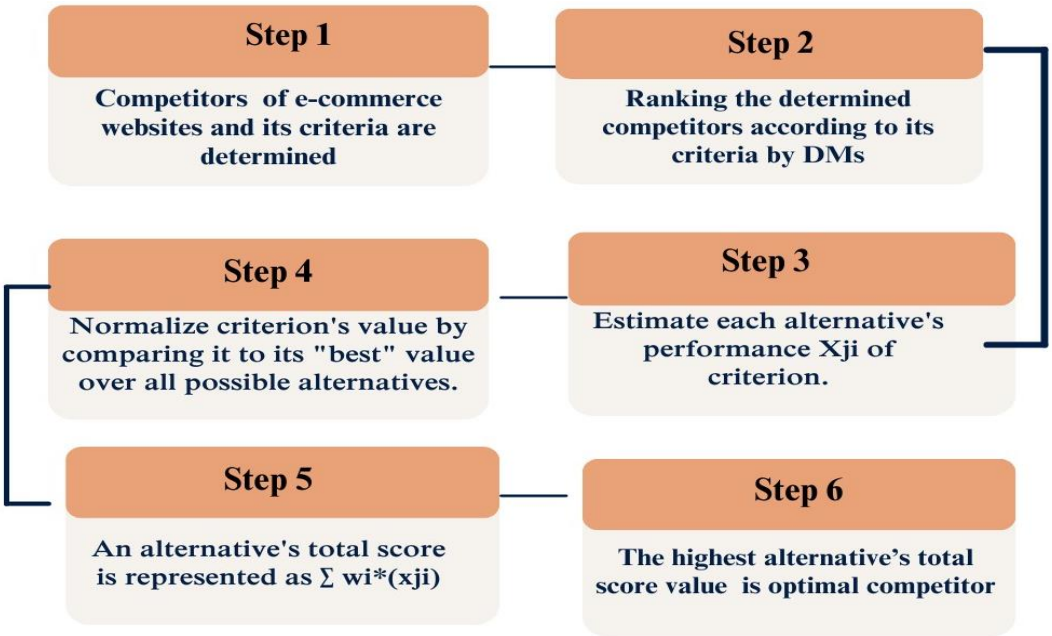

Figure 1. Summarized BHARAT decision process.

Step 1. The first procedure in the decision-making process, identifying the problem which entails in selection of an optimal e-commerce website competitor.

- E-commerce website competitors that contribute to the evaluation process are identified as E-WSs= {E-WS_1, E-WS_2… E-WS_n.}
- E-WSs' criteria are considered the main factor in the evaluation process. Hence, it is important to identify it as Cs= {C_1, C_2…. Cn}. For more clarification, the beneficial criteria are characterized by a high rating contrary to a non-beneficial rating with fewer values.

Step 2. Decision makers (DMs) who are related to this field are formed for rating E-WSs based on determined Cs. Hence, DMs' evaluation is performed by utilizing Linguistic expression and its corresponding values.

- DMs are ranking E-WSs based on determined criteria after determining beneficial and non-beneficial criteria.
- DMs' Average rating values are computed as in Eq. (1).

$$\text{Average of DMs' Preferences} = \frac{DM_{1rating} + DM_{2rating} + \cdots\ldots\ldots + DM_{nrating}}{n} \quad (1)$$

Where n is the number of DMs.

- $X_{i\text{-best}}$ is determined through DMs' averaged values. When criterion is beneficial, the highest value for $X_{i\text{-best}}$ has been chosen. otherwise the lowest value of $X_{i\text{-best}}$ has been choose

Step 3. Criteria's Average weighted have been computed.

- DMs are rating determined criteria based on Linguistic expression and its corresponding values.
- Average of DMs' rating have been computes based on Eq. (1).
- Ranks of criteria are assigned to each criterion as following:

- Rank for criterion $_x$ = Reciprocal of reciprocal of rank. For instance, Rank 1 for criterion $_x$ =1/(1/1)=1.
- Also, Rank 2 for criterion $_x$ =1/(1/1+1/2)=0.7, for more details see Ref. [8].

- These ranks are assigned to each DMs' average for criteria. When there are 2 criterions with the same value, the assigned rank calculates as:
  - First criterion assigned to rank 1 and the second criterion assigned to rank 2.
  - After that, 2 ranks for two criterions are summed and divided by 2 (i.e. (1+2)/2) =1.5
  - Another 2 criterion are ranked to 3 and 4 after that two ranks are summed and divided by 2.
- After average of DMs' are ranked, average criteria's weights are calculated according to Eqs. (2) and (3):

$$z = \sum_{i=1}^{i} \frac{1}{x_j} \tag{2}$$

$$w_i = \frac{1/z}{\sum_{i=1}^{m} 1/z} \tag{3}$$

where x_j indicates to rank of criterion, w_i indicates to criteria's weights.

- For instance, when assigned rank for criterion $_x$ =2, according to Eq. (3) criterion x average weighted = 1/(1/1+1/2)=0.7,and 0.7 is divided by summation of total ranking's values.

Step 4. DMs' averaged values for criteria is divided by $X_{i\text{-best}}$ for beneficial criterion as in Eq. (4).when criterion is non-beneficial , Eq. (5) is applied.

$$\text{Normalized value} = \frac{x_i}{x_{i-best}} \tag{4}$$

$$\text{Normalized value} = \frac{x_{i-best}}{x_i} \tag{5}$$

Step 5. The E-WSs' total scores are computed through Eq. (6).

$$\text{Total Score} = \text{Normalized value} * \text{Average weighted } (w_i) \tag{6}$$

Where, Normalized value is normalized value for criteria, w_i is criteria's weights in Eq. (3).

Step 6. the e-commerce competitor /alternative with highest total score value is optimal one amongst other competitors.

4 | Empirical Illustration

We propose a particular real-world case study to cover and achieve some of objectives. Firstly, we need to demonstrate the viability of our decision-making model. Herein, four e-commerce websites are contributed to evaluation process as alternatives. These websites referred to as E-WS$_1$, E-WS$_2$, E-WS$_3$, E-WS$_4$ which have been evaluated based on nine criteria from C_1 to C_9. Secondly, support customers to access and interact with suitable E-WS through selecting E-WS with highest score compared with four E-WSs. Selected E-WS considers optimal one and recommends to customers. Generally speaking, two determined objectives in this section are achieved through implementing the following steps.

- We communicate with five DMs for rating four E-WSs based on nine criteria which are highlighted in [13-16] . We described it in Figure 2.
- DMs are ranking E-WSs based on determined criteria through using linguistic scale listed in [8] and considering these criteria are belonging to beneficial as listed in Table A1 in appendix A.
- Table 1 represented DMs' Average rating values which have been computed by Eq. (1).
- Table 2 showcased Xi-best values for each criterion according to values of Average of DMs' rank in Table 1. In our study, all criteria are considered beneficial. Hence, we select highest $X_{i\text{-best}}$ value for each criterion.
- Linguistic scale in [8] have been used for second time by DMs to rate influenced criteria as listed in Table A2. This linguistics transform into values to obtain Average DMs' values through deploying Eq.(1). Average DMs' values are essential step to assign ranks. These ranks are calculated as in Table

A3. Subsequently, we leveraged Table A3 to generate Table 3 which showcases criteria's Average weights.

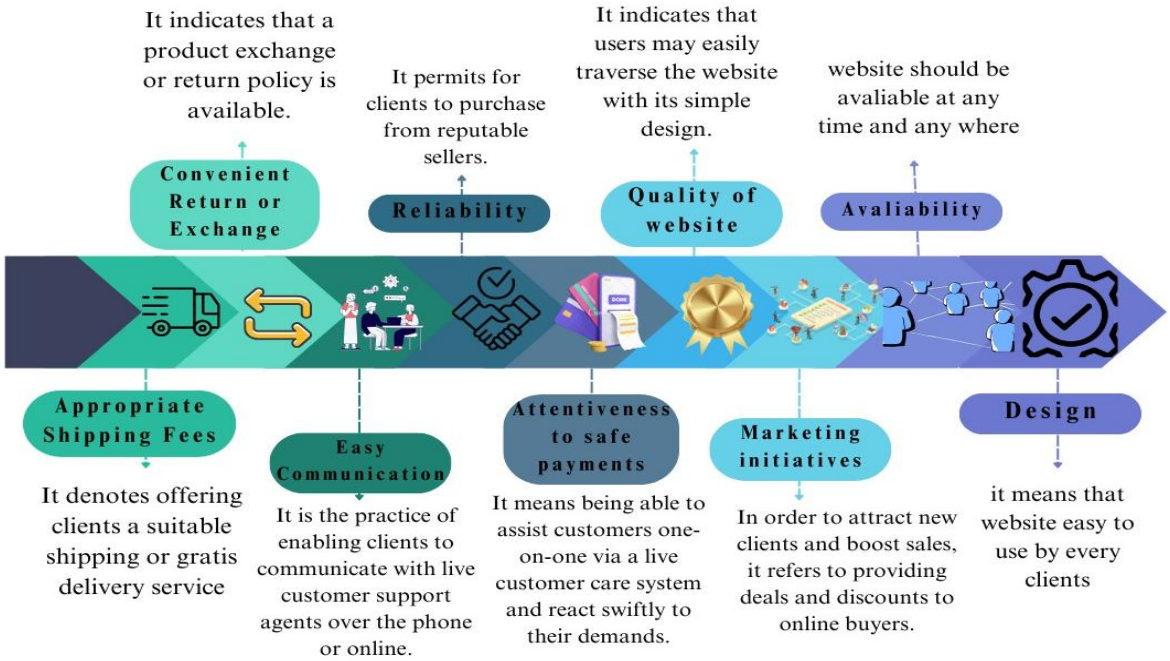

Figure 2. Determined nine criteria.

Table 1. Average ranking for Decision Makers

Criteria	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5	Average of DMs' rank
C_1	E-WS_1	1	0.833	0.666	0.5	0.666	0.733
	E-WS_2	0.833	0.5	1	0.833	0.5	0.7332
	E-WS_3	0.666	1	0.5	1	0.666	0.7664
	E-WS_4	0.833	0.5	0.5	0.666	0.5	0.5998
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5	Average of DMs' rank
C2	E-WS1	0.666	1	0.666	1	0.833	0.833
	E-WS2	1	0.5	0.833	0.833	0.666	0.7664
	E-WS3	1	0.666	1	0.666	1	0.8664
	E-WS4	0.833	0.5	0.666	0.833	0.5	0.6664
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5	Average of DMs' rank
C3	E-WS_1	0.666	0.5	0.833	0.666	1	0.733
	E-WS_2	1	0.833	1	0.833	0.833	0.8998
	E-WS_3	0.833	1	0.666	0.5	0.666	0.733
	E-WS_4	0.5	0.666	0.666	0.5	0.833	0.633
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5	Average of DMs' rank
C4	E-WS_1	0.5	0.833	0.5	0.666	0.833	0.6664
	E-WS_2	1	1	0.5	0.5	1	0.8
	E-WS_3	0.666	0.666	0.666	0.833	0.5	0.6662
	E-WS_4	0.833	0.5	0.666	1	0.833	0.7664
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5	Average of DMs' rank
C5	E-WS_1	0.5	0.833	1	0.833	0.666	0.7664
	E-WS_2	0.833	1	0.5	1	0.666	0.7998
	E-WS_3	1	0.5	1	0.666	1	0.8332
	E-WS_4	0.666	1	0.5	0.666	1	0.7664
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5	Average of DMs' rank
C6	E-WS_1	0.833	0.5	0.833	0.666	0.5	0.6664
	E-WS_2	1	0.833	1	1	1	0.9666

	E-WS3	0.5	1	0.666	0.666	1	0.7664
	E-WS4	1	0.666	0.666	0.5	0.666	0.6996
	Alternatives	DM1	DM2	DM3	DM4	DM5	Average of DMs' rank
C7	E-WS1	0.666	0.833	0.5	0.5	0.666	0.633
	E-WS2	0.833	1	0.833	1	1	0.9332
	E-WS3	1	0.5	1	1	0.666	0.8332
	E-WS4	0.666	1	0.666	0.666	0.5	0.6996
	Alternatives	DM1	DM2	DM3	DM4	DM5	Average of DMs' rank
C8	E-WS1	0.833	0.5	0.5	1	0.666	0.6998
	E-WS2	1	0.833	0.5	1	1	0.8666
	E-WS3	0.666	1	1	0.666	0.666	0.7996
	E-WS4	0.666	0.666	1	0.5	0.5	0.6664
	Alternatives	DM1	DM2	DM3	DM4	DM5	Average of DMs' rank
C9	E-WS1	0.666	0.666	0.833	0.666	1	0.7662
	E-WS2	0.666	1	1	1	0.5	0.8332
	E-WS3	1	0.5	0.5	0.5	0.5	0.6
	E-WS4	0.5	0.833	0.666	0.666	0.833	0.6996

Table 2. $X_{i\text{-best}}$ values for criteria.

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
$X_{i\text{-best}}$ value	0.7664	0.8664	0.8998	0.7664	0.8332	0.7664	0.9332	0.8666	0.8332

Table 3. Criteria average weights.

	DM1	**DM2**	**DM3**	**DM4**	**DM5**	**Average**	**Rank**	**Average weighted**
C1	0.666	0.833	0.5	0.5	0.666	0.633	9	0.0753
C2	0.833	1	0.833	1	1	0.9332	5	0.095
C3	1	0.5	1	1	0.666	0.8332	7	0.084
C4	0.666	1	0.666	0.666	0.5	0.699	1.5	0.1796
C5	0.833	0.5	0.5	1	0.666	0.699	1.5	0.1796
C6	1	0.833	0.5	1	1	0.8666	6	0.0882
C7	0.666	1	1	0.666	0.666	0.799	3.5	0.111
C8	0.666	0.666	1	0.5	0.5	0.6664	8	0.0796
C9	0.833	0.5	0.666	1	1	0.799	3.5	0.111

According to the above Table 3, we observed that rank for C4 and C5 are the same due to its average values are similar. Hence, its rank calculated as (1+2)/2=1.5. Also, C7 and C9, its rank is (3+4)/3=3.5.

- We leveraged Average weighted in Table 3 to multiply by normalized values to generate total score for each alternative as in Table 4.
- Final Total score for each alternative of E-WS are computed as:
  Final score for E-WS1 =
  0.0720184+0.09133772+0.06842854+0.1496068+0.16520096+0.06080745+0.07529254+0.06427888+0.10207417=0.849
  Final score for E-WS2 =
  0.07203805+0.08403509+0.084+0.1796+0.17240048+0.0882+0.111+0.0796+0.111=0.98
  Final score for E-WS3 =
  0.0753+0.095+0.06842854+0.1495619+0.1796+0.06993222+0.09910544+0.07344583+0.07993279=0.89
  Final score for E-WS4 =

0.05893129+0.07307018+0.05909313+0.1720568+0.16520096+0.06383687+0.08321432+0.06121099+0.09320163=0.83

- Alternatives of E-WSs can rank as E-WS_2> E-WS_3 > E-WS_1 >E-WS_4. This means that E-WS_2 is the optimal otherwise E-$WS_4$is the worst one as illustrated in Figure 3.

Table 4. E-commerce websites total scores.

Criteria	Alternatives	Average of DMs	Normalized value (xji/xi.best)	Average weight value assigned to the attributes (wi)	Scores (xji/xi.best)*wi
C_1	E-WS_1	0.733	0.956419624	0.0753	0.0720184
	E-WS_2	0.7332	0.956680585	0.0753	0.07203805
	E-WS_3	0.7664	1	0.0753	0.0753
	E-WS_4	0.5998	0.782620042	0.0753	0.05893129
C_2	E-WS1	0.833	0.961449677	0.095	0.09133772
	E-WS2	0.7664	0.884579871	0.095	0.08403509
	E-WS3	0.8664	1	0.095	0.095
	E-WS4	0.6664	0.769159741	0.095	0.07307018
C_3	E-WS_1	0.733	0.814625472	0.084	0.06842854
	E-WS_2	0.8998	1	0.084	0.084
	E-WS_3	0.733	0.814625472	0.084	0.06842854
	E-WS_4	0.633	0.703489664	0.084	0.05909313
C_4	E-WS_1	0.6664	0.833	0.1796	0.1496068
	E-WS_2	0.8	1	0.1796	0.1796
	E-WS_3	0.6662	0.83275	0.1796	0.1495619
	E-WS_4	0.7664	0.958	0.1796	0.1720568
C_5	E-WS_1	0.7664	0.919827172	0.1796	0.16520096
	E-WS_2	0.7998	0.959913586	0.1796	0.17240048
	E-WS_3	0.8332	1	0.1796	0.1796
	E-WS_4	0.7664	0.919827172	0.1796	0.16520096
C_6	E-WS_1	0.6664	0.689426857	0.0882	0.06080745
	E-WS_2	0.9666	1	0.0882	0.0882
	E-WS_3	0.7664	0.792882268	0.0882	0.06993222
	E-WS_4	0.6996	0.723774053	0.0882	0.06383687
C_7	E-WS_1	0.633	0.678311187	0.111	0.07529254
	E-WS_2	0.9332	1	0.111	0.111
	E-WS_3	0.8332	0.892841835	0.111	0.09910544
	E-WS_4	0.6996	0.749678526	0.111	0.08321432
C_8	E-WS_1	0.6998	0.807523656	0.0796	0.06427888
	E-WS_2	0.8666	1	0.0796	0.0796
	E-WS_3	0.7996	0.92268636	0.0796	0.07344583
	E-WS_4	0.6664	0.768982229	0.0796	0.06121099
C_9	E-WS_1	0.7662	0.919587134	0.111	0.10207417
	E-WS_2	0.8332	1	0.111	0.111
	E-WS_3	0.6	0.720115218	0.111	0.07993279
	E-WS_4	0.6996	0.839654345	0.111	0.09320163

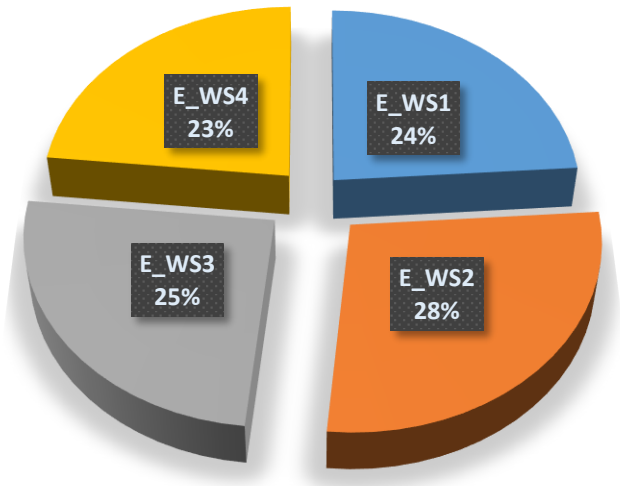

Figure 3. Ranking of e-commerce websites.

5 | Conclusions

The evolution of the internet and contemporary technological developments have altered the fundamentals of marketing, favorably influencing the e-commerce trend. Given that e-commerce websites are quicker and more affordable, customers now choose to purchase on these websites. Additionally, there are incentives that drive consumers to engage in online shopping. One of these motivations is the availability of products anytime and anywhere. Also, there is the ability to purchase the same item online for less money than in-store, the simplicity with which different brands and items can be compared for quality and pricing, and the convenience of shopping without becoming weary or wasting time. One well-known example is business-to-consumer (B2C), where businesses sell goods and services to clients directly through their websites. Hence, an enormous number of businesses are working very hard to create a B2C e-commerce website that draws users to purchase and sell any kind of good or service.

As a result, it's critical to evaluate and rank B2C e-commerce websites because doing so benefits both clients and businesses. The evaluation and prioritizing of e-commerce websites based on a group of attributes or criteria.

In this study, a novel methodology of MCDM is leveraged for the first time to achieve the study's objectives by evaluating alternatives to E-WSs and ranking these alternatives based on total score values. After that, we recommend the most effective E-WS for customers to fulfill their requirements. Moreover, BHARAT of MCDM was applied in our study through the construction of a decision-making model. This methodology can deal with conflicting criteria. Thereby, we implemented this decision-making model on real E-WSs as alternatives, which were evaluated based on nine influencing criteria.

The findings of the decision-making model application indicated that E-WS2 achieved the highest score value of 0.98, followed by E-WS3 with a 0.89 score value, and E-WS4 was the worst with a 0.83 score value, as mentioned in Figure 3.

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Author Contributaion

All authors contributed equally to this work.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

[1] Şimşek, H., & Güvendiren, İ. (2023). Soft computing based e-commerce website service quality index measurement. Electronic commerce research and applications, 61(August), 1–13. https://doi.org/10.1016/j.elerap.2023.101303

[2] [DeVaney, S. A. (2008). Review of Handbook of consumer finance research. , 19 Financial Counseling and Planning (Vol. 19).

[3] Popović, G., Pucar, Đ., & Smarandache, F. (2022). Merec-Cobra Approach in E-Commerce Development Strategy Selection. Journal of process management and new technologies, 10(3–4), 66–74. https://doi.org/10.5937/jpmnt10-41073

[4] Altıntaşlı, A., Temiz, M., & Şenvar, Ö. (2022). A case study for evaluating e-commerce websites using integrated fuzzy ahp and fuzzy topsis. Intelligent and fuzzy techniques for emerging conditions and digital transformation: proceedings of the infus 2021 conference, held august 24-26, 2021. volume 1 (pp. 308–315). Springer.

[5] Soares, J. C., Limongi, R., De Sousa Júnior, J. H., Santos, W. S., Raasch, M., & Hoeckesfeld, L. (2023). Assessing the effects of COVID-19-related risk on online shopping behavior. Journal of marketing analytics, 11(1), 82–94.

[6] Le, H. T. K., Carrel, A. L., & Shah, H. (2022). Impacts of online shopping on travel demand: a systematic review. Transport reviews, 42(3), 273–295.

[7] Jensen, K. L., Yenerall, J., Chen, X., & Yu, T. E. (2021). US consumers' online shopping behaviors and intentions during and after the COVID-19 pandemic. Journal of agricultural and applied economics, 53(3), 416–434.

[8] Rao, R. V. (2024). BHARAT: A simple and effective multi-criteria decision-making method that does not need fuzzy logic, Part-1: Multi-attribute decision-making applications in the industrial environment. International journal of industrial engineering computations, 15(1), 13–40. https://doi.org/10.5267/j.ijiec.2023.12.003

[9] Belouaar, H., Kazar, O., Zouai, M., & Merizig, A. (2022). A new ranking approach for E-commerce websites based on fuzzy TOPSIS algorithm. Bulletin of electrical engineering and informatics, 11(2), 936–946. https://doi.org/10.11591/eei.v11i2.3563

[10] Kumar, R., Khan, A. I., Abushark, Y. B., Alam, M. M., Agrawal, A., & Khan, R. A. (2020). An integrated approach of fuzzy logic, AHP and TOPSIS for estimating usable-security of web applications. IEEE access, 8, 50944–50957.

[11] Rouyendegh, B. D., Topuz, K., Dag, A., & Oztekin, A. (2019). An AHP-IFT integrated model for performance evaluation of E-commerce web sites. Information systems frontiers, 21, 1345–1355.

[12] Simjanović, D. J., Zdravković, N., & Vesić, N. O. (2022). On the Factors of Successful e-Commerce Platform Design during and after COVID-19 Pandemic Using Extended Fuzzy AHP Method. Axioms, 11(3), 105.

[13] Desticioğlu Taşdemir, B., Kumcu, S., & Özyörük, B. (2023). Comparison of E-Commerce Sites with Pythagorean Fuzzy AHP and TOPSIS Methods.

[14] Rita, P., Oliveira, T., & Farisa, A. (2019). The impact of e-service quality and customer satisfaction on customer behavior in online shopping. Heliyon, 5(10).

[15] Li, R., & Sun, T. (2020). Assessing factors for designing a successful B2C E-Commerce website using fuzzy AHP and TOPSIS-Grey methodology. Symmetry, 12(3). https://doi.org/10.3390/sym12030363

[16] Zavadskas, E. K., Bausys, R., Lescauskiene, I., & Usovaite, A. (2020). MULTIMOORA under interval-valued neutrosophic sets as the basis for the quantitative heuristic evaluation methodology HEBIN. Mathematics, 9(1), 66.

Appendix A

Table A1. Decision makers rating.

Criteria	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C_1	E-WS_1	Very high	High	Medium high	Fair	Medium high
	E-WS_2	High	Fair	Very high	High	Fair
	E-WS_3	Medium high	Very high	Fair	Very high	Medium high
	E-WS_4	High	Fair	Fair	Medium high	Fair
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C2	E-WS1	Medium high	Very high	Medium high	Very high	High
	E-WS2	Very high	Fair	High	High	Medium high
	E-WS3	Very high	Medium high	Very high	Medium high	Very high
	E-WS4	High	Fair	Medium high	High	Fair
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C3	E-WS_1	Medium high	Fair	High	Medium high	Very high
	E-WS_2	Very high	High	Very high	High	High
	E-WS_3	High	Very high	Medium high	Fair	Medium high
	E-WS_4	Fair	Medium high	Medium high	Fair	High
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C4	E-WS_1	Fair	High	Fair	Medium high	High
	E-WS_2	Very high	Very high	Fair	Fair	Very high
	E-WS_3	Medium high	Medium high	Medium high	High	Fair
	E-WS_4	High	Fair	Medium high	Very high	High
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C5	E-WS_1	Fair	High	Very high	High	Medium high
	E-WS_2	High	Very high	Fair	Very high	Medium high
	E-WS_3	Very high	Fair	Very high	Medium high	Very high
	E-WS_4	Medium high	Very high	Fair	Medium high	Very high
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C6	E-WS_1	High	Fair	High	Medium high	Fair
	E-WS_2	Very high	High	Very high	Very high	Very high
	E-WS_3	Fair	Very high	Medium high	Medium high	Very high
	E-WS_4	Very high	Medium high	Medium high	Fair	Medium high
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C7	E-WS_1	Medium high	High	Fair	Fair	Medium high
	E-WS_2	High	Very high	High	Very high	Very high
	E-WS_3	Very high	Fair	Very high	Very high	Medium high
	E-WS_4	Medium high	Very high	Medium high	Medium high	Fair
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C8	E-WS_1	High	Fair	Fair	Very high	Medium high
	E-WS_2	Very high	High	Fair	Very high	Very high
	E-WS_3	Medium high	Very high	Very high	Medium high	Medium high
	E-WS_4	Medium high	Medium high	Very high	Fair	Fair
	Alternatives	DM_1	DM_2	DM_3	DM_4	DM_5
C9	E-WS_1	Medium high	Medium high	High	Medium high	Very high
	E-WS_2	Medium high	Very high	Very high	Very high	Fair
	E-WS_3	Very high	Fair	Fair	Fair	Fair
	E-WS_4	Fair	High	Medium high	Medium high	High

Table A2. Decision-makers rating for influenced criteria.

	DM_1	**DM_2**	**DM_3**	**DM_4**	**DM_5**
C_1	Medium high	High	Fair	Fair	Medium high
C_2	High	Very high	High	Very high	Very high
C_3	Very high	Fair	Very high	Very high	Medium high
C_4	Medium high	Very high	Medium high	Medium high	Fair
C_5	High	Fair	Fair	Very high	Medium high
C_6	Very high	High	Fair	Very high	Very high
C_7	Medium high	Very high	Very high	Medium high	Medium high
C_8	Medium high	Medium high	Very high	Fair	Fair
C_9	High	Fair	Medium high	Very high	Very high

Table A3. Average weights based on reciprocal of ranks.

Reciprocal of reciprocal of ranks		**Average Weights**
$Rank_1$	1/(1/1)=1	1/4.65=0.22
$Rank_2$	1/(1/1+1/2)=0.67	0.67/4.65=0.144
$Rank_3$	1/(1/1+1/2+1/3)=0.55	0.55/4.65=0.12
$Rank_4$	1/(1/1+1/2+1/3+1/4)=0.48	0.48/4.65=0.103
$Rank_5$	1/(1/1+1/2+1/3+1/4+1/5)=0.44	0.44/4.65=0.09
$Rank_6$	1/(1/1+1/2+1/3+1/4+1/5+1/6)=0.41	0.41/4.65=0.088
$Rank_7$	1/(1/1+1/2+1/3+1/4+1/5+1/6+1/7)=0.39	0.39/4.65=0.083
$Rank_8$	1/(1/1+1/2+1/3+1/4+1/5+1/6+1/7+1/8)=0.37	0.37/4.65=0.079
$Rank_9$	1/(1/1+1/2+1/3+1/4+1/5+1/6+1/7+1/8+1/9)=0.35	0.35/4.65=0.075
Total Summation	1+0.67+0.55+0.48+0.44+0.41+0.39+0.37+0.35=4.65	