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Evaluation of Indian B2C E-Shopping Websites under Multi Criteria Decision-Making using Fuzzy Hybrid Technique

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Abstract

The extensive growth of Internet users as well as online buyers in India furnishes a developing prospect environment for E-commerce Industries in India in near future. Therefore the youthful eras are inclining more towards online shopping than ordinary shopping. The difficulty in choosing the right E-commerce website for buying things is becoming tough which can be termed as a Multi Criteria Decision-making (MCDM) problem. This paper proposes an E-commerce website evaluation model consisting hybrid MCDM techniques, specially designed for Indian market. A survey was conducted among expert persons through a questionnaire prepared to collect their opinions on online shopping in India. Based on this study, a Hybrid Evaluation Model is proposed and implemented. 6 major E-shopping websites of India are considered as our alternatives and 17 important criteria factors which influence online shopping the most are taken into account. Four level problem hierarchy is formed first. AHP method is then applied to get the criteria weights and later Fuzzy TOPSIS is introduced to get the final rank of the websites.

Keywords: E-commerce, Web-shopping, Multi Criteria Decision-making (MCDM), AHP, Fuzzy TOPSIS.

Introduction

Internet is one vast field which has always provided us with effective and convenient channels for gathering as well as distributing information and services. Since the internet has evolved drastically in the last decade, it has become one of the basic tools of communications into the interactive market of services and products which involves 1.2 billion Digital buyers worldwide as shown in Figure 1. Figure 2 shows the projected internet population growth in India.

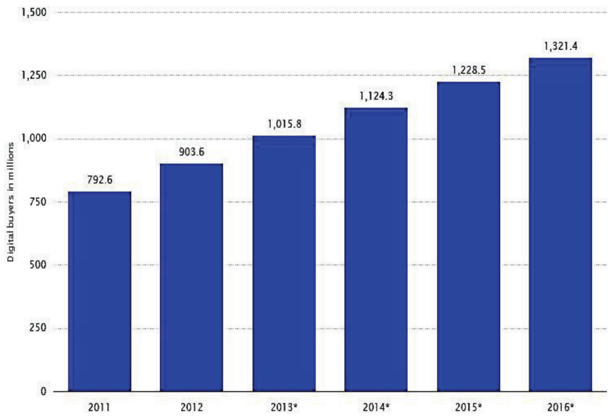

Figure 1: Statistics from statista.com showing projected total no of digital buyers across the world

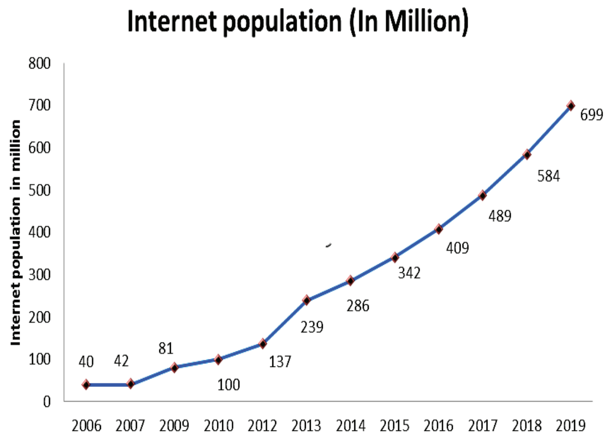

Figure 2: Indian Internet population in millions

E-Shopping is one form of Electronic Commerce which includes consumers to directly buy from a seller over the internet without even visiting the retailing store by him/herself. Many international enterprises across the world have embraced this digital revolution with the help of establishing their online store portal optimizing the E-commerce industry around the world.

E-commerce can be classified into 4 main categories:

B2B (Business to Business), B2C (Business to Consumer), C2C (Consumer to Consumer), C2B (Consumer to Business). Our study is mainly directed towards the B2C commerce.

Though the biggest E-commerce markets are China, USA, UK and Japan, but Malaysia, India and Indonesia are considered to be the fastest growing E-commerce markets in Asia.

In 1998 the internet user population in India was just 1.2 million but according to Forrester Mckinsey report of 2013, India has 137 million (approx 1.4 billion) internet user with a 11% penetration rate in which 18% are online buyers. If compared to its neighbours like China, Pakistan, Sri Lanka, they all have much better penetration rate than India. Therefore despite of having the world's 2nd largest population, the internet density remains a challenge. So the growth expectancy of the online market is immense. Though the retail market has overall CAGR (Commutative-Annual-Growth) of 7%, according to the study conducted by ASSOCHAM (Associated Chambers of Commerce and Industry of India), PwC (Price Waterhouse Coopers), Digital Commerce and IAMAI-IMRB (Internet And Mobile Association of India), E-commerce in India is growing at the CAGR of 34-35%. The current total industry asset is valued at $17 billion dollars and is expected to reach $100 billion mark over the next 5 years. Continuing on the growth momentum of 2014, the E-commerce industry in India is expected to see 67 percent increase in annual spending on online purchase per individual in this year 2015 compared to 2014, to Rs 10000 from Rs 6000, study said [48,49]. Young generation of India has risen up as the driving force behind this growth as nearly 90% of the online shoppers belong to the age between 18-35 of them nearly 65% are male shoppers. So our study is much more concentrated between 18-32 aged male candidates.

Many existing work and evaluations systems are there around the world but very few mature works are done in Indian Market. Due to the above mentioned statistics we have chosen the Indian market as our case study field. This study is mainly towards some difficulties for users to conduct B2C transactions. Finding the right product is not at all simple as users have to search through search engines as well as browse through many E-shopping sites one by one, which are suggested by search engines [1]. This process is really tedious and wastes a lot of time. Besides there comes a lot of factors based on which user gets perplexed while taking a decision on buying something before coming to any conclusion. This issue of many factors influencing the quality measurement consists both tangible and intangible measures, it can certainly be regarded as a Multiple Criteria Decision-Making (MCDM) problem. The main objective of this study is to come up with a Hybrid Evaluation technique for B2C family E-commerce websites focused on Indian market. There can be many methods available for solving MCDM problems such as Multi Attribute Utility Theory (MAUT) & AHP [2] as value measurement model, ANP [3], TOPSIS [4] as goal aspiration reference model, ELECTRE [5] & PROMEETHE [6] as outranking models, Vikor [7] etc. but we have applied Classical AHP and Fuzzy TOPSIS in our model due to their effectiveness. Though TOPSIS is however considered to be unable to deal with uncertain problems and vague data, Fuzzy set is incorporated as it deals with human reasoning and allows us to deal with approximate values & ambiguous data opposed to only relying on crisp data. So based on that we have used a Hybrid approach in which a multi-level criteria analysis with classical AHP combined with FTOPSIS is used in-order to rank few main E-commerce websites which are hosted in Indian Market. The rest of this study is organized as follows where Section 2 comprises Literature review, Section 3 consists Methods, Section 4 contains Proposed model, Section 5 describes Results and Discussions and Section 6 presents Conclusion.

Literature Review

Zhang and Dran in their studies, have extensively studied user perception on using websites. Quality features are investigated firstly using Kano's Model of Quality. Later independent study was done on that showing the limitations and several criteria [8,9]. Nilashi et al. in their paper have done a fully fledged survey on international students studying in Malaysian university which has a large customer base in E-shopping in Malaysia. They proposed a research framework by finding and ranking many criteria influencing E-shopping using classical TOPSIS and fuzzy TOPSIS methods [10]. Benbunan-Fich have tried to test the usability of a commercial website by considering 3 evaluation parameters, 15 usability parameters and using protocol analysis, a systematic qualitative technique as a framework [11]. Shergill and Chen have studied and found out the critical factors influencing different consumer level perception towards E-shopping in New Zealand [12]. Lowengart and Tractinsky analyzed the purchase probability from a specific vendor given multiple vendors using a Multinomial Logit Choice Model from experimental data by finding the salient factors influencing choice [13]. Lightner evaluated E-shopping websites by mainly focusing on customer satisfaction proposing 50 functional requirements representing factors influencing customer service in a B2C site and investigated their fulfilment process by those web companies [14]. Aydin and Kahraman have proposed a new methodology based on Fuzzy AHP and integral values method in order to rank the three most famous E-commerce websites in Turkey and also have compared their results with Fuzzy VIKOR method [15]. Büyüközkan, Ertek and Arsenyan evaluated Turkish E-Learning web Sites using an approach based on fuzzy axiomatic design and validation of the outcome was done using fuzzy TOPSIS [16]. Again Gülçin Büyüközkan & Gizem Çifçi have examined and proposed electronic Service quality model(e-sq model) framework for Turkey's E-healthcare sector and also ranked E-health stores in Turkey with help of hybrid FMCDM method [17]. Mehdi Fasanghari et al. evaluated customer satisfaction in E-commerce environment with a evaluation model consisting Fuzzy TOPSIS in Iran [18] and M.Fasanghari himself have also suggested a model for customer satisfaction for E-commerce in his famous article [19]. Mohammad Hossein Moshref Javadi et al. proposed a conceptual model consisting regression analysis for analyzing factors affecting behaviour of consumers in Iran towards online shopping from surveying Iran's online stores [20]. Chiu, Tzeng and Li proposed a new hybrid MADM model, combining DEMATEL, DEMATEL-based ANP and VIKOR method for improving strategies and finding influential criteria to get a better customer satisfaction in E-store business [21]. Bauer, Falk and Hammerschmidt captured E-service quality with an approach based on transaction process named eTransQual focusing mainly on E-service delivery process [22]. Rababah and Masoud have showed the key factors for success in developing a E-commerce website with the help of survey in Jordan [23]. Lee and Kozar investigated E-store quality factors and the relative importance for finding the most preffered E-store by extending DeLone and McLean’s IS success model using AHP [24]. Stefani and Xenos also proposed a quality assessment model for E-commerce by observing ISO9126 quality factors [25] & B2C system quality's weight modelling was done by them from two main point of view named software system and service to customers

[26]. By extending Keeney's work [27], Torkzadeh and Dhillon described two key instruments' development that measures factors influencing success of E-commerce. One measures the factors influencing line purchase and the other measures the factors related to customers perception towards E-shopping [28]. Zhu and Tong have proposed an 3 level evaluation index system for Chinese B2C fashion E-stores with the help of AHP [29]. Kong and Liu found out the key factors for success in E-commerce and also proposed a evaluation model based on Fuzzy AHP [30]. Li and Li have done an evaluation of the B2C web-stores in China focusing mainly on usability indices [31]. The article of Hasan and Abuelrub includes one of the most extensive field study which reviewed many different evaluation criteria method for E-business services and proposed their own extensive evaluation criteria set for evaluating any type of website [32]. Iwaarden et al. surveyed Erasmus University & Northeastern University students. They indentified different quality aspects important to the design and usability of web sites based on Cox and Dale's quality evaluation model. The results were then compared to SERVQUAL dimensions stated by Zeithaml, Parasuraman and Berry [33] and they found the model applicable [34]. Li and Zhang investigated online shopping behavior and attitudes through an extensive analysis resulting in a taxonomy which presented a conceptual model of E-shopping [35].

Methods

Analytic Hierarchy Process (AHP)

Prof. Thomas L.Saaty(1980) originally developed AHP [2]. Pair-wise comparison is the main feature of AHP due to which it performs and handles real time data much more efficiently than other methods. It is simple in nature which makes it more easily usable. Here we have only described the part that we have used in our technique.

Step 1. Make pair-wise comparison decision matrix

Suppose A is a $m \times m$ comparison matrix, where $'m'$ is the number of criteria. Each entry a_{ij} of the matrix A represents the importance of the i^{th} criterion corresponds to the j^{th} criterion. Each pair of a_{ij} and a_{ji} are satisfying the following constraint,

$$a_{ij} \,.\, a_{ji} = 1 \tag{1}$$

Step 2. Construction of the Normalized matrix and Weighted Normalized matrix.

As the comparison matrix is built, it should be in normalized form. Suppose A_1 is normalized matrix and each matrix entry, $\bar{a}_{ij}$ is calculated as

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^{m} a_{kj}} \tag{2}$$

Finally, the Criteria Weight Vector $'w'$ is calculated by averaging the entries on each row of A_1 i.e.

$$w_i = \frac{\sum_{k=1}^{m} \bar{a}_{ik}}{m} \tag{3}$$

Step 3. Checking the consistency

Inconsistency may occur during the pair-wise comparison computation, thus consistency check is very important the during the pair-wise comparison. Consistency check can be done as follows

1. Calculate the Principle Eigen value(λ_{max}), which is obtained from the summation of product between each element of Eigen vector and the sum of column of the decision matrix.
2. Calculate the Consistency Index(CI) as follows,

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (4)$$

where n is a number of objects.

3. Calculate the consistency ratio(CR), which is obtained from the following equation,

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

where RI stands for Random Consistency Index.

If the value of Consistency Ratio is smaller or equal to .1, then value of present inconsistency is acceptable.

Fuzzy Set Theory

To deal with vagueness and human thought, Fuzzy set theory was first introduced by Zadeh [36] in 1965. In different & diverse intensity daily decision making problems, there can be misleading results if the fuzziness of human judgement in not taken into account. Especially when the goal is to find approximate solution [37]. The attitude towards imprecision by taking the human subjectivity into account led to new decision analysis named Fuzzy decision making [38]. Fuzzy sets are powerful mathematical tools which are represented by linguistic terms that contains one or more linguistic variables.

If X is a collection of objects denoted generally by x, A fuzzy set 'F 'can be represented as,

$$\tilde{F} = \{(x, \mu_F(x)) \mid x \in X\}$$

where $\mu_F(x)$ is the Membership Function(MF) for the fuzzy set F. X is called as Universe of Discourse's, that is represented as linguistic values. Each element of X has membership grade between 0 and 1. Membership functions(MF) are different types ie. Triangular, Trapezoidal, Sigmoidal, Gaussian etc. Many other definitions can also be found in (Buckley [39,40], Dubois and Prade [41], Zadeh [36], Zimmermann [42], Chen et al [43], Pedrycz [44], Kaufmann and Gupta [45], Klir and Yuan [46], Yang and Hung [47]).

Triangular MF

A triangular MF (Figure 3) is represented by the three parameters (a, b, c)

$$\mu_F(x) = trimf(x: a, b, c) = \begin{cases} 0\,, & x \le a, \\ \frac{x-a}{b-a}\,, & a < x \le b\,, \\ \frac{c-x}{c-b}\,, & b < x \le c\,, \\ 0\,, & c \le x \end{cases} \tag{6}$$

Parameters (a, b, c) are the real number and the values of these parameters specify the x coordinates of the three corners of the triangular MF.

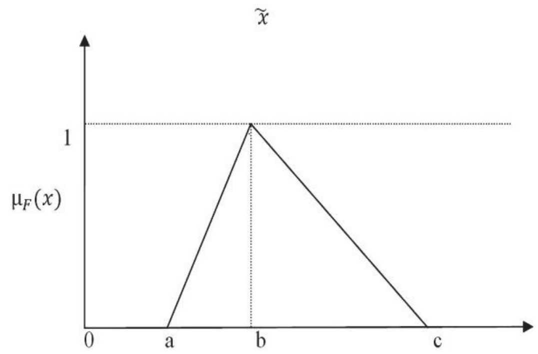

Figure 3: Triangular fuzzy number

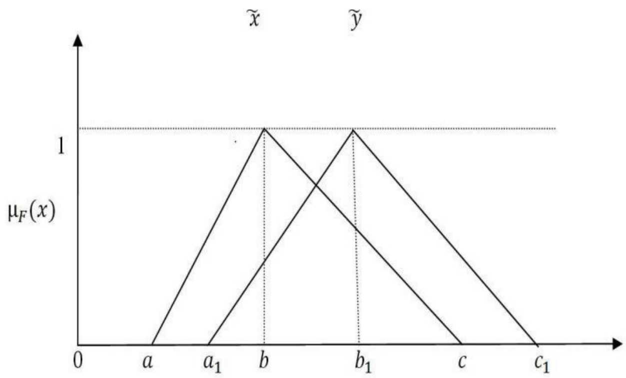

Figure 4: Two Triangular Fuzzy Numbers

Let $\tilde{x} = (x_1, x_2, x_3)$ and $\tilde{y} = (y_1, y_2, y_3)$ are triangular fuzzy numbers. The distance between two triangular fuzzy numbers (TFN) is calculated as given below by using vertex method.

$$d(\tilde{x}, \tilde{y}) = \sqrt{\frac{1}{3}\left[(x_1 - y_1)^2 + (x_2 - y_2)^2 + (x_3 - y_3)^2\right]} \tag{7}$$

Figure 3 and Figure 4 depict Single fuzzy triangular number and Two fuzzy triangular number respectively. Linguistic terms for alternatives ratings are represented in Table 2.

Fuzzy TOPSIS

Simple Technique for Order Performance by similarity to Ideal solution (TOPSIS), was first proposed by Hwan and Yoon [4]. It's one of the usefulness is that it aims to select the alternative that is farthest from the Negative Ideal Solution and closest from the Positive Ideal Solution by maximizing the Benefit criteria and minimizing the Cost criteria. However classical TOPSIS is unable to handle real time situation where human judgements are involved which are vague not crisp. Though classical AHP method is present in the first part but as human perception is involved, we felt the need of introducing a fuzzy method. So we have applied the Fuzzy TOPSIS as a part of our Hybrid Technique.

Step 1. Evaluation of alternatives performance ratings with respect to criteria.

As we have already got the weights of the criteria from our first part, we need not choose the linguistic values for the criteria. In this step we have chosen the linguistic values for the alternatives with respect to criteria. Let n is a set alternatives, where $A = (A_1, A_2, A_3, \dots, A_n)$. These are to be calculated against m criteria denoted by $C = (C_1, C_2, C_3, \dots, C_m)$. The weight of a criterion is denoted by w_i $(i = 1,2, \dots, m)$ which we have taken from AHP step. Each decision maker's performance rating D_k $(k = 1,2,..,K)$ with respect to criteria C_i $(i = 1,2,..,m)$ for each alterative A_j $(j = 1,2,..,n)$ are denoted by $\tilde{R}_k = \tilde{x}_{ijk}$ $(i = 1,2,..,m; j = 1,2,..,n; k = 1,2,..,K)$.

Step 2. The fuzzy decision matrix construction.

The fuzzy decision matrix for the alternatives $(\tilde{D})$ is given as follows by each decision maker, and the criteria weight $(\tilde{W})$ is the weight vector calculated in previous steps.

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \end{array}$$

$$\tilde{W} = [\tilde{w}_1 \quad \tilde{w}_2 \quad \dots \quad \tilde{w}_n]$$

Step 3. Computation of fuzzy aggregated ratings for the alternatives for the criteria.

Decision makers have given their fuzzy ratings in fuzzy triangular number for the alternatives for each criterion. So if we consider that TFN as $\tilde{R}_k = (a_k, b_k, c_k)$, where $k = 1,2,..,K$ then the fuzzy aggregated rating is given by $\tilde{R} = (a, b, c)$, where

$$a = \min_k \{a_k\},\ b = \frac{1}{K}\sum_{k=1}^{K} b_k,\ c = \max_k \{c_k\} \tag{8}$$

So in that way if the fuzzy rating for the alternatives of the k_{th} decision maker is $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ where $i = 1,2, \dots, m; j = 1,2, \dots, n$, respectively, then the fuzzy aggregated ratings $(\tilde{x}_{ij})$ of alternatives with respect to each criterion are given by

$$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \text{ where, } a_{ij} = \min_k \{a_{ijk}\},\ b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ijk},\ a_{ij} = \max_k \{c_{ijk}\} \tag{9}$$

Step 4. Normalization of the fuzzy decision matrix.

The normalized fuzzy decision matrix $\tilde{R}$ is given by $\tilde{R} = [\tilde{r}_{ij}]_{m \times n}, i = 1,2,\ldots,m;\ j = 1,2,\ldots,n$ where,

for benefit criteria,

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right),\ c_j^* = \max_i (c_{ij}) \quad (10)$$

and for cost criteria

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right),\ a_j^- = \min_i (a_{ij}) \quad (11)$$

Step 5. Computation of the weighted normalized matrix.

The weighted normalized matrix $\tilde{V}$ for criteria is computed by multiplying the weights(w_j) of evaluation criteria with the normalized fuzzy decision matrix $\tilde{r}_{ij}$

$$\tilde{V} = [\tilde{v}_{ij}]_{m \times n}, i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \text{ where } \tilde{v}_{ij} = \tilde{r}_{ij}\ (.) w_j \quad (12)$$

Step 6. Computation the fuzzy ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS).

The FPIS and FNIS for the alternatives with respect to criteria are computed as follows,

$$A^* = (v_1^*, v_2^*, \ldots, v_n^*) \text{ where } v_j^* = \max_i (v_{ij3}),\ i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \quad (13)$$

$$A^- = (v_1^-, v_2^-, \ldots, v_n^-) \text{ where } v_j^- = \min_i (v_{ij1}),\ i = 1,2,\ldots,m;\ j = 1,2,\ldots,n \quad (14)$$

Step 7. The distance computation of each alternative from FPIS and FNIS.

The distance (d_i^*, d_i^-) of each weighted alternative $i = 1,2,\ldots,m$ from the FPIS and the FNIS is computed as follows:

$$d_i^* = \sum_{j=1}^{n} d_v \left(\tilde{v}_{ij}, v_j^* \right), i = 1,2,..,m \quad (15)$$

$$d_i^- = \sum_{j=1}^{n} d_v \left(\tilde{v}_{ij}, v_j^- \right), i = 1,2,..,m \quad (16)$$

where $d_v(\tilde{a}, \tilde{b})$ is the distance between two TFNs $\tilde{a}$ *and* $\tilde{b}$ with the measurement which we have previously mentioned in this paper.

Step 8. The Closeness coefficient (CC_i) computation for each alternative.

The Closeness coefficient (CC_i) interprets the distances from the fuzzy positive ideal solution (A^*) and the fuzzy negative ideal solution (A^-) simultaneously for the alternatives. The closeness coefficient for each alternative is calculated as

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*},\ i = 1,2,..,m \quad (17)$$

Step 9. Ranking the alternatives

Ranking of the alternatives is done by sorting them according to their Closeness coefficient(CC_i) values.

Proposed Model

The Proposed Model for ranking Indian E-commerce websites consists AHP and Fuzzy TOPSIS having the following procedures is described in below,

1st Phase (Group work & Determination of Criteria and Alternatives)
In the first phase, the criteria which we think are the most suitable for the evaluation of Indian E-shopping Stores are determined. The Alternatives, on which the entire study is based upon, are also determined. The brief discussion about this phase is described in Section V. The Multi Level Decision Hierarchy is established . Figure 5 shows our Decision Hierarchy consisting of Goal, Criteria, Sub-criteria, Alternatives as Four levels respectively from top to bottom.

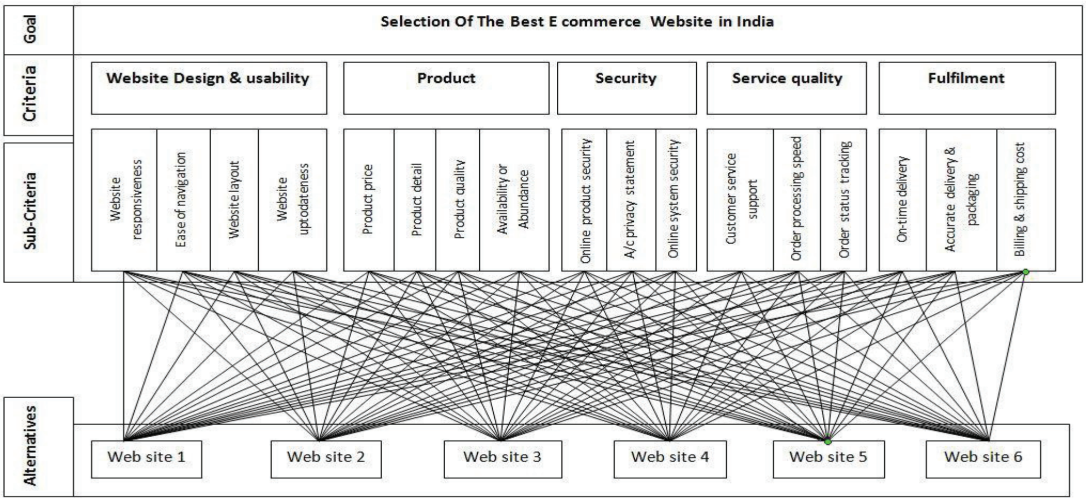

Figure 5: Four level hierarchy of the problem

2nd Phase (Determination of weights of the criteria)
In this stage, simple Analytical hierarchy process is used. We have invited Twenty regular online buyers to give their expert opinions for making the pair-wise comparisons. As we have built a 2-level hierarchy for the criteria, so 2^{nd} level local weights of the criteria are calculated in order to find the global weights. Consistency checks are also done for each comparison matrix. In AHP we have followed the original importance table used by Satty that is shown in Table 1. The intermediate values mentioned by Satty are also used depicted as bold letters in the table. The detailed results for this stage are given in the next segment.

3rd phase (Final evaluation of the E-commerce sites)
In this phase, the final ranking of the E-commerce websites is evaluated using Fuzzy TOPSIS with the help of the results acquired from the AHP in the previous phase. Here we haven't followed a classical Fuzzy TOPSIS method as we have tried to build a Hybrid technique. Though linguistic values are used but only for the Alternatives as the weights of the criteria are taken from the previous step. The linguistic values for the alternatives are shown in the Table 2. The ranking is determined in descending order with the help of Closeness co-efficient CC_i that is determined by the Fuzzy TOPSIS. Figure 6 shows the Proposed E-commerce Website Evaluation Model.

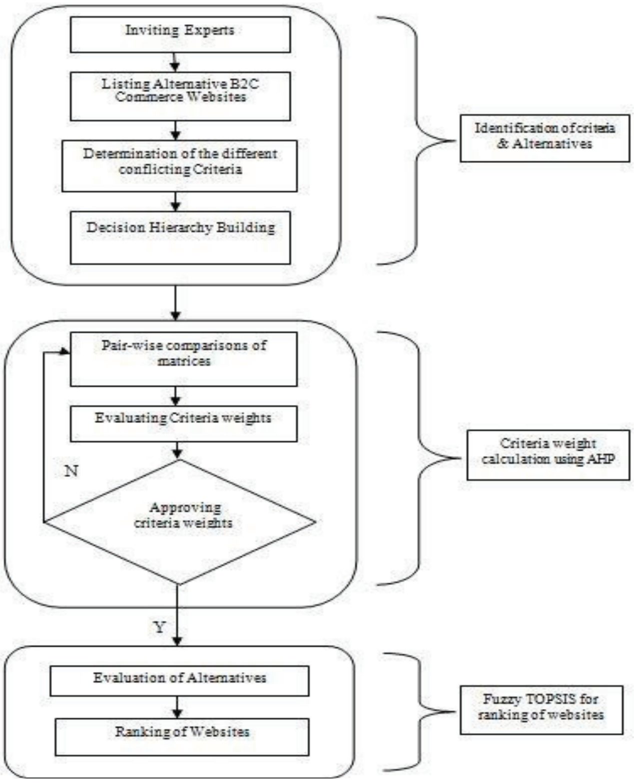

Figure 6: Proposed E-commerce Website Evaluation Model

Table 1: Criteria Importance Rating

Intensity of importance	Definition
1	**Equal importance**
2	Weak
3	**Moderate Importance**
4	Moderate Plus
5	**Strong importance**
6	Strong plus
7	**Very Strong or demonstrated Importance**
8	Very Very strong
9	**Extreme Importance**

Table 2: Linguistic values for alternative rating

Linguistic term for Alternatives	Membership Triangular number
Very Unsatisfied (VU)	(0,0,1)
Unsatisfied (U)	(0,1,3)
Medium Unsatisfied (MU)	(1,3,5)
Fair (F)	(3,5,7)
Medium Satisfied (MS)	(5,7,9)
Satisfied (S)	(7,9,10)
Very Satisfied (VS)	(9,10,10)

Results and Discussion

The above mentioned proposed model is used here for ranking the best Indian E-commerce websites as our goal is to present a new evaluation model for Indian E-commerce market based on the study done on Indian market. Questionnaires were prepared and experts as well as normal Indian customers were invited for taking a part in this study. Taking into account that study and the aforementioned model, results are calculated and explained as follows.

Phase 1: Group work and Determination of Criteria & Alternatives

Criteria Determination

We have determined 5 criteria and 17 sub-criteria, which we think can be the most suitable for assessing Indian E-commerce websites.

Criteria are Website Design & usability (CR1) is the first main criterion combining sub-criteria listed below- Website responsiveness (1A / C_1 / Benefit Criterion) how fast the website and its corresponding pages load in browser is taken as a criterion.

Ease of navigation (1B / C_2 / Benefit Criterion): The ease of browsing through the web pages to find something is taken into account too.

Website layout(1C / C_3 / Benefit Criterion) defines how good and user friendly the entire website looks like. The more the appearance is attractive, the longer the buyers will stay and purchase things.

Website up-to-datedness(1D / C_4 / Benefit Criterion) defines how often the website layout is changed for advancement for showing the updated services. The more the advanced features the website have, the more the buyers it attracts.

Product (CR2) is the second main criterion combining all the below mentioned sub-criteria

Product price(2A / C_5 / Cost Criterion) is always a very influencing criterion for purchasing goods irrespective on the medium(Online or Market).

Product detail(2B / C_6 / Benefit Criterion) describes the amount of information given for a certain product. The more the emphasis or detailing, the more the customer will be satisfied.

Product quality(2C / C_7 / Benefit Criterion) should also be considered based on the customer reviews provided in each of the websites. The better the quality, the longer the durability.

Availability or Abundance(2D / C_8 / Benefit Criterion) defines that the products are available in certain quantity or not. The more the abundance, the more the chance of getting purchased.

Security (CR3) is the third main criterion and sub-criteria under this are

Online purchase security(3A / C_9 / Benefit Criterion) defines how much secure the payment portals are and the no of different payment modes like Cash on delivery, Wallet payment, Debit card, Credit card etc.

A/c privacy statement (3B / C_{10} / Benefit Criterion) demonstrates security level of account settings and personal account information are like passwords, username, saved payments cards, name, addresses etc.

Online system security(3C / C_{11} / Benefit Criterion) determines the level of security the site posses from the threat of hackers and other web vulnerabilities.

And the fourth main criterion is Service quality (CR4), and its sub-criteria are

Customer service support(4A / C_{12} / Benefit Criterion) specifies how good their customer care is as and how well they resolve the issues including return and replace policies.

Order processing speed(4B / C_{13} / Benefit Criterion) delineates how fast they process the order and prepare the product for delivery.

Order status tracking(4C / C_{14} / Benefit Criterion) portrays how good their tracking system is. It basically depends on the logistic company they are tied up with.

And final main criterion is Fulfilment/ Feedback (CR5) and sub-criteria are

On-time delivery(5A / C_{15} / Benefit Criterion) depicts how fast they deliver products from the time of order placement.

Accurate delivery & packaging(5B / C_{16} / Benefit Criterion) considers whether they are giving accurate products are not and how durable their packaging is. Like in past few months many cases of customer finding stones and soaps instead of mobile phones were seen which mainly happened due to their bad packaging and logistics. So these things may lead to customer dissatisfaction.

Billing & shipping cost(5C / C_{17} / Cost Criterion): There can be few debates about giving away manual bills send straight with the corresponding products or giving away bills straight to the email like Flipkart does. And this criterion also considers the shipping costs.

Alternatives Determination

There are many E-shopping websites which are available in India but we only have considered 6 such websites who provide literally everything in day to day life. We have not taken a specific product domain of purchase. Like Myntra, Jabong, Fashinandyou, fashioara, koovs etc are leading fashion online stores, Firstcry, Mybabycart etc are the leading baby product stores, healthkart, dietkart, nykkaa, 365gorgeous, khoobsurati are the leading health and beauty products online stores in india. So these sites were not taken into account. Rather we have enlisted top 6 all in one family E-commerce websites in India based on the No of visitors in the last 30 days, Percentage of visitors from india, Daily Page views per Visitor, Daily Average time spend on site per visitor & Bounce Rate which are Flipkart.com (A_1), Snapdeal.com (A_2), Amazon.in (A_3), Ebay.in (A_4), Homeshop18.com (A_5), Shopclues.com (A_6).

Phase 2: Determination of weights of the criteria using AHP

We have already discussed in the previous section that expert online buyers were given the task of forming the pair-wise comparison matrices for both 1st level and 2nd level criteria with the help of a questionnaire prepared by us for taking the ratings of the criteria importance. In the 1st level one comparison matrix is formed and in the 2nd level six comparison matrices are formed and also their consistency check is done.

This is the 1st level comparison matrix that is deduced.

Table 3: Pair-wise comparison matrix for 1st level Criteria

1st Level	Website Design & usability	Product	Security	Service quality	Fulfilment	Weights (Eigen vector)
Website Design & usability	1	0.142857	0.25	0.333333	0.5	0.0503311
Product	7	1	2	4	7	0.445659
Security	4	0.5	1	5	6	0.324259
Service quality	3	0.25	0.2	1	3	0.11925
Fulfilment	2	0.142857	0.166667	0.333333	1	0.0605013

The below mentioned tables are the Pair-wise comparison matrices for 2nd level criteria.

Table 4: Website Design & usability's sub-criteria comparison matrix

2nd Level	Website Responsiveness	Ease of navigation	Website layout	Website up-to-datedness	Weights (Eigen vector)
Website Responsiveness	1	2	5	6	0.487819
Ease of navigation	0.5	1	5	7	0.356363
Website layout	0.2	0.2	1	3	0.103193
Website up-to-datedness	0.166667	0.142857	0.333333	1	0.0526246

Table 5: Product's sub-criteria comparison matrix

2nd Level	Product price	Product detail	Product quality	Availability /Abundance	Weights (Eigen vector)
Product price	1	7	1	5	0.441848
Product detail	0.142857	1	0.2	3	0.102314
Product quality	1	5	1	5	0.393339
Availability /Abundance	0.2	0.333333	0.2	1	0.0624983

Table 6: Security's sub-criteria comparison matrix

2nd Level	Online purchase security	A/c privacy statement	Online system security	Weights (Eigen vector)
Online purchase security	1	2	4	0.558425
A/c privacy statement	0.5	1	3	0.319618
Online system security	0.25	0.333333	1	0.121957

Table 7: Service quality 's sub-criteria comparison matrix

2nd Level	Customer service support	Order processing speed	Order status tracking	Weights (Eigen vector)
Customer service support	1	2	5	0.569541
Order processing speed	0.5	1	4	0.333069
Order status tracking	0.2	0.25	1	0.0973901

Table 8: Fulfilment/ Feedback 's sub-criteria comparison matrix

2nd Level	On-time delivery	Accurate delivery & packaging	Billing & shipping cost	Weights (Eigen vector)
On-time delivery	1	3	2	0.527836
Accurate delivery & packaging	0.333333	1	0.333333	0.139648
Billing & shipping cost	0.5	3	1	0.332516

Then we have calculated the global weights from the relative priority weights of the criteria and sub-criteria. The following Table 9 depicts all those relative importance or weights of all the criteria calculated from the upper tables and also shows the consistency ratios (CR) of those measures which are all less than .1, thus acceptable.

Table 9: Summary of the Evaluation Criteria weights

Criterion	Local priority of criterion	Sub-criterion	Local priority of Sub-criterion	Global priority of Sub-criterion (rounded of)	CR of Sub-criterion	CR of Criterion
C1	0.0503311	1A/C_1	0.487819	0.0246	0.0614842	0.059457
		1B/C_2	0.356363	0.0180		
		1C/C_3	0.103193	0.0052		
		1D/C_4	0.0526246	0.0027		
C2	0.445659	2A/C_5	0.441848	0.1970	0.0808758	
		2B/C_6	0.102314	0.0456		
		2C/C_7	0.393339	0.1753		
		2D/C_8	0.0624983	0.0279		
C3	0.324259	3A/C_9	0.558425	0.1811	0.0157713	
		3B/C_{10}	0.319618	0.1037		
		3C/C_{11}	0.121957	0.0396		
C4	0.11925	4A/C_{12}	0.569541	0.0680	0.0212026	
		4B/C_{13}	0.333069	0.0397		
		4C/C_{14}	0.0973901	0.0116		
C5	0.0605013	5A/C_{15}	0.527836	0.0314	0.0462255	
		5B/C_{16}	0.139648	0.0085		
		5C/C_{17}	0.332516	0.0201		

This below mentioned Figure 7 depicts the relative importance of all the criteria in Indian market. Here we can easily see that Product price is the most important criteria in Indian condition. These 17 weights of corresponding 17 criteria are taken into a weight row matrix termed as $\widetilde{w}_j$ which was used further in the Fuzzy TOPSIS phase for calculation of weighted normalized matrix.

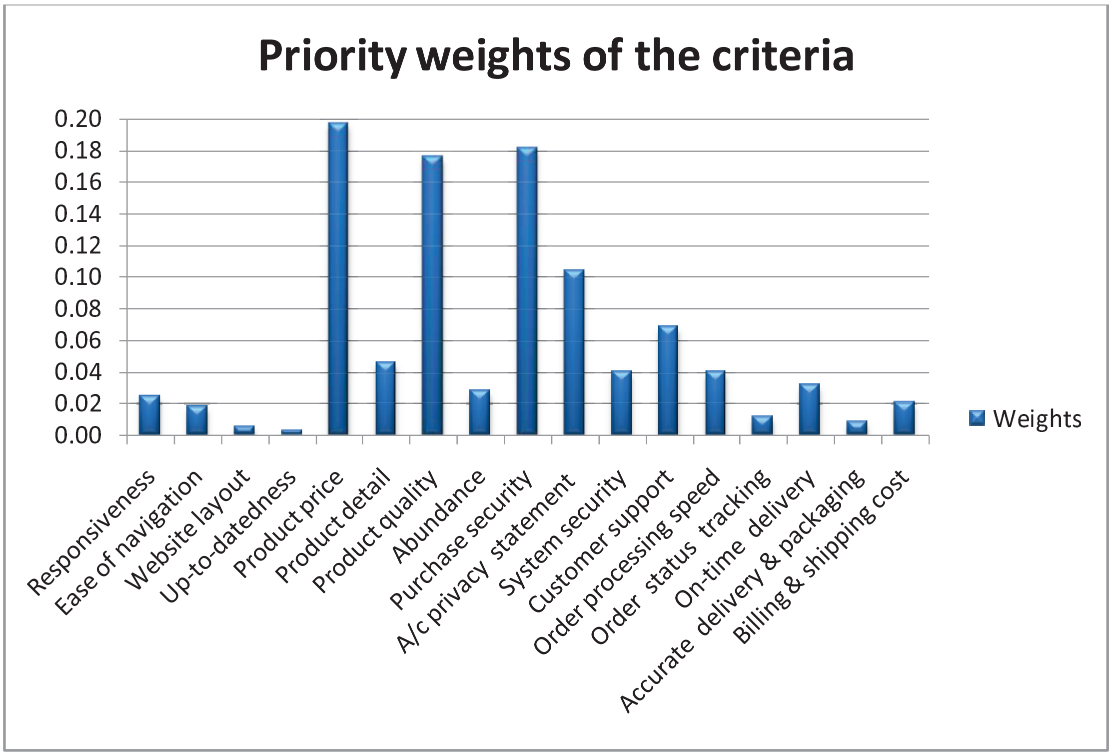

Figure 7: Respective weights of the criteria

Phase 3: Final evaluation of the E-commerce sites using Fuzzy TOPSIS

This is the last phase where the final ranking of the E-commerce websites is done through Fuzzy TOPSIS method with the weights acquired from the previous phase.

A committee of five expert decision makers have been established as they have provided the linguistic judgement ratings for the top 6 E-commerce websites in India with respect to 17 criteria. These ratings are given based on the linguistic terms depicted in Table 10.

The following table shows the linguistic judgment ratings given by the decision makers.

Table 10: Linguistic assessments by decision makers for the alternatives

		A_1	A_2	A_3	A_4	A_5	A_6			A_1	A_2	A_3	A_4	A_5	A_6
C_1	D_1	VS	S	S	S	VS	VS	C_{10}	D_1	S	MS	VS	MS	S	S
	D_2	MS	F	MS	S	MS	S		D_2	S	S	S	S	MS	MS
	D_3	S	S	S	MS	S	S		D_3	VS	MS	MS	MS	F	MS
	D_4	VS	S	S	S	S	S		D_4	MS	MS	VS	VS	S	MS
	D_5	S	VS	MS	VS	S	VS		D_5	VS	S	S	S	MS	F
C_2	D_1	S	S	S	MS	S	S	C_{11}	D_1	S	S	MS	S	S	F
	D_2	VS	S	MS	F	MS	VS		D_2	VS	S	S	S	S	MU
	D_3	S	MS	VS	VS	VS	MS		D_3	MS	MS	S	MS	MU	F
	D_4	S	S	S	MS	S	S		D_4	S	S	S	MS	F	S
	D_5	S	S	S	S	S	S		D_5	S	MS	MS	VS	F	S

C_3	D_1	S	VS	S	S	MS	MS	C_{12}	D_1	MS	MS	S	S	MS	MS
	D_2	S	S	S	S	S	S		D_2	MS	S	MS	VS	F	MU
	D_3	VS	VS	S	S	MS	S		D_3	VS	F	MS	S	F	MS
	D_4	VS	S	S	VS	MS	VS		D_4	S	MS	S	MS	S	F
	D_5	S	MS	VS	S	S	S		D_5	S	F	VS	VS	S	U
C_4	D_1	VS	MS	MS	S	F	S	C_{13}	D_1	S	S	S	MS	MS	S
	D_2	VS	VS	F	VS	S	F		D_2	VS	F	S	S	MS	MS
	D_3	MS	S	MS	VS	F	S		D_3	S	MS	S	S	MS	MU
	D_4	S	S	MS	S	S	MS		D_4	VS	F	MS	S	S	MU
	D_5	MS	MS	MU	MU	F	MS		D_5	S	MS	VS	VS	F	MS
C_5	D_1	MS	F	VS	MS	MU	S	C_{14}	D_1	S	S	S	MS	MS	MS
	D_2	S	MS	S	VS	MS	S		D_2	MU	F	MS	MS	F	F
	D_3	S	MS	MS	S	F	MS		D_3	S	F	S	S	MS	F
	D_4	S	MS	VS	S	S	F		D_4	S	MS	S	VS	MS	MS
	D_5	VS	S	VS	S	F	MU		D_5	VS	S	S	S	MS	VU
C_6	D_1	S	MS	S	S	U	S	C_{15}	D_1	VS	S	VS	S	S	S
	D_2	S	S	MS	MS	S	MS		D_2	MS	MS	MS	S	U	S
	D_3	S	MS	MS	VS	F	S		D_3	S	F	S	VS	F	MS
	D_4	MS	MU	S	S	MS	MS		D_4	VS	MS	MS	MS	MS	F
	D_5	VS	S	VS	MS	S	MS		D_5	S	MS	VS	S	VU	MS
C_7	D_1	VS	MS	VS	VS	S	MU	C_{16}	D_1	S	MS	VS	VS	MU	F
	D_2	S	MS	VS	S	F	F		D_2	F	S	VS	VS	F	MS
	D_3	S	S	S	S	MS	U		D_3	VS	MS	VS	S	F	MS
	D_4	MS	MS	S	MS	S	F		D_4	VS	MS	S	F	MS	F
	D_5	S	S	VS	S	MU	U		D_5	VS	S	VS	MS	S	MS
C_8	D_1	MS	S	VS	VS	S	VS	C_{17}	D_1	S	S	S	S	MS	S
	D_2	VS	VS	S	MS	S	VS		D_2	VS	MS	VS	MS	MS	MS
	D_3	S	MS	S	S	S	S		D_3	S	F	S	MS	S	S
	D_4	S	MS	VS	S	MS	S		D_4	S	F	S	S	F	S
	D_5	VS	S	VS	S	S	MS		D_5	MS	MS	S	MS	MS	S
C_9	D_1	MS	MS	S	VS	MS	MS								
	D_2	S	MS	VS	MS	S	MS								
	D_3	S	MS	VS	VS	F	F								
	D_4	VS	F	VS	MS	MS	MS								
	D_5	S	MS	S	S	F	F								

Then using Eq. (9) for each alternative, we have calculated the corresponding aggregated fuzzy weight. For example, alternative A_1's (Flipkart.com) aggregated fuzzy weight is calculated as

$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}) = (5,9,10)$

where

$a_{ij} = \min_k \{9,5,7,9,7\} = 5,$

$b_{ij} = \frac{1}{5}\sum_{k=1}^{5}(10+7+9+10+9) = 9,\ a_{ij} = \max_k \{10,9,10,10,10\} = 10.$

Similarly we have calculated the aggregated fuzzy weights for the rest of the alternatives with respect to 17 criteria which is presented in Table 11.

Table 11: Aggregated fuzzy weights for alternatives

		A_1	A_2	A_3	A_4	A_5	A_6
C_1	D_1	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)	(9,10,10)	(9,10,10)
	D_2	(5,7,9)	(3,5,7)	(5,7,9)	(7,9,10)	(5,7,9)	(7,9,10)
	D_3	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)
	D_4	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)
	D_5	(7,9,10)	(9,10,10)	(5,7,9)	(9,10,10)	(7,9,10)	(9,10,10)
Aggregate Ratings		[5,9,10]	[3,8.4000, 10]	[5,8.2000, 10]	[5,8.8000, 10]	[5,8.8000, 10]	[7,9.4000, 10]
C_2	D_1	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)
	D_2	(9,10,10)	(7,9,10)	(5,7,9)	(3,5,7)	(5,7,9)	(9,10,10)
	D_3	(7,9,10)	(5,7,9)	(9,10,10)	(9,10,10)	(9,10,10)	(5,7,9)
	D_4	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)
	D_5	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)
Aggregate Ratings		[5,8.8000, 10]	[5,8.6000, 10]	[5,8.8000, 10]	[3,7.6000, 10]	[5,8.8000, 10]	[5,8.8000, 10]
C_3	D_1	(7,9,10)	(9,10,10)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)
	D_2	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)
	D_3	(9,10,10)	(9,10,10)	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)
	D_4	(9,10,10)	(7,9,10)	(7,9,10)	(9,10,10)	(5,7,9)	(9,10,10)
	D_5	(7,9,10)	(5,7,9)	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)
Aggregate Ratings		[7,9.4000, 10]	[5,9,10]	[7,9.2000, 10]	[7,9.2000, 10]	[5,7.8000, 10]	[5,8.8000, 10]
C_4	D_1	(9,10,10)	(5,7,9)	(5,7,9)	(7,9,10)	(3,5,7)	(7,9,10)
	D_2	(9,10,10)	(9,10,10)	(3,5,7)	(9,10,10)	(7,9,10)	(3,5,7)
	D_3	(5,7,9)	(7,9,10)	(5,7,9)	(9,10,10)	(3,5,7)	(7,9,10)
	D_4	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)	(5,7,9)
	D_5	(5,7,9)	(5,7,9)	(1,3,5)	(1,3,5)	(3,5,7)	(5,7,9)
Aggregate Ratings		[5,8.6000, 10]	[5,8.4000, 10]	[1,5.8000, 9]	[1,8.2000, 10]	[3,6.6000, 10]	[3,7.4000, 10]
C_5	D_1	(5,7,9)	(3,5,7)	(9,10,10)	(5,7,9)	(1,3,5)	(7,9,10)
	D_2	(7,9,10)	(5,7,9)	(7,9,10)	(9,10,10)	(5,7,9)	(7,9,10)
	D_3	(7,9,10)	(5,7,9)	(5,7,9)	(7,9,10)	(3,5,7)	(5,7,9)
	D_4	(7,9,10)	(5,7,9)	(9,10,10)	(7,9,10)	(7,9,10)	(3,5,7)
	D_5	(9,10,10)	(7,9,10)	(9,10,10)	(7,9,10)	(3,5,7)	(1,3,5)
Aggregate Ratings		[5,8.8000, 10]	[3,7,10]	[5,9.2000, 10]	[5,8.8000, 10]	[1,5.8000, 10]	[1,6.6000, 10]
C_6	D_1	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)	(0,1,3)	(7,9,10)
	D_2	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)	(7,9,10)	(5,7,9)
	D_3	(7,9,10)	(5,7,9)	(5,7,9)	(9,10,10)	(3,5,7)	(7,9,10)
	D_4	(5,7,9)	(1,3,5)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)
	D_5	(9,10,10)	(7,9,10)	(9,10,10)	(5,7,9)	(7,9,10)	(5,7,9)
Aggregate Ratings		[5,8.8000, 10]	[1,7,10]	[5,8.4000, 10]	[5,8.4000, 10]	[3,7.4000, 10]	[5,7.8000, 10]
C_7	D_1	(9,10,10)	(5,7,9)	(9,10,10)	(9,10,10)	(7,9,10)	(1,3,5)
	D_2	(7,9,10)	(5,7,9)	(9,10,10)	(7,9,10)	(3,5,7)	(3,5,7)
	D_3	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(0,1,3)
	D_4	(5,7,9)	(5,7,9)	(7,9,10)	(5,7,9)	(7,9,10)	(3,5,7)
	D_5	(7,9,10)	(7,9,10)	(9,10,10)	(7,9,10)	(1,3,5)	(0,1,3)
Aggregate Ratings		[5,8.8000, 10]	[5,7.8000, 10]	[7,9.6000, 10]	[5,8.8000, 10]	[0,5,10]	[0,3,7]

C_8	D_1	(5,7,9)	(7,9,10)	(9,10,10)	(9,10,10)	(7,9,10)	(9,10,10)
	D_2	(9,10,10)	(9,10,10)	(7,9,10)	(5,7,9)	(7,9,10)	(9,10,10)
	D_3	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)
	D_4	(7,9,10)	(5,7,9)	(9,10,10)	(7,9,10)	(5,7,9)	(7,9,10)
	D_5	(9,10,10)	(7,9,10)	(9,10,10)	(7,9,10)	(7,9,10)	(5,7,9)
Aggregate Ratings		[5,9,10]	[5,8.4000, 10]	[7,9.6000, 10]	[5,8.8000, 10]	[5,8.6000, 10]	[5,9,10]
C_9	D_1	(5,7,9)	(5,7,9)	(7,9,10)	(9,10,10)	(5,7,9)	(5,7,9)
	D_2	(7,9,10)	(5,7,9)	(9,10,10)	(5,7,9)	(7,9,10)	(5,7,9)
	D_3	(7,9,10)	(5,7,9)	(9,10,10)	(9,10,10)	(3,5,7)	(3,5,7)
	D_4	(9,10,10)	(3,5,7)	(9,10,10)	(5,7,9)	(5,7,9)	(5,7,9)
	D_5	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)	(3,5,7)	(3,5,7)
Aggregate Ratings		[5,8.8000, 10]	[3,6.6000, 9]	[7,9.6000, 10]	[5,8.6000, 10]	[3,6.6000, 10]	[3,6.2000, 9]

		A_1	A_2	A_3	A_4	A_5	A_6
C_{10}	D_1	(7,9,10)	(5,7,9)	(9,10,10)	(5,7,9)	(7,9,10)	(7,9,10)
	D_2	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)
	D_3	(9,10,10)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)
	D_4	(5,7,9)	(5,7,9)	(9,10,10)	(9,10,10)	(7,9,10)	(5,7,9)
	D_5	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(3,5,7)
Aggregate Ratings		[5,9,10]	[5,7.8000,10]	[5,9,10]	[5,8.4000,10]	[3,7.4000,10]	[3,7,10]
C_{11}	D_1	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)	(3,5,7)
	D_2	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(1,3,5)
	D_3	(5,7,9)	(5,7,9)	(7,9,10)	(5,7,9)	(1,3,5)	(3,5,7)
	D_4	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(3,5,7)	(7,9,10)
	D_5	(7,9,10)	(5,7,9)	(5,7,9)	(9,10,10)	(3,5,7)	(7,9,10)
Aggregate Ratings		[5,8.8000,10]	[5,8.2000,10]	[5,8.2000,10]	[5,8.4000,10]	[1,6.2000,10]	[1,6.2000,10]
C_{12}	D_1	(5,7,9)	(5,7,9)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)
	D_2	(5,7,9)	(7,9,10)	(5,7,9)	(9,10,10)	(3,5,7)	(1,3,5)
	D_3	(9,10,10)	(3,5,7)	(5,7,9)	(7,9,10)	(3,5,7)	(5,7,9)
	D_4	(7,9,10)	(5,7,9)	(7,9,10)	(5,7,9)	(7,9,10)	(3,5,7)
	D_5	(7,9,10)	(3,5,7)	(9,10,10)	(9,10,10)	(7,9,10)	(0,1,3)
Aggregate Ratings		[5,8.4000,10]	[3,6.6000,10]	[5,8.4000,10]	[5,9,10]	[3,7,10]	[0,4.6000,9]
C_{13}	D_1	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)	(7,9,10)
	D_2	(9,10,10)	(3,5,7)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)
	D_3	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)	(5,7,9)	(1,3,5)
	D_4	(9,10,10)	(3,5,7)	(5,7,9)	(7,9,10)	(7,9,10)	(1,3,5)
	D_5	(7,9,10)	(5,7,9)	(9,10,10)	(9,10,10)	(3,5,7)	(5,7,9)
Aggregate Ratings		7,9.4000,10]	[3,6.6000,10]	[5,8.8000,10]	[5,8.8000,10]	[3,7,10]	[1,5.8000,10]
C_{14}	D_1	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(5,7,9)	(5,7,9)
	D_2	(1,3,5)	(3,5,7)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)
	D_3	(7,9,10)	(3,5,7)	(7,9,10)	(7,9,10)	(5,7,9)	(3,5,7)
	D_4	(7,9,10)	(5,7,9)	(7,9,10)	(9,10,10)	(5,7,9)	(5,7,9)
	D_5	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(0,0,1)
Aggregate Ratings		[1,8,10]	[3,7,10]	[5,8.6000,10]	[5,8.4000,10]	[3,6.6000,9]	[0,4.8000,9]

C_{15}	D_1	(9,10,10)	(7,9,10)	(9,10,10)	(7,9,10)	(7,9,10)	(7,9,10)
	D_2	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,10)	(0,1,3)	(7,9,10)
	D_3	(7,9,10)	(3,5,7)	(7,9,10)	(9,10,10)	(3,5,7)	(5,7,9)
	D_4	(9,10,10)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)
	D_5	(7,9,10)	(5,7,9)	(9,10,10)	(7,9,10)	(0,0,1)	(5,7,9)
Aggregate Ratings		[5,9,10]	[3,7,10]	[5,8.6000,10]	[5,8.8000,10]	[0,4.4000,10]	[3,7.4000,10]
C_{16}	D_1	(7,9,10)	(5,7,9)	(9,10,10)	(9,10,10)	(1,3,5)	(3,5,7)
	D_2	(3,5,7)	(7,9,10)	(9,10,10)	(9,10,10)	(3,5,7)	(5,7,9)
	D_3	(9,10,10)	(5,7,9)	(9,10,10)	(7,9,10)	(3,5,7)	(5,7,9)
	D_4	(9,10,10)	(5,7,9)	(7,9,10)	(3,5,7)	(5,7,9)	(3,5,7)
	D_5	(9,10,10)	(7,9,10)	(9,10,10)	(5,7,9)	(7,9,10)	(5,7,9)
Aggregate Ratings		[3,8.8000,10]	[5,7.8000,10]	[7,9.8000,10]	[3,8.2000,10]	[1,5.8000,10]	[3,6.2000,9]
C_{17}	D_1	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(5,7,9)	(7,9,10)
	D_2	(9,10,10)	(5,7,9)	(9,10,10)	(5,7,9)	(5,7,9)	(5,7,9)
	D_3	(7,9,10)	(3,5,7)	(7,9,10)	(5,7,9)	(7,9,10)	(7,9,10)
	D_4	(7,9,10)	(3,5,7)	(7,9,10)	(7,9,10)	(3,5,7)	(7,9,10)
	D_5	(5,7,9)	(5,7,9)	(7,9,10)	(5,7,9)	(5,7,9)	(7,9,10)
Aggregate Ratings		[5,8.8000,10]	[3,6.6000,10]	[7,9.2000,10]	[5,7.8000,10]	[3,7,10]	[5,8.6000,10]

Then using Eq. (10) and (11), Normalized fuzzy decision matrices are calculated for the alternatives. For an example, alternative A_1 's(Flipkart.com) Normalized fuzzy rating for criterion Website responsiveness (C_1) (benefit criteria) using Eq. (10) is calculated as

$$c_j^* = \max_i (10,10,10,10,10,10) = 10,$$

$$\tilde{r}_{ij} = \left(\frac{5}{10}, \frac{9}{10}, \frac{10}{10}\right) = (0.5, 0.9, 1)$$

Then same alternative A_1 's(Flipkart.com) Normalized fuzzy rating for Product price (C_5) (cost criteria) using Eq. (11) is calculated as

$$a_j^- = \min_i (5,3,5,5,1,1) = 1,$$

$$\tilde{r}_{ij} = \left(\frac{1}{10}, \frac{1}{8.8}, \frac{1}{5}\right) = (0.1,0.1136,0.2)$$

Similarly we have calculated Normalized fuzzy decision matrices for the rest of the alternatives with respect to 17 criteria which is presented in Table 12.

Table 13. consists Minimum values for Cost criteria (c_j^*) and Maximum values (a_j^-) for Benefit criteria that is used for calculating this step.

Table 12: Normalized fuzzy decision matrix

	A_1	A_2	A_3	A_4	A_5	A_6
C_1	[0.5000, 0.9000,1]	[0.3000, 0.8400,1]	[0.5000, 0.8200,1]	[0.5000, 0.8800,1]	[0.5000, 0.8800,1]	[0.7000, 0.9400,1]
C_2	[0.5000, 0.8800,1]	[0.5000, 0.8600,1]	[0.5000, 0.8800,1]	[0.3000, 0.7600,1]	[0.5000, 0.8800,1]	[0.5000, 0.8800,1]
C_3	[0.7000, 0.9400,1]	[0.5000, 0.9000,1]	[0.7000, 0.9200,1]	[0.7000, 0.9200,1]	[0.5000, 0.7800,1]	[0.5000, 0.8800,1]
C_4	[0.5000, 0.8600,1]	[0.5000, 0.8400,1]	[0.1000, 0.5800, 0.9000]	[0.1000, 0.8200,1]	[0.3000, 0.6600,1]	[0.3000, 0.7400,1]
C_5	[0.1000, 0.1136, 0.2000]	[0.1000, 0.1429, 0.3333]	[0.1000, 0.1087, 0.2000]	[0.1000, 0.1136, 0.2000]	[0.1000, 0.1724,1]	[0.1000, 0.1515,1]
C_6	[0.5000, 0.8800,1]	[0.1000, 0.7000,1]	[0.5000, 0.8400,1]	[0.5000, 0.8400,1]	[0.3000, 0.7400,1]	[0.5000, 0.7800,1]
C_7	[0.5000, 0.8800,1]	[0.5000, 0.7800,1]	[0.7000, 0.9600,1]	[0.5000, 0.8800,1]	[0,0.5000,1]	[0,0.3000, 0.7000]
C_8	[0.5000, 0.9000,1]	[0.5000, 0.8400,1]	[0.7000, 0.9600,1]	[0.5000, 0.8800,1]	[0.5000, 0.8600,1]	[0.5000, 0.9000,1]
C_9	[0.5000, 0.8800,1]	[0.3000, 0.6600, 0.9000]	[0.7000, 0.9600,1]	[0.5000, 0.8600,1]	[0.3000, 0.6600,1]	[0.3000, 0.6200, 0.9000]
C_{10}	[0.5000, 0.9000,1]	[0.5000, 0.7800,1]	[0.5000, 0.9000,1]	[0.5000, 0.8400,1]	[0.3000, 0.7400,1]	[0.3000, 0.7000,1]
C_{11}	[0.5000, 0.8800,1]	[0.5000, 0.8200,1]	[0.5000, 0.8200,1]	[0.5000, 0.8400,1]	[0.1000, 0.6200,1]	[0.1000, 0.6200,1]
C_{12}	[0.5000, 0.8400,1]	[0.3000, 0.6600,1]	[0.5000, 0.8400,1]	[0.5000, 0.9000,1]	[0.3000, 0.7000,1]	[0,0.4600, 0.9000]
C_{13}	[0.7000, 0.9400,1]	[0.3000, 0.6600,1]	[0.5000, 0.8800,1]	[0.5000, 0.8800,1]	[0.3000, 0.7000,1]	[0.1000, 0.5800,1]
C_{14}	[0.1000, 0.8000,1]	[0.3000, 0.7000,1]	[0.5000, 0.8600,1]	[0.5000, 0.8400,1]	[0.3000, 0.6600, 0.9000]	[0,0.4800, 0.9000]
C_{15}	[0.5000, 0.9000,1]	[0.3000, 0.7000,1]	[0.5000, 0.8600,1]	[0.5000, 0.8800,1]	[0,0.4400, 1]	[0.3000, 0.7400,1]
C_{16}	[0.3000, 0.8800,1]	[0.5000, 0.7800,1]	[0.7000, 0.9800,1]	[0.3000, 0.8200,1]	[0.1000, 0.5800,1]	[0.3000, 0.6200, 0.9000]
C_{17}	[0.3000, 0.3409, 0.6000]	[0.3000, 0.4545,1]	[0.3000, 0.3261, 0.4286]	[0.3000, 0.3846, 0.6000]	[0.3000, 0.4286,1]	[0.3000, 0.3488, 0.6000]

Table 13: Minimum value for cost criteria and maximum value for benefit criteria

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}
a_j^-	3	3	5	1	1	1	0	5	3	3	1	0	1	0	0	1	3
c_j^*	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

The next step is the computation of Weighted Normalized fuzzy decision matrix with the help of Eq. (12). The values of $\widetilde{w}_j$ are already mentioned in previous step and the values of $\tilde{r}_{ij}$ i.e. the normalized fuzzy decision matrix, are used to compute this matrix. The weighted normalized fuzzy rating of alternative A_1 for website responsiveness (C_1) is calculated as

$$\tilde{v}_{ij} = (0.5, 0.9, 1)(.)(0.0246) = (0.0123,0.0221,0.0246)$$

Similarly we have calculated the ratings for all 6 alternatives with respect to 17 criteria which is presented in Table 14.

Table 14: Weighted Normalized fuzzy decision matrix

	A_1	A_2	A_3	A_4	A_5	A_6
C_1	[0.0123,0.0221,0.0246]	[0.0074,0.0207,0.0246]	[0.0123,0.0202,0.0246]	[0.0123,0.0216,0.0246]	[0.0123,0.0216,0.0246]	[0.0172,0.0231,0.0246]
C_2	[0.0090,0.0158,0.0180]	[0.0090,0.0155,0.0180]	[0.0090,0.0158,0.0180]	[0.0054,0.0137,0.0180]	[0.0090,0.0158,0.0180]	[0.0090,0.0158,0.0180]
C_3	[0.0036,0.0049,0.0052]	[0.0026,0.0047,0.0052]	[0.0036,0.0048,0.0052]	[0.0036,0.0048,0.0052]	[0.0026,0.0041,0.0052]	[0.0026,0.0046,0.0052]
C_4	[0.0014,0.0023,0.0027]	[0.0014,0.0023,0.0027]	[0.00027,0.0016,0.0024]	[0.00027,0.0022,0.0027]	[0.00081,0.0018,0.0027]	[0.00081,0.0020,0.0027]
C_5	[0.0197,0.0224,0.0394]	[0.0197,0.0281,0.0657]	[0.0197,0.0214,0.0394]	[0.0197,0.0224,0.0394]	[0.0197,0.0340,0.1970]	[0.0197,0.0298,0.1970]
C_6	[0.0228,0.0401,0.0456]	[0.0046,0.0319,0.0456]	[0.0228,0.0383,0.0456]	[0.0228,0.0383,0.0456]	[0.0137,0.0337,0.0456]	[0.0228,0.0356,0.0456]
C_7	[0.0877,0.1543,0.1753]	[0.0877,0.1367,0.1753]	[0.1227,0.1683,0.1753]	[0.0877,0.1543,0.1753]	[0,0.0877,0.1753]	[0,0.0526,0.1227]
C_8	[0.0140,0.0251,0.0279]	[0.0140,0.0234,0.0279]	[0.0195,0.0268,0.0279]	[0.0140,0.0246,0.0279]	[0.0140,0.0240,0.0279]	[0.0140,0.0251,0.0279]
C_9	[0.0906,0.1594,0.1811]	[0.0543,0.1195,0.1630]	[0.1268,0.1739,0.1811]	[0.0906,0.1557,0.1811]	[0.0543,0.1195,0.1811]	[0.0543,0.1123,0.1630]
C_{10}	[0.0519,0.0933,0.1037]	[0.0519,0.0809,0.1037]	[0.0519,0.0933,0.1037]	[0.0519,0.0871,0.1037]	[0.0311,0.0767,0.1037]	[0.0311,0.0726,0.1037]
C_{11}	[0.0198,0.0348,0.0396]	[0.0198,0.0325,0.0396]	[0.0198,0.0325,0.0396]	[0.0198,0.0333,0.0396]	[0.0040,0.0246,0.0396]	[0.0040,0.0246,0.0396]
C_{12}	[0.0340,0.0571,0.0680]	[0.0204,0.0449,0.0680]	[0.0340,0.0571,0.0680]	[0.0340,0.0612,0.0680]	[0.0204,0.0476,0.0680]	[0,0.0313,0.0612]
C_{13}	[0.0278,0.0373,0.0397]	[0.0119,0.0262,0.0397]	[0.0199,0.0349,0.0397]	[0.0199,0.0349,0.0397]	[0.0119,0.0278,0.0397]	[0.0040,0.0230,0.0397]
C_{14}	[0.0012,0.0093,0.0116]	[0.0035,0.0081,0.0116]	[0.0058,0.0100,0.0116]	[0.0058,0.0097,0.0116]	[0.0035,0.0077,0.0104]	[0,0.0056,0.0104]
C_{15}	[0.0157,0.0283,0.0314]	[0.0094,0.0220,0.0314]	[0.0157,0.0270,0.0314]	[0.0157,0.0276,0.0314]	[0,0.0138,0.0314]	[0.0094,0.0232,0.0314]
C_{16}	[0.0026,0.0075,0.0085]	[0.0043,0.0066,0.0085]	[0.0060,0.0083,0.0085]	[0.0026,0.0070,0.0085]	[0.00085,0.0049,0.0085]	[0.0026,0.0053,0.0077]
C_{17}	[0.0060,0.0069,0.0121]	[0.0060,0.0091,0.0201]	[0.0060,0.0066,0.0086]	[0.0060,0.0077,0.0121]	[0.0060,0.0086,0.0201]	[0.0060,0.0070,0.0121]

Then computation of the Fuzzy Positive ideal solutions (FPIS) and Fuzzy Negative ideal solutions (FNIS) are done using Eq. (13) and (14) which is shown in Table 15.

Table 15: Positive ideal solution (FPIS) and Negative ideal solution (FNIS)

	FNIS(A^{-})	FPIS(A^{*})
C_1	[0.0074,0.0074,0.0074]	[0.0246,0.0246,0.0246]
C_2	[0.0054,0.0054,0.0054]	[0.0180,0.0180,0.0180]
C_3	[0.0026,0.0026,0.0026]	[0.0052,0.0052,0.0052]
C_4	[0.00027, 0.00027, 0.00027]	[0.0027,0.0027,0.0027]
C_5	[0.0197,0.0197,0.0197]	[0.1970,0.1970,0.1970]
C_6	[0.0046,0.0046,0.0046]	[0.0456,0.0456,0.0456]
C_7	[0,0,0]	[0.1753,0.1753,0.1753]
C_8	[0.0140,0.0140,0.0140]	[0.0279,0.0279,0.0279]
C_9	[0.0543,0.0543,0.0543]	[0.1811,0.1811,0.1811]
C_{10}	[0.0311,0.0311,0.0311]	[0.1037,0.1037,0.1037]
C_{11}	[0.0040,0.0040,0.0040]	[0.0396,0.0396,0.0396]
C_{12}	[0,0,0]	[0.0680,0.0680,0.0680]
C_{13}	[0.0040,0.0040,0.0040]	[0.0397,0.0397,0.0397]
C_{14}	[0,0,0]	[0.0116,0.0116,0.0116]
C_{15}	[0,0,0]	[0.0314,0.0314,0.0314]
C_{16}	[0.00085,0.00085, 0.00085]	[0.0085,0.0085,0.0085]
C_{17}	[0.0060,0.0060,0.0060]	[0.0201,0.0201,0.0201]

For an example, the FPIS(A^{*}) and FNIS(A^{-}) for website responsiveness (C_1) is calculated as

$A^{*} = (0.0246,0.0246,0.0246)$ and $A^{-} = (0.0074,0.0074,0.0074)$.

Now the distance $d_{v,}(.)$ between each alternatives and FPIS(A^{*}) and FNIS(A^{-}) for each criterion is computed using Eqs. (7). The distances $(d_{v}, A_1{}^{*})$ and $(d_{v}, A_1{}^{-})$ for alternative A_1 (Flipkart.com) with respect to website responsiveness (C_1) are computed as follows

$$(d_{v}, A_1{}^{*}) = \sqrt{\frac{1}{3}\left[(0.0123-0.0246)^2 + (0.0221-0.0246)^2 + (0.0246-0.0246)^2\right]} = 0.0072$$

$$(d_{v}, A_1{}^{-}) = \sqrt{\frac{1}{3}\left[(0.0123-0.0074)^2 + (0.0221-0.0074)^2 + (0.0246-0.0074)^2\right]} = 0.0134$$

Similarly we have computed the other distances which are presented in Table 16 and Table 17.

Then we have calculated the distances $d_i{}^{*}$ and $d_i{}^{-}$ using Eqs. (15) and (16). For example the distances $d_i{}^{*}$ and $(d_i{}^{-})$ for alternative A_1 are calculated as follows

$$(d_i{}^{*}) = \sqrt{\frac{1}{3}\left[(0.0123-0.0246)^2 + (0.0221-0.0246)^2 + (0.0246-0.0246)^2\right]} +$$

$$\sqrt{\frac{1}{3}\left[(0.0090-0.0180)^2 + (0.0158-0.0180)^2 + (0.0180-0.0180)^2\right]} +$$

$$\ldots + \sqrt{\frac{1}{3}\left[(0.0060-0.0201)^2 + (0.0069-0.0201)^2 + (0.0121-0.0201)^2\right]}$$

$$= 0.4128$$

$$(d_i^{-}) = \sqrt{\frac{1}{3}\left[(0.0123-0.0074)^2 + (0.0221-0.0074)^2 + (0.0246-0.0074)^2\right]} +$$

$$\sqrt{\frac{1}{3}\left[(0.0090-0.0054)^2 + (0.0158-0.0054)^2 + (0.0180-0.0054)^2\right]} +$$

$$\ldots + \sqrt{\frac{1}{3}\left[(0.0060-0.0060)^2 + (0.0069-0.0060)^2 + (0.0121-0.0060)^2\right]}$$

$$= 0.5389$$

The final step is to compute the closeness coefficient (CC_i) for all the alternatives using corresponding distances d_i^* and d_i^- with the help of Eq. (17). For example the CC_i of alternative A_1 (Flipkart.com) was computed as follows

$$CC_i = \frac{0.5389}{0.5389 + 0.4128} = 0.5662$$

Similarly we have compute all the CC_i for rest of the alternatives presented in Table 18.

Table 16: Distance $d_i(A_i, A^-)$ for alternatives

	$d_v(A_1, A^-)$	$d_v(A_2, A^-)$	$d_v(A_3, A^-)$	$d_v(A_4, A^-)$	$d_v(A_5, A^-)$	$d_v(A_6, A^-)$
C_1	0.0134	0.0126	0.0127	0.0132	0.0132	0.0146
C_2	0.0097	0.0095	0.0097	0.0087	0.0097	0.0097
C_3	0.0021	0.0019	0.0021	0.0021	0.0017	0.0019
C_4	0.0019	0.0019	0.0015	0.0018	0.0017	0.0017
C_5	0.0115	0.027	0.0114	0.0115	0.1027	0.1025
C_6	0.0331	0.0285	0.0324	0.0324	0.0295	0.0315
C_7	0.144	0.138	0.1572	0.144	0.1132	0.0771
C_8	0.0103	0.0097	0.0114	0.0101	0.0099	0.0103
C_9	0.0973	0.0732	0.1089	0.096	0.0823	0.0711
C_{10}	0.0565	0.0522	0.0565	0.0543	0.0495	0.0483
C_{11}	0.0287	0.0279	0.0279	0.0282	0.0238	0.0238
C_{12}	0.0549	0.0485	0.0549	0.0563	0.0493	0.0397
C_{13}	0.0314	0.0247	0.0288	0.0288	0.0252	0.0234
C_{14}	0.0086	0.0084	0.0094	0.0094	0.0077	0.0068
C_{15}	0.026	0.0228	0.0256	0.0258	0.0198	0.0232
C_{16}	0.0059	0.0059	0.0068	0.0057	0.005	0.0048
C_{17}	0.0035	0.0083	0.0015	0.0036	0.0083	0.0035

Table 17: Distance $d_i(A_i, A^*)$ for alternatives

	$d_v(A_1, A^*)$	$d_v(A_2, A^*)$	$d_v(A_3, A^*)$	$d_v(A_4, A^*)$	$d_v(A_5, A^*)$	$d_v(A_6, A^*)$
C_1	0.0072	0.0102	0.0075	0.0073	0.0073	0.0043
C_2	0.0053	0.0054	0.0053	0.0077	0.0053	0.0053
C_3	0.0009185	0.0015	0.00093214	0.00093214	0.0016	0.0015
C_4	0.0008094	0.00081836	0.0016	0.0014	0.0012	0.0012
C_5	0.1701	0.1604	0.1704	0.1701	0.1391	0.1407
C_6	0.0135	0.025	0.0138	0.0138	0.0197	0.0144
C_7	0.052	0.0553	0.0306	0.052	0.1132	0.1272
C_8	0.0082	0.0085	0.0049	0.0083	0.0084	0.0082
C_9	0.0538	0.082	0.0316	0.0543	0.0814	0.0839
C_{10}	0.0305	0.0327	0.0305	0.0314	0.0447	0.0456
C_{11}	0.0118	0.0121	0.0121	0.012	0.0223	0.0223
C_{12}	0.0206	0.0306	0.0206	0.02	0.0299	0.0448
C_{13}	0.007	0.0178	0.0118	0.0118	0.0175	0.0228
C_{14}	0.0062	0.0051	0.0035	0.0035	0.0053	0.0076
C_{15}	0.0092	0.0138	0.0094	0.0093	0.0208	0.0135
C_{16}	0.0035	0.0027	0.0015	0.0035	0.0049	0.0039
C_{17}	0.0121	0.0103	0.0131	0.0118	0.0105	0.012

Table 18: Closeness coefficients(CC_i) of the alternatives & Final ranking of alternatives

	A_1	A_1	A_1	A_1	A_1	A_1	Ranking Order
d_i^-	0.5389	0.5010	0.5587	0.5319	0.5526	0.4939	$A_3 > A_1 > A_4 > A_2 > A_5 > A_6$
d_i^+	0.4128	0.4742	0.3693	0.4192	0.5329	0.5594	
CC_i	0.5662	0.5137	0.6021	0.5592	0.5091	0.4689	

So finally we have sorted the major E-commerce websites in India according to their corresponding closeness coefficients and have got the final ranking as follows

Amazon.in > Flipkart.com > Ebay.in > Snapdeal.com > Homeshop18.com > Shopclues.com

So in Indian scenario we can observe that Amazon.in has the best reputation according to our study. The entire evaluation model is implemented and calculated in MATLAB R2013a software. Figure 8 shows the MATLAB result depicting the final ranking of the E-coomerce website in India.

Figure 8: Matlab results: Ranking bar graph for Alternatives

Conclusion

As the need of an extensive decision model for Indian E-commerce websites is found, we have shed some light on the E-commerce industry by conducting a market survey in introduction part. Then formulating the decision-making problem of selecting the best site while purchasing things online, the top 6 E-commerce sites with 17 corresponding conflicting attributes have been selected. A 4 level problem hierarchy is established. Finally it is concluded that successful implementation of a hybrid approach is done in which incorporates multi-level criteria analysis with classical AHP combined with Fuzzy TOPSIS. It is used in order to rank main E-commerce websites which are hosted in Indian Market by conducting another survey on online buyers as well as expert consumers. These methods have been selected mainly because both AHP & FTOPSIS are widely used methods as well as very simple to understand. The main reason behind selecting these techniques are also discussed. The evaluation of the relative importance of each criterion weight is also shown in this study. This study enlightenes the fact that product price, purchase security, product quality, account privacy statement and customer support to be the top 5 most influential criteria in terms of online purchasing respectively in Indian market. From the result it is found that Amazon.in got the highest rating, while flipkart and Ebay are sharing the second and third spot respectively by very a little margin differentiating them.

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