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Evaluation of Websites Quality Using Fuzzy TOPSIS Method

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Abstract
Competition in trade is increasing every day along with the influence of globalization. The primary factor allowing globalization to reach large dimensions in our day has been the intense use of the internet and internet technologies in trade. In this intense completive environment, internet offers significant advantages to all businesses, either large or small. One of the most important factors that place enterprises serving customers in the web environment and one step ahead is the quality of the web pages. The design of websites in a manner to meet the expectations of the consumers is quite important for them to succeed. Primarily the quality of the online shopping sites has been focused on and quality perceptions of consumers regarding websites, where books are sold online have been evaluated. The Fuzzy TOPSIS method is used for the evaluation of five Turkish bookstores websites quality. Fifteen sub-criteria under four main categories were used in the evaluation of bookstore websites quality.
Keywords: Website quality, Fuzzy TOPSIS, Multicriteria decision making, Linguistic variable
Jel Codes: M39, C02

1. Introduction

Online shopping sites gıve customers the opportunity to shop online and offer significant advantages to both the businesses and the consumers. Consumers are able to search for, and access, products easily and at an affordable price thanks to the internet; business are able to derive advantages in many areas such as advertisement, public relations, promotion, management of sales and human resources, etc. through the websites they create. This has caused the competition between sectors to be carried over to the electronic media. The continued expansion of electronic trade has caused the quality of the electronic services on the web to become important in addition to the quality of the traditional services to the customers.

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By measuring the quality of websites, it is possible to measure how efficiently and effectively the business is able to perform. The operations for the sales and distribution of services recommended over the internet site and at which level the generated output meets the demands and requirements. Therefore, the evaluation of the quality of websites is very important for businesses performing online sales.
The purpose of this research is to determine the important parameters that define the qualities of the online shopping sites; and demonstrate the level of significance of these criteria in the preferences of university students for sites dealing with online book sales.

2. Literature review

The quality of the web page is quite important in both increasing the sales and in generating customer satisfaction. The academic studies conducted on this subject have primarily approached the issue from the service quality dimension. The majority of these studies have been based on the traditional SERVQUAL developed by Parasuraman et al. (1993). Later on, Parasuraman et al. (2005) developed the E- S-QUAL, which is a quite successful scale to measure online service quality. There are numerous academic studies evaluating the qualities of web pages as based on service quality. Yen and Lu (2008) have defined the quality dimensions of web pages as efficiency, system availability, privacy and fulfillment. In addition, the variables of web page quality are defined as fulfillment, system availability and efficiency in many papers (Sun et.al. 2009; Chang et al. 2009; Kuenzel, 2009; Semeijn et al. 2005).

Table 1. The Criteria of Website Quality

Main Criteria	Sub-criteria	Authors
Service Quality	Trust	Barnes and Vidgen (2001); Devaraj et al. (2002); Kim and Lim (2001); Parasuraman et al. (2005); Sun and Lin (2009); Wang (2003); Marks et al. (2005); Negash et al. (2003); Nilashi et al. (2012); Ong et al. (2004)
	Reliability	Çebi (2013); DeLone and McLean (2003); Ecer (2014); Lee and Kozar (2006); Lin (2007); Negash et al. (2003); Nilashi et al. (2012); Parasuraman et al. (2005); Roca et al. (2006); Teo et al. (2003); Webb and Webb (2004)
	Responsiveness	Çebi (2013); DeLone and McLean (2003); Lee et al. (2005); Lee and Kozar (2006); Lin (2007); Negash et al. (2003); Nilashi et al. (2012); Palmer (2002); Parasuraman et al. (2005); Roca et al. (2006)
	Navigability	Çebi (2013); Chiu et al. (2005); DeLone and McLean (2003); Ecer (2014); Janda et al. (2002); Katerattanakul (2002); Kim and Lim (2001); Lee and Kozar (2006); Nilashi et al. (2012); Palmer (2002); Tzeng et al. (2007); Webb and Webb (2004)

System Quality	Response time	Cho et al. (2009); DeLone and McLean (2003); Ecer (2014); Lee and Kozar (2006); Nilashi et al. (2012); Roca et al. (2006); Teo et al. (2003); Tzeng et al. (2007)
	Accessibility	Çebi (2013); Cho et al. (2009); Ecer (2014); Lin (2007); Negash et al. (2003); Nilashi et al. (2012); Parasuraman et al. (2005); Tzeng et al. (2007)
	Security	DeLone and McLean (2003); Parasuraman et al. (2005); Sun and Lin (2009); Webb and Webb (2004)
	Usability	Argawal and Venkatesh (2002); Barnes and Vidgen (2001); DeLone and McLean (2003); Devaraj et al. (2002); Koufaris (2002); Webb and Webb (2004); Yang et al. (2005)
Information Quality	Accuracy	Çebi (2013); Janda et al. (2002); Lin (2007); Tung and Chang (2008) Tzeng et al. (2007) Wang (2003) Webb and Webb (2004)
	Completeness	Chiu et al. (2005); DeLone and McLean (2003) Lin (2007); Nilashi et al. (2012); Tung and Chang (2008); Wang (2003)
	Timeliness	Devaraj et al. (2002); Janda et al. (2002); Katerattanakul (2002); Kim and Lim (2001); Nilashi et al. (2012)
	Relevance	DeLone and McLean (2003); Ecer (2014); Lee and Kozar (2006) Webb and Webb (2004)
	Understandability	DeLone and McLean (2003); Ecer (2014); Lee and Kozar (2006)
Vendor-Specific Quality	Awareness	Lee and Kozar (2006)
	Price savings	DeLone and McLean (2003); Devaraj et al. (2002); Lee and Kozar (2006)

What can be found from these studies while some authors concentrate on sub-criteria regarding system quality, some authors have concentrated on sub-criteria regarding service quality. All of these main and sub-dimensions are important in determining the quality in respect of web pages. In Table 1, the main and sub-criteria that are effective on the quality of online shopping websites according to certain authors have been summarized. In Table 1, the four main criteria regarding web page quality as Service Quality, System Quality, Information Quality and Vendor-Specific Quality.

2.1. Service Quality

E-service, is defined as beıng an interactive web-based service making distribution over the internet. It is often a self-service process that the customer performs, without any direct intervention of service staff, by interacting with the website supported by the service company with technological infrastructure. E-service quality is defined as the general evaluations and judgements of customers regarding e-service provision and quality in the virtual market. E-Service Quality is a key factor for customers because comparing the prices and technical specifications of products online is much easier than the traditional channels (Santos, 2003). In order to be able to measure service quality, there are three basic dimensions that stand out in the studies, as trust, reliability and responsiveness that are also used in other studies (Barnes and Vidgen, 2001; Çebi, 2013; DeLone and McLean, 2003; Devaraj et al. 2002; Ecer, 2014; Lee and Kozar, 2006; Kim and Lim, 2001; Lee et al. 2005; Lin, 2007; Parasuraman et al. 2005; Sun and Lin, 2009; Wang, 2003; Webb and Webb, 2004; Marks et al. 2005; Negash et al. 2003; Nilashi et al. 2012; Ong et al. 2004, Palmer, 2002; Roca et al. 2006; Teo et al. 2003).

Trust: This is the foundatıon that the customer of the product or services offered on the website have a good reputation and at the same time, clear and trustworthy information is provided on the website (Parasuraman et al. 2005). In short, it is the creation of a feeling of trust in the customer by the businesses.

Reliability: This is the provision of accurate information and the performance of the promised service on the internet site (Li et al. 2003). If customers cannot trust the business regarding an operation they make over the internet, the perception regarding the internet site will also be negative. The accuracy of the orders, performance of the delivery as promised, the accuracy of the invoice data influence the reliability dimension of the internet site (Negash et al. 2003; Lee and Kozar, 2006). In short, reliability is the accuracy, consistency of a promised service and the ability to perform that service.

Responsiveness: This is the ability of the website to respond to the needs of the customer and the availability of customer services. In addition, this concept also includes the ability to respond to the customer's demands on time, in a correct and clear manner. In short, it may also be defined as the desire to assist the customer and offer the service fully (Negash et al. 2003; Lee and Kozar, 2006; Parasuraman et al. 2005).

2.2. System Quality

System quality may be defined as the ability of the technical infrastructure of web pages to perform the expected services as required. System quality is the ability of the technological hardware and e-service technical infrastructure, which the business providing the e-service benefits from, to perform the expected services in the best manner (Sevim, 2012). As the sub-dimensions of the *system quality* dimension, Navigability, Response time, Accessibility, Security and Usability may be listed **(**Parasuraman et al. 2005; Argawal and Venkatesh, 2002;Barnes and Vidgen, 2001; Chiu et al. 2005; Cho et al. 2009; Lin, 2007; Çebi, 2013; DeLone and McLean, 2003; Devaraj et al. 2002; Ecer, 2014; Janda et al. 2002; Katerattanakul, 2002; Kim and Lim, 2001; Koufaris, 2002; Lee and Kozar, 2006; Negash et al. 2003; Nilashi et al. 2012; Palmer, 2002;

Roca et al. 2006; Sun and Lin, 2009; Teo et al. 2003; Tzeng et al. 2007; Webb and Webb, 2004; Yang et al. 2005):

Navigability: This is the ability of the web page to allow the customers to navigate the site, obtain the information they want and to search by key words. This condition is evaluated as easily usable by the customers (Lee and Kozar, 2006).

The availability of functions on the website in order to assist customers in finding what they are looking for easily, presence of a good search engine and the ability of customer to navigate between pages quickly and easily are important (Moustakis et al. 2004).

Response Time: The web site should be loaded to the computer quickly and rapidly react to all transaction requests of the customer. The ability to respond rapidly to any changes that may occur in the customer's requests and order shows that the web site has flexibility (Lee and Kozar, 2006). In short, this criterion indicates that the website should have a short response time (Parasuraman et al. 2005).

Accessibility: This is the ability to access the website easily every day of the week, at any desired time, without any extra efforts and costs. It expresses the ease to access the relevant site at the moment it is necessary.

Security: One of the most important quality factors influencing the success of web pages is ensuring security at the website during exchange and the confidentiality of the personal data provided by the customer. The customers have to be assured that their personal data are protected (Tzeng et al. 2007; Parasuraman et al. 2005).

Usability: In the conducted studies, it has been found out that a website that is easily used and the use of which is easily learned positively influences customer satisfaction and the future purchasing trends of the customer. In short, this criterion indicates that the website should be user friendly (Barnes and Vidgen, 2001; DeLone and McLean, 2003; Devaraj et al. 2002).

2.3. Information Quality

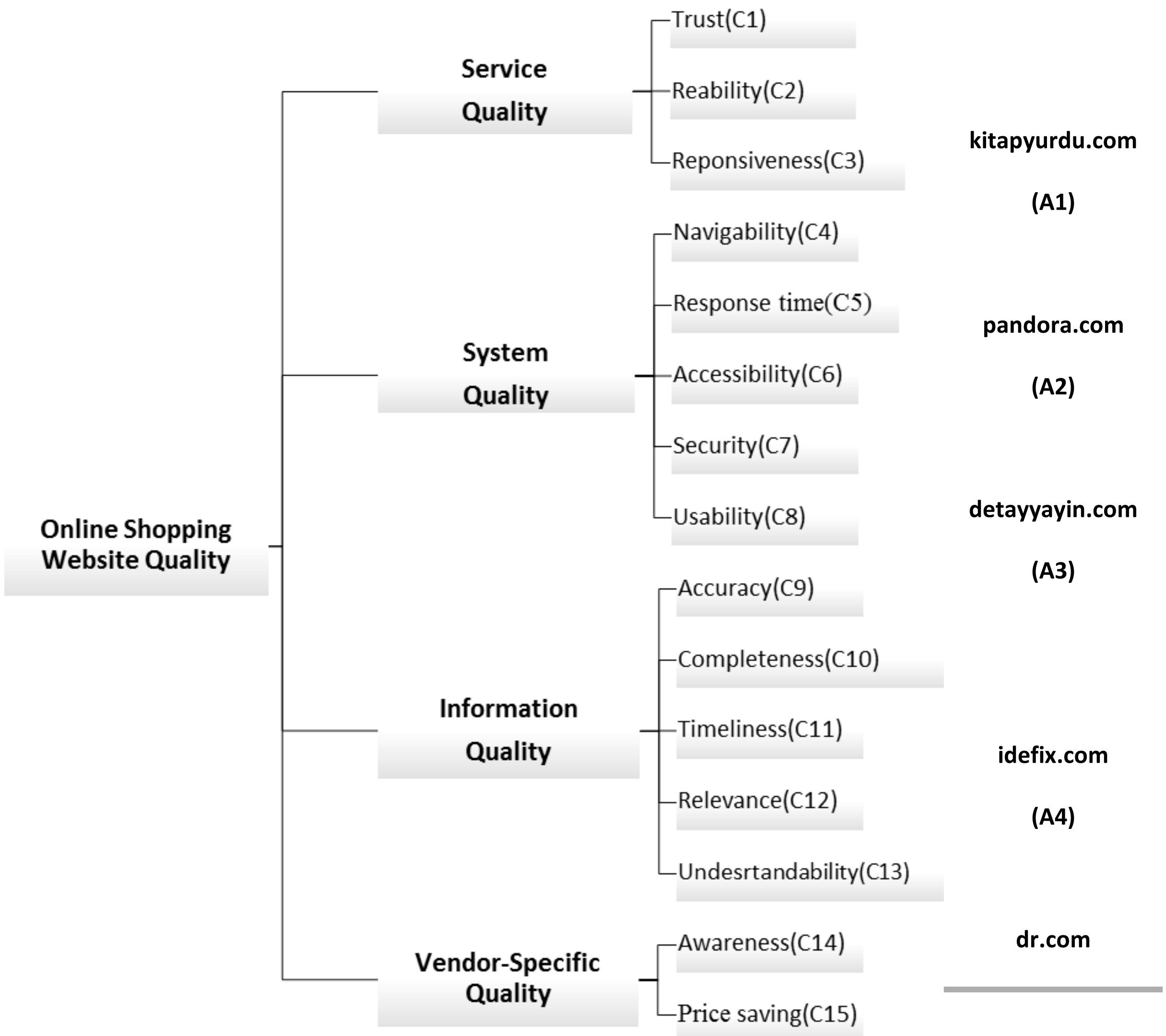
The richness of the information contents and the diversity of the services available on the site lead among the factors that make customers willing to use an e-service website. The conducted studies show that in a website that offers qualified information and service contents, the site design quality perceived by the customers are also positive as dependent on these factors. Qualified information content should meet all information requirements of the customer regarding all properties of services recommended on the site, the procedures of the sale process, details of payment methods and the details of the distribution process. A website is an important piece in the connection between the business offering the service and the customers. Therefore, these components specific to the web environment are points that also need to be taken into consideration in the design of a good information system. These basic components taken into account by the user in using the information system are directly related with customer satisfaction and thus the success of the information system. Together with web quality, the opinions of users on the web information systems and their evaluations regarding these are important. We may list the components that influence information quality in web sites as *Accuracy, Completeness, Timeliness, Relevance and Understandability* (Chiu et al. 2005; Çebi, 2013; DeLone and McLean, 2003; Devaraj et al. 2002; Ecer, 2014; Janda et al. 2002;

Katerattanakul, 2002; Kim and Lim, 2001; Lee and Kozar, 2006; Lin, 2007; Nilashi et al. 2012; Tung and Chang, 2008; Tzeng et al. 2007; Wang, 2003; Webb and Webb, 2004) :
Accuracy: The information available on websites is required to be accurate (Çebi, 2013). For customers, the accuracy of information is quite important in determining the quality of the web page.
Completeness: In addition to the accuracy of the information available on the web page, its completeness is also a criterion that positively influences success. In short, it expresses the ability of web pages to provide the information fully (DeLone and McLean, 2003; Lin, 2007).
Timeliness: Another important feature regarding information quality on a web page is being up-to-date. It is quite important to update the data (Lee and Kozar, 2006)
Relevance: The relevance of the information available on the web page with the service features is an important factor that influences the business success. Similarly, the suitability of the e-service process for the customer and its provision to the customer in compliance with the distribution specifications is an important criterion used by the customer in evaluating the web page. (Lee, Kozar 2006; Cho et al. 2005).
Understandability: This consists of factors such as the understandability of the website, legibility of the fonts used on the site, the easy understandability of the texts available on the site, the meaningfulness of the options in the menu lists, easiness of learning to use the site and gaining experience in the performed transactions. These factors positively influence the web quality perceived by the customers (DeLone and McLean, 2003; Lee and Kozar, 2006).

2.4. Vendor-Specific Quality

Following the three criteria provided above that define the quality of a website, vendor-specific quality comes next as the fourth criterion. Awareness of the website and the offered price savings are of importance in the success factors of businesses (Lee and Kozar, 2006; DeLone and McLean, 2003; Devaraj et al. 2002).
Awareness of the website: The awareness on the website is of great importance for businesses. Enterprises conducting business on the internet spend a lot of money on advertisements in order to increase their recognition in the media. The reputation of the web page assumes an important role in attracting customers to the business and directly influences brand loyalty positively (Lee and Kozar, 2006).
Price savings: Advantages offered by the preferred online shopping site with respect to prices has positive influences on the awareness on the web page and thus the quality of the web page. Devaraj et al. (2002) have found out that price savings have a very important positive influence on shopping for CD's or books on the internet.

Figure 1 Hierarchical Structure of Online Website Quality



The research framework generated in light of the four main criteria and sub-criteria discussed above that define Website quality is provided in Figure 1. Figure 1 shows there are 15 sub-criteria in hierarchical structure. The goal is to rank the sub-criteria in this hierarchical structure. A ranking will be made by evaluating five websites that sell books to the consumers over the internet.

3. Methodology and Analysis

This section briefly describes the linguistic variables and fuzzy sets, and fuzzy TOPSIS method.

3.1. Linguistic variables and fuzzy sets

Most of the times, the decision makers are not able to define the importance of the criteria or the goodness of the alternatives with respect to each criterion in a strict way. In many situations, we use measures or quantities which are not exact but approximate (Garcia-Cascales et al., 2010). A linguistic variable is a variable whose values are words or sentences in a natural or artificial language (Zadeh, 1975). The concept of a linguistic variable is very useful in dealing with situations, which are too complex or not well defined. For example, ‘‘height’’ is a linguistic variable whose values are very low, low, medium, high, very high.

Table 2. Linguistic terms for the criteria weights

Linguistic variable	Corresponding Triangular Fuzzy Number
Very Low(VL)	(0.0, 0.1, 0.3)
Low(L)	(0.1, 0.3, 0.5)
Medium(M)	(0.3, 0.5, 0.7)
High(H)	(0.5, 0.7, 0.9)
Very High(VH)	(0.7, 0.9, 1.0)

Table 3. Linguistic terms for the alternatives weights

Linguistic variable	Corresponding Triangular Fuzzy Number
Very Poor(VP)	(1, 1, 3)
Poor(P)	(1, 3, 5)
Fair(F)	(3, 5, 7)
Good(G)	(5, 7, 9)
Very Good(VG)	(7, 9, 10)

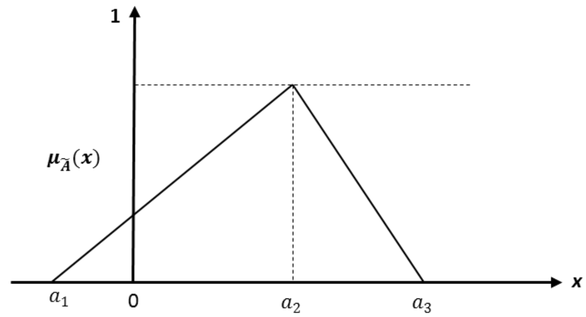
A fuzzy set is an extension of a crisp set. Crisp sets only allow full membership or non-membership, whereas fuzzy sets allow partial memberships. The fuzzy set theory, introduced by Zadeh (1965) to deal with vague, imprecise and uncertain problems has been used as a modelling tool for complex systems that can be controlled by humans but are hard to define precisely. A collection of objects (universe of discourse) X has a fuzzy set $\tilde{A}$ described by a membership function with values in the interval $[0,1]$.

$\mu_{\tilde{A}}: X \to [0,1]$

$$x \to \mu_{\tilde{A}}(x) \in [0,1].$$

A triangular fuzzy number is presented as a triplet $\tilde{A} = (a_1, a_2, a_3)$ in Figure 1. Due to their conceprual and computation simplicity, triangular fuzzy numbers are very commonly used in practical applications (Klir and Yuan, 1995).

Figure 1. Triangular fuzzy number



The membership function of $\mu_{\tilde{A}}(x)$ triangular fuzzy number is given by

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a_1 \text{ ve } x > a_3 \\ \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \leq x \leq a_3 \end{cases} \quad (1)$$

where a_1, a_2 and a_3 are real numbers and $a_1 < a_2 < a_3$.

3.2. Fuzzy TOPSIS Method

The fuzzy TOPSIS method involves fuzzy assessments of criteria and alternatives in TOPSIS method which is presented by Hwang and Yoon (1981). The basic principle of the TOPSIS method is that the chosen alternative should have the ''shortest distance'' from the positive ideal solution and the ''farthest distance'' from the negative ideal solution. The TOPSIS method introduces two ''reference'' points, but it does not consider the relative importance of the distances from these points. In real-word situation, because of incomplete or non-obtainable information, the data (attributes) are often not so deterministic, there for they usually are fuzzy/imprecise, so, we try to extend TOPSIS for fuzzy data. The steps of fuzzy TOPSIS method are following:

Step 1. *Computing aggregate fuzzy ratings for the criteria and the alternative*

Let us assume that there are *m* possible alternatives called $A = \{A_1, A_2, \ldots, A_m\}$ which are to evaluated against to *n* criteria, $C = \{C_1, C_2, \ldots, C_n\}$. The criteria weights are denoted by $w_i, i = 1, 2, \ldots, n$.

Assume that a decision group has *K* persons, then the rating of alternatives with respect to each criterion can be calculated as

$$\tilde{x}_{ij} = \frac{1}{K}\left[\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \cdots + \tilde{x}_{ij}^K\right] \quad (2)$$

where $\tilde{x}_{ij}^K$ is the rating of alternative A_i with respect to criterion C_j evaluated by the *K*th decision maker and $\tilde{x}_{ij}^K = \left(a_{ij}^K, b_{ij}^K, c_{ij}^K\right)$. The aggregated fuzzy weights of each criterion are calculated as

$$\tilde{w}_j = \frac{1}{K}\left[\tilde{w}_j^1 + \tilde{w}_j^2 + \cdots + \tilde{w}_j^K\right].$$
(3)

Step 2. *Constructing the fuzzy decision matrix*

The fuzzy decision matrix is constructed as follows:

$$\tilde{D} = \begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \vdots \\ A_m \end{array} & \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m1} & \cdots & \tilde{x}_{mn} \end{bmatrix} \end{array}$$
(4)

Step 3. *Normalizing the fuzzy decision matrix*

The normalized fuzzy decision matrix is shown as

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{mxn}, \ i = 1,2,\dots,m; j = 1,2,\dots,n.$$
(5)

Then the normalization of fuzzy decision matrix can be performed by following formula:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \ c_j^* = \max_i \ c_{ij}$$
(6)

Step 4. *Weighting the fuzzy normalized decision matrix*

The elements of normalized fuzzy decision matrix, $\tilde{r}_{ij}$, are still triangular fuzzy numbers. The weighted fuzzy normalized decision matrix, $\tilde{V}$, is shown as following form:

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{mxn} \quad i = 1,2,\dots,m; \ j = 1,2,\dots,n \qquad \text{where} \qquad \tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j$$
(7)

The elements $\tilde{v}_{ij}$are normalized positive triangular fuzzy numbers and their values range in closed interval [0,1].

Step 5. *Determining the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (NPIS)*

According to the weighted normalized fuzzy decision matrix, we can define the FPIS A^+ and NPIS A^- by following formula:

$$A^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \dots, \tilde{v}_n^+)$$
(8)

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-)$$
(9)

where, $\tilde{v}_j^+ = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0), j = 1,2,\dots,n.$

Step 6. *Calculating the distance of each alternative from FPIS and NPIS*

The distance of each alternative from FPIS A^+ and NPIS A^- can be calculated by following formulas,

$$d_i^+ = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^+\right), \ i = 1,2,\dots,m$$
(10)

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

(11)

where, $d(.,.)$ shows the distance between two triangular fuzzy number. It is calculated by using the Vertex method. Let $\tilde{a} = (\tilde{a}_1, \tilde{a}_2, \tilde{a}_3)$ and $\tilde{b} = (\tilde{b}_1, \tilde{b}_2, \tilde{b}_3)$ are two triangular fuzzy numbers. The distance between these two numbers are calculated by using Vertex method as shown in below:

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}\left[\left(\tilde{a}_1 - \tilde{b}_1\right)^2 + \left(\tilde{a}_2 - \tilde{b}_2\right)^2 + \left(\tilde{a}_3 - \tilde{b}_3\right)^2\right]}.$$

(12)

Step 7. *Obtaining the closeness coefficients and ranking the order of alternatives*

The closeness coefficient of each alternative is obtained once the d_i^+ and d_i^- of each alternative have been calculated. It determines the ranking order of all alternatives. Closeness coefficient of each alternative, CC_i, is calculated by the following formula,

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad i = 1,2, \dots, m.$$

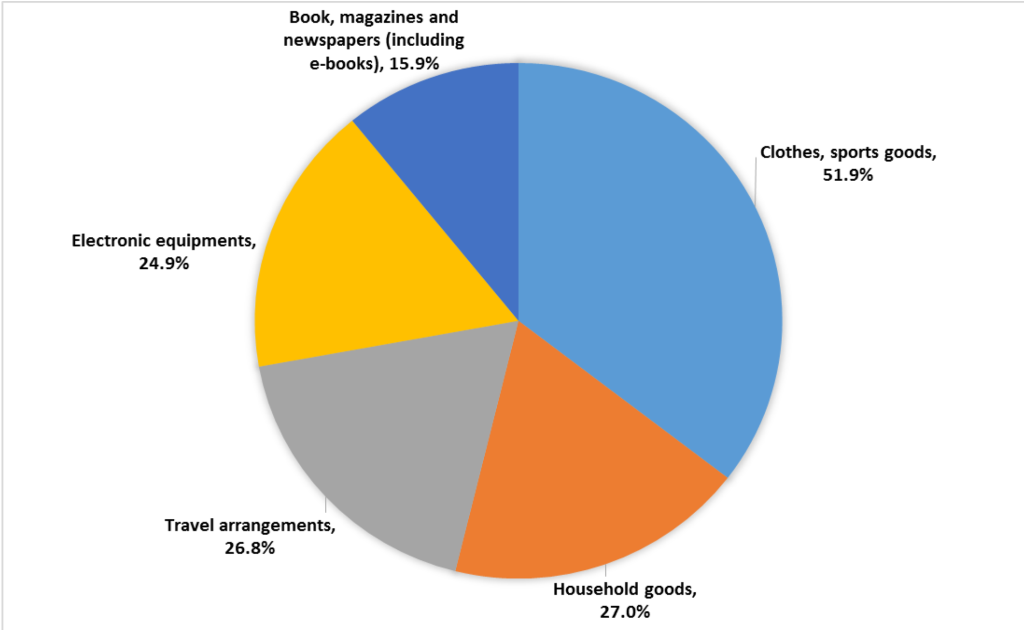
(13)

CC_i takes its values between 0 and 1. Alternatives are ranked according to the CC_is in descending order. Then we can choose the alternative with maximumCC_i. While the CC_i approaches to 1, *i*th alternative approaches to the FPIS. On the other hand, while the CC_i moves away from 1, *i*th alternative approaches to the FNIS.

3.3. Website Quality Evaluation of Turkish Bookstores

Internet access in Turkey has been available to the public since 1993. Cable internet has appeared in 1998 and ADSL in 2001. Computer and internet usage in Turkey has been growing. Computer and Internet usage of individuals aged 16-74 were 53.5% and 53.8%, respectively in 2014. Proportion of male that use computer and Internet were 62.7% and 63.5%, while these proportions were 44.3% and 44.1% for female, respectively in 16-74 age group. Computer and Internet usage of individuals were 49.9% and 48.9% in 2013 (TUIK, Turkish Statistical Instıtute, 2014).

Figure 2. Sectorial Distribution of Online Stores in Turkey



30.8% of Internet users aged 16-74 bought goods or services over the Internet for private purposes. The proportion of Internet customers was 24.1% in the previous year. Figure 2 gives the distribution of online stores by sectors in Turkey in 2014. 51.9% of Internet customers bought clothes and sports goods, 27% of that household goods, 26.8% of that travel arrangements (transport tickets, car hire, etc.), %24.9 of that electronic equipment, 15.9% of that books, magazines, newspapers (including e-books) in the last twelve months (TUIK, Turkish Statistical Instıtute, 2014).

Regarding the evaluation of the shopping website, 21 graduate students were invited to survey five alternatives using the research framework shown in Figure 1. After the construction of the hierarchy the different priority weights of each criteria, and alternatives are calculated using the fuzzy TOPSIS approach.

Table 4. Fuzzy criteria weights based on responses from questionnaire

Criteria	Fuzzy weights
C1	(0.67, 0.87, 0.99)
C2	(0.68, 0.88, 0.99)
C3	(0.63, 0.83, 0.96)
C4	(0.57, 0.77, 0.93)
C5	(0.61, 0.81, 0.95)
C6	(0.59, 0.79, 0.93)

C7	(0.69, 0.89, 1.00)
C8	(0.54, 0.74, 0.90)
C9	(0.66, 0.86, 0.98)
C10	(0.65, 0.85, 0.98)
C11	(0.63, 0.83, 0.97)
C12	(0.59, 0.79, 0.93)
C13	(0.60, 0.80, 0.94)
C14	(0.40, 0.59, 0.77)
C15	(0.60, 0.80, 0.94)

The comparison of the importance of one criterion, alternative over another can be done with the help of the questionnaire. The graduate students provide linguistic assessments to rate the fifteen criteria according to Table 2 and five alternatives according to Table 3. These linguistic assessments were then transformed to fuzzy triangular numbers using Eqs.(2,3). The fuzzy ratings for the criteria are shown in Table 4 and the five alternatives in Table 5, respectively.
In the next step, we perform normalization of the fuzzy decision matrix of alternatives using Eq. (6). For example, the normalized value for alternative A_1 for criteria C_1 is given by

$$c_j^* = \max_i(9.10, 9.10, 9.10)$$

$$\tilde{r}_{ij} = \left(\frac{5.52}{9.10}, \frac{7.48}{9.10}, \frac{8.95}{9.10}\right) = (0.61, 0.82, 0.98).$$

Likewise, we compute the normalized values of the alternatives for the remaining criteria. The normalized fuzzy decision matrix for the five alternatives is given in Table 6.

Table 5. Fuzzy decision matrix

Criteria	Alternatives				
	A_1	A_2	A_3	A_4	A_5
C1	(5.52, 7.48, 8.95)	(4.90, 6.90, 8.71)	(4.29, 6.24, 7.57)	(6.05, 8.05, 9.43)	(5.76, 7.76, 9.24)
C2	(5.48, 7.48, 9.00)	(4.81, 6.81, 8.71)	(4.67, 6.62, 8.29)	(5.95, 7.95, 9.38)	(5.33, 7.29, 8.86)

C3	(4.90, 6.90, 8.71)	(4.52, 6.52, 8.38)	(3.24, 5.19, 7.10)	(5.57, 7.57, 9.00)	(4.81, 6.71, 8.33)
C4	(4.86, 6.81, 8.43)	(4.81, 6.81, 8.57)	(3.24, 5.19, 7.05)	(6.05, 8.05, 9.38)	(5.52, 7.48, 8.95)
C5	(4.67, 6.62, 8.33)	(4.62, 6.62, 8.43)	(4.29, 6.24, 7.90)	(5.10, 7.10, 8.71)	(4.52, 6.52, 8.24)
C6	(5.67, 7.67, 9.10)	(5.76, 7.76, 9.24)	(5.29, 7.29, 8.76)	(6.24, 8.24, 9.57)	(6.29, 8.24, 9.43)
C7	(5.38, 7.38, 8.86)	(5.10, 7.10, 8.71)	(3.86, 5.76, 7.57)	(6.43, 8.43, 9.62)	(6.10, 8.05, 9.29)
C8	(4.95, 6.90, 8.57)	(4.81, 6.81, 8.48)	(3.62, 5.57, 7.29)	(6.24, 8.24, 9.52)	(5.71, 7.67, 9.10)
C9	(5.33, 7.29, 8.90)	(5.19, 7.19, 8.81)	(4.48, 6.43, 8.10)	(5.86, 7.86, 9.33)	(5.38, 7.38, 9.00)
C10	(5.05, 7.00, 8.62)	(4.81, 6.81, 8.48)	(4.10, 6.05, 7.76)	(5.86, 7.86, 9.29)	(5.10, 7.10, 8.76)
C11	(4.95, 6.90, 8.52)	(5.00, 7.00, 8.62)	(4.10, 6.05, 7.67)	(6.14, 8.14, 9.48)	(6.05, 8.05, 9.38)
C12	(4.86, 6.81, 8.48)	(5.14, 7.10, 8.71)	(4.05, 5.95, 7.67)	(5.52, 7.48, 8.95)	(5.00, 6.90, 8.52)
C13	(5.38, 7.38, 8.86)	(5.19, 7.19, 8.81)	(4.71, 6.62, 8.14)	(6.24, 8.24, 9.52)	(5.62, 7.57, 8.95)
C14	(5.62, 7.57, 9.00)	(4.10, 6.05, 7.90)	(2.81, 4.62, 6.48)	(6.29, 8.24, 9.43)	(5.95, 7.86, 9.10)
C15	(4.95, 6.90, 8.57)	(4.19, 6.14, 8.05)	(3.90, 5.86, 7.71)	(4.48, 6.43, 8.29)	(3.62, 5.48, 7.33)

Table 6. Normalized fuzzy decision matrix for alternatives

Criteria	Alternatives				
	A_1	A_2	A_3	A_4	A_5
C1	(0.61, 0.82, 0.98)	(0.53, 0.75, 0.94)	(0.49, 0.71, 0.86)	(0.63, 0.84, 0.98)	(0.61, 0.82, 0.98)
C2	(0.60, 0.82, 0.99)	(0.52, 0.74, 0.94)	(0.53, 0.76, 0.95)	(0.62, 0.83, 0.98)	(0.57, 0.77, 0.94)
C3	(0.54, 0.76, 0.96)	(0.49, 0.71, 0.91)	(0.37, 0.59, 0.81)	(0.58, 0.79, 0.94)	(0.51, 0.71, 0.88)
C4	(0.53, 0.75, 0.93)	(0.52, 0.74, 0.93)	(0.37, 0.59, 0.80)	(0.63, 0.84, 0.98)	(0.59, 0.79, 0.95)
C5	(0.51, 0.73, 0.92)	(0.50, 0.72, 0.91)	(0.49, 0.71, 0.90)	(0.53, 0.74, 0.91)	(0.48, 0.69, 0.87)
C6	(0.62, 0.84, 1.00)	(0.62, 0.84, 1.00)	(0.60, 0.83, 1.00)	(0.65, 0.86, 0.99)	(0.67, 0.87, 1.00)
C7	(0.59, 0.81, 0.97)	(0.55, 0.77, 0.94)	(0.44, 0.66, 0.86)	(0.67, 0.88, 1.00)	(0.65, 0.85, 0.98)
C8	(0.54, 0.76, 0.94)	(0.52, 0.74, 0.92)	(0.41, 0.64, 0.83)	(0.65, 0.86, 0.99)	(0.61, 0.81, 0.96)
C9	(0.59, 0.80, 0.98)	(0.56, 0.78, 0.95)	(0.51, 0.73, 0.92)	(0.61, 0.82, 0.97)	(0.57, 0.78, 0.95)
C10	(0.55, 0.77, 0.95)	(0.52, 0.74, 0.92)	(0.47, 0.69, 0.89)	(0.61, 0.82, 0.97)	(0.54, 0.75, 0.93)
C11	(0.54, 0.76, 0.94)	(0.54, 0.76, 0.93)	(0.47, 0.69, 0.88)	(0.64, 0.85, 0.99)	(0.64, 0.85, 0.99)
C12	(0.53, 0.75, 0.93)	(0.56, 0.77, 0.94)	(0.46, 0.68, 0.89)	(0.57, 0.78, 0.93)	(0.53, 0.73, 0.90)
C13	(0.59, 0.81, 0.97)	(0.56, 0.78, 0.95)	(0.54, 0.76, 0.93)	(0.65, 0.86, 0.99)	(0.60, 0.80, 0.95)
C14	(0.62, 0.83, 0.99)	(0.44, 0.65, 0.86)	(0.32, 0.53, 0.74)	(0.65, 0.86, 0.98)	(0.63, 0.83, 0.96)

C15	(0.54, 0.76, 0.94)	(0.45, 0.66, 0.87)	(0.45, 0.67, 0.88)	(0.47, 0.67, 0.86)	(0.38, 0.58, 0.78)

The fuzzy weighted decision matrix for the alternatives is constructed using Eq.(7). The $\tilde{r}_{ij}$ values from Table 6 and $\tilde{w}_j$ values from Table 4 are used to compute the fuzzy weighted decision matrix. For example, for alternative A_1 for criteria C_1 is given by

$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j = (0.61, 0.82, 0.98) \otimes (0.67, 0.88, 0.99) = (0.41, 0.71, 0.97).$

The weighted fuzzy values of the alternatives for the remaining criteria are given in Table 7.

Table 7. Weighted normalized fuzzy decision matrix for alternatives

Criteria	Alternatives				
	A_1	A_2	A_3	A_4	A_5
C1	(0.41, 0.71, 0.97)	(0.36, 0.65, 0.93)	(0.33, 0.62, 0.86)	(0.42, 0.73, 0.97)	(0.41, 0.72, 0.97)
C2	(0.41, 0.72, 0.98)	(0.35, 0.65, 0.93)	(0.36, 0.66, 0.94)	(0.42, 0.73, 0.97)	(0.38, 0.68, 0.93)
C3	(0.34, 0.63, 0.92)	(0.31, 0.59, 0.87)	(0.23, 0.49, 0.78)	(0.36, 0.65, 0.90)	(0.32, 0.59, 0.85)
C4	(0.30, 0.58, 0.86)	(0.30, 0.57, 0.86)	(0.21, 0.46, 0.75)	(0.36, 0.64, 0.91)	(0.33, 0.61, 0.88)
C5	(0.31, 0.59, 0.87)	(0.30, 0.58, 0.87)	(0.30, 0.58, 0.86)	(0.32, 0.60, 0.86)	(0.29, 0.56, 0.83)
C6	(0.37, 0.67, 0.93)	(0.37, 0.66, 0.93)	(0.36, 0.66, 0.93)	(0.38, 0.68, 0.93)	(0.39, 0.69, 0.93)
C7	(0.41, 0.72, 0.97)	(0.38, 0.68, 0.94)	(0.30, 0.59, 0.86)	(0.46, 0.78, 1.00)	(0.45, 0.76, 0.98)
C8	(0.29, 0.56, 0.85)	(0.28, 0.55, 0.83)	(0.22, 0.47, 0.75)	(0.35, 0.63, 0.89)	(0.33, 0.60, 0.87)
C9	(0.39, 0.69, 0.96)	(0.37, 0.67, 0.93)	(0.34, 0.63, 0.91)	(0.40, 0.70, 0.95)	(0.38, 0.67, 0.94)
C10	(0.36, 0.65, 0.93)	(0.34, 0.63, 0.90)	(0.30, 0.59, 0.87)	(0.40, 0.69, 0.95)	(0.35, 0.64, 0.91)

C11	(0.34, 0.63, 0.91)	(0.34, 0.63, 0.90)	(0.29, 0.57, 0.85)	(0.40, 0.70, 0.96)	(0.40, 0.71, 0.96)
C12	(0.31, 0.59, 0.87)	(0.33, 0.61, 0.88)	(0.27, 0.54, 0.81)	(0.34, 0.61, 0.87)	(0.31, 0.58, 0.84)
C13	(0.35, 0.65, 0.91)	(0.34, 0.62, 0.90)	(0.32, 0.60, 0.87)	(0.39, 0.69, 0.93)	(0.36, 0.64, 0.89)
C14	(0.25, 0.49, 0.76)	(0.18, 0.39, 0.66)	(0.13, 0.31, 0.57)	(0.26, 0.51, 0.75)	(0.25, 0.49, 0.74)
C15	(0.33, 0.61, 0.89)	(0.27, 0.53, 0.82)	(0.27, 0.53, 0.83)	(0.28, 0.53, 0.81)	(0.23, 0.46, 0.73)

Then we compute the distance $d_i^+$of each alternative from the fuzzy positive ideal solutions $A^+ = (1,1,1)$ and the distance d_i^- of each alternative from the fuzzy negative ideal solutions $A^- = (0,0,0)$ are computed using vertex method in Eq. (12). For example, for alternative A_1 and criteria C_1, the distances $d(A_1, A^-)$ and $d(A_1, A^+)$ are computed as follows:

$$d(A_1, A^-) = \sqrt{\frac{1}{3}[(0.41-0)^2 + (0.71-0)^2 + (0.97-0)^2]} = 0.736$$

$$d(A_1, A^+) = \sqrt{\frac{1}{3}[(0.41-1)^2 + (0.71-1)^2 + (0.97-1)^2]} = 0.380$$

The results are shown in Table 8.

Table 8. Distance d_i^- and d_i^+ for alternatives

Criteria	$d_i^-(A_i, A^-)$					$d_i^+(A_i, A^+)$				
	A_1	A_2	A_3	A_4	A_5	A_1	A_2	A_3	A_4	A_5
C1	0.736	0.688	0.639	0.741	0.735	0.380	0.425	0.454	0.370	0.379
C2	0.741	0.687	0.695	0.739	0.701	0.377	0.426	0.418	0.370	0.403
C3	0.673	0.632	0.548	0.675	0.625	0.440	0.471	0.547	0.422	0.466
C4	0.624	0.620	0.520	0.675	0.649	0.477	0.483	0.572	0.427	0.451
C5	0.633	0.627	0.621	0.633	0.602	0.468	0.475	0.480	0.462	0.491

C6	0.693	0.693	0.689	0.698	0.706	0.415	0.415	0.423	0.405	0.395
C7	0.738	0.707	0.628	0.779	0.763	0.378	0.403	0.474	0.336	0.349
C8	0.611	0.594	0.526	0.663	0.638	0.488	0.501	0.562	0.435	0.458
C9	0.717	0.697	0.666	0.721	0.700	0.398	0.412	0.441	0.387	0.408
C10	0.688	0.662	0.630	0.715	0.674	0.422	0.443	0.474	0.392	0.432
C11	0.668	0.666	0.615	0.723	0.729	0.439	0.440	0.484	0.386	0.384
C12	0.632	0.644	0.585	0.643	0.616	0.467	0.455	0.509	0.449	0.474
C13	0.679	0.659	0.641	0.704	0.668	0.427	0.445	0.459	0.399	0.429
C14	0.542	0.453	0.382	0.546	0.534	0.543	0.625	0.688	0.532	0.543
C15	0.648	0.585	0.590	0.583	0.517	0.455	0.511	0.511	0.507	0.563

By using the Eqs. (10)-(11), we compute the distances d_i^- and d_i^+ for five alternatives from each criteria. Then, we compute the closeness coefficients (CC_i) of the alternatives using Eq.(13). The final results are shown in Table 9.

Table 9. Closeness coefficients (CC_i) of the alternatives

	Alternatives				
	A_1	A_2	A_3	A_4	A_5
A^-	10.024	9.616	8.975	10.237	9.859
A^+	6.573	6.930	7.495	6.279	6.623
CC_i	0.604	0.581	0.545	0.620	0.598
	(2)	(4)	(5)	(1)	(3)

By comparing the CC_i values of the five alternatives (Table 9), we find that $A_4 > A_1 > A_5 > A_2 > A_3$. Therefore, alternative A_4 (idefix.com) is chosen as the online bookstore with the best website quality by the 21 website users.

4. Conclusion

During the recent years, shopping through the internet and thus the volume of electronic trade has increased considerably. The increasing volume of electronic trade has also led to the emergence or modification of businesses, processes and opportunities with new business models. Available businesses have even had to reconsider the business relationships between their organizations and customers. Especially the electronic trade applications have led to the need to handle matters that assume a key role in the field of sales, marketing and customer support also from this perspective. It is very important to manage customers and customer relations electronically over the internet. In businesses performing online sales, there is a need to monitor and manage internet based electronic trade events that are capable of responding in a customized manner. At this point, the websites provide businesses the opportunity to reach the customers without any restrictions. There needs to be a way for companies to evaluate their websites for effectiveness and quality. This paper was in the examination of these techniques.

Evaluation of website quality is a multi-criteria problem which both quantitative and qualitative attributes must be considered. The four main criteria for measurıng quality of web page are Service Quality, System Quality, Information Quality and Vendor-Specific Quality. Since the qualitative criteria make the evaluation process hard and imprecise, it is easier to make the judgments of users in fuzzy numbers rather than crisp ones. In this paper, we used the fuzzy TOPSIS approach in evaluation of website quality. Our proposed model consists of four main criteria, fifteen sub-criteria and five alternatives. In first step of proposed approach, 21 graduate students evaluated the websites quality according to the criteria. In the next step, the questionnaire responses were aggregated to generated overall performance rating for measuring website quality using fuzzy TOPSIS. The alternative with the highest score is finally chosen.

For further research, the results of this study may be compared with the results of other fuzzy MCDM methods like, AHP, VIKOR, ELECTRE and PROMETHEE.

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