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A FUZZY APPROACH TO E-BANKING WEBSITE QUALITY ASSESSMENT BASED ON AN INTEGRATED AHP-ELECTRE METHOD

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Abstract. Given the lack of physical constraints of retail banking; attraction, satisfaction, and retention of customers in e-banking mostly depend on the quality of service delivered by the website. Hence, effective assessment and monitoring of website quality have become prerequisites for profitable e-banking. Determining the overall quality of a banking website is a multidimensional issue that involves evaluation of information system (IS) quality, customer services quality, and product quality. The purpose of this study is to propose an e-banking website quality assessment methodology based on an integrated fuzzy AHP-ELECTRE approach. The fuzzy set theory has been developed for dealing with the problems arising from the vagueness, ambiguity, and subjectivity of human judgment. In the proposed methodology, the weights of the criteria are generated by a fuzzy AHP analysis. Next, fuzzy ELECTRE is used to assess the quality levels of the websites. In the third step, a fuzzy dominance relation approach is used to rank the alternatives. In order to show the potentials of the proposed method, a case study in Turkish banking sector is reported together with a sensitivity analysis.

Keywords: multicriteria, e-banking, website quality, AHP, ELECTRE, fuzzy dominance relation.

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1. Introduction

The incredible growth of the Internet has changed the way financial corporations serve their customers in the last two decades. While most of the conventional banks offered customers online access to their accounts, many new virtual banks entered the banking industry. Internet banking (e-banking) can be defined as the services which allow customers to conduct financial transactions on a secure website operated by a retail or virtual bank, credit union or building society. Given the lack of physical or geographical constraints of conventional banking, attracting and retaining customers in e-banking mostly depend on the quality of service delivered by the website. As building long term customer relationships generates positive customer value on the Internet, effective evaluation and monitoring of website quality have become prerequisites for profitable e-banking (Bauer *et al.* 2005; Jayawardhena 2004; Jun and Cai 2001; Lee and Chung 2009).

When a customer enters a website, the website can be considered as an information system (IS) and the customer as an end user of the IS. When compared to traditional banking, e-banking heavily involves interaction between online IS's and customers. Therefore, end user computing satisfaction generated during computer and networking-based impersonal interactions is one of the main determinants of e-banking website quality. Besides, banking services variety and quality provided by the website are also crucial dimensions of customer satisfaction in e-banking sector. Thus, assessing the quality of an e-banking website is a multiple criteria evaluation problem which requires consideration of aspects associated with not only product and customer services qualities but also IS quality (Jun and Cai 2001).

Operationally, website quality assessments must deal with multiple attributes which are often subjective, difficult to define and components that may involve both quantitative and qualitative factors. In view of these difficulties, methods based on fuzzy logic may be quite useful in undertaking difficult assessment procedures. The fuzzy set theory was introduced by Zadeh (1965) to express the linguistic terms in decision-making process in order to resolve the vagueness, ambiguity and subjectivity of human judgment. In the past, researchers used fuzzy extensions of multiple criteria decision making (MCDM) techniques like Analytic Hierarchy Process (AHP), Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for website evaluation problems (Bilsel *et al.* 2006; Lee and Kozar 2006; Sun and Lin 2009).

The *ELimination Et Choix Traduisant la REalite* (ELECTRE) method for choosing the best action from a given set of actions was developed in 1965. ELECTRE is a well known MCDM technique which has been successfully applied to various types of decision-making situations. ELECTRE requires an input of criteria evaluations for the alternatives, called decision matrix, preference information, expressed as weights, thresholds, and other parameters (Sevkli 2010). All the ELECTRE-type methods involve two major procedures: the modeling of preferences with outranking relations, followed by an exploitation procedure. ELECTRE methods can operate with one or several crispy or fuzzy outranking relations (Benayoun *et al.* 1966; Montazer *et al.* 2009; Roy 1985; Roy 1990; Shanian and Savadogo 2006).

In fuzzy ELECTRE, linguistic preferences can easily be converted to fuzzy numbers. For the determination of the relative importance of evaluation criteria, fuzzy AHP can be used since it is based on pairwise comparisons and allows the utilization of linguistic variables. From paired comparisons a relative scale of measurement is derived. The pairwise comparisons approach of AHP offers maximum insight, particularly in terms of assessing consistency of the experts' judgments. This technique is ideal for closer examination of a selected set of website quality evaluation criteria within e-banking context.

The aim of this study is to suggest an e-banking website quality evaluation methodology based on an integrated fuzzy AHP-ELECTRE approach. In the suggested methodology, the weights of the evaluation criteria are produced by a fuzzy AHP procedure. Next, fuzzy ELECTRE is used to assess the quality levels of the websites. In the third step, a fuzzy dominance relation approach is used to rank the alternatives. Using the proposed methodology, the website qualities of four leading banks operating in Turkey are compared. The attributes employed in the evaluations are product quality, reliability, responsiveness, competence, access, information content, ease of use, and security. To the authors' knowledge, this will be the first e-banking website quality evaluation study which makes use of MCDM techniques.

The rest of the paper is organized as follows: In Section 2, a brief literature review on commonly used attributes in website quality evaluation is given. In Section 3, the proposed integrated fuzzy AHP-ELECTRE methodology is presented. In Section 4, the suggested methodology is applied to a preference ranking problem in Turkish e-banking sector. In Section 5, a sensitivity analysis is provided. In the last section, concluding remarks are given.

2. Website Quality Assessment in E-banking

E-banking can be defined as the automated delivery of banking products and services directly to customers through electronic, interactive communication channels. E-banking includes the systems that enable financial institution customers, individuals or businesses, to access accounts, transact business, or obtain information on financial products and services through a public or private network, including the Internet. Customers access e-banking services utilizing an electronic device, such as a personal computer (PC), personal digital assistant (PDA), automated teller machine (ATM), kiosk, or Touch Tone telephone (Goi 2005; FFIEC 2010). Since an e-banking website must be considered as an IS, assessing its quality requires consideration of not only the products and services delivered but also aspects which determine online systems quality within the context of Internet banking. As website quality factors are mostly under the control of the company, they have significant effects on user beliefs and behavioral intentions about the firm (Hernández *et al.* 2009).

In the last two decades, DeLone and Mclean's (1992, 2003, 2004) multi-attribute model of information system (IS) success is widely used in assessing the quality of websites and other areas of IS research. According to the model; information quality, system quality, and service quality are the main factors which determine the success level of an IS. Following Delone and Mclean (1992) many papers have carried out detailed studies about the aspects that a high quality website should contain. Table 1 gives a summary of the dimensions used in website quality evaluation models in literature.

Among the studies listed in Table 1, the works of Jun and Cai (2001), Jayawardhena (2004), and Bauer *et al.* (2005) are studies of higher importance for us as they were conducted within e-banking context. Jun and Cai (2001) identified a total of 17 quality dimensions for the services delivered by an e-banking website which can be classified into three broad categories: online systems quality, customer service quality, and product quality. They have found that reliability, responsiveness, access and accuracy are the main sources of satisfaction or dissatisfaction. Jayawardhena (2004) developed a battery of quality measures for e-banking website services spread across five dimensions, namely, access, interface, trust, attention and credibility. Bauer *et al.* (2005) intended to develop a clear definition of the services and characteristics that actually transform a simple web address into an extensive e-banking portal. Taking this definition as a starting point, they analyzed the different facets of the quality of services delivered through e-banking portals in order to process a concrete measurement model.

Table 1. Website quality evaluation models in literature

	Attributes of website quality
Sun and Lin (2009)	Practicality, ease of use, use of time, communication, confidence, security, trust, familiarity, past experience, proficiency, information quality
Bai *et al.* (2008)	Functionality, usability, customer satisfaction
Ahn *et al.* (2007)	System quality, information quality, service quality, playfulness, perceived ease of use, perceived usefulness, attitude toward use, behavioral intention to use
Barnes and Vidgen (2001)	Usability, information quality, service interaction
Moustakis *et al.* (2006)	Content, navigation, design and structure, appearance and multimedia, uniqueness
Lee and Kozar (2006)	Relevance, currency, understandability, empathy, reliability, responsiveness, navigability, response time, personalization, telepresence, security, awareness, reputation, price savings.
Bauer *et al.* (2005)	Security and trust, basic services quality, cross-buying services quality, added values, transaction support, responsiveness
Yang *et a*l. (2005)	Usefulness of content, adequacy of information, usability, accessibility, privacy / security, interaction
Iwaarden *et al.* (2004)	Tangibles, reliability, responsiveness, assurance, empathy
Kim and Stoel (2004)	Information fit to task, tailored communication, online completeness, relative advantage, visual appeal, innovativeness, emotional appeal, consistent image, ease of understanding, intuitive operations, response time, trust
Jayawardhena (2004)	Access, website interface, trust, attention, credibility
Delone and McLean (2003)	System quality, information quality, service quality
Wu *et al.* (2003)	Information content, cognitive outcomes, enjoyment, privacy, user empowerment, visual appearance, technical support, navigation, organization of information, credibility, impartiality
Torkzadeh and Dhillon (2002)	Product choice, online payment, trust, shopping travel, shipping errors
Palmer (2002)	Download speed, navigation & organization, responsiveness, information & content, interactivity
Koufaris (2002)	Perceived control, perceived usefulness, perceived ease of use, shopping enjoyment, concentration
Ranganathan and Ganapathy (2002)	Information content, design, security, privacy
Loiacono *et al.* (2002)	Ease of use, usefulness, entertainment, complementary relationship
Agarwal and Venkatesh (2002)	Ease of use, content, promotion, made for the medium, emotion
Barnes and Vidgen (2006)	Information, usability, design, trust, empathy

End of Table 1

	Attributes of website quality
Jun and Cai (2001)	Product quality, customer service quality, online systems quality
Smith (2001)	Information content (orientation to website, content, currency, metadata, services, accuracy, privacy, external recognition), ease of use (links, feedback mechanisms, accessibility, design, navigability)
Liu and Arnett (2000)	System use, playfulness, design quality, information & service quality
Bell and Tang (1998)	Access, content, graphics, structure, familiarity, navigation, usefulness, specific characteristics
Delone and McLean (2004)	System quality, information quality, satisfaction, individual impact, organizational impact, use

As noted before, website quality evaluation is a problem which has a multidimensional nature. Therefore, though not that extensive, there is a special literature on the issue which makes use of MCDM techniques. Bilsel *et al.* (2006) made use of PROMETHEE and AHP methodologies in order to develop a fuzzy preference-ranking model for a quality evaluation of hospital web sites in Turkey. Lee and Kozar (2006) used AHP for investigating the effect of website quality on e-business success. Bai *et al.* (2008) investigated the impact of website quality on customer satisfaction and purchase intentions based on empirical evidence from Chinese e-commerce market. Harrison and Boonstra (2008) presented an assessment model to assist airline companies in evaluating their online activities, including ticketing websites, on a financial, technical as well as a customer behavior level. Sun and Lin (2009) evaluated the competitive advantages of shopping websites in Taiwan market using a fuzzy TOPSIS methodology. Although there are studies dealing with website quality assessment which make use of MCDM methods, the authors have not encountered any within the context of e-banking. To the authors' knowledge, the only study conducted in e-banking sector which makes use of a MCDM technique is the work of Rasolinezhad (2009). However, rather than website quality evaluation, the aim of the study is to rank five electronic banking methods comprising ATM banking, phone banking, Internet banking, mobile banking and SMS banking in terms of convenience for developing markets using AHP technique.

3. An Integrated Fuzzy AHP-ELECTRE Methodology for E-banking Website Quality Evaluation

3.1. Fuzzy AHP

Buckley (1985) uses the geometric mean method to derive fuzzy weights and performance scores. This method is used because it is easy to extend to the fuzzy case and guarantees a unique solution to the reciprocal comparison matrix. The weight assessing method by geometric mean is chosen for its simplicity and ease in its application to the fuzzy case. The positive reciprocal comparison matrix of criteria weights is given as:

$$C = \begin{bmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & & & \vdots \\ C_{n1} & C_{n2} & \cdots & C_{nn} \end{bmatrix}. \quad (1)$$

The geometric mean of each row is calculated as:

$$z_j = \left[\prod_{k=1}^{n} C_{jk} \right]^{1/n} \quad \text{for } j, k = 1, 2, \ldots, n. \tag{2}$$

The weight w_j is calculated as:

$$w_j = \frac{z_j}{z_1 + z_2 + \ldots + z_n}, \quad \forall j. \tag{3}$$

To facilitate the calculation of fuzzy weights, the following arithmetic operations of trapezoidal fuzzy numbers are presented. A trapezoidal fuzzy number (TrFN) can be defined as $\tilde{m} = (a, b, c, d)$ where $0 \le a \le b \le c \le d$ as shown in Fig. 1. The main arithmetic operations of TrFNs can be found in (Chen *et al.* 2006).

The steps of the fuzzy AHP algorithm can be summarized as follows:

Step 1. Evaluate the relative importance of the criteria using pairwise comparisons. The experts are required to provide their judgments on the basis of their knowledge and expertise. The experts' linguistic preferences are converted into trapezoidal fuzzy numbers using Table 2.

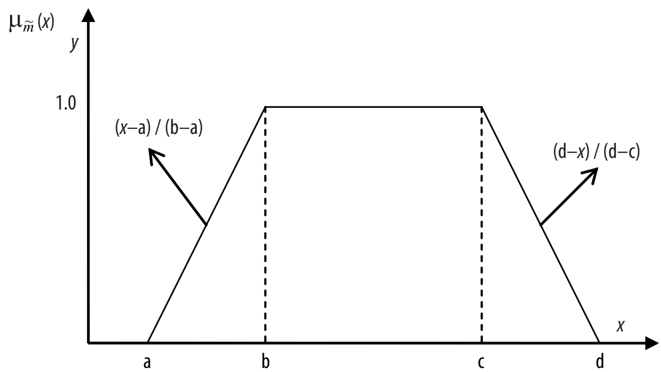

Fig. 1. Membership Function of TrFN $\tilde{m}$

Step 2. Aggregate experts' individual preferences into group preference by applying the fuzzy trapezoidal averaging operator, which is defined by

$$\tilde{C}_{jk} = \frac{1}{K}\left[\tilde{C}_{jk}^{1} (+) \tilde{C}_{jk}^{2} (+) \ldots (+) \tilde{C}_{jk}^{K} \right], \tag{4}$$

where K is the number of experts and $\tilde{C}_j^K$ is the evaluation of the K^{th} decision maker on the pairwise importance comparison of j^{th} and k^{th} criteria.

Step 3. Obtain the fuzzy weights $\tilde{w}_j$. The derivation of z_j values (Eq. 2) and fuzzy weights $\tilde{w}_j$ (Eq. 3) can be detailed as follows. Let,

$$a_j = \left[\prod_{k=1}^{n} a_{jk} \right]^{1/n} \quad \text{and } a = \sum_{j=1}^{n} a_j. \tag{5}$$

Table 2. Fuzzy evaluation scale for the weights

Linguistic terms	Fuzzy score
Absolutely Strong (AS)	(5/2, 3, 7/2, 4)
Very Strong (VS)	(2, 5/2, 3, 7/2)
Fairly Strong (FS)	(3/2, 2, 5/2, 3)
Slightly Strong (SS)	(1, 3/2, 2, 5/2)
Equal (E)	(1, 1, 1, 1)
Slightly Weak (SW)	(2/5, 1/2, 2/3, 1)
Fairly Weak (FW)	(1/3, 2/5, 1/2, 2/3)
Very Weak (VW)	(2/7, 1/3, 2/5, 1/2)
Absolutely Weak (AW)	(1/4, 2/7, 1/3, 2/5)

We can define b_j and b, c_j and c, and d_j and d. The fuzzy weight φ is determined as (Chen and Hwang 1992):

$$\tilde{w}_j = (\frac{a_j}{d}, \frac{b_j}{c}, \frac{c_j}{b}, \frac{d_j}{a}), \quad \forall j. \tag{6}$$

Step 4. Defuzzify and normalize the trapezoidal fuzzy weights. To defuzzify the TrFN in Eq. (6), Eq. (7) is used:

$$w'_j = \frac{\frac{a_j}{d} + 2\left(\frac{b_j}{c} + \frac{c_j}{b}\right) + \frac{d_j}{a}}{6}. \tag{7}$$

Now, to normalize the crisp weights Eq. (8) is used:

$$w_j = \frac{w'_j}{\sum_{j=1}^{n} w'_j}, \quad j = 1, 2, \ldots, n. \tag{8}$$

3.2. Fuzzy ELECTRE

Given two alternatives A_k and A_l, "A_k outranks A_l" signifies that the analyst has enough reasons to admit that in the eyes of the decision maker, A_k is at least as good as A_l. Hence, A_k is indifferent from or preferred to A_l. The statement "A_k does not outrank A_l" implies that the arguments in favor of the proposition "A_k is at least as good as A_l" are judged insufficient and that there exist arguments in favor of "A_l is at least as good as A_k". Hence, A_l is preferred or incomparable to A_k (Roy 1977; Chen and Hwang 1992). A fuzzy outranking relation $s^d(k,l)$ can be characterized by a membership function $\mu(k,l)$ which indicates the degree of outranking associated with each pair of alternatives (A_k, A_l) (Siskos *et al.* 1984).

Roy (1977) proposed the use of the degree of concordance and the degree of discordance to construct fuzzy outranking relations. There are three thresholds which must be specified: (1) t^i (indifference threshold), (2) t^p (preference threshold), (3) t^v (veto threshold). The degree of concordance, ψ_j, which expresses the credibility proposition "A_k over A_l" with respect to the j^{th} criterion, is defined as (Chen and Hwang 1992; Zimmerman 1987):

$$\psi_j(k,l)=\begin{cases}1, & r_{kj}+t_j^i \geq r_{lj},\\ \dfrac{r_{lj}-(r_{kj}+t_j^p)}{t_j^i-t_j^p}, & r_{kj}+t_j^i \leq r_{lj} \leq r_{kj}+t_j^p.\\ 0, & r_{lj} \geq r_{kj}+t_j^p,\end{cases} \quad (9)$$

Similarly, the degree of discordance, d_j, which expresses the credibility of the proposition "A_k is not at least as good as A_l" is defined as:

$$d_j(k,l)=\begin{cases}0, & r_{kj}+t_j^p \geq r_{lj},\\ \dfrac{r_{lj}-(r_{kj}+t_j^p)}{t_j^v-t_j^p}, & r_{kj}+t_j^p \leq r_{lj} \leq r_{kj}+t_j^p.\\ 1, & r_{lj} \geq r_{kj}+t_j^p,\end{cases} \quad (10)$$

The concordance and the discordance relations are defined for each pair of alternatives and with respect to a single criterion. The next step is to aggregate all the single criterion concordance relations, $\psi_j, \forall j$, into a unified ψ, as:

$$\psi(k,l)=\sum_{j=1}^{n} w_j \cdot \psi_j(k,l), \ \forall k,l, \quad (11)$$

where $w_j, \forall j$, are the weights assigned by the decision maker. To this end a discordance relation, D, is defined in order to reduce the concordance by the discordance. The discordance relation, D is defined as:

$$D(k,l)=\frac{1}{n}\sum_{j=1}^{n} f(d_j(k,l), \psi_j(k,l)), \quad (12)$$

where

$$f(d_j(k,l), \psi_j(k,l))=\begin{cases}1, & d(\cdot)<\psi(\cdot)\\ \dfrac{1-d_j(\cdot)}{1-\psi(\cdot)}, & d_j(\cdot)>\psi(\cdot), \psi(\cdot)\neq 1.\end{cases} \quad (13)$$

The concordance relation, ψ, and the discordance relation, D are then combined to give the fuzzy outranking relation $s^d(k,l)$ as:

$$s^d(k,l)=\psi(k,l)\cdot D(k,l), \forall k,l. \quad (14)$$

The algorithm of the approach is presented as follows:

Step 1. Experts evaluate the alternatives with respect to the criteria. The experts' linguistic preferences are converted into triangular or trapezoidal fuzzy numbers using Figure 2.

Step 2. The experts' individual preferences are aggregated using Eq. (4).

Step 3. The thresholds $t_j^i \leq t_j^p \leq t_j^v$ ($j=1,...,n$) for the criteria are determined in accordance with the evaluations of the experts.

Step 4. The concordance relation ψ_j for the j^{th} criterion, C_j, is constructed using Eq. (9).

Step 5. The discordance relation d_j for the j^{th} criterion, C_j, is constructed using Eq. (10).

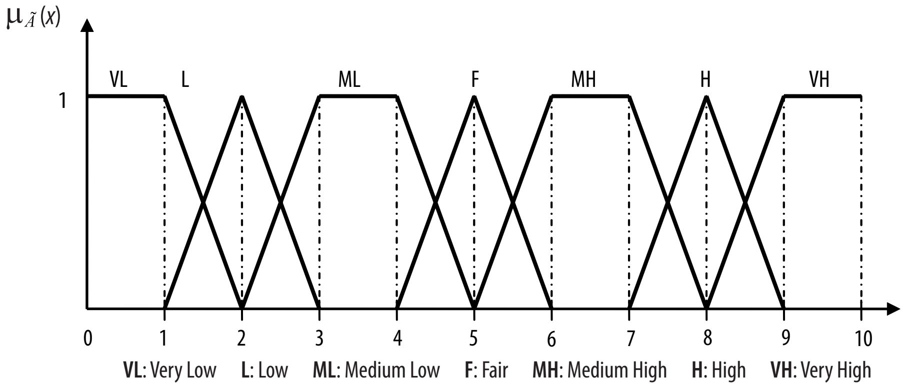

Fig. 2. Fuzzy EIA evaluation scale for the alternatives

Step 6. Given the single criterion concordance relations $\psi_j, \forall j,$ an aggregated concordance relation ψ is obtained using Eq. (11).

Step 7. Given the single criterion concordance relations $d_j, \forall j,$ and the aggregated concordance relation ψ , an aggregated concordance relation *D* is obtained using Eqs. (12–13).

Step 8. By using Eq. (14) to combine the aggregated concordance relation ψ and the aggregated discordance relation *D,* the fuzzy outranking relation s^d is obtained.

Step 9. Finally, a fuzzy dominance relation is used to prioritize the alternatives in descending order. The details of this fuzzy dominance relation can be found in (Chen and Hwang 1992; Siskos *et al.* 1984). Figure 3 summarizes the procedure of the proposed methodology:

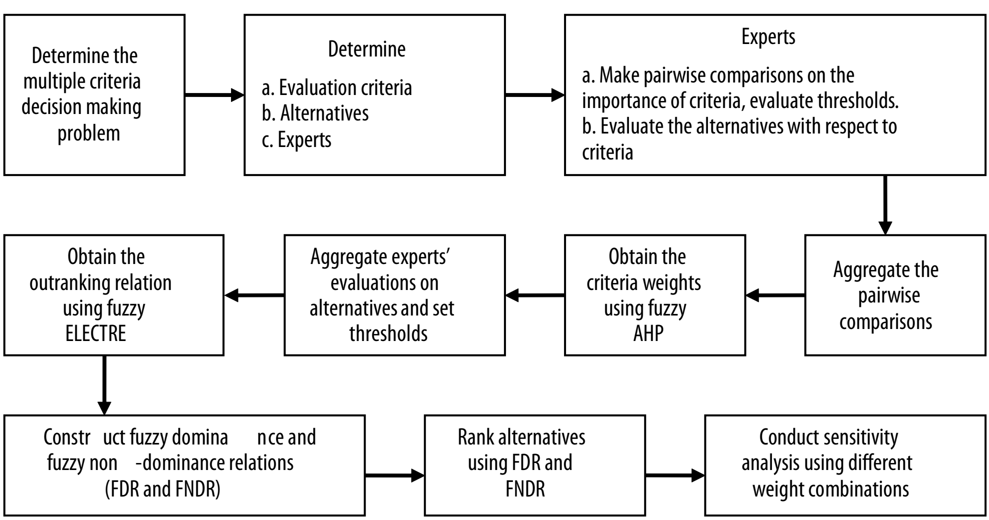

Fig. 3. Procedure of the proposed methodology

4. Fuzzy Multicriteria Website Quality Evaluation

4.1. The Case of Turkish E-banking Sector

Turkey occupies the seventh position among Internet top 10 European countries, having 26.5 million subscribers as of March 2009, overtaking Poland, Netherlands and Romania, while Germany, UK and France grab first, second and third places, respectively. As for the Internet penetration it marks significant growth of 1,225%, rising from 2,000,000 (or 2.9%) in 2000 to 26,500,000 (34.5%) in 2009. However, Turkey still has just 6.6% of European total market share. Internet access has been available in Turkey since 1993. Cable Internet appeared in 1998. Asymmetric digital subscriber line (ADSL) was launched in 2003. The development in the Turkish telecoms market started increasing with the ending of fixed-line operator Turk Telekom's monopoly and the commencement of incumbent privatization. Currently, around 100 commercial Internet service providers in Turkey supply broadband connection. Internet usage level in Turkey is lower than the European Union (EU) average.

Although online business in Turkey has been growing rapidly, it has still not been fully established. Most medium-sized and large companies have their own websites; however, they are used mainly for promotion rather than commercial transactions. Nevertheless, banking, where the main incentive is lower costs rather than increased sales, is an exception (Akinci *et al.* 2004). Most of the commercial banks in Turkey offer e-banking services. As for the other companies offering online services, the most active are airlines, supermarket chains, and retailers of books and electrical goods. According to August 2009 figures there are 20153 online stores operating in Turkey. These e-stores realized 77.9 million transactions (total amount of which is around 3.5 billion USD) in the first 8 months of 2009. This figure indicates a 5% growth when the first eight months of the previous year is considered.Currently users are reflecting increased acceptance of new technologies in Turkey as the broadband market has experienced phenomenal growth. In recent years, Turkish banks have made large investments in IT applications such as ATMs, POS, smart card, data mining, call centres, and Internet banking. More than 20% of the Internet users use Internet banking channels since 2002. Turkish banks provide a wide range of services from their Internet branches (Sayar and Wolfe 2007) and nearly 50% of all banking transactions are made outside the retail branches. Studies show that ease of use and usefulness are the main drivers of the usage of e-banking services in Turkey, while lack of confidence in the security of the websites is standing as a barrier on further increases in the number of online transactions (Calisir and Gumussoy 2008; Celik 2008).

E-banking was first introduced as a new distribution channel in Turkey by Isbank in 1997. In 1997, Garanti Bank also joined the competition on the Web. In 2004, serving around one million customers with non-traditional channels Garanti Bank made a turnover of US$3 billion per month through web channels. Garanti Bank also holds the leadership in the number and volume of IB transactions in Turkey. Another strong competitor, Akbank, introduced its first IB branch for retail customers in 1999, allowing them to access accounts, buy/sell foreign exchange, transfer money, perform securities, and trade on the Istanbul Stock Exchange (Akinci *et al.* 2004). Today, most of the banking companies provide e-banking services in Turkey. According to the entry statistics of Alexa (2010), "garanti.com.tr" is the most popular banking website of Turkey followed by "isbank.com.tr". According to February 2010 figures, there are four e-banking websites among the most popular 250 Turkish websites. These are "garanti.com.tr" (28th), "isbank.com.tr" (45th), "ykb.com" (85th), and "finansbank.com.tr" (217th) [4].

In this study, the study of Jun and Cai (2001) has been taken as a basis and a group of eight criteria were determined for the evaluation of four mostly used e-banking websites the hosts of which are operating in Turkey. Explanations of the evaluation criteria are briefly given below:

Product quality criterion

Product quality (C_1): Banking service product quality criterion represents the product range and features delivered by the e-banking website.

Customer service quality criteria

Reliability (C_2): This dimension considers the correctness of services, accuracy of records, and to what extent the promises are kept.

Responsiveness (C_3): This criterion takes the promptness and convenience of services into consideration.

Competence (C_4): Customer service quality dimensions like ability to solve problems, knowledge to answer questions are evaluated using this criterion.

Access (C_5): A quick and responsive e-mail service is a distinct and most important facet of the access dimension. Availability for help, ATM access, phone access, and account access (when abroad) are the remaining aspects of this attribute.

Online systems quality criteria

Information content (C_6): This attribute measures aspects like the quality of the online information given about the products and services, the quality of the supplementary information that customers need, accuracy of online transactions, and minimisation of errors in content and interface.

Ease of use (C_7): This criterion is used in the evaluation of features like compatibility, user friendliness, ease of login, accessibility, response speed, ease of navigation, and the availability of the functions that customers need.

Security (C_8): This dimension takes privacy and information transaction safety into account (Jun and Cai 2001).

Figure 4 gives the hierarchical structure of e-banking website quality evaluation problem. Beyond this point, we represent the banks mentioned above by the symbols B_1, B_2, B_3, and B_4 because of privacy issues:

After determining the evaluation criteria and the alternatives, the steps of the integrated fuzzy AHP-ELECTRE methodology are implemented. In order to obtain the weights of the criteria, the experts utilized a nine point scale given in Table 2. The results of the comparisons are given in Table 3.

Next, the aggregated fuzzy evaluation matrix for the criteria weights is obtained as in Table 4. Consistency Ratio (CR) for the defuzzified version of the evaluation matrix is calculated as 0.081 and it is less than 0.10. Hence, the results can be considered consistent.

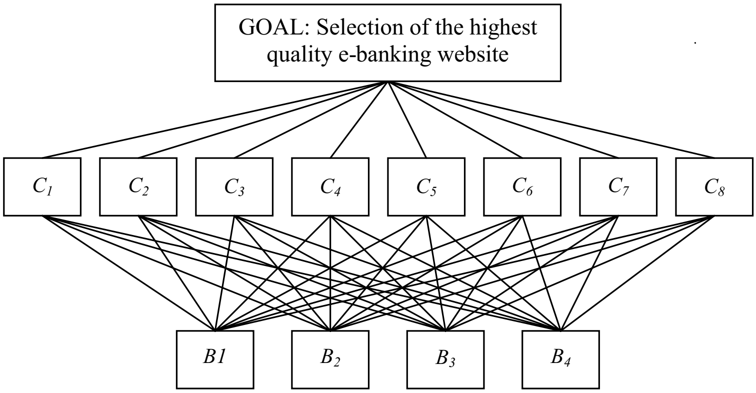

Fig. 4. Hierarchical structure of e-banking website quality evaluation problem

Table 3. Pairwise comparisons of evaluation criteria

Expert 1	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	1	SW	FS	FW	SW	VS	SW	VW
C_2		1	FS	E	SS	AS	SS	VW
C_3			1	FW	FW	SS	VW	AW
C_4				1	FW	SS	FW	VW
C_5					1	FS	SW	FW
C_6						1	SW	VW
C_7							1	SW
C_8								1
Expert 2	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	1	E	E	E	E	E	E	E
C_2		1	FS	E	FS	FS	FS	E
C_3			1	E	E	E	SW	SW
C_4				1	FS	E	E	E
C_5					1	E	E	E
C_6						1	SW	SW
C_7							1	E
C_8								1
Expert 3	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	1	E	E	E	E	E	E	E
C_2		1	E	SS	E	SW	SS	E
C_3			1	E	SS	E	SS	FW
C_4				1	E	E	SW	VW
C_5					1	SS	SW	VW

End of Table 3

C_6						1	E	VW
C_7							1	VW
C_8								1
Expert 4	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	1	SW	FS	SS	SS	E	SS	SS
C_2		1	FS	FS	SS	SS	FS	SS
C_3			1	SW	E	SW	E	FW
C_4				1	E	E	E	SW
C_5					1	SW	E	SW
C_6						1	SS	SW
I_7							1	SW
C_8								1

Table 4. Fuzzy evaluation matrix for the criteria weights

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	**(1, 1, 1, 1)**	(0.7, 0.75, 0.75, 1)	(1.25, 1.5, 1.5, 2)	(0.83, 0.98, 0.98, 1.29)	(0.85, 1, 1, 1.38)	(1.25, 1.38, 1.38, 1.63)	(0.85, 1, 1, 1.38)	(0.82, 0.96, 0.96, 1.25)
C_2	(1, 1.5, 1.5, 1.75)	**(1, 1, 1, 1)**	(1.38, 1.75, 1.75, 2.5)	(1.13, 1.38, 1.38, 1.88)	(1.13, 1.5, 1.5, 2.25)	(1.35, 1.75, 1.75, 2.63)	(1.25, 1.75, 1.75, 2.75)	(0.82, 0.96, 0.96, 1.25)
C_3	(0.67, 0.75, 0.75, 0.83)	(0.5, 0.63, 0.63, 0.75)	**(1, 1, 1, 1)**	(0.68, 0.73, 0.73, 0.92)	(0.83, 0.98, 0.98, 1.29)	(0.85, 1, 1, 1.38)	(0.67, 0.83, 0.83, 1.25)	(0.33, 0.4, 0.4, 0.68)
C_4	(0.98, 1.29, 1.29, 1.5)	(0.68, 0.79, 0.79, 0.92)	(1.13, 1.63, 1.63, 1.88)	**(1, 1, 1, 1)**	(0.96, 1.1, 1.1, 1.42)	(1, 1.13, 1.13, 1.38)	(0.68, 0.73, 0.73, 0.92)	(0.49, 0.54, 0.54, 0.75)
C_5	(0.85, 1.17, 1.17, 1.38)	(0.53, 0.71, 0.71, 0.92)	(0.98, 1.29, 1.29, 1.5)	(0.96, 1.25, 1.25, 1.42)	**(1, 1, 1, 1)**	(0.98, 1.25, 1.25, 1.88)	(0.7, 0.75, 0.75, 1)	(0.5, 0.56, 0.56, 0.79)
C_6	(0.82, 0.85, 0.85, 0.88)	(0.5, 0.88, 0.88, 1.14)	(0.85, 1.17, 1.17, 1.38)	(0.85, 0.92, 0.92, 1)	(0.68, 1.04, 1.04, 1.29)	**(1, 1, 1, 1)**	(0.7, 0.88, 0.88, 1.38)	(0.34, 0.42, 0.42, 0.75)
C_7	(0.85, 1.17, 1.17, 0.85)	(0.37, 0.58, 0.58, 0.83)	(1.1, 1.67, 1.67, 2)	(1.13, 1.63, 1.63, 1.88)	(1, 1.5, 1.5, 1.75)	(0.85, 1.42, 1.42, 1.75)	**(1, 1, 1, 1)**	(0.52, 0.58, 0.58, 0.88)
C_8	(1.1, 1.42, 1.42, 1.63)	(1.1, 1.42, 1.42, 1.63)	(1.63, 2.63, 2.63, 3.13)	(1.5, 2.25, 2.25, 2.63)	(1.38, 2.13, 2.13, 2.5)	(1.5, 2.5, 2.5, 3)	(1.25, 2, 2, 2.38)	**(1, 1, 1, 1)**

Next, the fuzzy weights ($\tilde{w}_j$) are obtained employing Eqs. (4–6). Then, in order to defuzzify and normalize of the obtained weight vector, Eqs. (7–8) are used, respectively. Results of the fuzzy AHP are given in Table 5:

Next step is the determination of the highest quality e-banking website with the proposed fuzzy ELECTRE procedure. To do this, four experts evaluated four e-banking websites with respect to each criterion using Table 3. Evaluation results are given in Table 6.

Using Table 3 and Table 7, evaluation matrix is aggregated. Then, evaluation matrix is defuzzified as in Table 7.

Table 5. Results of the fuzzy AHP analysis for the determination of the weights

	$\tilde{W}_j$	W'_j	W_j
C_1	(0.08, 0.12, 0.12, 0.19)	0.123	0.119
C_2	(0.1, 0.16, 0.16, 0.27)	0.167	0.161
C_3	(0.06, 0.08, 0.08, 0.14)	0.09	0.087
C_4	(0.08, 0.11, 0.11, 0.16)	0.113	0.109
C_5	(0.07, 0.11, 0.11, 0.17)	0.111	0.107
C_6	(0.06, 0.1, 0.1, 0.15)	0.1	0.097
C_7	(0.07, 0.12, 0.12, 0.18)	0.125	0.121
C_8	(0.12, 0.2, 0.2, 0.3)	0.205	0.199

Table 6. Evaluation results

Expert 1		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
	B_1	MH	H	F	ML	H	MH	VH	MH
	B_2	ML	F	L	L	MH	F	L	H
	B_3	MH	F	ML	H	H	MH	F	MH
	B_4	H	F	MH	MH	H	F	MH	H
Expert 2		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
	B_1	VH	MH	H	H	H	H	H	VH
	B_2	VH	MH	F	F	H	H	H	VH
	B_3	VH	MH	MH	MH	H	H	H	VH
	B_4	VH	MH	MH	H	H	H	H	VH
Expert 3		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
	B_1	VH	VH	F	MH	VH	VH	VH	VH
	B_2	MH	MH	ML	F	F	ML	L	VH
	B_3	MH	H	ML	F	MH	MH	F	VH
	B_4	MH	H	VH	H	H	H	H	VH
Expert 4		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
	B_1	H	MH	H	H	H	H	MH	MH
	B_2	MH	MH	F	F	MH	F	MH	MH
	B_3	MH	MH	MH	MH	MH	MH	MH	MH
	B_4	H	MH	MH	H	H	H	H	H

Based on the opinions of the experts and their evaluations on criteria, indifference (t_j^i), preference (t_j^p), and veto (t_j^v) thresholds are determined as in Table 8.

Table 7. Evaluation matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
B_1	8.292	7.583	6.5	6.5	8.333	7.958	8.292	7.917
B_2	6.458	6.125	3.875	4.25	6.5	5.375	4.625	8.292
B_3	7.208	6.5	5	6.5	7.25	6.875	6.125	7.917
B_4	7.958	6.5	7.208	7.625	8	7.25	7.625	8.667

Table 8. Indifference, preference, and veto thresholds for the criteria

	t_j^i	t_j^p	t_j^v
C_1	0.76	1.51	5.29
C_2	0.56	1.12	3.36
C_3	1.04	2.08	6.25
C_4	0.83	1.66	4.97
C_5	0.84	1.68	5.04
C_6	0.93	1.87	5.61
C_7	0.75	1.50	4.49
C_8	0.45	0.91	2.73

Next, concordance relation ψ_j and discordance relation d_j are constructed using Eqs. (9–10). Then, aggregated concordance relation ψ (see Table 9) and aggregated discordance relation D (see Table 10) are obtained using Eqs. (11–13). In the next step, the fuzzy outranking relation s^d is maintained by using Eq. (14) (see Table 11).

Table 9. Aggregated concordance relation matrix

	B_1	B_2	B_3	B_4
B_1	1	1	1	0.832
B_2	0.199	1	0.705	0.385
B_3	0.592	1	1	0.624
B_4	0.849	1	1	1

Table 10. Aggregated discordance relation matrix

	B_1	B_2	B_3	B_4
B_1	1	1	1	1
B_2	0.918	1	1	0.949
B_3	1	1	1	1
B_4	1	1	1	1

Table 11. Fuzzy outranking relation matrix

	B_1	B_2	B_3	B_4
B_1	1	1	1	0.832
B_2	0.182	1	0.705	0.365
B_3	0.592	1	1	0.624
B_4	0.849	1	1	1

After maintaining the fuzzy outranking relation, in order to provide a ranking among the alternatives, FDR and FNDR matrices are obtained as in Table 12 and Table 13. Finally, the degree of dominance is obtained as in Table 14.

Table 12. Fuzzy dominance relation matrix

	B_1	B_2	B_3	B_4
B_1	0	0.818	0.408	0
B_2	0	0	0	0
B_3	0	0.295	0	0
B_4	0.017	0.635	0.376	0

Table 13. Fuzzy non-dominance relation matrix

	B_1	B_2	B_3	B_4
B_1	1	0.182	0.592	1
B_2	1	1	1	1
B_3	1	0.705	1	1
B_4	0.983	0.365	0.624	1

Table 14. Degree of dominance

	B1	B2	B3	B4
Min(FNDR)	0.983	0.182	0.592	1

According to Table 14, with a slight difference from B_1, B_4 is the e-banking website with the highest quality. The rank order of the alternatives is B_4, B_1, B_3, and B_2.

Results show that the strength of B_4 comes from the competence (C_2) and security (C_4) attributes. It should be noted that security is rated as the most important attribute by the experts. Besides, B_1 has higher rates with respect to most of the attributes but competence (C_2) and security (C_4). Minor improvements in competence (C_2) and security (C_4) may bring B_1 to the first place among the alternatives. This requires particular improvements in the ability of solving problems, knowledge to answer questions, privacy, and information transaction safety. In particular, B_2 is rated as one of the most secure websites. Nevertheless, B_2 and B_3 should make significant performance improvements with respect to a great majority of the attributes in order to reach the quality performances of B_1 and B_4. Although e-banking customers are considered as end-users of a certain IS, the interactions between the customers and the website have their own unique aspects. In particular, the ease of use dimension contains some unique characteristics that can be attributed to the nature of the Internet. Online systems quality components like response speed and ease of navigation are also critical to the success of e-banking websites. The banks B_2 and B_3 should make performance improvements in these aspects as well.

4.2. Sensitivity Analysis

In this section, a sensitivity analysis is conducted to monitor the sensitivity of the ranking between the e-banking websites to changes in the criteria weights. Table 15 includes the composition of criteria weights in the considered cases. Figure 5 shows the order of the alternatives based on their membership of fuzzy dominance values with respect to different weight configurations.

Table 15. Criteria weights with respect to the considered cases

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Current weights	0.119	0.161	0.087	0.109	0.107	0.097	0.121	0.199
Case 1	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Case 2	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Case 3	0.05	0.2	0.2	0.2	0.2	0.05	0.05	0.05
Case 4	0.08	0.08	0.08	0.08	0.08	0.2	0.2	0.2

In Figure 5, in the current situation (CS) B_4 and B_1 are the websites with highest quality. In Case 1, the situation which all the criteria weights are equal is considered. The preference ranking among the alternatives does not change when the weights are equal. When the weight of the *reliability* (C_2) criterion increases (as in Case 2) B_1 becomes the highest quality website. In Case 3, weights of the criteria associated with service quality (C_2, C_3, C_4, and C_5) significantly increase. This change makes B_1 the best alternative. When there is a similar increase in the weights of the set of system quality criteria (C_6, C_7, and C_8), B_4 takes the first place again.

Sensitivity analysis shows that the ranking among the alternatives is sensitive to the changes in the weights of customer services quality criteria. In particular, ranking among the first two websites (B_4 and B_1) is sensitive to the weight of *reliability* (C_2) criterion. In order to strengthen its position, B_4 should improve its quality performance with respect to reliability related issues like the correctness of services, accuracy of records, and keeping promises given in advertisements and service agreements. On the other hand, in order to attract customers, B_1 should focus on aspects related with online systems quality. This requires improvements in the perception of transaction safety, privacy, playfulness, and information content. As the Internet-based data processing can be regarded as an extreme case in an end user comput-

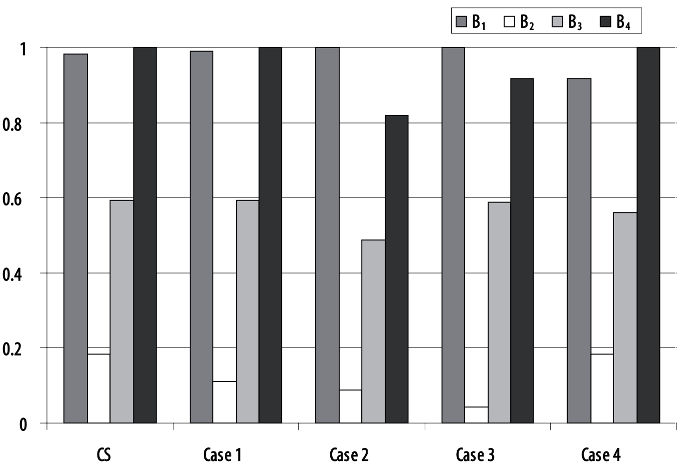

Fig. 5. Sensitivity analysis

ing environment where the customers of e-banking websites seldom have direct interaction the operations staffs of the websites, B_1 should also increase its performance with respect to aspects like interactivity, ease of login, ease of navigation, user friendliness, system design quality, and download speed.

5. Conclusions

In recent years, many researchers expect rapid growth in the number of customers using e-banking products and services. As successful web sites create value for present and potential customers, Internet has been considered to have a big potential to allow virtual and retail banking organizations to make even more profit in an increasingly competitive environment. It is certain that e-banking has a significant cost advantage in providing financial services. Moreover, it has the potential for increasing the value of these services by making them more convenient for consumers to achieve, encouraging them to make better choices, and personalizing these services to their personal needs.

In order to gain the ability to increase the attractiveness of their products and services, banks have to use Internet as a fully integrated part of their business strategy. Banking executives should have the skills to effectively identify, measure, monitor, and control risks and benefits associated with e-banking. This requires receiving regular reports on the technologies employed, the risks and benefits assumed, and how these risks will be managed. Thus, assessing and monitoring the quality performance of the online system is a key success factor in e-banking.

Assessing the quality of an e-banking website is a multifaceted problem that involves evaluation of product quality, customer services quality, and IS quality. As the problem has a multidimensional nature and requires simultaneous consideration of multiple and conflicting criteria, MCDM techniques can be quite useful in dealing with it. The aim of this study was to propose an e-banking website quality evaluation methodology based on an integrated fuzzy MCDM approach. As the suggested method allows conducting sensitivity analyses, it is also possible to monitor the individual effects of the website quality sub-attributes on the overall quality performance scores. To the authors' knowledge, this paper is the first e-banking website quality evaluation study which is based on MCDM techniques.

In the proposed methodology the criteria weights were generated by a fuzzy AHP procedure. AHP is considered as one of the most reliable weight assigning methods in MCDM literature. This is partly because of the pairwise comparisons technique which provides extra precision to AHP based weights. Another advantage of AHP is the consistency control mechanism which prevents inconsistencies among experts' judgments. Next, fuzzy ELECTRE is used to evaluate alternative e-banking websites. Usage of a fuzzy outranking MCDM method rather than a crisp one has the advantage of exploiting imprecise and vague knowledge together with exact information. As a typical quality assessment procedure within the context of e-banking may often involve subjective and qualitative components, methods based on fuzzy set theory may prove quite useful. Finally, a fuzzy dominance relation methodology is used to rank the alternatives. The main reason for the integration of this component was to provide our methodology an ability of maintaining a complete ranking order among the e-banking websites. The figures of dominance obtained in this level also enable the conduction of sensitivity analyses.

The proposed methodology has been successfully applied to Turkish banking industry. The criteria used in the comparisons were product quality, reliability, responsiveness, competence, access, information content, ease of use, and security. Results showed that, two of the customer service quality attributes, namely, security and competence, had a major effect on the ranking among the alternatives. Sensitivity analysis showed that the quality ranking among the alternatives is partly sensitive to changes in the weights of customer service quality criteria.

In the future research, the proposed methodology can be applied to the banking industries of other countries. The criteria structure used in this study could be reorganized taking the interdependency relations into account. Moreover, the suggested method can be employed in website quality evaluation studies conducted in other industries such as airlines, e-commerce, or scientific publishing. Finally, using the same attribute framework, studies based on other fuzzy MCDM techniques such as fuzzy TOPSIS, fuzzy PROMETHEE, or fuzzy evidential reasoning can be conducted for comparative purposes.

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E-BANKININKYSTĖS TINKLAPIŲ KOKYBĖS VERTINIMAS PAREMTAS INTEGRUOTU NEAPIBRĖŽTŲJŲ AIBIŲ AHP-ELECTRE METODU

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Santrauka. Mažmeninės e-bankininkystės sėkmė priklauso nuo klientų aptarnavimo kokybės tinklapyje. Taigi, tinklapio kokybės stebėjimas ir vertinimas yra svarbi sąlyga e-bankininkystės pelningumui. Tinklapio kokybės nustatymas yra daugiadimensis uždavinys, kuris apima informacinės sistemos, klientų aptarnavimo ir produktų kokybę. Šio tyrimo tikslas – pasiūlyti e-bankininkystės tinklapio vertinimo metodiką, paremtą integruotu neapibrėžtųjų aibių AHP-ELECTRE metodu. Neapibrėžtųjų aibių teorija buvo sukurta tam, kad spręsti subjektyvaus žmogiško vertinimo problemą. Siūlomoje metodikoje rodiklių reikšmingumai apskaičiuojami neapibrėžtųjų aibių AHP metodu, po to ELECTRE metodu įvertinamas tinklapių kokybės lygis. Toliau, taikant neapibrėžtųjų aibių dominavimo teoriją, surikiuojamos alternatyvos. Metodo tinkamumas demonstruojamas atliekant Turkijos bankininkystės sektoriaus tyrimą ir jautrumo analizę.

Reikšminiai žodžiai: daugiakriterinis vertinimas, e-bankininkystė, tinklapio kokybė, AHP, ELECTRE, neapibrėžtų aibių dominavimo teorija.

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