



AN INTEGRATED FUZZY AHP AND ARAS MODEL TO EVALUATE MOBILE BANKING SERVICES

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Abstract. Mobile banking (M-banking) which integrates software, hardware, and human is a new platform for banks. Determining the performance of M-banking services helps bank practitioners identify better policy to improve their positions. The aim of this study is to develop an integrated model for evaluating M-banking services by two methods, namely the Fuzzy Analytic Hierarchy Process (FAHP) with an extent analysis approach and ARAS (Additive Ratio ASsessment). In this study, the priority weights obtained through the FAHP are combined with the ARAS method to assess and rank the M-banking services. Moreover, in order to verify the applicability of this proposed model, a case study in Turkey is offered. The findings indicate that facilitating conditions play the most determining role in the adoption of the M-banking, followed by self-efficacy, privacy risk, and security risk. Consequently, the proposed model helps to overcome difficulties in M-banking service evaluation process and increases the efficiency of the M-banking service activities. Besides, the case study validates that the proposed model is an effective and efficient decision making tool for the evaluation of M-banking services under fuzzy environments.

Keywords: M-banking services, M-banking adoption, Fuzzy AHP, ARAS.

JEL Classification: C44, D81, M11.

Introduction

With the use of the right technological equipment and techniques, firms achieve their business goals more rapidly. In a globalizing and competitive industry, technological applications play an essential role in facilitating the processes of knowledge production, storage, sharing and application. Through these processes, it is possible to benefit from the opportunities arising from environmental changes. Nevertheless, just a technological infrastructure cannot guarantee the effectiveness of a knowledge management program. The solution

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stems from the strategic integration between human and knowledge resources, technologies, organizational culture, and processes (Canzano, Grimaldi 2012).

Banking sector, one of the leading sectors utilizing internet and mobile technology, is consistently seeking for ways to use technology in order to reduce costs and take the lead of the competition, and for the clients, create more proper methods of banking. A great success story in this area is made by electronic banking (Peevers *et al.* 2008; Laukkanen 2007). There are four electronic banking channels: ATMs, touch-dial telephone banking, Internet banking, and mobile banking (M-banking). In spite of M-banking has a huge potential, its real potential does not used. M-banking is defined as “a channel through which customers interact with a bank through non-voice applications such as text- or WAP-based banking services using a mobile device, such as a mobile phone or personal digital assistant” (Hoehle *et al.* 2012; Zhou 2012). M-banking has different characteristics from other electronic banking channels such as ubiquity, flexibility, and mobility (Lin 2011). From the standpoint of clients, M-banking provides a suitable and efficient by means of managing finance facilities, connecting perfectly anytime and anywhere (Riivari 2005). Nevertheless, because of the virtuality and lack of control, M-banking contains more uncertainty and risk (Zhou 2012).

Turkey, as an emerging market, has seen some significant developments over the past decade within the context of M-banking. In 2004, M-banking was first presented in Turkey by Garanti Bankasi. Nowadays, one third of all mobile clients are registered to Garanti M-banking. In 2007, another strong competitor, Isbank, also joined the competition. Isbank introduced Isbank M-banking in 2007 with “IsCep”. According to Banks Association of Turkey (BAT) report covering 16 banks those supplying electronic banking services, the total number of registered customers that logged in at least once was 6.8 million and the total number of investment transactions performed by using M-banking services were 2.1 million with an amount of \$7.6 billion as of June 2015. Accordingly, the number of customers using M-banking has grown by 117% in the last year. In addition, the total number and the volume of financial transactions (excluding investment transactions) performed by using M-banking services, was 252.5 million and \$12.8 billion, respectively, in the second quarter of 2015 (BAT 2015).

In that M-banking is a gaining currency electronic banking channel to be offered by banks, evaluating their performances is crucial for bank owners, clients, shareholders, policy makers, and service providers. Determining the performance of M-banking services helps bank owners, policy makers, and service providers. Hence, this performance evaluation problem can be considered as a multiple-criteria decision making (MCDM) problem. Aggregating both quantitative and qualitative criteria in the evaluation process, analyzing complex problems, and participating decision makers actively in the decision making process are the main advantages of MCDM (Zavadskas *et al.* 2014). In reality, exact numbers may not always be sufficient to introduce the decision making process, since human perception, judgment, intuition, and preference remain uncertain and hard to gauge. Fuzzy Set Theory (FST) (Zadeh 1965) is a way of investigating ambiguous notions and mediates for representing vagueness (Chou, Cheng 2012; Chen, Wang 2009). It is similar to human

reasoning process in its use of incomplete information and ambiguity to create decisions. It was especially designed for mathematical representation of uncertainty and ambiguity and allows useful instrument to struggle with the imprecision intrinsic to many problems. Since knowledge can be expressed in a more easily by using fuzzy sets, many decision problems can be significantly simplified. FST is applied to classes of data with boundaries which are not precisely defined. Hence, real-world problems can be solved more easily. Thereby, linguistic variables have a critical importance in the fuzzy logic applications (Kahraman *et al.* 2004). In this respect, the study aims to propose an integrated model that combines FAHP with an extent analysis approach and ARAS methods for evaluating and ranking the M-banking services. The AHP proposed by Saaty in 1980 is a well-known MCDM method and the FAHP method is a generalization of the AHP on fuzzy environment. The ARAS method is utilized to prioritize the alternatives. It is relatively simple but effective MCDM method. Further, it is desirable that the appropriate alternative should have the biggest ratio to the optimal solution (Zavadskas, Turskis 2010). In the present study, the FAHP method is employed for obtaining the priority weights of the criteria. Hence, ARAS is utilized to calculate the performance of M-banking services. The contributions of this study in extant literature are threefold. First, to date, there is no research to our knowledge which integrates FAHP and ARAS methods. Second, till date, the ARAS method has very limited applications in the economic field. Lastly, in particular, no study to the best of our knowledge has been studied in the area of evaluation of M-banking services previously. Accordingly, in this study, for the determination of the weights of the main factors and sub-factors, FAHP method is used since it is based on pairwise comparisons. Then, the weights obtained through the FAHP method are combined with the ARAS to assess and rank the M-banking services. Furthermore, in order to verify the usefulness of this proposed model, a case study of the 16 M-banking services in Turkey is offered. The findings of this study, therefore, can help banks for a clear picture of their M-banking services and then prioritize the strategies to thrive. To meet the objective, the remainder of this study is structured as follows: the next section reviews the M-banking and adoption factors while Section 2 describes the theoretical background of FAHP and ARAS methods. Next, Section 3 gives an illustrating example. The penultimate section presents discussion and limitations of this study. Finally, last section draws the conclusions and discusses topics for further research.

1. M-banking adoption factors

Recently, M-banking adoption has gained attention from researchers and there is an intense interest for adoption of the M-banking. The adoption factors of M-banking are concerned closely ease of use, access to the service from anywhere and anytime, safety and savings in time and exertion. Despite the advantages, mobile phone usage in banking facilities is not expected level. There seem to be some barriers that decelerate mobile phone usage in banking operations (Laukkanen 2007). Consequently, recent studies on M-banking adoption factors are listed in Table 1.

Table 1. Recent studies on M-banking adoption

| Authors | Adoption factors |
|-----------------------------------|---|
| Luarn and Lin (2005) | usefulness, convenience, credibility, self-efficacy, cost |
| Laukkanen (2007) | efficiency, convenience, safety |
| Lee <i>et al.</i> (2007) | perceived risk, perceived usefulness, trust |
| Laukkanen and Cruz (2008) | usage, value, risk, tradition and image |
| Kim <i>et al.</i> (2009) | relative benefits, trust, structural assurances |
| Gu <i>et al.</i> (2009) | usefulness, convenience, trust |
| Crabbe <i>et al.</i> (2009) | perceived credibility, facilitating conditions |
| Püschel <i>et al.</i> (2010) | compatibility, convenience, relative benefit, visibility, demonstrability, image, triability, perceived behavioral control, facilitation condition, subjective norm, testability, intention |
| Koenig-Lewis <i>et al.</i> (2010) | compatibility, perceived usefulness, risk, trust, cost |
| Cruz <i>et al.</i> (2010) | cost, risk, perceived advantage, complexity |
| Wessels and Drennan (2010) | usefulness, risk, convenience, financial cost, compatibility |
| Zhou <i>et al.</i> (2010) | task characteristics, technology characteristics, convenience conditions, task technology fit, performance expectancy, effort expectancy, social influence |
| Riquelme and Rios (2010) | intention, perceived relative advantage, perceived risk, social norms, convenience, usefulness |
| Singh <i>et al.</i> (2010) | usefulness, ease of use, subjective norms, self-efficacy, cost, safety, trust |
| Lin (2011) | perceived advantage, ease of use, compatibility, competence, benevolence, integrity |
| Negash (2011) | usefulness, convenience, enjoyment, network quality, security, privacy, trust, awareness, regulation, compliance |
| Akturan and Tezcan (2012) | risk, ease of use, usefulness, benefit |
| Zhou (2012) | structural assurance, ubiquity, ease of use, personal innovativeness |
| Chen (2013) | advantage, concurrency, trialability, complexity, different risk types, attitude, intention to use, brand image, brand awareness |
| Hanafizadeh <i>et al.</i> (2014) | usefulness, ease of use, the need for interaction, risk, cost, compatibility with life style, credibility, trust |
| Bidar <i>et al.</i> (2014) | usefulness, ease of use, security, privacy, compatibility, social influence, facilitating conditions, cost |

2. Methodology

This study combines the FAHP method with the ARAS method to establish a new integrated fuzzy MCDM model to assess M-banking services. To achieve this, the FAHP method is utilized to process the fuzzy information from expert judgments to determine the priority weights. Then, the ARAS method is employed to show preference of the alternatives with regard to evaluation factors and determine the final rankings of the M-banking services. The methods are explained detailed in the following subsections.

2.1. The Fuzzy AHP (FAHP) method

There are various approaches for determining weights, e.g., AHP, SWARA, expert method, eigenvalue method, entropy method, etc. As one of the most widely utilized MCDM techniques AHP is developed by Saaty (1980) to solve complex MCDM problems involving qualitative decisions (Ecer 2014). AHP analyzes hierarchical relations between different decision levels without considering interrelations among factors or alternatives (Aliakbari Nouri *et al.* 2015). Decision makers separate the decision process into sub-parts, i.e. goal, factors and alternatives. As soon as the hierarchical structures, decision makers decide the importance of each factor in pairwise comparison thanks to Saaty’s 9-point scale. What is more, AHP is a subjective methodology where information and priority weights of factors can be obtained from decision makers’ judgments (Calabrese *et al.* 2013; Das *et al.* 2012). The decision makers’ thoughts and preferences are difficult to evaluate in crisp numbers. In other words, the traditional MCDM methods do not clarify human thinking exactly (Chou, Cheng 2012). In this study, therefore, FST and AHP are integrated into the FAHP model to deal with ambiguity. To achieve this, FAHP converts linguistic judgments in Triangular Fuzzy Numbers (TFNs). These matrices are thus handled to obtain the importance weights of the items and alternatives’ ranking (Calabrese *et al.* 2013). Laarhoven and Pedrycz (1983) have first used FAHP by adapting the TFN of the FST (Bulut *et al.* 2012). Fuzzy sets and FAHP extent analysis method are as follows (Tavana *et al.* 2013; Aghdaie *et al.* 2013; Ecer 2015).

A fuzzy number is a special fuzzy set $M = \{(x, \mu_M(x)), x \in \mathfrak{R}\}$, where x takes its values on the real line, $\mathfrak{R} : -\infty \leq x \leq \infty$ and $\mu_M(x)$ is a membership function in the closed interval $[0,1]$. TFNs are the most popular fuzzy numbers due to their simplicity and linearity of the triangular membership function and permitting rather simple implementation of the fuzzy arithmetical operations (Calabrese *et al.* 2016). A TFN represents each pair of elements in the same hierarchy, and can be denoted as $M = (l, m, u)$, where $l \leq m \leq u$. The parameters l, m, u express the lower bound value, the peak or center, and the upper bound value respectively. A TFN M can be described as in Eq. (1).

$$\mu_M(x) = \begin{cases} 0 & , x < l \\ (x - l) / (m - l) & , l \leq x \leq m \\ (u - x) / (u - m) & , m \leq x \leq u \\ 0 & , x > u \end{cases} \tag{1}$$

Consider two TFNs $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$. The following describes fuzzy arithmetical operations:

$$(l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) ; \tag{2}$$

$$(l_1, m_1, u_1) \otimes (l_2, m_2, u_2) \approx (l_1 l_2, m_1 m_2, u_1 u_2) ; \tag{3}$$

$$(l_1, m_1, u_1)^{-1} \approx \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1} \right). \tag{4}$$

Table 2 presents the fuzzy conversion utilized to transform the linguistic variables into membership functions.

Table 2. The fuzzy conversion

| Definition | Membership function |
|---|---------------------|
| Just equal | (1.00,1.00,1.00) |
| Between equal and moderate | (1.00,2.00,3.00) |
| Moderate importance | (2.00,3.00,4.00) |
| Between moderate and fairly strong | (3.00,4.00,5.00) |
| Fairly strong importance | (4.00,5.00,6.00) |
| Between fairly strong and very strong | (5.00,6.00,7.00) |
| Very strong importance | (6.00,7.00,8.00) |
| Between very strong and absolute | (7.00,8.00,9.00) |
| Absolute importance | (8.00,9.00,9.00) |
| Reciprocal: $M_1^{-1} \approx \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1} \right)$ | |

Source: Chan and Kumar (2007)

The major criticism of Chang’s extent analysis (1992) is that the weights derived by this method do not represent the priority weights of decision criteria or alternatives (Zhu *et al.* 1999; Leung, Cao 2000; Mikhailov 2003; Wang *et al.* 2008; Wang, Chin 2011). Despite the fact that some criticisms for Chang’s extent analysis, the vast majority of the applications use it. Hence, the extent analysis is utilized due to its implementation simplicity to calculate importance weights in this study.

Let $X = \{x_1, x_2, \dots, x_n\}$ be an object set, and $U = \{u_1, u_2, \dots, u_m\}$ be a goal set. As to the extent analysis, each object is taken and extent analysis for each goal, g_i , is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m, \quad i = 1, 2, \dots, n, \tag{5}$$

where all the $M_{g_i}^j$ ($j = 1, 2, \dots, m$) are TFNs. The steps of extent analysis can be given as follows (Chang 1996; Kahraman *et al.* 2004; Aghdaie *et al.* 2013):

Step 1: The value of fuzzy synthetic extent with respect to the i th object is defined as

$$S_i = \sum_{j=1}^m M_{g_i}^j \otimes \left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j \right]^{-1}. \tag{6}$$

To obtain $\sum_{j=1}^m M_{g_i}^j$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that:

$$\sum_{j=1}^m M_{g_i}^j = \left(\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j \right), \tag{7}$$

and to obtain $\left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j \right]^{-1}$ perform the fuzzy addition operation of $M_{g_i}^j$ ($j=1,2,\dots,m$) values such that:

$$\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j = \left(\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n u_i \right), \tag{8}$$

and then compute the inverse of the vector in Eq. (8) such that:

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \right). \tag{9}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y)) \right], \tag{10}$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \text{hgt}(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & \text{if } (m_2 \geq m_1), \\ 0, & \text{if } (l_1 \geq u_2), \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise,} \end{cases} \tag{11}$$

where d is the ordinate of the highest intersection point D between $\mu_{M_1}(x)$ and $\mu_{M_2}(x)$ as shown in Figure 1. To compare M_1 and M_2 it is requires both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

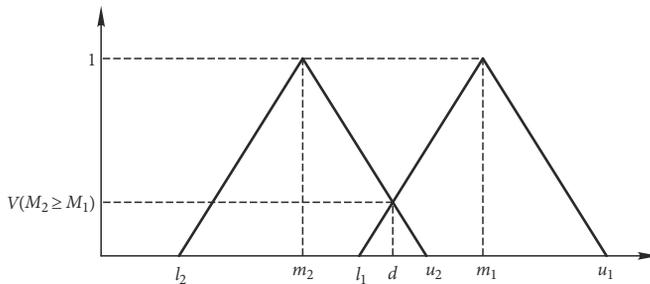


Fig. 1. The intersection between M_1 and M_2
Source: Aghdaie et al. 2013

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i = 1, 2, \dots, k$) can be defined as:

$$\begin{aligned} V(M \geq M_1, M_2, \dots, M_k) &= V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \dots \text{ and } (M \geq M_k)] \\ &= \min V(M \geq M_i), \quad i = 1, 2, \dots, k. \end{aligned} \tag{12}$$

Assume that:

$$d'(A_i) = \min V(S_i \geq S_k). \tag{13}$$

For $k = 1, 2, \dots, n$; $k \neq i$. Then the weight vector is given by:

$$W' = (d'(A_1), d'(A_2), \dots, d'(A_n))^T, \tag{14}$$

where A_i ($i = 1, 2, \dots, n$) are n elements.

Step 4: Via normalization, the normalized weight vectors are:

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T, \tag{15}$$

where W is a non-fuzzy number.

2.2. The ARAS method

MCDM is frequently used in the sciences and business and can improve the quality of decisions more explicit, rational, and efficient (Zavadskas *et al.* 2010).

A MCDM problem is closely related to the task of ranking decision alternatives (Dadelo *et al.* 2012). In this paper, the ARAS method is selected to rank alternatives. The ARAS method is based on simple relative comparisons. Decision criteria describe the optimal alternative (Kutut *et al.* 2013). In other words, the ARAS method gives a ratio of each alternative to the ideal alternative. In ARAS method, a utility function value is directly proportional to the weights of the main criteria and relative impact of alternatives (Zavadskas *et al.* 2010). It proposes to compare the ratios of utility function's scores of investigating alternatives with an optimal alternative utility function's score. For example, if an optimal score of criterion is 10 points, but among alternatives the biggest score of the criterion is 8. Therefore, it is clear that the optimality level of criterion is 0.8 but not 1.0. Among MCDM methods, the ARAS method would be the most important candidate to make an objective ranking (Sliogeriene *et al.* 2013). According to Zamani *et al.* (2014), the ARAS method has several advantages: (i) the computations are comprehensible, (ii) the concepts are rather logical, (iii) simple, and (iv) the priority weights are obtained by comparisons. Hence, the ARAS method is used in this study because of its applicability for different decision making problems successfully, because of its simplicity algorithm, and because of its decision methodology which is based on comparison to the optimal alternative.

In recent years, the ARAS method has been implemented to the solution of complicated MCDM problems. Prior studies based on the ARAS method are listed in Table 3.

Table 3. Recent studies based on the ARAS method

| Authors | Objective |
|------------------------------------|---|
| Tupenaite <i>et al.</i> (2010) | Assessing cultural heritage renovation projects |
| Zavadskas <i>et al.</i> (2010) | Selecting the foundation instalment alternative |
| Zavadskas and Turskis (2010) | The evaluation of microclimate in office rooms |
| Bakshi and Sarkar (2011) | Selecting the best project |
| Sušinskas <i>et al.</i> (2011) | Selecting the pile-columns instalment alternative |
| Zavadskas <i>et al.</i> (2012) | Assessing project managers in construction |
| Dadelo <i>et al.</i> (2012) | Personnel assessment and ranking |
| Baležentis <i>et al.</i> (2012) | Assessing Lithuanian economic sectors |
| Sliogeriene <i>et al.</i> (2013) | Analyzing energy generation technologies |
| Kutut <i>et al.</i> (2013) | Assessing preservation of historical buildings |
| Reza and Majid (2013) | Ranking financial institutions |
| Chatterjee and Chakraborty (2013) | Selecting material |
| Baležentis and Štreimikienė (2013) | Evaluating the progress achieved in implementing sustainable development priorities |
| Medineckiene <i>et al.</i> (2015) | Selecting criteria for building sustainability assessment |
| Ecer (2016) | The evaluation of ERP software alternatives |

The procedure of the ARAS method consists of the following steps (Zavadskas, Turskis 2010):

Step 1: Establish decision making matrix.

The following decision making matrix is constructed.

$$X = \begin{bmatrix} x_{01} & x_{02} & \dots & x_{0n} \\ x_{11} & x_{12} & \dots & x_{1n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}; \quad i = 0,1,\dots,m; \quad j = 1,2,\dots,n, \tag{16}$$

where m – number of alternatives, n – number of criteria describing each alternative, x_{ij} – value representing the performance value of the i alternative in terms of the j criterion, x_{0j} – optimal value of j criterion. If optimal value of j criterion is unknown, then:

$$\begin{cases} \max_i x_{ij}, & \text{if } \max_i x_{ij} \text{ is preferable} \\ \min_i x_{ij}^*, & \text{if } \min_i x_{ij}^* \text{ is preferable} \end{cases} \tag{17}$$

Step 2: Construct normalized decision making matrix.

In the second step, decision making matrix is normalized:

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \bar{x}_{02} & \dots & \bar{x}_{0n} \\ \bar{x}_{11} & \bar{x}_{12} & \dots & \bar{x}_{1n} \\ \vdots & \vdots & \dots & \vdots \\ \bar{x}_{m1} & \bar{x}_{m2} & \dots & \bar{x}_{mn} \end{bmatrix}; \quad i = 0,1,\dots,m; \quad j = 1,2,\dots,n. \tag{18}$$

The criteria, whose preferable values are maxima, are normalized as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^m x_{ij}} . \tag{19}$$

The criteria, whose preferable values are minima, are normalized as follows:

$$\bar{x}_{ij} = \frac{1/x_{ij}}{\sum_{i=0}^m 1/x_{ij}} . \tag{20}$$

Step 3: Calculate weighted normalized matrix.

The third stage is defining normalized-weighted matrix – \hat{X} .

$$\hat{X} = \begin{bmatrix} \hat{x}_{01} & \hat{x}_{02} & \cdots & \hat{x}_{0n} \\ \hat{x}_{11} & \hat{x}_{12} & \cdots & \hat{x}_{1n} \\ \vdots & \vdots & \cdots & \vdots \\ \hat{x}_{m1} & \hat{x}_{m2} & \cdots & \hat{x}_{mn} \end{bmatrix} ; \quad i = 0, 1, \dots, m; \quad j = 1, 2, \dots, n. \tag{21}$$

Normalized-weighted values of all the criteria are calculated as follows:

$$\hat{x}_{ij} = \bar{x}_{ij} w_j ; \quad i = 0, 1, \dots, m, \tag{22}$$

where w_j is the weight (importance) of the j criterion and \bar{x}_{ij} is the normalized rating of the j criterion.

Step 4: Determine values of optimality function S_i :

$$S_i = \sum_{j=1}^n \hat{x}_{ij} ; \quad i = 0, 1, \dots, m . \tag{23}$$

The bigger the value of the S_i , the more efficient the alternative.

Step 5: Calculate final ranking.

The utility degree K_i of an alternative a_i is calculated as follows:

$$K_i = \frac{S_i}{S_0} ; \quad i = 0, 1, \dots, m, \tag{24}$$

where S_i and S_0 are the optimality criterion values.

K_i values are in the interval [0,1] and can be ordered in an increasing sequence, which is the wanted order of precedence.

3. Proposed model for M-banking services evaluation

In literature, there are many different MCDM techniques. The selection of appropriate decision making technique depends on the purpose of the problem, obtainable information, costs of decision, and decision makers' qualification. In this study, two of MCDM techniques are applied: ARAS and FAHP.

In the present study, 16 M-banking services in Turkey have been selected as a case study. That is to say, the whole M-banking services in Turkey are determined as the alternatives

of the model. These are Akbank, Aktif Yatirim Bankasi, Denizbank, Finansbank, Garanti Bankasi, Halk Bankasi, HSBC, ING, Is Bankasi, Odea Bank, Sekerbank, Sinai Kalkinma Bankasi, TEB, Vakiflar Bankasi, Yapi Kredi Bankasi, and Ziraat Bankasi.

The proposed model can be divided into three sub-sections: (i) decision making team working, (ii) weighing the determined factors and sub-factors via the FAHP, and (iii) ranking the alternatives via the ARAS. Figure 2 demonstrates the schematic diagram of the proposed model.

The following subsection shows how to evaluate M-banking services in Turkey using the proposed model.

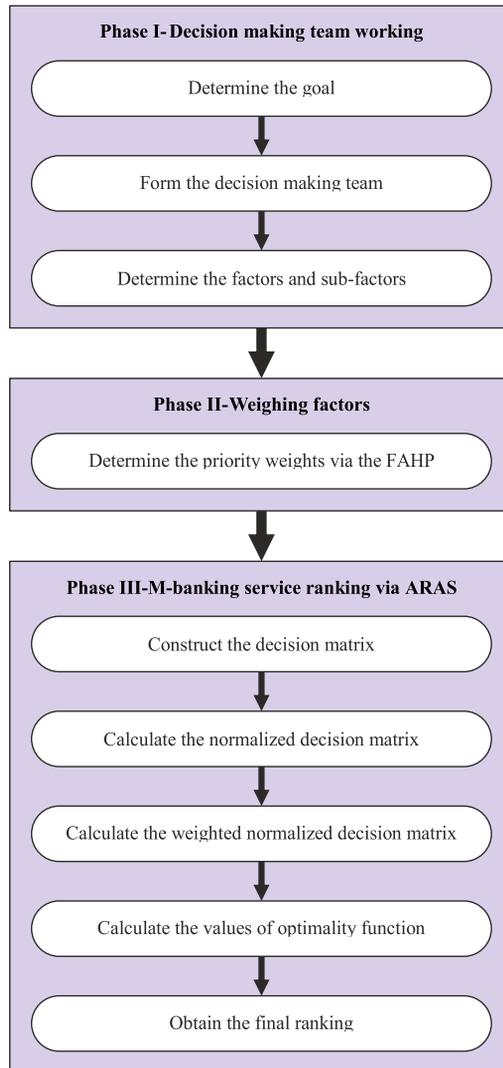


Fig. 2. The proposed integrated fuzzy model

3.1 Decision making team working

This step is rather important for any banking evaluation problem. According to Zamani *et al.* (2014) and Bilsel *et al.* (2006), using a group of expert opinions are generally better than a single person to avoid prejudice to minimize the partiality in the case of complex problems.

Nowadays, managers often work in teams to make decisions because the complexity and ambiguity of the issues with which they must grapple can overwhelm the capacities of any one individual. A team's decision-making effectiveness depends in part upon its members' cooperativeness in providing information and in fully airing differences in assumptions and interpretations. What is more having input into a decision makes people feel the decision maker and affirms their status in the decision making team (Korsgaard *et al.* 1995). In order to determine and assess the factors affecting M-banking adoption, a decision making team including four practitioners (clients) and two experts having more than five years experience in the banking sector is constructed. Information about decision making team members is shown in Table 4. According to Table 4, most of the respondents are female. Moreover, the majority of the respondents falls into the 36–46 year-old age group. Finally, all respondents complete at least a bachelor.

Table 4. Demographic characteristics of decision making team members

| Demographics | Frequency |
|------------------|-----------|
| <i>Gender</i> | |
| Male | 2 |
| Female | 4 |
| <i>Age</i> | |
| 25–35 | 2 |
| 36–46 | 3 |
| Over 47 | 1 |
| <i>Education</i> | |
| Bachelor | 3 |
| Master | 2 |
| PhD | 1 |

Many researchers have examined M-banking from the perspectives of TAM. Thereby, M-banking client adoption will be trying to explain based on user perceptions of the technology in this study. In accordance with the M-banking adoption factors, this study evaluates M-banking services from the perspectives of perceived usefulness, perceived ease of use, and perceived risk. In this context, In Table 5, factors and sub-factors considered in this study are given with their definitions. Those factors are collected from the earlier studies mentioned Section 2 under the supervision of the decision making team. Hence, the hierarchy of the model includes 3 factors and 8 sub-factors.

Table 5. M-banking adoption factors as evaluation criteria

| Criteria | Sub-criteria | Definition | Goal |
|-----------------------------|------------------------------|---|---------|
| Perceived usefulness (PUS) | | When a person uses a particular system, it could enhance his/her job performance (Davis 1989). The more useful M-banking is, the more it will be used. | Maximum |
| | Social influence (SI) | Fishbein and Ajzen (1975) and Gu <i>et al.</i> (2009) define social influence as “A person’s perception that most people who are import to him think he should or should not perform the behavior in question”. | Maximum |
| | System quality (SQ) | DeLone and McLean (2003) and Gu <i>et al.</i> (2009) state that “Perceived network speed and system stability. System quality affects intention and client satisfaction. Clients will perceive it to be useful if the M-banking services are provided accurately and with high speed”. | Maximum |
| Perceived ease of use (PEU) | | According to Davis (1989), PEU means “The degree to which the prospective user expects the target system to be free of effort”. The easier M-banking is, the more it will be used. | Maximum |
| | Self-efficacy (SE) | Gu <i>et al.</i> (2009) and Venkatesh (2000) define SE as “A belief that an individual has the capabilities to execute the particular behavior with information technology (IT)”. | Maximum |
| | Facilitating conditions (FC) | Lu <i>et al.</i> (2003) and Gu <i>et al.</i> (2009) define FC as “The external environments of helping clients overcome barriers and hurdles to use a new IT. Clients will perceive M-banking service to be easy to use when they recognize that there are environmental conditions to help them learn how to use M-banking service, although they cannot use it skillfully”. | Maximum |
| | Familiarity (FM) | Gu <i>et al.</i> (2009) defines FM as “An understanding, often based on previous interactions, experiences, and learning of what, why, where and when others do what they do”. | Maximum |
| Perceived risk (PRI) | | Chen (2013) defines PRI as “A perception about implicit risk in using the open internet infrastructure to exchange private information and it is often operationalized as a multi-dimensional construct”. | Minimum |
| | Privacy risk (PR) | Akturan and Tezcan (2012) defines PR as “Potential loss of control over personal information”. | Minimum |
| | Performance risk (PF) | Akturan and Tezcan (2012) defines PF as “The possibility of the product malfunctioning”. | Minimum |
| | Security risk (SR) | Akturan and Tezcan (2012) defines SR as “Potential loss of control over transactions and financial information”. | Minimum |

Eventually, optimization directions of evaluation factors as follows:

- $SI, SQ, SE, FC, FM \xrightarrow{\text{optimization direction}} \text{max};$
- $PR, PF, SR \xrightarrow{\text{optimization direction}} \text{min}.$

3.2. Weighing factors

First of all, the pairwise comparison matrix of three main factors and eight sub-factors are constructed to get their priority weight over another. Then, the fuzzy values are converted to crisp numbers by the Chang's extent analysis. The following tables (Tables 6–9) show the fuzzy evaluation of the factors. In order to achieve this, fuzzy synthetic extent values and the degree of synthetic extent values are calculated. Then, the weight vector is normalized defined as Eq. (15). After normalizing weight vector, the obtained priority weight vector of factors is figured out in the last column of Tables 6–9.

Table 6. Fuzzy evaluation of the main factors

| | PUS | PEU | PRI | Priority weight |
|-----|---------|---------------|-------------|-----------------|
| PUS | (1,1,1) | (1/4,1/3,1/2) | (1/3,1/2,1) | 0.0771 |
| PEU | (2,3,4) | (1,1,1) | (1,2,3) | 0.5665 |
| PRI | (1,2,3) | (1/3,1/2,1) | (1,1,1) | 0.3564 |

Notes: $V(S_{PUS} \geq S_{PEU}) = 0.14$, $V(S_{PEU} \geq S_{PUS}) = 1.00$, $V(S_{PUS} \geq S_{PRI}) = 0.53$, $V(S_{PRI} \geq S_{PUS}) = 1.00$, $V(S_{PEU} \geq S_{PRI}) = 1.00$, $V(S_{PRI} \geq S_{PEU}) = 0.63$.

Table 7. Fuzzy evaluation of sub-factors as to perceived usefulness (PUS)

| | SI | SQ | Priority weight |
|----|---------|-------------|-----------------|
| SI | (1,1,1) | (1/3,1/2,1) | 0.3080 |
| SQ | (1,2,3) | (1,1,1) | 0.6920 |

Notes: $V(S_{SI} \geq S_{SQ}) = 0.45$, $V(S_{SQ} \geq S_{SI}) = 1.00$.

Table 8. Fuzzy evaluation of sub-factors as to perceived ease of uhse (PEU)

| | SE | FC | FM | Priority weight |
|----|-------------|---------------|---------|-----------------|
| SE | (1,1,1) | (1/3,1/2,1) | (1,2,3) | 0.3564 |
| FC | (1,2,3) | (1,1,1) | (2,3,4) | 0.5665 |
| FM | (1/3,1/2,1) | (1/4,1/3,1/2) | (1,1,1) | 0.0771 |

Notes: $V(S_{SE} \geq S_{FC}) = 0.63$, $V(S_{FC} \geq S_{SE}) = 1.00$, $V(S_{SE} \geq S_{FM}) = 1.00$, $V(S_{FM} \geq S_{SE}) = 0.53$, $V(S_{FM} \geq S_{FC}) = 0.14$, $V(S_{FC} \geq S_{FM}) = 1.00$.

Table 9. Fuzzy evaluation of sub-factors as to perceived risk (PRI)

| | PR | PF | SR | Priority weight |
|----|-------------|---------|-------------|-----------------|
| PR | (1,1,1) | (1,2,3) | (1,1,1) | 0.4089 |
| PF | (1/3,1/2,1) | (1,1,1) | (1/3,1/2,1) | 0.1822 |
| SR | (1,1,1) | (1,2,3) | (1,1,1) | 0.4089 |

Notes: $V(S_{PR} \geq S_{PF}) = 1.00$, $V(S_{PF} \geq S_{PR}) = 0.45$, $V(S_{SR} \geq S_{PF}) = 1.00$, $V(S_{PF} \geq S_{SR}) = 0.45$, $V(S_{SR} \geq S_{PR}) = 1.00$, $V(S_{PR} \geq S_{SR}) = 1.00$.

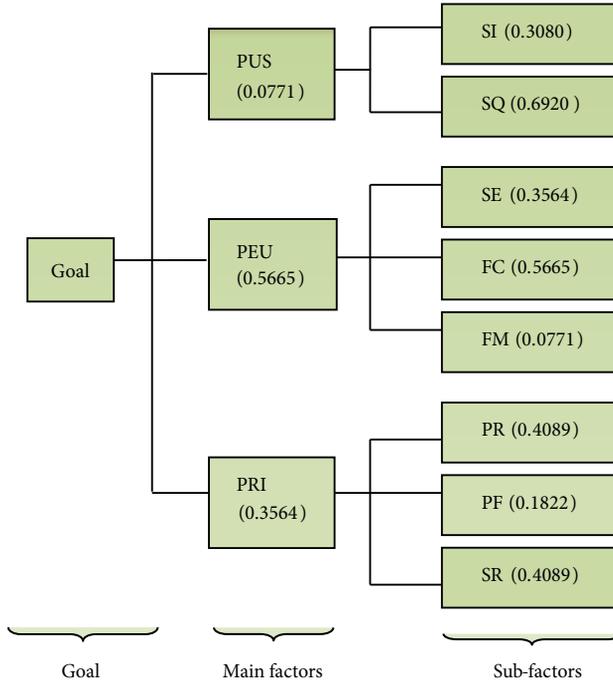


Fig. 3. Priority weights of main factors and sub-factors

Hence, Figure 3 shows a graphical plot of the weights. The final priority weights of eight sub-factors, therefore, SI, SQ, SE, FC, FM, PR, PF, and SR become 0.0237, 0.0534, 0.2019, 0.3209, 0.0437, 0.1457, 0.065, and 0.1457 respectively. As a result, FC, SE, PR, and SR are the top M-banking adoption factors. SI, however, has the lowest importance weight of 0.0237. The priority weights will be utilized in ARAS method.

3.3. M-banking service ranking via the ARAS method

The decision making matrix is built during this stage related to the evaluation of M-banking services. In this respect, 16 M-banking services in Turkey are selected as a case study. Moreover, 8 M-banking adoption factors characterizing these alternatives are determined. According to the algorithm of the ARAS method mentioned in Section 3, the problem is solved and the results are presented in Tables 10–13.

Initial decision making matrix (Table 10) contains an evaluation of the alternatives, factor values, and priority weights. According to Table 10, it could be stated that four adoption factors “Facilitating Conditions”, “Self-efficacy”, “Privacy Risk” and “Security Risk” have the maximum priority weight. After this, the initial decision making matrix is normalized as discussed in Section 3. The normalized decision making matrix is presented in Table 12. Then, the weighted decision making matrix presented in Table 12 is constructed. It follows the procedure described earlier and determines optimality function (S_i) each alternative using Eq. (23). Finally, the utility degree of each alternative (K_i) is determined using Eq. (24).

Table 10. Determined initial data for analysis (initial decision making matrix)

| | M-banking adoption factors | | | | | | | |
|-------------------------------------|----------------------------|--------|--------|--------|--------|--------|--------|--------|
| | SI | SQ | SE | FC | FM | PR | PF | SR |
| | x_1 | x_2 | x_3 | x_4 | x_5 | x_6 | x_7 | x_8 |
| Optimum direction | max | max | max | max | max | min | min | min |
| Priority weights | 0.0237 | 0.0533 | 0.2019 | 0.3209 | 0.0432 | 0.1457 | 0.0656 | 0.1457 |
| a_0 (optimal values) | 100 | 100 | 100 | 100 | 100 | 1 | 1 | 1 |
| Akbank (a_1) | 97 | 100 | 100 | 100 | 95 | 1 | 4 | 3 |
| Aktif Yatirim Bankasi (a_2) | 62 | 57 | 58 | 57 | 57 | 32 | 33 | 35 |
| Denizbank (a_3) | 55 | 49 | 49 | 50 | 46 | 40 | 41 | 42 |
| Finansbank (a_4) | 84 | 80 | 82 | 83 | 81 | 12 | 15 | 12 |
| Garanti Bankasi (a_5) | 89 | 85 | 95 | 91 | 87 | 7 | 8 | 7 |
| Halk Bankasi (a_6) | 79 | 77 | 78 | 77 | 76 | 15 | 19 | 15 |
| HSBC (a_7) | 57 | 54 | 52 | 50 | 49 | 37 | 37 | 41 |
| ING (a_8) | 95 | 92 | 95 | 98 | 92 | 3 | 4 | 3 |
| Is Bankasi (a_9) | 88 | 87 | 85 | 86 | 85 | 9 | 11 | 9 |
| Odea Bank (a_{10}) | 67 | 62 | 62 | 62 | 61 | 29 | 30 | 30 |
| Sekerbank (a_{11}) | 81 | 77 | 80 | 81 | 78 | 13 | 17 | 14 |
| Sinai Kalkinma Bankasi (a_{12}) | 71 | 67 | 68 | 69 | 66 | 24 | 27 | 25 |
| TEB (a_{13}) | 95 | 90 | 93 | 93 | 92 | 5 | 6 | 4 |
| Vakiflar Bankasi (a_{14}) | 75 | 71 | 72 | 74 | 72 | 20 | 24 | 21 |
| Yapi Kredi Bankasi (a_{15}) | 96 | 91 | 96 | 97 | 96 | 2 | 4 | 1 |
| Ziraat Bankasi (a_{16}) | 59 | 54 | 55 | 54 | 52 | 35 | 36 | 38 |

Table 11. Changed initial data for analysis (initial decision making matrix)

| | M-banking adoption factors | | | | | | | |
|---------------------------------|----------------------------|--------|--------|--------|--------|--------|--------|--------|
| | SI | SQ | SE | FC | FM | PR | PF | SR |
| | x_1 | x_2 | x_3 | x_4 | x_5 | x_6 | x_7 | x_8 |
| Optimum direction | max | max | max | max | max | min | min | min |
| Priority weights | 0.0237 | 0.0533 | 0.2019 | 0.3209 | 0.0432 | 0.1457 | 0.0656 | 0.1457 |
| a_0 (optimal values) | 100 | 100 | 100 | 100 | 100 | 1 | 1 | 1 |
| Akbank (a_1) | 97 | 100 | 100 | 100 | 95 | 1.000 | 0.250 | 0.333 |
| Aktif Yatirim Bankasi (a_2) | 62 | 57 | 58 | 57 | 57 | 0.031 | 0.030 | 0.029 |
| Denizbank (a_3) | 55 | 49 | 49 | 50 | 46 | 0.025 | 0.024 | 0.024 |
| Finansbank (a_4) | 84 | 80 | 82 | 83 | 81 | 0.083 | 0.067 | 0.083 |
| Garanti Bankasi (a_5) | 89 | 85 | 95 | 91 | 87 | 0.143 | 0.125 | 0.143 |
| Halk Bankasi (a_6) | 79 | 77 | 78 | 77 | 76 | 0.067 | 0.053 | 0.067 |
| HSBC (a_7) | 57 | 54 | 52 | 50 | 49 | 0.027 | 0.027 | 0.024 |
| ING (a_8) | 95 | 92 | 95 | 98 | 92 | 0.333 | 0.250 | 0.333 |
| Is Bankasi (a_9) | 88 | 87 | 85 | 86 | 85 | 0.111 | 0.091 | 0.111 |

End of Table 11

| | M-banking adoption factors | | | | | | | |
|-------------------------------------|----------------------------|-------|-------|-------|-------|-------|-------|-------|
| | SI | SQ | SE | FC | FM | PR | PF | SR |
| | x_1 | x_2 | x_3 | x_4 | x_5 | x_6 | x_7 | x_8 |
| Odea Bank (a_{10}) | 67 | 62 | 62 | 62 | 61 | 0.034 | 0.033 | 0.033 |
| Sekerbank (a_{11}) | 81 | 77 | 80 | 81 | 78 | 0.077 | 0.059 | 0.071 |
| Sinai Kalkinma Bankasi (a_{12}) | 71 | 67 | 68 | 69 | 66 | 0.042 | 0.037 | 0.040 |
| TEB (a_{13}) | 95 | 90 | 93 | 93 | 92 | 0.200 | 0.167 | 0.250 |
| Vakiflar Bankasi (a_{14}) | 75 | 71 | 72 | 74 | 72 | 0.050 | 0.042 | 0.048 |
| Yapi Kredi Bankasi (a_{15}) | 96 | 91 | 96 | 97 | 96 | 0.500 | 0.250 | 1.000 |
| Ziraat Bankasi (a_{16}) | 59 | 54 | 55 | 54 | 52 | 0.029 | 0.028 | 0.026 |
| Total | 1350 | 1293 | 1320 | 1322 | 1285 | 3.752 | 2.532 | 3.616 |

Table 12. Normalised decision making matrix

| | M-banking adoption factors | | | | | | | |
|-------------------------------------|----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | SI | SQ | SE | FC | FM | PR | PF | SR |
| | \bar{x}_1 | \bar{x}_2 | \bar{x}_3 | \bar{x}_4 | \bar{x}_5 | \bar{x}_6 | \bar{x}_7 | \bar{x}_8 |
| Optimum direction | max | max | max | max | max | min | min | min |
| Priority weights | 0.0237 | 0.0533 | 0.2019 | 0.3209 | 0.0432 | 0.1457 | 0.0656 | 0.1457 |
| a_0 (optimal values) | 0.0741 | 0.0773 | 0.0758 | 0.0756 | 0.0778 | 0.2665 | 0.3949 | 0.2765 |
| Akbank (a_1) | 0.0719 | 0.0773 | 0.0758 | 0.0756 | 0.0739 | 0.2665 | 0.0987 | 0.0922 |
| Aktif Yatirim Bankasi (a_2) | 0.0459 | 0.0441 | 0.0439 | 0.0431 | 0.0444 | 0.0083 | 0.0120 | 0.0079 |
| Denizbank (a_3) | 0.0407 | 0.0379 | 0.0371 | 0.0378 | 0.0358 | 0.0067 | 0.0096 | 0.0066 |
| Finansbank (a_4) | 0.0622 | 0.0619 | 0.0621 | 0.0628 | 0.0630 | 0.0222 | 0.0263 | 0.0230 |
| Garanti Bankasi (a_5) | 0.0659 | 0.0657 | 0.0720 | 0.0688 | 0.0677 | 0.0381 | 0.0494 | 0.0395 |
| Halk Bankasi (a_6) | 0.0585 | 0.0596 | 0.0591 | 0.0582 | 0.0591 | 0.0178 | 0.0208 | 0.0184 |
| HSBC (a_7) | 0.0422 | 0.0418 | 0.0394 | 0.0378 | 0.0381 | 0.0072 | 0.0107 | 0.0067 |
| ING (a_8) | 0.0704 | 0.0712 | 0.0720 | 0.0741 | 0.0716 | 0.0888 | 0.0987 | 0.0922 |
| Is Bankasi (a_9) | 0.0652 | 0.0673 | 0.0644 | 0.0651 | 0.0661 | 0.0296 | 0.0359 | 0.0307 |
| Odea Bank (a_{10}) | 0.0496 | 0.0480 | 0.0470 | 0.0469 | 0.0475 | 0.0092 | 0.0132 | 0.0092 |
| Sekerbank (a_{11}) | 0.0600 | 0.0596 | 0.0606 | 0.0613 | 0.0607 | 0.0205 | 0.0232 | 0.0198 |
| Sinai Kalkinma Bankasi (a_{12}) | 0.0526 | 0.0518 | 0.0515 | 0.0522 | 0.0514 | 0.0111 | 0.0146 | 0.0111 |
| TEB (a_{13}) | 0.0704 | 0.0696 | 0.0705 | 0.0703 | 0.0716 | 0.0533 | 0.0658 | 0.0691 |
| Vakiflar Bankasi (a_{14}) | 0.0556 | 0.0549 | 0.0545 | 0.0560 | 0.0560 | 0.0133 | 0.0165 | 0.0132 |
| Yapi Kredi Bankasi (a_{15}) | 0.0711 | 0.0704 | 0.0727 | 0.0734 | 0.0747 | 0.1333 | 0.0987 | 0.2765 |
| Ziraat Bankasi (a_{16}) | 0.0437 | 0.0418 | 0.0417 | 0.0408 | 0.0405 | 0.0076 | 0.0110 | 0.0073 |

Table 13. Weighted normalised decision making matrix and solution results

| | Criteria | | | | | | | | Results | | |
|-------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------|--------|---------|
| | SI | SQ | SE | FC | FM | PR | PF | SR | S | K | Rank |
| | \hat{x}_1 | \hat{x}_2 | \hat{x}_3 | \hat{x}_4 | \hat{x}_5 | \hat{x}_6 | \hat{x}_7 | \hat{x}_8 | | | |
| a_0 (optimal values) | 0.0018 | 0.0041 | 0.0153 | 0.0243 | 0.0034 | 0.0388 | 0.0259 | 0.0403 | 0.1538 | 1 | Optimal |
| Akbank (a_1) | 0.0017 | 0.0041 | 0.0153 | 0.0243 | 0.0032 | 0.0388 | 0.0065 | 0.0134 | 0.1073 | 0.6977 | 2 |
| Aktif Yatirim Bankasi (a_2) | 0.0011 | 0.0023 | 0.0089 | 0.0138 | 0.0019 | 0.0012 | 0.0008 | 0.0012 | 0.0312 | 0.2029 | 13 |
| Denizbank (a_3) | 0.0010 | 0.0020 | 0.0075 | 0.0121 | 0.0015 | 0.0010 | 0.0006 | 0.0010 | 0.0267 | 0.1737 | 16 |
| Finansbank (a_4) | 0.0015 | 0.0033 | 0.0125 | 0.0201 | 0.0027 | 0.0032 | 0.0017 | 0.0034 | 0.0485 | 0.3153 | 7 |
| Garanti Bankasi (a_5) | 0.0016 | 0.0035 | 0.0145 | 0.0221 | 0.0029 | 0.0055 | 0.0032 | 0.0058 | 0.0592 | 0.3845 | 5 |
| Halk Bankasi (a_6) | 0.0014 | 0.0032 | 0.0119 | 0.0187 | 0.0026 | 0.0026 | 0.0014 | 0.0027 | 0.0444 | 0.2885 | 9 |
| HSBC (a_7) | 0.0010 | 0.0022 | 0.0080 | 0.0121 | 0.0016 | 0.0010 | 0.0007 | 0.0010 | 0.0277 | 0.1800 | 15 |
| ING (a_8) | 0.0017 | 0.0038 | 0.0145 | 0.0238 | 0.0031 | 0.0129 | 0.0065 | 0.0134 | 0.0797 | 0.5182 | 3 |
| Is Bankasi (a_9) | 0.0015 | 0.0036 | 0.0130 | 0.0209 | 0.0029 | 0.0043 | 0.0024 | 0.0045 | 0.0530 | 0.3446 | 6 |
| Odea Bank (a_{10}) | 0.0012 | 0.0026 | 0.0095 | 0.0150 | 0.0021 | 0.0013 | 0.0009 | 0.0013 | 0.0339 | 0.2201 | 12 |
| Sekerbank (a_{11}) | 0.0014 | 0.0032 | 0.0122 | 0.0197 | 0.0026 | 0.0030 | 0.0015 | 0.0029 | 0.0465 | 0.3023 | 8 |
| Sinai Kalkinma Bankasi (a_{12}) | 0.0012 | 0.0028 | 0.0104 | 0.0167 | 0.0022 | 0.0016 | 0.0010 | 0.0016 | 0.0376 | 0.2442 | 11 |
| TEB (a_{13}) | 0.0017 | 0.0037 | 0.0142 | 0.0226 | 0.0031 | 0.0078 | 0.0043 | 0.0101 | 0.0674 | 0.4383 | 4 |
| Vakiflar Bankasi (a_{14}) | 0.0013 | 0.0029 | 0.0110 | 0.0180 | 0.0024 | 0.0019 | 0.0011 | 0.0019 | 0.0406 | 0.2638 | 10 |
| Yapi Kredi Bankasi (a_{15}) | 0.0017 | 0.0038 | 0.0147 | 0.0235 | 0.0032 | 0.0194 | 0.0065 | 0.0403 | 0.1131 | 0.7350 | 1 |
| Ziraat Bankasi (a_{16}) | 0.0010 | 0.0022 | 0.0084 | 0.0131 | 0.0017 | 0.0011 | 0.0007 | 0.0011 | 0.0294 | 0.1912 | 14 |

According to the solution results M-banking service ranks as follows:

$$a_{15} \succ a_1 \succ a_8 \succ a_{13} \succ a_5 \succ a_9 \succ a_4 \succ a_{11} \succ a_6 \succ a_{14} \succ a_{12} \succ a_{10} \succ a_2 \succ a_{16} \succ a_7 \succ a_3.$$

Consequently, the estimation results show that the best alternative is Yapi Kredi Bankasi with a utility degree (performance ratio) of 73.5%. According to Table 13, Akbank with a utility degree of 69.77% is the second ranking M-banking service. ING Bank with a utility degree of 51.82% is the third ranking M-banking service in Turkey. Finally, TEB and Garanti Bankasi with utility degrees of 43.83% and 38.45%, respectively, are selected as

the fourth and fifth choices for M-banking services. However, Ziraat Bankasi, HSBC, and Denizbank with utility degrees of 19.12%, 18% and 17.37%, respectively, are the worst M-banking services.

In the present study, a sensitivity analysis is applied to show how the rank order of M-banking services behaves when the priority weights of the criteria are changed. To do this, the priority weights are changed for two criteria while the others are constant. For example, the priority weight of the *SI* is changed with *SQ*, *SE*, *FC* and so on, sequentially, while the others are constant. Table 14 shows the cases that considered. Whilst the priority weights are changing mutually, the utility value of alternatives is changing. In Case 1, if *SI* and *SQ*'s priority weights are exchanged, then the utility value of a_{15} arises from 0.735 to 0.736 and a_1 falls from 0.698 to 0.697. Hence, the preference ranking of a_{15} does not change except Case 7. Besides, P_3 is determined to be the best alternative in all cases except Case 7 as to the sensitivity analysis results since it has maximum utility value after the priority weight exchanges realized here.

Table 14. The sensitivity analysis results

| Cases | Variables | Alternatives | | | | | | | | | | | | | | | |
|-------|-----------|--------------|-------|-------|-------|-------|-------|-------|-------|-------|----------|----------|----------|----------|----------|----------|----------|
| | | a_1 | a_2 | a_3 | a_4 | a_5 | a_6 | a_7 | a_8 | a_9 | a_{10} | a_{11} | a_{12} | a_{13} | a_{14} | a_{15} | a_{16} |
| 1 | K | 0.697 | 0.203 | 0.174 | 0.316 | 0.385 | 0.288 | 0.180 | 0.518 | 0.344 | 0.221 | 0.303 | 0.244 | 0.439 | 0.264 | 0.736 | 0.192 |
| | Ranking | 2 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 1 | 14 |
| 2 | K | 0.694 | 0.206 | 0.178 | 0.316 | 0.378 | 0.288 | 0.184 | 0.517 | 0.346 | 0.224 | 0.302 | 0.246 | 0.439 | 0.265 | 0.735 | 0.194 |
| | Ranking | 2 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 1 | 14 |
| 3 | K | 0.692 | 0.209 | 0.180 | 0.315 | 0.380 | 0.290 | 0.189 | 0.513 | 0.346 | 0.226 | 0.301 | 0.246 | 0.440 | 0.264 | 0.733 | 0.197 |
| | Ranking | 2 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 1 | 14 |
| 4 | K | 0.698 | 0.203 | 0.174 | 0.315 | 0.384 | 0.289 | 0.181 | 0.518 | 0.345 | 0.220 | 0.302 | 0.244 | 0.438 | 0.264 | 0.735 | 0.192 |
| | Ranking | 2 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 1 | 14 |
| 5 | K | 0.641 | 0.275 | 0.237 | 0.410 | 0.480 | 0.379 | 0.245 | 0.594 | 0.440 | 0.298 | 0.394 | 0.327 | 0.533 | 0.351 | 0.809 | 0.259 |
| | Ranking | 2 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 1 | 14 |
| 6 | K | 0.756 | 0.232 | 0.200 | 0.356 | 0.426 | 0.327 | 0.207 | 0.559 | 0.386 | 0.252 | 0.342 | 0.279 | 0.482 | 0.301 | 0.797 | 0.219 |
| | Ranking | 2 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 1 | 14 |
| 7 | K | 0.812 | 0.278 | 0.239 | 0.413 | 0.483 | 0.382 | 0.248 | 0.597 | 0.443 | 0.300 | 0.398 | 0.330 | 0.523 | 0.354 | 0.682 | 0.262 |
| | Ranking | 1 | 13 | 16 | 7 | 5 | 9 | 15 | 3 | 6 | 12 | 8 | 11 | 4 | 10 | 2 | 14 |

4. Discussion and limitations

In this study, criteria weights are determined by applying the FAHP method. In order to rank M-banking service alternatives and select the best M-banking service, the ARAS method is used to evaluate alternatives.

As this study has shown, *facilitating condition* (FC) is the most important factor effecting M-banking adoption. The results of this study are also consistent with the findings of previous studies (Lee, Chung 2009; Püschel *et al.* 2010; Zhou *et al.* 2010). This demonstrates that when clients perceive they are able to use M-banking and mobile devices that

are available to them, the more likely it is they will continue using M-banking. This also means, in Turkey, fundamental necessities for use of M-banking are satisfied. Therefore, it is suggested that clients should be provided adequate information related to M-banking and its advantages.

The next factor affecting M-banking adoption is *self-efficacy* (SE). Püschel *et al.* (2010) indicates that self-efficacy is one of the most important factors influencing the client to adopt M-banking. Furthermore, self-efficacy is also an important M-banking adoption factor in Luarn and Lin's (2005) study. They stated that the total effect of self-efficacy on behavioral intention was 0.54. Hence, bank managers, owners, and practitioners should focus on constructing of self-efficacy.

The third and fourth factors in the adoption of M-banking are *privacy risk* (PR) and *security risk* (SR). Clients perceive these factors as substantial barriers to the adoption of the M-banking services. In other words, the higher the perception of privacy risk and security risk of M-banking services, the less clients intend to use this new channel. Banks should therefore address the risk concern to ensure that their commercial transactions are safe and that the whole M-banking service is operable (Chen 2013). In addition, privacy risk and security risk have been examined in M-banking adoption related studies. This is consistent with extant literature, which has shown privacy risk and security risk to have a strong positive relationship with behavioral intentions (Lee *et al.* 2007; Laukkanen, Cruz 2008; Koenig-Lewis *et al.* 2010; Wessels, Drennan 2010; Negash 2011; Akturan, Tezcan 2012; Chen 2013).

Another factor affecting M-banking adoption is their *performance risk* (PF) which is determined as the fifth factor in this study. This result confirms Zhou's (Zhou *et al.* 2010) and Chen's (Chen 2013) studies that performance risk as one of the key barriers for M-banking adoption. As a result, the extent to which if a person believes that an M-banking service is not meeting the requirements (i.e. download speed, transaction time, etc.) of him/her, he or she will not disposed to use it. In this context, it is suggested that M-banking systems are designed in a way so that they can be increased performance risk and can be used confidently different clients. To do this, decreasing in performance risk should be promoted resolutely by bank practitioners. Thus, the more customers believe the M-banking service performing poorly, the less they are likely to use and adopt it.

The next factor affecting M-banking adoption is *system quality* (SQ). Consistent with other studies (Gu *et al.* 2009; Negash 2011), system quality affects continuing to use. For instance, Gu *et al.*'s (2009) study recommends that system quality has rather important on clients' continuing to use M-banking in Korea. Accordingly, system quality impacts not only adoption behavior, but also customer satisfaction. If the M-banking services are reliable, flexible, accessible, accurate and speedy, clients will perceive them to be useful.

According to the findings, *familiarity* (FM) is found as a seventh factor in the M-banking adoption. In Gu *et al.*'s (2009) study, the hypothesis that familiarity positively affects perceived ease of use has been confirmed. This indicates that clients will perceive it to be easy to use since they are familiar with M-banking services. Consequently, thanks to prior experience, familiarity increases the continuing to use M-banking services.

Finally, *social influence* (SI) is found as an eighth factor in M-banking adoption. In Zhou's *et al.* (2010) study, social influence has significant effects on user adoption. In ad-

dition, these findings are in parallel with the study of Bidar's *et al.* (2014) study. Hence, Turkish clients may be influenced by new advertising methods, their society, and social networks and these interactions can lead their decisions.

The case study also shows that the proposed model is simple and proper to solve complex M-banking problems. Application of the FAHP and the ARAS combination revealed that the best M-banking service is Yapi Kredi Bankasi. Furthermore, the proposed FAHP&ARAS model indicates the performance ratio of each M-banking service alternative to the optimal M-banking service alternative. The performance of Yapi Kredi Bankasi nearly achieves 74% of the performance of the optimal M-banking service.

There are some limitations in this study. First of all, the adoption factors of M-banking services were determined from the literature review under the supervision of the decision making team. Hence, it may exclude some possible adoption factors. In future research, different M-banking adoption factors can be used to evaluate M-banking services. Second, this study focuses on Turkey, which is a developing economy compared with some others. Future research can evaluate M-banking services in developed countries with relatively mature M-banking. This may better insights on M-banking situation around the world. Finally, future research efforts can utilize alternate MCDM techniques, such as TOPSIS, ANP, SAW, MOORA, MULTIMOORA, WASPAS, TODIM, COPRAS, COPRAS-G, and VIKOR to evaluate M-banking services.

Conclusions

Nowadays, M-banking has ceased to be an alternative distribution channel and become the main channel. Hence, M-banking users view M-banking as a necessity not as an extra service. Moreover, they are expected to improve the quality of service from their banks.

Banks invested in M-banking previously have expanded their investments thanks to rapidly rising user numbers in M-banking. Banks not invested in it, on the other hand, are directed to step into this new channel. In Turkey, considering nearly one fifth of transactions conducted in 16 banks via mobile, it is clear that banks which are extending the mobile transaction sets will increase their mobile share. Unfortunately, other banks will not get a share of the market and fell back in the competition. M-banking users expect from banks to increase the quality of service. Banks which are realizing customer expectations in this process and working in this direction will provide a competitive advantage.

The realistic modeling of many business problems requires to consider the conflicting opinions of decision makers, the existence of multiple criteria, the complex and subjective nature of the evaluation process. Multi criteria evaluation, therefore, contributes in the business area via the determination of priority weights, via the selection of the suitable alternative, and the disclosure of the choices in the decision making process. Above all, aggregating both qualitative and quantitative decision criteria in the evaluation process, analyzing and solving complex problems easily, making reliable decisions, and allowing decision makers to choose the best alternative in the process of decision making are the main advantages of ARAS as a MCDM method. Therefore, ARAS method is preferred to form this proposed integrated model.

Overall, M-banking services of 16 banks which are serving branch property in Turkey are evaluated by FAHP and ARAS integrated model. First, significance of expert estimations is evaluated with the help of the FAHP method. This means the use of proposed model allows considering opinions of all decision making team members in the decision making process. Then, the ARAS method is applied for determination of the best M-banking service. In the present study, the priority weights of factors affecting the M-banking adoption are determined in the context of Turkey. When the results are analyzed, it can obviously be seen that facilitating conditions, self-efficacy, privacy risk, and security risk are the most important factors of M-banking adoptions. It means that perceived ease of use is found as the most important dimension affecting M-banking adoption and it should be paid more attention and should be continuously improved. Ranking results stated that the best M-banking service in Turkey is Yapi Kredi Bankasi. However, Denizbank is found to have the worst M-banking service.

In spite of working with a decision making team provides some advantages, it requires a coordinated act which can require great effort. Thereby, fuzzy numbers are utilized in AHP to avoid uncertainties in group decision making. The proposed model gives reliable and robust results. M-banking adoption factors obtained by literature review and decision making team, are used, which means that the proposed model can be used for similar studies. Nevertheless, modification in evaluating factors may be required for different sectors.

In conclusion, the proposed model builds a new simple and hierarchical structure approach to evaluate M-banking services and select the best service. This novel model not only increases the efficiency of the M-banking services, it also reduces the time taken by bank managers and clients to gather experience and knowledge in the evaluation of an M-banking service. In sum, it helps to overcome difficulties in M-banking service evaluation process and increases the efficiency of the M-banking service activities. Hence, the proposed model has a great future in the banking sector and business field. Additionally, this novel model would use other electronic banking channels smoothly. In terms of future research, the proposed model could be performed different sectors by revision of factors. Finally, various approaches for determining weights (SWARA, entropy, eigenvector method, expert method, etc.) may be employed instead of the FAHP to calculate the priority weights in evaluation and selection process.

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