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PERFORMANCE EVALUATION OF INTERNET BANKING BRANCHES VIA A HYBRID MCDM MODEL UNDER FUZZY ENVIRONMENT

Abstract. *In this age of competitive markets, Internet Banking (IB) has attracted much attention from banks, clients, and governments. This study aims to suggest a hybrid model including two techniques, namely the Fuzzy Analytic Hierarchy Process (FAHP) and COmplex PRoportional ASsessment of alternatives with Grey relations (COPRAS-G) to evaluate the performance of IB branches. First, the FAHP is used to calculate the importance weight of the seven IB adoption factors, namely usefulness, price, security, complexity, service quality, 7/24 availability, and satisfaction. Subsequently, the COPRAS-G method is utilized to select the best IB branch. For the case study IB branches of four Turkish banks are evaluated. With the use of FAHP method, "security" is the most important factor affecting IB performance and followed by "complexity". Furthermore, Garanti Bankasi has the best IB branch in Turkey. Consequently, the proposed model provides comprehensive and systematic approach to evaluate the performance of IB branches and can be recommended to banks so that they can improve their IB operations to achieve a higher performance and client satisfaction level under fuzzy environments.*

Keywords: *Internet banking, FAHP, COPRAS-G, extent analysis, branch, performance.*

JEL Classification: C44, C61, L25.

1. INTRODUCTION

The rapid expansion of information and communication technologies has had a tremendous impact on all areas of human life. Globalization of finance, integration, advances in information technologies and financial innovations in the past two decades have deeply changed banking in the world and forced the state authorities to deregulate national financial systems. Besides, developments of modern computer technology have also enabled banks to lessen the cost of bank transactions by having the client interact with an e-banking facility rather than with a human being. In the 1990s, with the emergence of the Internet, banks further extended their existing distribution channels by offering web-based banking applications. Internet Banking (IB) applications, therefore, became one of the main battlefields of the banking industry (Schneider, 2006; Aktan, Teker and Ersoy, 2009; DeYoung, Hunter and Udell, 2004; Hoehle, Scornavacca and Huff, 2012).

Online performance evaluation has been an emerging research area for both researchers and practitioners. In information system research, Technology Acceptance Model (TAM) is considered to be the most widely used and robust model to predict the individual adoption of a new technology (DeLone and McLean, 2003; Kesharwani and Bisht, 2012). Using TAM as a theoretical base, therefore, this study aimed to propose a hybrid model in conjunction with adoption factors for IB.

In line with the multi-dimensional characteristics of IB, the problem is a kind of Multi Criteria Decision Making (MCDM) problem. MCDM can provide a framework for an inter-IB branches comparison involving the evaluation of multi criteria. In the past, many MCDM methods for evaluating and selecting alternatives have been developed. Analytic Hierarchy Process (AHP) is a well-known MCDM method and introduced by Saaty (1980) to assess the finite number of alternatives in MCDM problems. The AHP method provides incorporation of judgments on both intangible qualitative factors and tangible quantitative factors (Badri, 2001; Akincilar and Dagdeviren, 2014). Recently, a compromise ranking method, namely the COmplex PRoportional ASsessment of alternatives with Grey relations (COPRAS-G) has been presented by Zavadskas, Kaklauskas, Turskis and Tamosaitiene (2008) as an applicable method for implementation within MCDM. The idea of COPRAS-G method is based on the real conditions of decision making and applications of the Grey System Theory (GST). It utilizes a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree (Hashemkhani Zolfani, Rezaeiniya, Aghdaie and Zavadskas, 2012a).

In reality, crisp numbers may not always be adequate to present the decision making process, since human perception, judgment, intuition, and preference remain vague and difficult to measure. Fuzzy Set Theory (FST) (Zadeh, 1965) is a way of addressing vague concepts and provides a means for representing uncertainty in order to handle the vagueness involved in the real situation (Chou and Cheng, 2012; Chen and Wang, 2009). Accordingly, this paper presents a hybrid Fuzzy MCDM (FMCDM) model combining Fuzzy AHP (FAHP) and COPRAS-G to evaluate IB branches. The ultimate goal of this study, therefore, is to construct a decision model for evaluating performances of IB branches. For determining the weighting of each evaluation factor, FAHP is utilized since it is based on pairwise comparisons and allows the utilization of linguistic variables. Then, the importance weights obtained through FAHP are combined with COPRAS-G method to compute a ranking for each IB branch. Furthermore, in order to verify the applicability and usefulness of this hybrid model, a case study of the IB branches of four banks in Turkey is presented. From a theoretical standpoint, this study contributed to the existing literature in a number of ways. First, the proposed hybrid FMCDM model is easy to deal with; it is robust and complex mathematics is not required. The second contribution stems from, best to our knowledge, there is no study evaluating IB branches based on FAHP and COPRAS-G methods in conjunction with adoption factors. Finally, the findings of this study can help banks form a clear picture of their IB branches' status and then prioritize the strategies for improvement. Thereby, the proposed hybrid FMCDM model represents an effective tool for evaluating IB branches.

This paper is divided into six parts: Section 2 describes theoretical background of proposed hybrid FMCDM model. Section 3 gives information about data and computation. Section 4 summarizes the results and empirical findings. The last section draws conclusions and limitations and suggests directions for future research.

2. THEORETICAL BACKGROUND

2.1. Identification of Evaluation Factors

In order to evaluate the performances of IB branches, 12 professionals from the banking industry were formed as an expert team. Information about experts is shown in Table 1.

Table 1: Demographic characteristics of the bank professionals

Demographics	Frequency
Gender	
Male	8
Female	4
Age	
25-35	5
36-46	5
Over 47	2
Education	
Bachelor	5
Master	6
Ph.D.	1

We prepared a questionnaire containing many questions related to evaluation factors selection and the same was circulated among the experts. Delphi method was utilized to improve consensus among the experts. Green, Armstrong, and Graefe (2007) emphasize that Delphi method is relatively simple to implement and might be adopted for diverse applications in business.

First of all, therefore, questionnaires are distributed to experts to verify which adoption factors are more convenient for this study and to acquire the experts' views on them for IB evaluations. Second, according to the expert interview, the evaluation factors are generated.

Based on the literature review and aggregating experts' views by doing Delphi method evaluation factors are listed in Table 2.

Table 2: Evaluation factors

Factors	Goal
Usefulness (UF)	Maximum
Security (SC)	Maximum
Service quality (SQ)	Maximum
Satisfaction (ST)	Maximum
7/24 availability (7/24)	Maximum
Price (PR)	Minimum
Complexity (CP)	Minimum

Consequently, optimization directions of evaluation factors as follows:

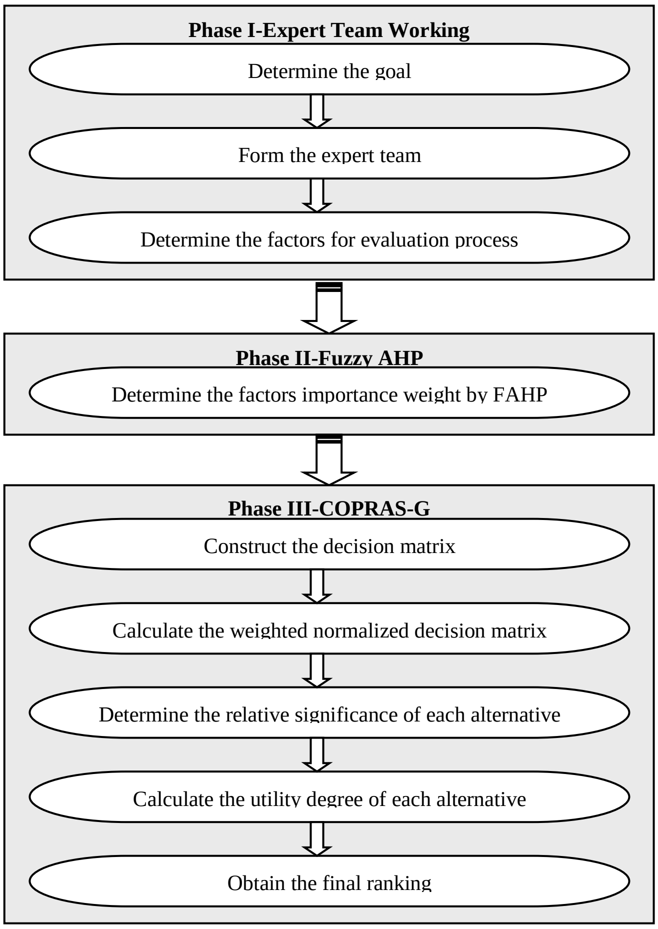
- ✓ $UF,\ SC,\ ,SQ,\ ST,\ 7/24 \xrightarrow{optimization\ \ direction} \max$;
- ✓ $PR,\ CP \xrightarrow{optimization\ \ direction} \min$.

2.2. Building a New Hybrid Model for IB Branch Evaluation

The proposed hybrid model begins with the definition of decision matrix which has in general four components, namely: (i) alternatives (ii) evaluation factors (iii) importance weight of each factor and (iv) measure of performance of alternatives with regard to the factors. The decision matrix can be expressed as follows:

$$
\begin{array}{cc}
 & \begin{array}{ccc} C_1 & \cdots & C_n \end{array} \\
 & \begin{array}{ccc} W_1 & \cdots & W_n \end{array} \\
D=[X_{ij}]= \begin{array}{c} A_1 \\ \vdots \\ A_m \end{array} & \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}
\end{array} \tag{1}
$$

Figure 1: The proposed hybrid model



2.2.1. Fuzzy Analytic Hierarchy Process (FAHP)

As one of the most widely utilized MCDM techniques AHP is developed to solve complex MCDM problems involving qualitative decisions.

The outlines of fuzzy sets and extent analysis method for FAHP are given below (Tavana, Momeni, Rezaeiniya, Mirhedayatian and Rezaeiniya, 2013; Aghdaie, Zolfani and Zavadskas, 2013).

A fuzzy number is a special fuzzy set $F = \{(x, \mu_F(x)), x \in \Re\}$, where x takes its values on the real line, $\Re : -\infty \le x \le \infty$ and $\mu_F(x)$ is a membership function in the closed interval [0,1]. A TFN expresses the relative strength of each pair of elements in the same hierarchy, and can be denoted as $M=(l,m,u)$, where $l \le m \le u$. The parameters *l, m, u* indicate the lower bound value, the peak or center, and the upper bound value respectively in a fuzzy event.

Triangular type membership function of *M* fuzzy number can be described as in Eq. 2.

$$\mu_M(x)=\begin{cases} 0 & ,x<l \\ (x-l)/(m-l) & ,l \le x \le m \\ (u-x)/(u-m) & ,m \le x \le u \\ 0 & ,x>u \end{cases} \tag{2}$$

Consider two TFNs $M_1=(l_1,m_1,u_1)$ and $M_2=(l_2,m_2,u_2)$. The following describes the addition, multiplication, and inverse of the two fuzzy numbers M_1 and M_2, respectively:

$$(l_1,m_1,u_1)\oplus(l_2,m_2,u_2)=(l_1+l_2,m_1+m_2,u_1+u_2) \tag{3}$$

$$(l_1,m_1,u_1)\otimes(l_2,m_2,u_2)=(l_1l_2,m_1m_2,u_1u_2) \tag{4}$$

$$(l_1,m_1,u_1)^{-1}\approx\left(1/u_1,1/m_1,1/l_1\right) \tag{5}$$

Table 3 presents the fuzzy conversion utilized to transform the linguistic variables into fuzzy scales.

Table 3: The fuzzy conversion

Linguistic scale	Fuzzy scale *(l,m,u)*
Just equal	(1.0,1.0,1.0)
Equal importance	(1.0,1.0,3.0)
Weak importance of one over another	(1.0,3.0,5.0)
Essential or strong importance	(3.0,5.0,7.0)
Very strong importance	(5.0,7.0,9.0)
Extremely preferred	(7.0,9.0,9.0)

If factor *i* has one of the above numbers assigned to it when compared to factor *j*, then *j* has the reciprocal value when compared with *i*: $M_1^{-1}\approx\left(\frac{1}{u_1},\frac{1}{m_1},\frac{1}{l_1}\right)$

In this paper, the extent analysis introduced by Chang (1992) is utilized due to its implementation simplicity to calculate importance weights.

Let $X=\{x_1,x_2,...,x_n\}$ be an object set, and $U=\{u_1,u_2,...,u_m\}$ be a goal set. According 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:

$$M_{g_i}^1, M_{g_i}^2,...,M_{g_i}^m, \qquad i=1,2,...,n \tag{6}$$

where all the $M_{g_i}^j \ (j = 1,2,...,m)$ are TFNs. The steps of extent analysis can be given as follows:

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

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \tag{7}$$

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

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{8}$$

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

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

and then compute the inverse of the vector in Eq. (9) such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} = \left(1 \Big/ \sum_{i=1}^{n} u_i, 1 \Big/ \sum_{i=1}^{n} m_i, 1 \Big/ \sum_{i=1}^{n} l_i \right) \tag{10}$$

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

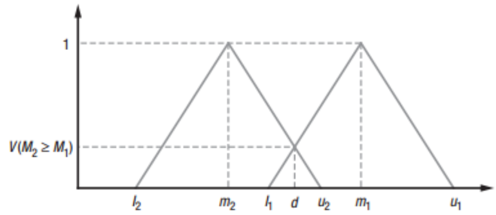
$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y) \right] \tag{11}$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & if\,(m_2 \geq m_1), \\ 0, & if\,(l_1 \geq u_2), \\ (l_1 - u_2) / [(m_2 - u_2) - (m_1 - l_1)], & otherwise, \end{cases} \tag{12}$$

where d is the ordinate of the highest intersection point D between $\mu_{M_1}(x)$ and $\mu_{M_2}(x)$ as shown in Fig. 2. To compare M_1 and M_2 it is required both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

Figure 2: The intersection between M_1 and M_2 (Source: Aghdaie, Zolfani and Zavadskas, 2013).



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

$$V(M \geq M_1, M_2, ..., M_k) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \ldots \text{ and } (M \geq M_k)]$$
$$= \min V(M \geq M_i), \;\; i = 1,2,...,k. \tag{13}$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k) \tag{14}$$

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

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T, \tag{15}$$

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

Step 4: Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2), ..., d(A_n))^T,$$

where W is a non-fuzzy number.

2.2.2. The COPRAS-G Method

COPRAS method that was first announced by Zavadskas, Kaklauskas and Sarka (1994) can be applied. COPRAS method assumes direct and proportional dependences of the significance and utility degree of the available alternatives under the presence of mutually conflicting factors. It considers the performance of the alternatives as to different evaluation factors and the corresponding factor weights. Finally, this method selects the best alternative considering both the ideal and the ideal-worst solutions (Chatterjee, Athawale and Chakraborty, 2011).

In recent years, it has been applied to the solution of complicated MCDM problems in social sciences and COPRAS-G has an increasing popularity in the literatüre (Ecer, 2014).

The procedure of the COPRAS-G method consists of the following steps (Zavadskas, Kaklauskas, Turskis and Tamosaitiene, 2008):

Step 1. Selection of the available set of the most important evaluation factors, which describes alternatives. To apply COPRAS-G method, the type of evaluation factors (maximizing or minimizing) is determined. The best values of minimizing factors are the smallest values, while the largest values are the best for maximizing factors.

Step 2. Constructing the decision making matrix X :

$$X = \begin{bmatrix} [s_{11};b_{11}] & [s_{12};b_{12}] & \cdots & [s_{1m};b_{1m}] \\ [s_{21};b_{21}] & [s_{22};b_{22}] & \cdots & [s_{2m};b_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [s_{n1};b_{n1}] & [s_{n2};b_{n2}] & \cdots & [s_{nm};b_{nm}] \end{bmatrix}; \; i = 1,2,...,m; \; j = 1,2,...,n \tag{16}$$

where s_{ij} the smallest value, b_{ij} the biggest value.

Step 3. Determining importance weights of the evaluation factor q_j.

Step 4. Normalization of the decision making matrix $\overline{X}$. The normalized values of this matrix are calculated as:

$$\overline{s_{ij}} = 2s_{ij} \Big/ \left(\sum_{j=1}^{n} s_{ij} + \sum_{j=1}^{n} b_{ij} \right); \; \overline{b_{ij}} = 2b_{ij} \Big/ \left(\sum_{j=1}^{n} (s_{ij} + b_{ij}) \right) \tag{17}$$

In Eq. (17) s_{ij} is the lower value of the j th factor in the i th alternative of a solution; b_{ij} is the upper value of the j th factor in the i th alternative of a solution; m is the number of evaluation factors; n is the number of the alternatives compared. After this step, we get the normalized decision making matrix:

$$\overline{X} = \begin{bmatrix} [\overline{s_{11}};\overline{b_{11}}] & [\overline{s_{12}};\overline{b_{12}}] & \cdots & [\overline{s_{1m}};\overline{b_{1m}}] \\ [\overline{s_{21}};\overline{b_{21}}] & [\overline{s_{22}};\overline{b_{22}}] & \cdots & [\overline{s_{2m}};\overline{b_{2m}}] \\ \vdots & \vdots & \ddots & \vdots \\ [\overline{s_{n1}};\overline{b_{n1}}] & [\overline{s_{n2}};\overline{b_{n2}}] & \cdots & [\overline{s_{nm}};\overline{b_{nm}}] \end{bmatrix}. \tag{18}$$

Step 5. Calculating the weighted normalized decision matrix $\hat{X}$. The weighted normalized values $\hat{x}_{ij}$ are calculated as follows:

$$\hat{s}_{ij} = \overline{s_{ij}}.q_j; \qquad \hat{b}_{ij} = \overline{b_{ij}}.q_j. \tag{19}$$

Here q_j is importance weight of the j th factor.

Then, the weighted normalized decision making matrix is:

$$\hat{X} = \begin{bmatrix} [\hat{s}_{11};\hat{b}_{11}] & [\hat{s}_{12};\hat{b}_{12}] & \cdots & [\hat{s}_{1m};\hat{b}_{1m}] \\ [\hat{s}_{21};\hat{b}_{21}] & [\hat{s}_{22};\hat{b}_{22}] & \cdots & [\hat{s}_{2m};\hat{b}_{2m}] \\ \vdots & \vdots & \ddots & \vdots \\ [\hat{s}_{n1};\hat{b}_{n1}] & [\hat{s}_{n2};\hat{b}_{n2}] & \cdots & [\hat{s}_{nm};\hat{b}_{nm}] \end{bmatrix} \tag{20}$$

Step 6. Calculating the sums P_j of factors whose larger values are more preferable (i.e. optimization direction is maximization):

$$P_j = \sum_{i=1}^{k} (\hat{s}_{ij} + \hat{b}_{ij}) \Big/ 2 . \tag{21}$$

In Eq. (21), k is the number of factors which must be maximized.

Step 7. Calculating the sums R_j of factors whose smaller values are more preferable (i.e. optimization direction is minimization):

$$R_j = \sum_{i=k+1}^{m} (\hat{s}_{ij} + \hat{b}_{ij}) \Big/ 2 \ ; \ i = k,...,m. \tag{22}$$

In Eq. (22), $(m-k)$ is number of factors which must be minimized.

Step 8. Determining the minimal value of R_j:

$$R_{\min} = \min_j R_j \ ; \quad j = j,...,m. \tag{23}$$

Step 9. Calculating the relative importance of each alternative Q_j

$$Q_j = P_j + \left[\sum_{j=1}^{n} R_j \Big/ R_j \sum_{j=1}^{n} \frac{1}{R_j} \right] \tag{24}$$

Step 10. Determining the optimality factor K:

$$K = \max_j Q_j \ ; \quad j = 1,...,n. \tag{25}$$

Step 11. Determining the priority order of the alternatives. The greater relative importance of alternative Q_j, the higher is the priority of the alternative. The relative importance Q_j of alternative j indicates the satisfaction degree of the needs of the respondents. In case of $Q_{\max}$, the satisfaction degree is the highest.

Step 12. Calculating the utility degree of each alternative. The utility degree is determined by comparing the analyzed alternatives with the best one. The values of the utility degree are from 0% to 100% between the worst and the best alternatives. The utility degree N_j of each alternative j is calculated by the formula:

$$N_j = \left(Q_j / Q_{\max} \right) .100\% , \tag{26}$$

where Q_j and $Q_{\max}$ are the significance of alternatives obtained from Eq. (24).

3. CASE STUDY OF IB BRANCHES

Internet usage is becoming more and more commonplace in Turkey with a population 76 million. Besides, Turkey is one of the unique countries that adopt new technologies at once especially in banking industry. Paralleled to computer use, internet usage has been increasing within Turkish society (Aktan, Teker and Ersoy, 2009). IB was first introduced as a new distribution channel in Turkey by Isbank in 1997. In 1997, Garanti Bankasi also joined the competition on the Web. Another strong competitor, Akbank, introduced its first IB branch for retail clients in 1999, allowing them to access accounts, buy/sell foreign exchange, transfer money, perform securities, and trade on the Borsa Istanbul which is a stock exchange of Turkey. Depending on the rapid increase in the Internet access and growing popularity of IB among clients, other banks have gradually followed the first movers (Akinci, Aksoy and Atilgan, 2004). According to Banks Association of Turkey (BAT) report covering 26 banks those supplying IB services, the total number of registered retail clients that logged in at least once was 26.6 million. The total number of registered retail clients that logged in at least once in one-year period was 15.5 million. The number of total active clients increased 2 million as compared to 2012. Besides, the total number and volume of financial transactions (excluding investment transactions) performed by using IB services, was 112 million $ and 235 billion $ respectively, in the third quarter of 2013. The total volume of money orders, EFT, and foreign currency transfers was 84 percent of whole financial transactions (BAT, 2013).

The proposed hybrid FMCDM model for performance evaluation of IB branches consists of the following stages: (i) determination of importance weight of evaluation factors utilizing FAHP and (ii) evaluation and ranking of alternatives using COPRAS-G. After identification of evaluation factors with the help of expert team, linguistic variables are used to determine importance weights. Furthermore, in order to illustrate applicability of proposed hybrid model a case study based on the opinion of experts of four IB branches in Turkey - Akbank, Garanti Bankasi, Halkbank, and Is Bankasi is conducted.

3.1. Determination of Importance Weights Using the FAHP

At first, we form pairwise comparison matrix of seven factors to get their importance weight over other. Table 4 shows the fuzzy evaluation of the factors.

Table 4: Evaluation of the factors

	UF	SC	SQ	ST	7/24	PR	CP
UF	(1,1,1)	(1/9,1/7,1/5)	(1/5,1/3,1	(3,5,7)	(1,3,5)	(1/7,1/5,1/3)	(5,7,9)
SC	(5,7,9)	(1,1,1)	(1,3,5)	(7,9,9)	(1,3,5)	(3,5,7)	(1,3,5)
SQ	(1,3,5)	(1/5,1/3,1)	(1,1,1)	(1,3,5)	(1,3,5)	(1,1,1)	(1/5,1/3,1)
ST	(1/7,1/5,1/3)	(1/9,1/9,1/7)	(1/5,1/3,1	(1,1,1)	(3,5,7)	(1/5,1/3,1)	(1/7,1/5,1/3)
7/24	(1/5,1/3,1)	(1/5,1/3,1)	(1/5,1/3,1	(1/7,1/5,1/3)	(1,1,1)	(1/7,1/5,1/3)	(1/9,1/7,1/5)
PR	(3,5,7)	(1/7,1/5,1/3)	(1,1,1)	(1,3,5)	(3,5,7)	(1,1,1)	(1,1,1)
CP	(1/9,1/7,1/5)	(1/5,1/3,1)	(1,3,5)	(3,5,7)	(5,7,9)	(1,1,1)	(1,1,1)

Using Eqs. (7)-(10) and evaluation values in Table 4, we determine the TFNs of seven factors. According to Eq. (12) the degree of possibility of $S_j \geq S_i$ can be computed by comparing the values of S_i. Table 5 shows the values of $V(S_j \geq S_i)$ for $i, j = 1,2,...,k$.

Table 5: Values of $V(S_j \geq S_i)$

$V(S_j \geq S_i)$	Value	$V(S_j \geq S_i)$	Value	$V(S_j \geq S_i)$	Value
$V(S_1 \geq S_2)$	0.6027	$V(S_3 \geq S_4)$	1.0000	$V(S_5 \geq S_6)$	0.7203
$V(S_1 \geq S_3)$	1.0000	$V(S_3 \geq S_5)$	1.0000	$V(S_5 \geq S_7)$	0.6608
$V(S_1 \geq S_4)$	1.0000	$V(S_3 \geq S_6)$	0.8157	$V(S_6 \geq S_1)$	0.7387
$V(S_1 \geq S_5)$	1.0000	$V(S_3 \geq S_7)$	0.7721	$V(S_6 \geq S_2)$	0.3391
$V(S_1 \geq S_6)$	0.9953	$V(S_4 \geq S_1)$	0.4849	$V(S_6 \geq S_3)$	0.9627
$V(S_1 \geq S_7)$	0.9521	$V(S_4 \geq S_2)$	0.1161	$V(S_6 \geq S_4)$	1.0000
$V(S_2 \geq S_1)$	1.0000	$V(S_4 \geq S_3)$	0.7285	$V(S_6 \geq S_5)$	1.0000
$V(S_2 \geq S_3)$	1.0000	$V(S_4 \geq S_5)$	1.0000	$V(S_6 \geq S_7)$	0.7051
$V(S_2 \geq S_4)$	1.0000	$V(S_4 \geq S_6)$	0.5033	$V(S_7 \geq S_1)$	1.0000
$V(S_2 \geq S_5)$	1.0000	$V(S_4 \geq S_7)$	0.4484	$V(S_7 \geq S_2)$	0.6257
$V(S_2 \geq S_6)$	1.0000	$V(S_5 \geq S_1)$	0.6992	$V(S_7 \geq S_3)$	1.0000
$V(S_2 \geq S_7)$	1.0000	$V(S_5 \geq S_2)$	0.2677	$V(S_7 \geq S_4)$	1.0000
$V(S_3 \geq S_1)$	0.7999	$V(S_5 \geq S_3)$	0.9581	$V(S_7 \geq S_5)$	1.0000
$V(S_3 \geq S_2)$	0.4429	$V(S_5 \geq S_4)$	1.2757	$V(S_7 \geq S_6)$	1.0000

We calculate the minimum degree of possibility $d'(A_i)$ of $V(S_j \geq S_i)$ using Eq. (14). Then the weight vector becomes,

$W' = (0.6027, 1.0000, 0.4429, 0.1161, 0.2677, 0.3391, 0.6257)^T$

Normalizing the weight vector we get,

$W = (0.1776, 0.2946, 0.1305, 0.0342, 0.0789, 0.0999, 0.1843)^T$

The final importance weights of seven factors, therefore, UF, SC, SQ, ST, 7/24, PR, and CP become 0.1776, 0.2946, 0.1305, 0.0342, 0.0789, 0.0999, and 0.1843 respectively. Hence, SC, CP, and UF are the top IB evaluation factors. ST, however, has the lowest importance weight of 0.0342. The importance weights will be utilized in COPRAS-G method the following subsection.

3.2. Evaluation of IB Branches Using the COPRAS-G

At this stage, expert team evaluates each IB branch with respect to each factor and Table 6 is developed. It points out the initial decision making matrix, with the factor values described in intervals. The initial decision making matrix is normalized first as discussed in Section 2. The next step is normalization of performance scores of the alternatives as to the considered attributes. It is done using Eq. (17). The results are shown in Table 7. Then we compute the weighted normalized performance scores using Eq. (19) and they are shown in Table 8.

The sums of weighted normalized values are computed for both P_j and R_j using Eqs. (21) and (22), respectively. The relative importance of each alternative Q_j is computed using Eq. (24) and they are shown in Table 9. Then we determine the utility degree N_j for each alternative using Eq. (26) considering $Q_{\max}$ to be 0.2899. Table 9 also exhibits the COPRAS-G method based comparative ranking of alternatives as Garanti Bankasi > Halkbank > Akbank > Is Bankasi when arranged with respect to descending order of their utility degree.

Table 6: The initial decision making matrix

	UF		*SC*		*SQ*		*ST*		*7/24*		*PR*		*CP*	
Optimization	Max		Max		Max		Max		Max		Min		Min	
Importance weight	0.1776		0.2946		0.1305		0.0342		0.0789		0.0999		0.1843	
	s_1	b_1	s_2	b_2	s_3	b_3	s_4	b_4	s_5	b_5	s_6	b_6	s_7	b_7
Akbank	50	70	70	90	50	80	60	90	80	90	60	70	40	60
Garanti Bankasi	60	90	70	85	80	100	70	80	80	90	40	50	30	40
Halkbank	70	90	60	85	60	80	60	80	85	95	45	60	50	70
Is Bankasi	40	60	70	90	80	95	50	70	70	90	70	80	70	90

Table 7: The normalized decision making matrix

	UF		*SC*		*SQ*		*ST*		*7/24*		*PR*		*CP*	
	$\overline{s}_1$	$\overline{b}_1$	$\overline{s}_2$	$\overline{b}_2$	$\overline{s}_3$	$\overline{b}_3$	$\overline{s}_4$	$\overline{b}_4$	$\overline{s}_5$	$\overline{b}_5$	$\overline{s}_6$	$\overline{b}_6$	$\overline{s}_7$	$\overline{b}_7$
Akbank	0.1887	0.2642	0.2258	0.2903	0.1600	0.2560	0.2143	0.3214	0.2353	0.2647	0.2526	0.2947	0.1778	0.2667
Garanti Bankasi	0.2264	0.3396	0.2258	0.2742	0.2560	0.3200	0.2500	0.2857	0.2353	0.2647	0.1684	0.2105	0.1333	0.1778
Halkbank	0.2642	0.3396	0.1935	0.2742	0.1920	0.2560	0.2143	0.2857	0.2500	0.2794	0.1895	0.2526	0.2222	0.3111
Is Bankasi	0.1509	0.2264	0.2258	0.2903	0.2560	0.3040	0.1786	0.2500	0.2059	0.2647	0.2947	0.3368	0.3111	0.4000

Table 8: The weighted normalized decision making matrix

	UF		*SC*		*SQ*		*ST*		*7/24*		*PR*		*CP*	
	$\hat{s}_1$	$\hat{b}_1$	$\hat{s}_2$	$\hat{b}_2$	$\hat{s}_3$	$\hat{b}_3$	$\hat{s}_4$	$\hat{b}_4$	$\hat{s}_5$	$\hat{b}_5$	$\hat{s}_6$	$\hat{b}_6$	$\hat{s}_7$	$\hat{b}_7$
Akbank	0.0335	0.0469	0.0665	0.0855	0.0209	0.0334	0.0073	0.0110	0.0186	0.0209	0.0252	0.0294	0.0328	0.0491
Garanti Bankasi	0.0402	0.0603	0.0665	0.0808	0.0334	0.0418	0.0086	0.0098	0.0186	0.0209	0.0168	0.0210	0.0246	0.0328
Halkbank	0.0469	0.0603	0.0570	0.0808	0.0251	0.0334	0.0073	0.0098	0.0197	0.0220	0.0189	0.0252	0.0410	0.0573
Is Bankasi	0.0268	0.0402	0.0665	0.0855	0.0334	0.0397	0.0061	0.0086	0.0162	0.0209	0.0294	0.0337	0.0573	0.0737

Table 9: Results of COPRAS-G method

	Optimization direction is maximization **Pj**	Optimization direction is minimization **Rj**	IB branches' relative importances **Qj**	IB branches' utility degree **Nj (%)**	Rank
Akbank	0.1723	0.0683	0.2416	83.35	*3*
Garanti Bankasi	0.1904	0.0476	0.2899	100.00	*1*
Halkbank	0.1812	0.0712	0.2477	85.44	*2*
Is Bankasi	0.1720	0.0971	0.2208	76.15	*4*

4. DISCUSSION

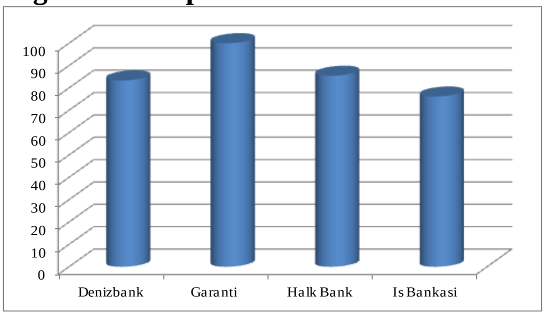
Table 10 compares the performance of some popular MCDM methods with regard to type of the information, transparency, calculation time, simplicity, and mathematical computations involved (Chatterjee, Athawale and Chakraborty, 2011; Das, Sarkar and Ray, 2012). Thereby, the proposed hybrid model is simple to apprehend and easy to apply.

Table 10: Performance of some popular MCDM methods

MCDM method	Type of information	Transparency	Calculation time	Simplicity	Mathematical computations involved
TOPSIS	Quantitative	Good	High	Moderately critical	Moderate
VIKOR	Quantitative	Low	Less	Simple	Moderate
DEA	Quantitative	Low	High	Critical	High
EVAMIX	Mixed	Low	Moderate	Moderately critical	Less
Proposed model	Quantitative	Very good	Moderate	Simple	Moderate

The overall utility degrees illustrated in Fig. 3 demonstrated Garanti Bankasi with a utility degree of 100% had the best IB branch. Halkbank with a utility degree of 85.44% had the second IB branch (with 100% as the desired level). Akbank with a utility degree of 83.35% was the third ranking IB branch.

Figure 3: The performance of IB branches



Based on the results, it is concluded that the performance of Akbank and Halkbank are close. Yet surprisingly, although IB was first introduced in Turkey by Is Bankasi, its IB branch performance is less compared to other three IB branches.

A possible reason is that performance of Is Bankasi as to evaluation factors of CP, UF, PR, and ST are not satisfactory. Furthermore, Halkbank, Akbank, and Is Bankasi should improve their business strategies to meet clients' needs and devise the best adoption strategies with the most effective and efficient ways to achieve client satisfaction.

According to the importance weight, the factor priorities are sequenced as security, complexity, usefulness, service quality, price, 7/24 availability, and satisfaction. This sequence is an important point for bank professionals. Thus, in order to better understand the inner meaning, we consulted them for their comments. Bank professionals believed IB for the benefits, free of effort, and secure it provides. Efforts in this direction will produce IB effects on client adoption.

Based on the result above, we can establish adoption strategies by eliminating the uncertainties to clients to use IB to improve the factor "security (SC)". For the factor "complexity (CP)", bank professionals can provide an interface that is easy to use and navigate. Put differently, bank clients are able to use the IB without a lot of effort. To improve the factor of "usefulness (UF)", bank professionals can extra effort to correct any unfavorable perception to use IB. For the factor "service quality (SQ)", they can try to make clients satisfied with their services to remain competitive in the market. What is more, they can display other IB references to improve the factor "price (PR)" because lower costs by using IB services can improve to adopt IB. For the factor "7/24 availability (7/24)", an IB can easily accessible whenever the clients want to enter for any banking transaction. To improve "satisfaction (ST)", bank professionals can pay more attention to providing a higher information and system quality.

Overall, this study shows that authorities of each bank need to do some operations in order to perform well against evaluation factors. Notably, banks are recommended to eliminate any shortcomings of evaluation factors having higher importance weight. Because the clients not only complete their financial activities in a cost-effective and efficient manner at any time of the day but also engage in a vast array of financial services, a well-designed IB website may confirm the expectations and result in client adoption. Finally, new technology integration could also be an important effect on the IB adoption.

5. CONCLUSION

Over the last two decades, IB has become a popular issue because of cost and time savings and freedom from place. Within the context of the IB, there are some justifiable reasons to evaluate a bank's IB branch. On one hand, IB becomes one of the main competition areas of the banking industry. On the other hand, IB allows bank clients to tackle many financial services such as transferring money, paying bills, and checking cash flow via IB branches. Evaluating IB branches, on the other hand, is a difficult task since it is a MCDM problem. Thus, there have been very few studies measuring IB performance in literature. In order to measure IB performance, it is important to know how to measure it. This paper, therefore, presented a hybrid model which is capable of evaluating and selecting the best IB branch by using two of the well-known methods, namely the FAHP and COPRAS-G in order to obtain more robust and realistic results. First, the FAHP method was utilized to determine the importance weights of the IB evaluation factors in this study. Next, the COPRAS-G method was used to rank and select the best IB branch. This study’s main contribution is to construct a framework, combining FAHP with COPRAS-G method, and use them for comprehensive evaluation of IB based on the opinion of experts under fuzzy environments.

A case study is implemented to demonstrate the procedure of the proposed hybrid FMCDM model. Main findings of the study can be summarized as follows. The results of FAHP, examining the factors affecting IB performance, reveal that the final ranking of seven evaluation factors such as security, complexity, usefulness, service quality, price, 7/24 availability, and satisfaction respectively. In terms of managerial implications, in particular, the findings of the FAHP can provide some insight that may allow bank professionals to improve IB performance based on security. Hence, this result further provides bank authorities information about the planning and development of IB. Second, the IB branch Garanti Bankasi is the best and Is Bankasi is the worst. Furthermore, Akbank and Is Bankasi need special attention to improve their performance with respect to the factors of complexity, usefulness, price, and satisfaction. This study, therefore, not only presents and demonstrates the applicability of the hybrid model but also assists Turkish bank authorities how to reach the desired performance in the context of IB adoption. The required computation is simple and understandable and uses the MS Excel program.

Moving forward, the proposed model is expected to be of great use to the banks, clients, and researchers. What is more, the proposed hybrid model can be applied to evaluate and select the best alternative in other fields. Since the evaluation factors play a vital role in the decision making process, they should be determined very carefully. However, the study has several limitations. First, it has not evaluated all IB branches in Turkey, this study was limited to dominant IB branches. Second, other associated evaluation factors (e.g. innovativeness, reliability, reputation) were not considered in this study. Yet, these limitations may pave the way to future researches. Consequently, the proposed hybrid model is valuable for not only the IB branch evaluation and selection, but also other evaluation and selection issues in the business field.

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