

## **A new hybrid method based on fuzzy Shannon's Entropy and fuzzy COPRAS for CRM performance evaluation (Case: Mellat Bank)**

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### **Abstract**

Customer relationship management is a multiple perspective business paradigm which helps companies gaining competitive advantage through relationships with their customers. An integrated framework for evaluating CRM performance is an important issue which is not addressed completely in previous studies. The main purpose and the most important contribution of this study is introducing a framework based on the integration of two novel MCDM methods. In this regard, first, by the survey of related literature, five main criteria of the CRM performance measurement were identified. In the second step, by means of judgmental sampling, a committee of 20 experts of Mellat Bank and its three subsidiary branches were formed and their idea about the importance of the five CRM evaluation criteria was extracted through questionnaire. Fuzzy Shannon's entropy was applied for calculating the relative importance. In the third step, for demonstrating the applicability of the model three subsidiary branches which were applying CRM systems, were ranked by fuzzy COPRAS based on their CRM performance.

### **Keywords**

COPRAS, Customer relationship management, Entropy, Multiple criteria decision making, Performance evaluation.

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## Introduction

There has been a growing interest over the past few years for applying Customer relationship management (CRM) frameworks in various fields of industries specially banking industry. In fact, CRM is crucial in today's banking business because of increasing competition, market saturation and rapid advances in technology. CRM is a dynamic process of managing a mutual customer-company relationship such that customers select to continue their commercial exchanges with the company. It is a key business strategy in which the firm should stay focused on customers' needs and must integrate a customer-oriented approach throughout the organization (Liou, 2009). Boulding *et al.* (2005), note that CRM has the potential to increase both firm performance and customer benefits through the dual value creation. Despite the power of CRM for creating competitive advantage for companies, recently failures of CRM implementation are highly publicized. According to International Data Corporation (IDC), the rate of successful CRM implementations is below 30 percent (Kim & Kim, 2009). The majority of CRM projects may fail in delivering strategic value because they can not grow customer loyalty, revenues, and profits sufficiently (Krasnikov, *et al.*, 2009).

In the context of CRM there are various criteria used to evaluate the CRM performance, including financial, process or sales related, customer satisfaction and economic performance. But it is important to select the most appropriate criteria to evaluate the firm implementation of CRM (Chang, *et al.*, 2014). In this regard, an integrated framework for evaluating the performance of CRM plans could be helpful (Öztaysi, *et al.*, 2011). This framework first needs proper and customized criteria. In addition it needs a useful methodology for the purpose of evaluating the company performance based on these criteria.

Two questions which arise here are: first, which criteria are useful for assessing the CRM performance? and second, how should these criteria is being evaluated? We address these two questions by proposing an integrated framework for CRM evaluation using data

from the banking industry and fuzzy Multiple Criteria Decision Making (MCDM) methods.

The most important contribution of the study is introducing a framework based on the integration of two novel MCDM methods which can be applied for evaluating the CRM performance.

The paper is organized as follows. Section 2 reviews the literature on CRM, especially with a focus on criteria for evaluating CRM performance. In Section 3 the proposed framework for CRM evaluation and the methods required to this framework are presented. The empirical case study is described in Section 4. Finally, discussion and conclusion are presented in Section 5 and Section 6 respectively.

## **Literature review**

### **CRM definition and importance**

There are various definitions of CRM in the literature. These definitions have different perspectives as a strategy, as a process and as a system. We adopt the system perspective of CRM. In this regard among the most representative, are following definitions:

- CRM is an information system that tracks customers' interactions with the firm and allows the firms to integrate information about the customers such as past and current sales, service records, outstanding records or unresolved problems (Nguyen, *et al.*, 2007).
- CRM are a group of information systems that enable organizations to get in touch with customers and collect, store, and analyze customer's data to provide a competitive view of their customers (Khodakarami & Chan, 2014).

A CRM system stores all information about firm's customers in a database. Information such as customer names, product or services they bought, and the problems they have had with their purchases. The CRM system not only uses this data to generate simple reports, but can produce vital information to help coordinate sales, marketing, and customer service departments to better and faster serve firm's customers. CRM increases customer loyalty, helps organizations

present superior service, and empower organizations for superior information gathering and knowledge sharing. (Nguyen, *et al.*, 2007).

Nowadays, many banks offer CRM on their web sites. Almost all banks offer online banking in their web sites. These web sites offer customers access to their account anytime they wish. In addition, the banks also offer other information such as credit rating reports, promotional rates for credit cards, personal loans, mortgage and etc. Online banking customers find this kind of service very useful. On the other hand, the banks track these web sites and use this information to improve customer service (Beasty, 2006). Despite all of the advantages that CRM brings for companies, as we discussed earlier, managing the performance of CRM is especially important because of the low success rates. Thus, in the next section we produce the most important criteria which are used for the purpose of CRM performance evaluation.

### CRM performance evaluation criteria

Performance is defined as the potential of future success of actions in order to reach its objectives (Lebas, 1995). In order to evaluate CRM performance, proper criteria are needed to assess reaching the CRM system to its objectives. These criteria are introduced and categorized in many research works. In order to select the most appropriate criteria for assessing the CRM performance in banking system, a survey of the literature was conducted. The most repeated and the most related criteria was selected. These criteria are listed and described in Table 1.

Table 1. Proposed criteria for CRM performance measurement

Criteria	Sub-criteria	References
Customer (C <sub>1</sub> )	Customer value Customer satisfaction Customer loyalty	Kim and Kim, 2009; Jones, Brown, Zoltners and Weitz, 2005; Chen and Popovich, 2003; Verhoef, 2003; Winer, 2001; Zikmund, McLeod and Gilbert, 2003; Buttle, 2004; Tanner, Ahrearn, Mason and Moncrief, 2005; Öztaysi, Kaya and Kahraman, 2011; Daniels, 2000; Zineldin, 2006; Haemoon, 1999; Augusto de Matos, Luiz Henrique and de Rosa, 2009; Adebajo, 2001; Mihelis, <i>et al.</i> , 2001; Shafia, Mazdeh, Vahedi and Pournader, 2011
CRM process (C <sub>2</sub> )	Customer targeting Customer knowledge generation	Öztaysi <i>et al.</i> , 2011; Reinartz, Krafft and Hoyer, 2004; Woodcock, Stone and Foss, 2003; Stefanou, Sarmaniotis and Stafyla, 2003; Sin, Tse and Yim, 2005

Continue Table 1. Proposed criteria for CRM performance measurement

Criteria	Sub-criteria	References
CRM output (C <sub>3</sub> )	Customer retention Customer acquisition	Kim and Kim, 2009; Öztaysi, <i>et al.</i> , 2011; Shafia <i>et al.</i> , 2011; Reinartz, 2004; Richards and Jones, 2008; Ahmed, Ahmed and Salman, 2005; Farquhar and Panther, 2008; Augusto de Matos <i>et al.</i> , 2009; Curry and Kkolou, 2004; Espejel, Fandos and Flavian, 2009; Hidalgo, Manzur, Olavarrieta and Farias, 2008; Odekerken-Schroder, Wulf and Schumacher, 2003
Infrastructure (C <sub>4</sub> )	IT Employee	Kim and Kim, 2009; Shafia, <i>et al.</i> , 2011; Sirikrai and Tang, 2006; Zhang and Lado, 2001; Curry and Kkolou, 2004; Harris and Ogbonna, 2001; Dabholkar and Abston, 2008
Organizational alignment (C <sub>5</sub> )	Intellectual alignment Social alignment Technological alignment	Öztaysi <i>et al.</i> , 2011; Shafia <i>et al.</i> , 2011; Ocker and Mudambi, 2003; Sirikrai and Tang, 2006; Curry and Kkolou, 2004

The rationale behind the selection of the banking system in order to evaluate CRM performance stems from this fact that banking sector and the industry of large financial institutions are among the pioneers in CRM programs and strategies (Giannakis-Bompolis & Boutsouki, 2014). The most repeated criteria utilized in CRM performance evaluation are listed in Table 1 and are described as following.

### Customer

Customer criterion consists of three sub- criteria which are measured through them. Customer value is the evaluation of customers' perceived benefit from organization's products or services (Kotler, 2000). Customer satisfaction is the gap between customer's expectations and the observed performance of the products or services. Customers are satisfied when their expectations of the value of a product or service, the company brand, and their relationship with the company are met. CRM aims to fulfill the expectations of the customers (Kim & Kim, 2009). Thus, customer satisfaction is an important sub-criterion for measuring CRM performance. Finally, Customer loyalty has been defined as "an inclination to perform a diverse set of behaviors that signal a motivation to enhance an ongoing relationship with the service provider (Agustin & Singh, 2005). Customer loyalty could be improved by CRM.

### **CRM Process**

In the CRM field, the process perspective is important in these buyer–seller relationships. Therefore the process of a company's relationship marketing should be redesigned in terms of maintaining and developing such relationship (Evans & Laskin, 1994). This relationship was measured through two sub-criteria in this study, customer targeting and customer knowledge generation. Customer targeting emphasizes the ability of the company to identify potential customers and keeping interaction with the appropriate communication channels. Customer knowledge generation is the process of gathering information from multi channels, integrate, store, and analyze the customer's data by the organization CRM system (Öztaysi *et al.*, 2011). These two criteria are vital in every successful CRM process. Therefore we measure CRM process through these two criteria.

### **CRM Output**

CRM outputs are the main expectations of companies from CRM projects (Reinartz, *et al.*, 2004). CRM aims to improve economic performance of companies by affecting customer retention and customer acquisition with up sell and cross sell activities. Therefore, customer output criterion consists of two sub- criteria which is measured through them. Customer retention represents the achievement of the company in keeping the existing customers through CRM. Customer acquisition indicates achievement of the company in acquiring profitable new customers (Öztaysi *et al.*, 2011).

### **Infrastructure**

Infrastructure includes two main sub-criteria which are considered necessary conditions for an efficient and effective CRM process. When companies measure the level of IT, they need to assess whether or not their CRM technologies effectively support the customer information. Employee behaviors and their satisfaction with CRM system is another crucial factor. In addition, if a key contact employee is no longer available, the customer relationship may become vulnerable from customer orientation and it impacts on CRM results.

This means that companies should satisfy their employees first as internal customers (Kim & Kim, 2009).

### **Organizational alignment**

Through three sub-criteria we measure the alignment of company's strategy and management with the CRM initiatives. Intellectual alignment contains the strategy, structure and management of the company. Social alignment is composed of organizational culture, interaction with shareholders and domain knowledge. And Technological alignment includes the alignment of CRM software with the current business needs and IT capabilities (Öztaysi *et al.*, 2011).

### **CRM performance evaluation methods**

Fendy *et al.* (2012) evaluated the performance of CRM System based on the cloud computing. The performance evaluation divided into three sections which are financial, technology, and business evaluation. The result shows that the system has good financial, technology, and business performance.

Zhou *et al.* (2008) presented a CRM performance evaluation method based on fuzzy comprehensive evaluation. In this paper comprehensive evaluation method of CRM performance based on fuzzy comprehensive algorithm is studied. The architecture of the system is built and the function of the system is analyzed. Based on this article a prototype system of CRM performance evaluation is developed.

Wu *et al.* (2008) introduced the concept of the Balanced Scorecard as a framework for evaluating CRM. They utilized the Balanced Scorecard's five dimensions in a non-profit organization. Also Structural Equation Modelling (SEM) verified the relationship and interaction between each performance dimension.

Al-Safi *et al.* (2012) proposed a CRM scorecard to evaluate the performance of CRM systems based on the literature review in a major bank in Saudi Arabia.

Jinzhao (2010) Evaluated CRM performance by networked manufacturing and effective optimization measures. Development

process's quality, operational process's quality, customer relationship's quality and emergency ability are the critical factors of CRM's performance under networked manufacturing. CSM system was evaluated based on these four factors and grey correlative analysis combined with analytic hierarchy process were applied.

As we can see in some of the above articles, Multiple Criteria Decision Making (MCDM) techniques could be applied to prioritize the CRM performance evaluation criteria or the CRM success factors (see e.g. Kim & Kim, 2009; Öztaysi, Kaya & Kahraman, 2011; Taghizadeh & Rajabani, 2014). MCDM constitutes a set of techniques which can be used for evaluating the alternatives in terms of a number of qualitative and/or quantitative criteria with different measurement units, for the purpose of selecting or ranking (Safari and Ebrahimi, 2014). Great efforts in the field of developing and improving MCDM techniques are resulted in numerous approaches for effectively addressing general multiple criteria analysis decision problems (Deng, 2007). But in this study a relatively different approach was adopted. First, in this study in contrast to other related articles, the relative importance or weights of criteria is being considered. In this regard the Fuzzy Shannon's entropy was applied to calculate the criteria weights. In addition, in this study three bank branches as our alternatives were being ranked based on their CRM performance through a relatively new MCDM method COPRAS. This approach in general enables the corporations to compare the CRM performance of their branches according to their customized weighted criteria.

### **Research methodology**

The main purpose of this study is to propose a suitable model for CRM performance evaluation based on fuzzy multiple criteria decision making (MCDM) methods. According to this goal, first by a comprehensive survey of the literature related to CRM, the most important criteria for CRM performance measurement were recognized. Scholars and managers of the case bank which implemented CRM plans validated the framework of the study, the criteria and the proposed branches to rank as our alternatives. All of



the criteria which are selected as our main criteria for evaluating CRM performance were confirmed by the three managers of Mellat bank branches. In the second step, the weights of each criterion were analyzed. In this regard, a committee of 20 experts of Mellat Bank and its three subsidiary branches was formed to evaluate the related importance of the criteria. Fuzzy Shannon's entropy method was applied to calculate the related criteria weights. Finally, according to these weights, the fuzzy COPRAS method was applied for the purpose of ranking three bank branches based on their CRM performance. The input information for this phase was obtained by CRM experts of Mellat Bank which were selected by judgmental sampling. They scored the CRM performance of each three branches based on the identified criteria. Then fuzzy COPRAS method was applied in order to translate their judgments in to an exact ranking based on an integrated approach. After that we compare the result of fuzzy COPRAS with Fuzzy TOPSIS method. Then we select the best branch based on these results. The overall framework of the study is shown in Figure 1.

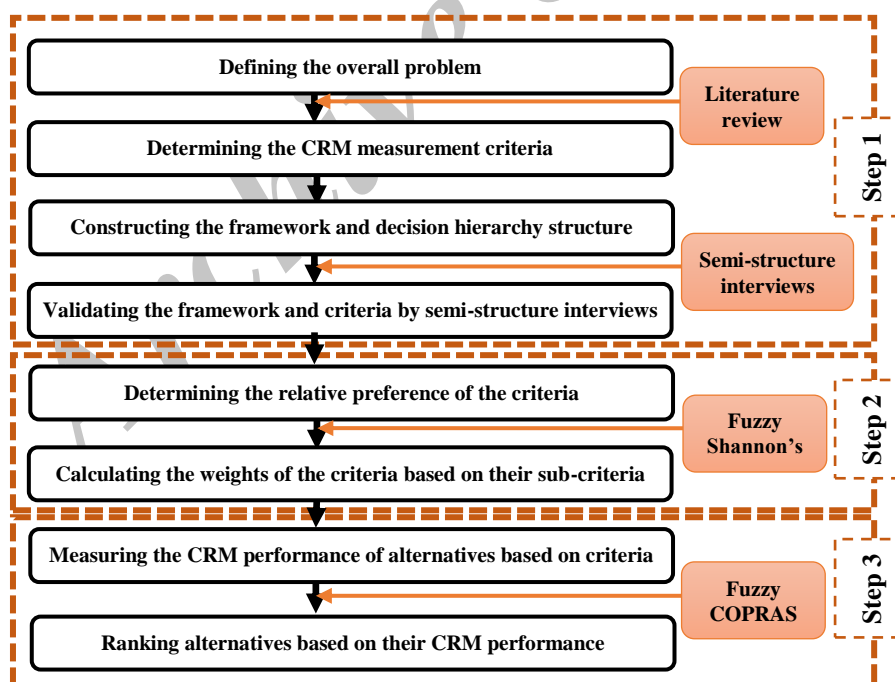


Fig. 1. Schematic diagram of the proposed model

In addition Decision hierarchy for ranking bank branches based on their CRM performance is illustrated in Figure 2.

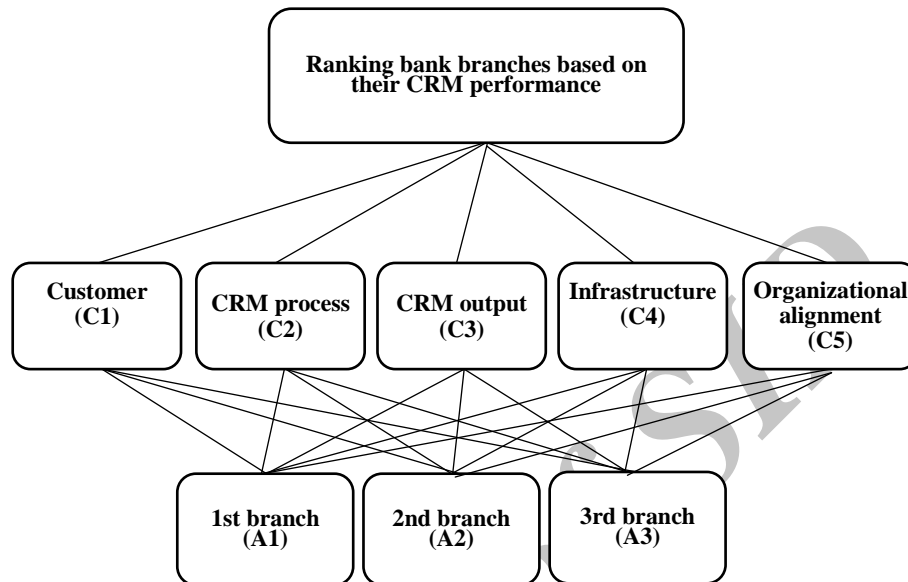


Fig. 2. Decision hierarchy

### Fuzzy sets and fuzzy number

Fuzzy set theory, which was introduced by Zadeh (1965) to deal with problems in which a source of vagueness is involved, has been utilized for incorporating imprecise data into the decision framework. A fuzzy set  $\tilde{A}$  can be defined mathematically by a membership function  $\mu_{\tilde{A}}(X)$ , which assigns each element  $x$  in the universe of discourse  $X$  a real number in the interval  $[0,1]$ . A triangular fuzzy number  $\tilde{A}$  can be defined by a triplet  $(a, b, c)$  as illustrated in figure 3.

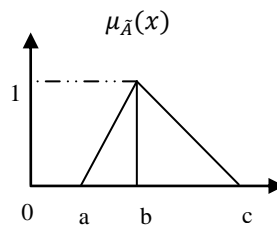


Fig. 3. A triangular fuzzy number  $\tilde{A}$

The membership function  $\mu_{\tilde{A}}(x)$  is defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a}{b-a} & a \leq x \leq b \\ \frac{x-c}{b-c} & b \leq x \leq c \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Although multiplication and division operations on triangular fuzzy numbers do not necessarily yield a triangular fuzzy number, triangular fuzzy number approximations can be used for many practical applications (Kaufmann & Gupta, 1988). Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems including personnel selection (e.g. rating for creativity, personality, leadership, etc.). The primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation (Karsak, 2002). A linguistic variable is defined as a variable whose values are not numbers, but words or sentences in natural or artificial language. The concept of a linguistic variable appears as a useful means for providing approximate characterization of phenomena that are too complex or ill-defined to be described in conventional quantitative terms (Zadeh, 1975).

#### Fuzzy Shannon's Entropy based on $\alpha$ -level sets

Hosseinzadeh *et al.* (2010), extend the Shannon entropy for the imprecise data, especially interval and fuzzy data cases. In this paper we obtain the weights of criteria based on their method. The steps of fuzzy Shannon's Entropy explained as follow (Hosseinzadeh *et al.*, 2010):

**Step 1.** transforming fuzzy data into interval data by using the  $\alpha$ -level sets:

The  $\alpha$ -level set of a fuzzy variable  $\tilde{x}_{ij}$  is defined by a set of elements that belong to the fuzzy variable  $\tilde{x}_{ij}$  with membership of at least  $\alpha$  i.e.,  $(\tilde{x}_{ij})_{\alpha} = \{x_{ij} \in \mathbb{R} \mid \mu_{\tilde{x}_{ij}}(x_{ij}) \geq \alpha\}$ .

The  $\alpha$ -level set can also be expressed in the following interval form:

$$[(\tilde{x}_{ij})_{\alpha}^L, (\tilde{x}_{ij})_{\alpha}^U] = [\min_{x_{ij}} \{x_{ij} \in R | \mu_{\tilde{x}_{ij}}(x_{ij}) \geq \alpha\}, \max_{x_{ij}} \{x_{ij} \in R | \mu_{\tilde{x}_{ij}}(x_{ij}) \geq \alpha\}] \quad (2)$$

where  $0 < \alpha \leq 1$ . By setting different levels of confidence, namely  $1-\alpha$ , fuzzy data are accordingly transformed into different  $\alpha$ -level sets  $\{(\tilde{x}_{ij})_{\alpha} | 0 < \alpha \leq 1\}$ , which are all intervals.

**Step 2.** The normalized values  $p'_{ij}$  and  $p''_{ij}$  are calculated as:

$$p'_{ij} = \frac{x'_{ij}}{\sum_{j=1}^m x'_{ij}}, p''_{ij} = \frac{x''_{ij}}{\sum_{j=1}^m x''_{ij}}, j=1, \dots, m, i=1, \dots, n \quad (3)$$

**Step 3.** Lower bound  $h'_i$  and upper bound  $h''_i$  of interval entropy can be obtained by:

$$h'_i = \min \{-h_0 \sum_{j=1}^m p'_{ij} \cdot \ln p'_{ij}, -h_0 \sum_{j=1}^m p''_{ij} \cdot \ln p''_{ij}\}, i=1, \dots, n \text{ and} \\ h''_i = \max \{-h_0 \sum_{j=1}^m p'_{ij} \cdot \ln p'_{ij}, -h_0 \sum_{j=1}^m p''_{ij} \cdot \ln p''_{ij}\}, i=1, \dots, n \quad (4)$$

where  $h_0$  is equal to  $(\ln m)^{-1}$ , and  $p'_{ij} \cdot \ln p'_{ij}$  or  $p''_{ij} \cdot \ln p''_{ij}$  is defined as 0 if  $p'_{ij} = 0$  or  $p''_{ij} = 0$ .

**Step 4.** Set the lower and the upper bound of the interval of diversification  $d'_i$  and  $d''_i$  as the degree of diversification as follows:

$$d'_i = 1 - h''_i, d''_i = 1 - h'_i, i=1, \dots, n \quad (5)$$

**Step 5.** Set  $w_i^L = \frac{d_i^L}{\sum_{s=1}^n d_s^L}$ ,  $w_i^U = \frac{d_i^U}{\sum_{s=1}^n d_s^L}$ ,  $i=1, \dots, n$  as the lower and upper bound of interval weight of attribute  $i$ .

### Fuzzy COPRAS

The COPRAS (Complex Proportional Assessment) method (Zavadskas & Kaklauskas, 1996) assumes direct and proportional dependence of the significance and utility degree of the investigated versions in a system of criteria adequately describing the alternatives and of values and weights of the criteria (Kaklauskas *et al.*, 2010). This method is widely applied when a decision-maker has to select the optimal alternative among a pool of alternatives by considering a set of evaluation criteria. In the classical COPRAS method, the weights of

the criteria and the ratings of alternatives are known precisely and crisp values are employed in the evaluation process. However, under many conditions crisp data are not capable to model real-life decision problems and it is often difficult for evaluators to determine the precise ratings of alternatives and the exact weights of the evaluation criteria. The merit of using a fuzzy approach is to determine the relative importance of attributes using fuzzy numbers instead of precise numbers (Önüt & Soner, 2008; Sun & Lin, 2009; Sun, 2010; Kara, 2011). Therefore, the fuzzy COPRAS method is developed to deal with the deficiency in the traditional COPRAS. The procedure of the Fuzzy COPRAS method includes the following steps:

**Step 1.** Determine the weighting of evaluation criteria.

A systematic approach to extend the COPRAS is proposed to selecting the best branch under a fuzzy environment in this section. In order to perform a pairwise comparison among the parameters, a linguistic scale has been developed. Our scale is depicted in Figure 4 and the corresponding explanations are provided in Table 2. Similar to the importance scale defined in Saaty's classical AHP (Saaty, 1980), we have used five main linguistic terms to compare the criteria: "equal importance", "moderate importance", "strong importance", "very strong importance" and "demonstrated importance". We have also considered their reciprocals: "equal unimportance", "moderate unimportance", "strong unimportance", "very strong unimportance" and "demonstrated unimportance". For instance, if criterion A is evaluated "strongly important" than criterion B, then this answer means that criterion B is "strongly unimportant" than criterion A.

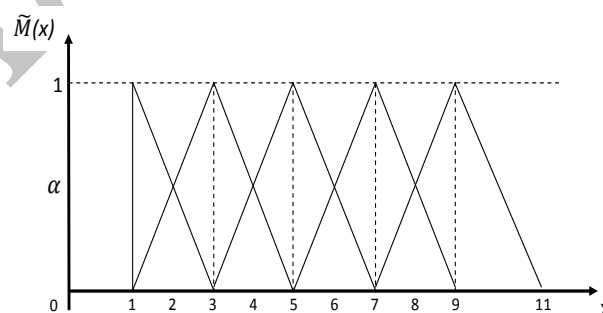


Fig. 4. Membership functions of triangular fuzzy numbers corresponding to the linguistic scale (Safari, *et al.*, 2013)

Table 2. The linguistic scale and corresponding triangular fuzzy numbers

Linguistic scale	Triangular fuzzy numbers	The inverse of triangular fuzzy numbers
Equal Importance	(1, 1, 1)	(1, 1, 1)
Moderate Importance	(1, 3, 5)	(1/5, 1/3, 1)
Strong importance	(3, 5, 7)	(1/7, 1/5, 1/3)
Very strong importance	(5, 7, 9)	(1/9, 1/7, 1/5)
Demonstrated importance	(7, 9, 11)	(1/11, 1/9, 1/7)

**Step 2.** Construct the fuzzy decision matrix. The preference ratings of alternatives are expressed with linguistic variables in positive TFNs.

**Step 3.** Determine the aggregated fuzzy rating  $\tilde{x}_{ij}$  of alternative  $A_i$ ,  $i=1,2,\dots,m$  under criterion  $C_j$ ,  $j=1,2,\dots,n$ .

$$\tilde{D} = \begin{matrix} & \begin{matrix} C_1 & C_2 & \dots & C_N \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_M \end{matrix} & \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{matrix} \quad i=1,2,\dots,m; j=1,2,\dots,n \quad (6)$$

$$\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3})$$

$$x_{ij1} = \min \{x_{ijk1}\}, x_{ij2} = \frac{1}{k} \sum_{k=1}^k x_{ijk2}, x_{ij3} = \max \{x_{ijk3}\}$$

where  $\tilde{x}_{ijk}$  is the rating of alternative  $A_i$  with respect to criterion  $C_j$  evaluated by  $k$ th expert (here  $k=20$ ),  $\tilde{x}_{ijk} = (x_{ijk1}, x_{ijk2}, x_{ijk3})$

**Step 4.** Defuzzify the aggregated fuzzy decision matrix obtained in previous step and derive their crisp values. This research for transforming the fuzzy weights into the crisp weights applies the center of area method which is a simple and practical method to calculate the best non fuzzy performance (BNP) value of the fuzzy weights of each dimension. The BNP value of the fuzzy number  $\tilde{x}_{ij}$  can be found using Eq. (7):

$$x_{ij} = \frac{[(Ux_{ij}-Lx_{ij})+(Mx_{ij}-Lx_{ij})]}{3} + Lx_{ij} \quad (7)$$

**Step 5.** Normalize the decision matrix ( $f_{ij}$ ). The normalization of the decision making is calculated by dividing each entry by the largest

entry in each column to eliminate anomalies with different measurement units, so that all the criteria are dimensionless.

**Step 6.** Calculate the weighted normalized decision matrix ( $\hat{x}_{ij}$ ). The fuzzy weighted normalized values are calculated by multiplying the weight of evaluation indicators ( $w_j$ ) with normalized decision matrices:

$$\hat{x}_{ij} = f_{ij} * w_j \quad (8)$$

**Step 7.** Sums  $P_i$  of attributes values which larger values are more preferable (optimization direction is maximization) calculation for each alternative (line of the decision-making matrix):

$$P_i = \sum_{j=1}^k \hat{x}_{ij} \quad (9)$$

**Step 8.** Sums  $R_i$  of attributes values which smaller values are more preferable (optimization direction is minimization) calculation for each alternative (line of the decision-making matrix):

$$R_i = \sum_{j=k+1}^m \hat{x}_{ij} \quad (10)$$

In formula (14) (m-k) is number of attributes which must to be minimized.

**Step 9.** Determine the minimal value of  $R_{io}$ :

$$R_{\min} = \min_i R_i, i=1,2,\dots,n \quad (11)$$

**Step 10.** Calculate the relative weight of each alternative  $Q_i$ :

$$Q_i = P_i + \frac{R_{\min} \sum_{i=1}^n R_i}{R_i \sum_{i=1}^n \frac{R_{\min}}{R_i}} \quad (12)$$

Formula (12) can to be written as follows:

$$Q_i = P_i + \frac{\sum_{i=1}^n R_i}{R_i \sum_{i=1}^n \frac{1}{R_i}} \quad (13)$$

**Step 11.** Determine the optimality criterion K:

$$K = \max_i Q_i, i=1,2,\dots,n \quad (14)$$

**Step 12.** Assign the priority of the alternatives. The greater weight (relative weight of alternative)  $Q_i$ , the higher is the priority (rank) of the alternatives. In the case of  $Q_{max}$ , the satisfaction degree is the highest.

$$N_i = \frac{Q_i}{Q_{max}} 100\%, \quad (15)$$

**Step 13.** Calculate the utility degree of each alternative: where  $Q_i$  and  $Q_{max}$  are the weight of projects obtained from Eq. (14).

#### A numerical application of proposed approach

The proposed approach is applied in Mellat Bank, Iran. Through the survey of related literature, five main criteria of the CRM performance measurement were identified. These criteria include Customer ( $C_1$ ), CRM process ( $C_2$ ), CRM output ( $C_3$ ), Infrastructure ( $C_4$ ) and Organizational alignment ( $C_5$ ). In addition, there are three alternatives include  $A_1$ ,  $A_2$  and  $A_3$ .

#### Fuzzy Shannon's Entropy

In fuzzy Shannon's Entropy, firstly, the criteria and alternatives' importance weights must be compared. Afterwards, the comparisons about the criteria and alternatives, and the weight calculation need to be made. Thus, the evaluation of the criteria according to the main goal and the evaluation of the alternatives for these criteria must be realized. Then, after all these evaluation procedure, the weights of the alternatives can be calculated. In the second step, these weights are used to Fuzzy COPRAS calculation for the final evaluation. The aggregate decision matrix for Shannon's Entropy can be seen from Table 3.

Table 3. Aggregate decision matrix for fuzzy Shannon's Entropy

DM	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$
$A_1$	(0.00, 1.00, 3.00)	(1.00, 3.00, 5.00)	(1.00, 3.00, 5.00)	(3.00, 5.00, 7.00)	(0.00, 1.00, 3.00)
$A_2$	(1.00, 3.00, 5.00)	(5.00, 7.00, 9.00)	(1.00, 3.00, 5.00)	(5.00, 7.00, 9.00)	(3.00, 5.00, 7.00)
$A_3$	(5.00, 7.00, 9.00)	(0.00, 1.00, 3.00)	(5.00, 7.00, 9.00)	(1.00, 3.00, 5.00)	(1.00, 3.00, 5.00)

After forming decision matrix, we transformed fuzzy data of Table 3 into interval data. For transforming fuzzy data into interval data, we consider  $\alpha = 0.4$ .



The interval decision matrix can be seen from Table 4.

**Table 4. Interval decision matrix**

DM	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>
A <sub>1</sub>	[0.40,2.20]	[1.80,4.20]	[1.80,4.20]	[3.80,6.20]	[0.40,2.20]
A <sub>2</sub>	[1.80,4.20]	[5.80,8.20]	[1.80,4.20]	[5.80,8.20]	[3.80,6.20]
A <sub>3</sub>	[5.80,8.20]	[0.40,2.20]	[5.80,8.20]	[1.80,4.20]	[1.80,4.20]

Then, according to Eq. (3), we normalized the interval decision matrix. The normalized interval decision matrix is shown in Table 5.

**Table 5. The normalized interval decision matrix**

DM	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>
A <sub>1</sub>	[0.027,0.275]	[0.123,0.525]	[0.108,0.446]	[0.204,0.543]	[0.031,0.366]
A <sub>2</sub>	[0.123,0.525]	[0.397,1.025]	[0.108,0.446]	[0.311,0.719]	[0.301,1.033]
A <sub>3</sub>	[0.397,1.025]	[0.027,0.275]	[0.349,0.872]	[0.096,0.368]	[0.142,0.700]

In the next step, we calculate the lower bound  $h'_i$  and upper bound  $h''_i$  of criteria based on the Eq. (4). After that the degrees of diversification are calculated using Eq. (5), as shown in Table 6.

**Table 6. The values of  $h'_i$ ,  $h''_i$ ,  $d'_i$  and  $d''_i$**

H	$[h'_i, h''_i]$	$[d'_i, d''_i]$
C <sub>1</sub>	[0.41,0.44]	[0.55,0.58]
C <sub>2</sub>	[0.41,0.44]	[0.55,0.58]
C <sub>3</sub>	[0.521,0.527]	[0.472,0.478]
C <sub>4</sub>	[0.56,0.58]	[0.41,0.43]
C <sub>5</sub>	[0.36,0.46]	[0.53,0.63]

Finally, the interval gweight and crisp weight are calculated, as shown in Table 7.

**Table 7. The interval and crisp weight of criteria**

	$[w_i^L, w_i^U]$	$W_i$
C <sub>1</sub>	[0.215,0.217]	0.2165
C <sub>2</sub>	[0.215,0.217]	0.2165
C <sub>3</sub>	[0.176,0.186]	0.1815
C <sub>4</sub>	[0.159,0.165]	0.1623
C <sub>5</sub>	[0.211,0.234]	0.2230

### Fuzzy COPRAS

The weights of the alternatives are calculated by fuzzy Shannon's

Entropy up to now, and then these values can be used in Fuzzy COPRAS. Thus, Defuzzified decision matrix can be prepared. This matrix can be seen from Table 8.

Table 7. Defuzzified decision matrix

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>
A <sub>1</sub>	1.333	3.000	3.000	5.000	1.333
A <sub>2</sub>	3.000	7.000	3.000	7.000	5.000
A <sub>3</sub>	7.000	1.333	7.000	3.000	3.000

Then, the normalized decision matrix is multiplied with the importance weights of the evaluation indicators derived from the previous step to form the weighted decision matrix as shown in Table 8.

Table 8. Weighted decision matrix

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>
A <sub>1</sub>	0.041	0.093	0.078	0.116	0.059
A <sub>2</sub>	0.093	0.217	0.078	0.162	0.223
A <sub>3</sub>	0.217	0.041	0.182	0.070	0.134

## Discussion

Based on the proposed model, each alternative has the preferable values for the maximizing and minimizing indices. Then, the relative weight and the optimality criterion are computed as shown in Table 9.

Table 9. Fuzzy COPRAS results

	P <sub>i</sub>	R <sub>i</sub>	R <sub>min</sub> /R <sub>i</sub>	Q <sub>i</sub>	N <sub>i</sub>	Rank
A <sub>1</sub>	0.116	0.041	1.000	0.1793	64.05	3
A <sub>2</sub>	0.223	0.078	0.530	0.2566	91.68	2
A <sub>3</sub>	0.217	0.041	1.000	0.2799	100.00	1

The Fuzzy COPRAS results are shown in Table 9. The evaluation of branches is realized and according to the N<sub>i</sub> values the ranking of branch are A<sub>3</sub>– A<sub>2</sub>– A<sub>1</sub> from most preferable to least. If the best one is needed to be selected, then the alternative A<sub>3</sub> must be chosen.

One of the most commonly used approaches in multiple criteria decision making field is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) developed by Hwang and Yoon

(1981). Ranking alternatives in the TOPSIS method is based on the shortest distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal Solution (NIS) (1981). Kim *et al.* (1997), and Shih *et al.* (2007), addressed four TOPSIS advantages: (1) a sound logic represents the rationale of human choice; (2) a scalar value simultaneously considers both the best and worst alternatives; (3) a simple computation process that can be easily programmed and (4) ability of the performance measures of all alternatives on attributes to be visualized on a polyhedron, at least for any two dimensions. Despite these advantages, the process of calculating the performance index for each alternative across all criteria in the TOPSIS approach may need more consideration (1992). Mathematically, comparing two alternatives in the form of two vectors is better represented by the magnitude of the alternatives and the degree of conflict between each alternative and the ideal solution, instead of just calculating the relative distance between them (2007). To avoid this concern about TOPSIS approach, Similarity approach presented by Deng (2007) makes use of the ideal solution concept in such a way that the most preferred alternative should have the highest degree of similarity to the positive ideal solution and the lowest degree of similarity to the negative ideal solution. The overall performance index of each alternative across all criteria is determined based on the combination of this two degree of similarity concepts using alternative gradient and magnitude.

After that we ranked branches of Melleat bank based on fuzzy TOPSIS and fuzzy Similarity procedures. The results of Fuzzy COPRAS, Fuzzy TOPSIS, and Fuzzy Similarity are shown in Table 10.

Table 10. Ranking by fuzzy COPRAS, Fuzzy TOPSIS and fuzzy methods

	Ranking by Fuzzy COPRAS	Ranking by Fuzzy TOPSIS	Ranking by Fuzzy Similarity
A <sub>1</sub>	3	3	3
A <sub>2</sub>	2	1	2
A <sub>3</sub>	1	2	1

According to result of Fuzzy COPRAS and Fuzzy Similarity, A<sub>3</sub> is

the best alternative and according to Fuzzy TOPSIS method,  $A_2$  is the best alternative that should be chosen. The result of Fuzzy Similarity is the same of Fuzzy COPRAS.

## Conclusion

CRM is a dynamic process of managing a mutual customer–company relationship such that customers select to continue their commercial exchanges with the company. It is a key business strategy in which the firm should stay focused on customers' needs and must integrate a customer-oriented approach throughout the organization.

The main purpose of this paper is to propose a suitable model for CRM performance evaluation based on fuzzy multiple criteria decision making (MCDM) methods. In this regard, first by the survey of the related literature, five main criteria of the CRM performance measurement were identified. In the second step by means of judgmental sampling and its three subsidiary branches was formed and fuzzy Shannon's entropy method was applied for calculating the relative importance or the criteria weights. In the third step for demonstrating the applicability of the model three subsidiary branches which were applying CRM systems, were ranked by fuzzy COPRAS method based on the idea CRM experts of Mellat Bank which were selected by judgmental sampling.

According to fuzzy Shannon's Entropy approach, C5 (Organizational alignment) has the first priority in order to implementing an effective CRM project. This dimension provides information about the environment and factors that improve the CRM processes. It means that factors such as intellectual alignment, social alignment and technological alignment are the first ranked criteria in implementing a CRM project successfully. It necessitate the accordance of the firm strategy and management, organizational culture, interaction with shareholders, domain knowledge and the technology and IT capabilities with CRM processes. In addition according to the five CRM criteria and their related weights, experts chose the third branch (C3) as the best branch based on its CRM performance. The other two branches can focus on the most important

criteria such as organizational alignment (C5), customers (C1) and CRM processes (C2) in order to improve their CRM performance. They can concentrate on the practices such as customer value, customer loyalty, customer satisfaction and so on in order to improve their customer criteria. In addition they can focus on customer targeting and knowledge generation about their customers in order to improve their CRM process criteria and as a result improve their overall CRM performance and their ranking among other branches.

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