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## Article

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## Evaluation of customer oriented success factors in mobile commerce using fuzzy AHP

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### **Abstract:**

**Purpose:** With the development of information technology, ordinary commercial activities are evolving into e-commerce. In e-commerce, users can access services from any place as long as information technology is available. Currently, e-commerce is moving toward mobile commerce that allows users to do commercial activities while they are moving. This study aims to elucidate the factors that affect success in mobile commerce, and then evaluate and rate these factors by analyzing components of commercial activity in the mobile internet environment and give an evaluation method for mobile commerce in order to help researches and managers to determine the drawbacks and opportunities.

**Design/methodology/approach:** A consumer survey was conducted through a structured undisguised questionnaire towards meeting the objectives of the study. An online questionnaire constituted the data collection instrument, while only internet users participated in the sample. The main goal of the questionnaire is to identify the success factors or criteria and sub-criteria for mobile commerce from the viewpoint of users' perception and to assess the decision-making executives for pair-wise comparisons using the fuzzy analytic hierarchical process (FAHP).

**Findings:** A subjective and objective integrated approach has been put forward to determine attributes weights in Fuzzy AHP problems. The study identified the success factors or criteria and sub-criteria for mobile commerce from the

viewpoint of users' perception. The main attractive factors for the customer are the trust and mobility factors. In addition, content quality, system quality, use, support, personalization factors are also important.

**Research limitations/implications:** Sampling is a major limitation in this study. Since the survey was conducted based on a sample in Bangladesh, the prudent reader may need to interpret the results of the study with caution, particularly with respect to the generalization of research findings to Bangladesh mobile commerce customers as a whole.

**Practical implications:** The principal practical implication is to identify the success factors or criteria and sub-criteria for mobile commerce from the viewpoint of users' perception. The criteria and decision alternatives or sub-criteria that are applied in this evaluation were selected based on the feedback from the questionnaire and literature review. On the other hand, from a professional point of view, future research should make several extensions to measure users' satisfaction with mobile commerce using user satisfaction index and evaluate commercial activities in ubiquitous environment, which is a process in the transition of commerce, using the success factors and alternatives of mobile commerce.

**Originality/value:** There are no comparative studies about evaluation of customer oriented success factors for Bangladeshi mobile commerce users. A structured analysis of such customer-oriented factors provides good insights, and will help business managers to time the launch of mobile commerce businesses. It will become a useful assessment model for predicting and evaluating market tendencies.

**Keywords:** fuzzy AHP, MCDM, mobile commerce, success factors

## 1 Introduction

The Internet has been evolved from a basic tool of communications into a vast and interactive market of products and services involving over 240 million users worldwide (Guo & Shao, 2005). The Internet has the potential to market products and services to customers, to communicate information to a global community, to provide an electronic forum for communications and to process business transactions such as orders and payments. Naturally many enterprises across the world attempt to embrace the digital revolution and place a wide range of materials on the web, from infrastructure to databases to actual services online for the convenience of customers. E-commerce is no longer just an option now but a necessity for enterprises aiming for better performance (Hsieh, Jones, & Lin, 2008).

In the 1990s, mobile commerce was recognized as a part of e-commerce. With the increase of mobile devices, the use of mobile commerce, which accesses and use desired information at any time while moving (Anywhere, Anytime), was popularized. In the late 1990s, over 3.5 million devices were used, but entering the 2000s, the number exceeded a trillion (Varshney & Vetter, 2002).

The advance in information technology from wire-connected Internet to mobile Internet access is radically affecting customer needs and purchasing patterns. Based on a study by the Wireless Data and Computing Service, a division of Strategy Analytics, the annual mobile commerce market may rise to \$200 billion by 2004 (Strategy Analytics, 2000) and by 2006, 325 million people will generate mobile commerce revenues of \$230 billion (Information Superhighways Newsletter, 2011). Information acquisition pattern desired by customers in mobile commerce involves processes such as identification, information search, alternative evaluation, purchase and delivery, and evaluation after purchase. Such a series of processes is an important factor for companies that intend to engage in mobile commerce (Turban, King, Lee, Warkentin, & Chung, 2002).

Although mobile commerce is forming a large-scale market, previous researches have been focused on limited analysis of e-commerce. E-commerce is similar to mobile commerce in some parts but they are different in many points (Molla & Licker, 2001), so it is difficult to promote mobile commerce based on the factors of e-commerce. There are many confusing factors for m-commerce. Thus, it is very

important to know what the important success factors or decision alternatives in mobile commerce. If the limitations of mobile commerce are understood in advance and overcome and factors for maximizing its advantages are analyzed and utilized, changes in the market can be coped with more actively. As mobile commerce is different from e-commerce in many aspect, it is very useful to examine the success factors of mobile commerce from the user aspect, the developer and contents provider aspect and the system aspect and furthermore from the functional aspect, the technological aspect and the market aspect.

Previous researches have been based on a limited part, but in this study, the components of mobile commerce environment have been analyzed by stage. According to theses that emphasized the various aspects of mobile commerce, Tarasewich, Nickerson and Warkentin (2002) explained differences in mobile customers, the substructure of communication, and mobile application system, and (Delone & Maclean, 1992) distinguished in terms of system quality, contents quality, users and user satisfaction (Muller-Veerse, 1999) analyzed the social and technology aspect of mobile commerce, the partially used environmental aspect, and the mobile commerce market in Western Europe. These aspects are quite important factors for businesses that intend to enter the mobile commerce market.

Several conflicting tangible and intangible factors exist for evaluating m-commerce. Identifying these evaluation criteria, defining the effects of them on each other, assessing their importance, and choosing a particular success factors necessitate a well designed multiple criteria decision making (MCDM) based evaluation (Andreou et al., 2005; Topcu & Burnaz, 2006). Generally, the MCDM methods deal with the process of making decisions in the presence of multiple criteria or objectives. AHP is one of the decision-aiding methods of MCDM that was developed by Saaty (1998). Some researchers extract critical success factors for entering into the market of new mobile commerce and evaluate those using analytics hierarchical process (AHP) (Kim & Hwang, 2005; Oh, Kim, & Rhew, 2006). Most of these methods have been developed based on the concepts of accurate measurements and crisp evaluation. However most of the selection parameters cannot be given precisely. Besides the objectives are usually conflicting and therefore, the solution is highly dependent on the preferences of the decision maker. Hence, the evaluation data of m-commerce for various subjective criteria, and the weights of the criteria are usually expressed in linguistic terms. This makes fuzzy logic a more

natural approach to this kind of problems. The MCDM methods can also be integrated with fuzzy methods to tackle uncertainties in the data. Chiu, Shyu, and Tzeng (2004) used fuzzy MCDM for evaluating the e-commerce strategy.

This study aims to elucidate the factors that affect success in mobile commerce, and then evaluate and rate these factors by analyzing components of commercial activity in the mobile Internet environment, using the Fuzzy Analytic Hierarchy Process (FAHP). In the proposed methodology, the AHP with its fuzzy extension, namely fuzzy AHP, is applied to obtain more decisive judgments by substituting membership scales for Saaty's 1-9 scales and weighting them in the presence of vagueness. There are various fuzzy AHP applications in the literature that propose systematic approaches for selection of alternatives and justification of problem by using fuzzy set theory and hierarchical structure analysis (Anand, Selvaraj, Kumanan, & Johnny, 2008; Bozbura & Beskese, 2007; Çakir, Tozan, & Vayvay, 2009; Kahraman, Cebeci, & Ruan, 2004; Tang & Beynon, 2005; Xia & Wu, 2007). Büyüközkan (2009) proposed a fuzzy analytic approach to determine the mobile commerce user requirements. Decision makers usually find it more convenient to express interval judgments than fixed value judgments due to the fuzzy nature of the comparison process (Bozdog, Kahraman, & Ruan, 2003).

The remainder of this paper is organized as follows. The success factors and alternatives that affect mobile commerce have been described in the next section. After that, an overview of the fuzzy set theory and fuzzy AHP technique is presented. To evaluate the success factors, this technique has been applied in next section and outlined the findings in this respect. Finally, the last section contains some conclusions reached in this paper.

## **2 Criteria affecting commerce with mobile access**

As a channel for electronic commerce (e-commerce), the emerging power of the Internet has seen for at least the last half-decade. Today, the mobile Internet is rapidly emerging, and the transaction paradigm in e-commerce is shifting to mobile commerce (m-commerce). M-commerce, like e-commerce, represents an immense opportunity for business. Success in m-commerce will go to those companies that enter the field early, and to those that focus on creating compelling value for customers (Venkatesh, Ramesh, & Massey, 2003). The term m-

commerce covers an emerging set of applications and services that people can access from their Web-enabled mobile devices (Venkatesh et al., 2003) using the “wireless Web. M-commerce inherits many attributes from e-commerce, and some e-commerce characteristics from the e-commerce success model (Molla & Licker, 2001) have employed.

In the mobile Internet environment, people can use a mobile application with a wireless connection anywhere and at anytime. Mobility of devices and applications raises the issue of the appropriateness of their use under certain circumstances (Tarasewich, 2003), that is, mobility is a strategic consideration for m-commerce to utilize in aiming for success. The electronic commerce success factors (Molla & Licker, 2001) can find and extract the major aspects of m-commerce (Gunasekaran & McGaughey, 2009; Tarasewich, 2003). The major m-commerce success factors are: System Quality, Content Quality, Use, Trust, Support, Mobility and Personalization. More detailed information on these categories can be found in references (Molla & Licker, 2001; Sarker & Wells, 2003; Tarasewich, 2003; Venkatesh et al., 2003).

#### A. System Quality

This is the principal criterion for judging whether site performance is sufficiently smooth and seamless in m-commerce. Earlier MIS works investigated the reliability of the system, online response time, and so on (Varshney & Vetter, 2002). Recent works (Guo & Shao, 2005) focusing on e-commerce have suggested additional variables: online response time, 24-hour availability, page loading speed, visual appearance.

#### B. Content Quality

Content quality is very important in attracting customers to m-commerce. Content quality includes the attributes of the content that are presented directly on mobile devices. Information systems' literature has emphasized the importance of information quality as one of the determinants of user satisfaction, and has identified a number of attributes: up-to-datedness, understandability, timeliness, and preciseness (Delone & Maclean, 1992).

#### C. Use

The extent to which a system is used is one of the measures that are widely used to define the success of a business. Considering the purposes of e-commerce systems suggested by (Venkatesh et al., 2003), the use of an e-commerce system can be divided into informational and transactional components. Such attributes are applied in exactly the same way to m-commerce. The informational use logged by a customer can be described as requesting and obtaining information. These terms are often shortened to information and transaction.

#### D. Trust

Trust is another significant challenge in the m-commerce environment. Customers are concerned about the level of security when providing sensitive information online (Warrington, Abgrab, & Caldwell, 2000). Also, they expect that personal information will be protected from external access; there are two alternative - security and privacy. There are potential benefits in storing data, including personal and financial information, on mobile devices for use in m-commerce applications (Andreou et al., 2005).

#### E. Support

If m-commerce services provide customer satisfaction, customers will return to the service after their initial experience. Support is a customer-oriented criterion and includes the following components: tracking order status, account maintenance, payment alternatives, Frequently Asked Question (FAQ), etc (Tarasewich, Nickerson, & Warkentin, 2002).

#### F. Mobility

The customer can employ mobile services and transactions from anywhere, at anytime; m-commerce must support this customer mobility. Mobility of device and application raises the issue of their suitability for the user under some circumstances (Tarasewich, 2003).

#### G. Personalization

Personalization is defined as the customization of products and services to the context of the user (Andreou et al., 2005). The importance of personalization, and therefore context, in m-commerce is widely recognized as a critical success factor



(Tarasewich et al., 2002). Its significance is conveyed in a quote from Muller-Veerse (1999), "personalization will be absolutely crucial in the m-commerce arena, where every additional click required from the user reduces the transaction probability by 50%". Since mobile devices have particular limitations, e.g., low battery capacity, and small memory and screen size, personalization is needed to increase their usability.

### 3 Fuzzy set theory and fuzzy analytic hierarchy process

Nevertheless, there is an extensive literature which addresses the situation in the real world where the comparison ratios are imprecise judgments. In the conventional AHP, the pair wise comparisons for each level with respect to the goal of the best alternative selection are conducted using a nine-point scale. So, the application of Saaty's AHP has some shortcomings as follows (Saaty, 1998); (1) The AHP method is mainly used in nearly crisp decision applications, (2) The AHP method creates and deals with a very unbalanced scale of judgment, (3) The AHP method does not take into account the uncertainty associated with the mapping of one's judgment to a number, (4) Ranking of the AHP method is rather imprecise, (5) The subjective judgment, selection and preference of decision-makers have great influence on the AHP results. In addition, a decision-maker's requirements on evaluating alternatives always contain ambiguity and multiplicity of meaning. Furthermore, it is also recognized that human assessment on qualitative attributes is always subjective and thus imprecise. Therefore, conventional AHP seems inadequate to capture decision-maker's requirements explicitly. In order to model this kind of uncertainty in human preference, fuzzy sets could be incorporated with the pairwise comparison as an extension of AHP. The fuzzy AHP approach allows a more accurate description of the decision making process.

#### 3.1 Fuzzy set theory

Zadeh (1965) came out with the fuzzy set theory to deal with vagueness and uncertainty in decision making in order to enhance precision. Thus the vague data may be represented using fuzzy numbers, which can be further subjected to mathematical operation in fuzzy domain. Thus fuzzy numbers can be represented by its membership grade ranging between 0 and 1. A triangular fuzzy number (TFN)  $M^{\square}$  is shown (Figure 1).

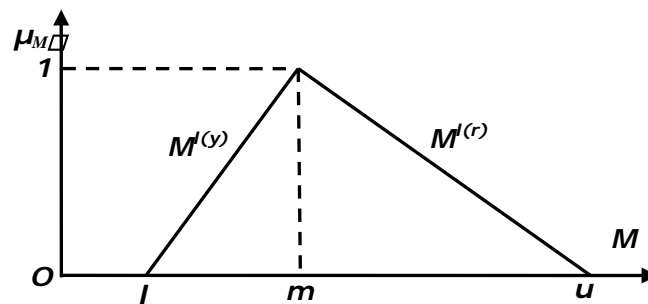


Figure 1. "Triangular fuzzy number  $M$ ".

A TFN is denoted simply as  $(l/m, m/u)$  or  $(l, m, u)$ , represents the smallest possible value, the most promising value and the largest possible value respectively. The TFN having linear representation on left and right side can be defined in terms of its membership function as:

$$\mu(x|M) = \begin{cases} 0, & x < l, \\ (x-l)/(m-l), & l \leq x \leq m, \\ (u-x)/(u-m), & m \leq x \leq u, \\ 0, & x > u, \end{cases}$$

### 3.2 Fuzzy analytic hierarchy process

In this paper fuzzy-AHP methodology has been discussed for the mobile commerce success factors evaluation. Basically fuzzy-AHP is the fuzzy modified form of AHP. It has the ability to extract the merits of both approaches to efficiently and effectively tackle the multi-attribute decision making problems like mobile commerce success factors evaluation.

The following section outlines the extent analysis method on FAHP. 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 per Chang (1992, 1996) each object is taken and analysis for each goal,  $g_i$ , is performed, respectively. Therefore  $m$  extent analysis values for each object can be obtained, as under:

$$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m, \quad i = 1, 2, 3, \dots, n$$

where all the  $M_{g_i}^m$  ( $j = 1, 2, \dots, m$ ) are TFNs whose parameters are, depicting least, most and largest possible values respectively and represented as  $(a, b, c)$ . The steps of Chang’s extent analysis are discussed in the Appendices.

Figure 2 and Table 1, shows the linguistics scale along with corresponding triangular fuzzy scale.

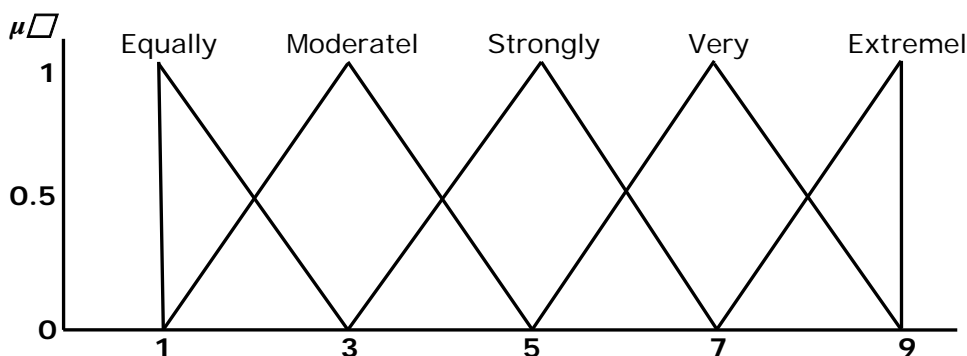


Figure 2. “Linguistic variables for the importance weight of each criterion”.

Linguistic scale for importance	Fuzzy numbers	Membership function	Domain	Triangular fuzzy scale $(l, m, u)$
Just equal	1□			(1, 1, 1)
Equally important		$\mu_M(x) = (3-x) / (3-1)$	$1 \leq x \leq 3$	(1, 1, 3)
Weakly important	3□	$\mu_M(x) = (x-1) / (3-1)$	$1 \leq x \leq 3$	(1, 3, 5)
		$\mu_M(x) = (5-x) / (5-3)$	$3 \leq x \leq 5$	
Essential or Strongly important	5□	$\mu_M(x) = (x-3) / (5-3)$	$3 \leq x \leq 5$	(3, 5, 7)
		$\mu_M(x) = (7-x) / (7-5)$	$5 \leq x \leq 7$	
Very strongly important	7□	$\mu_M(x) = (x-5) / (7-5)$	$5 \leq x \leq 7$	(5, 7, 9)
		$\mu_M(x) = (9-x) / (9-7)$	$7 \leq x \leq 9$	
Extremely Preferred	9□	$\mu_M(x) = (x-7) / (9-7)$	$7 \leq x \leq 9$	(7, 9, 9)
If factor $i$ has one of the above numbers assigned to it when compared to factor $j$ , then $j$ has the reciprocal value when compare to $i$			Reciprocals of above $M_{ij}^{-1} = (1/u_i, 1/m_i, 1/l_i)$	

Table 1. “Linguistic variables describing weights of the criteria and values of ratings”.

Source: Bozbura & Beskese, (2007)

#### 4 Evaluation of the success factors through fuzzy AHP

The Fuzzy AHP model was formulated and data were collected through a structured undisguised questionnaire. A consumer survey was conducted towards meeting the

objectives of the present study. An online questionnaire constituted the data collection instrument, while only Internet users participated in the sample. The questionnaire was sent to a random sample of the mobile commerce service providers, users, academic experts and professional executives of about 353 contacts on March 23rd 2010 and 281 respondents completed the questionnaire, a response rate of 79.6%.

For the actual survey, individuals from the sample were invited by e-mail to participate in the Web survey. The e-mail invitation letter described the purpose of the study and assured the confidentiality of information provided by respondents. Participants were asked to continue the survey only if they currently use the mobile phone. Then, participants were directed to a Web site by clicking on a URL in the email to reach the survey webpage. About a week later, a second reminder e-mail was sent to the people who did not respond to the Web survey. Two week after, a third reminder e-mail was sent to the people who had not responded to the Web survey.

The majority of respondents aged between 17-40 years old, while 50.1% of the respondents were female. The respondents of the study also indicated that they were employed in many different occupations. 28.7% of the respondents had a job related to the professional, technical, and related occupations, and about 13.9% had a job related to executive, administrative, and managerial occupations, as well as administrative support occupations. As far as the educational level is concerned, most of the respondents (83%) were highly educated (hold university and master degrees). Finally, 78% respondents live in big towns (>100,000 inhabitants). The main goal of the questionnaire is to identify the success factors or criteria and sub-criteria for mobile commerce from the viewpoint of users' perception and to assess the decision-making executives for pair-wise comparisons. The criteria and decision alternatives or sub-criteria that are applied in this evaluation were selected based on the feedback from the questionnaire and literature review described in Section 2. While decision criteria have been included, decision-makers (DM) wishing to use fuzzy AHP must identify criteria appropriate to their own particular situation. The results of this application provide better analytical penetration regarding mobile commerce success factors in the market. The process of described in more detail.

#### 4.1 Break down decision problems

In this step, a decision hierarchy has been constructed by breaking a general problem into individual criteria. The success factors based on the feedback from the questionnaire and described in Section 2 are shown in Figure 3 in the form of a hierarchical diagram. The top of the hierarchy is the overall objective or goal, the middle nodes are the relevant attributes (criteria) and the last level are the decision alternatives or sub-criteria's of the decision problem.

#### 4.2 Pair-wise comparison

The use of ratings enables DMs to analyze each criterion with respect to other criterion for their subsequent ranking relative to each other. A decision matrix 'D' as shown in Table 2 may be constructed to measure the relative degree of importance for each success factors or criteria, based on the proposed methodology. The decision matrix consist  $7 \times 7$  elements.

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$	$C_7$
$C_1$	(1,1,1)	(3,5,7)	(3,5,7)	(1/9,1/9,1/7)	(3,5,7)	(1/7,1/5,1/3)	(1,3,5)
$C_2$	(1/7,1/5,1/3)	(1,1,1)	(1/5,1/3,1)	(1/9,1/9,1/7)	(1/5,1/3,1)	(1/9,1/9,1/7)	(1/7,1/5,1/3)
$C_3$	(1,3,5)	(1/7,1/5,1/3)	(1,1,1)	(1/9,1/9,1/7)	(1/3,1,1)	(1/9,1/9,1/7)	(1/7,1/5,1/3)
$C_4$	(7,9,9)	(7,9,9)	(7,9,9)	(1,1,1)	(3,5,7)	(1,1,3)	(5,7,9)
$C_5$	(1,3,5)	(1/7,1/5,1/3)	(1,1,3)	(1/7,1/5,1/3)	(1,1,1)	(1/9,1/7,1/5)	(1/5,1/3,1)
$C_6$	(7,9,9)	(3,5,7)	(7,9,9)	(1/3,1,1)	(5,7,9)	(1,1,1)	(3,5,7)
$C_7$	(3,5,7)	(1/5,1/3,1)	(3,5,7)	(1/9,1/7,1/5)	(1,3,5)	(1/7,1/5,1/3)	(1,1,1)

Table 2. "Fuzzy comparison matrix of criteria with respect to the overall objective".

Inconsistency of TFN used can be checked and the consistency ratio (CR) may be calculated (Satty, 1998). The results obtained are:  $\lambda_{max} = 7.733$ ;  $CI = 0.1221$ ;  $RI = 1.35$  and  $CR = 0.0911$ . As  $CR < 0.1$  the level of inconsistency present in the information stored in 'D' matrix is satisfactory (Satty, 1998).

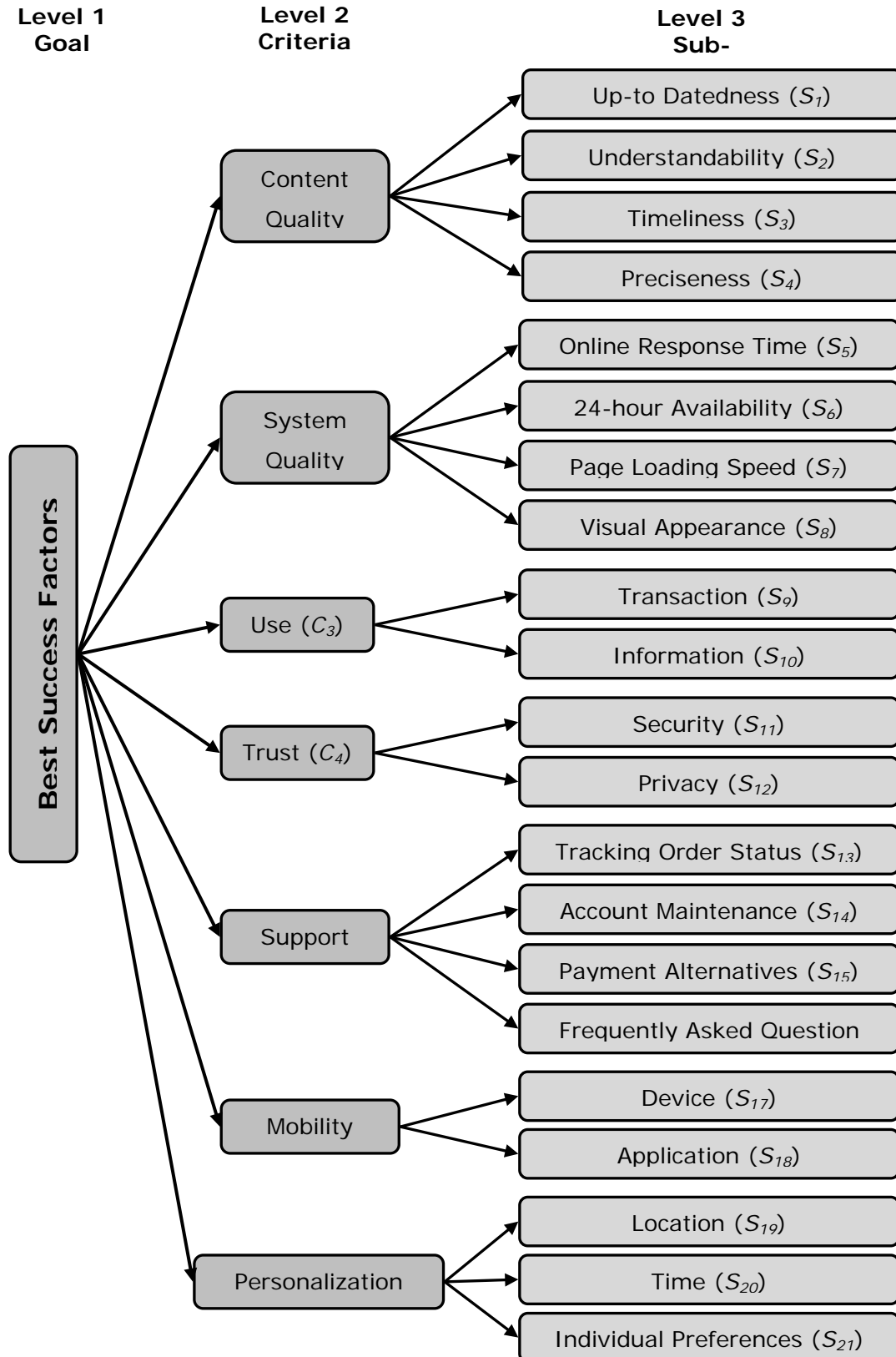


Figure 3. "Objective hierarchies for the evaluation of mobile commerce success factors".

$$SC_1 = (11.26, 19.31, 27.41) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.07, 0.153, 0.321)$$

$$SC_2 = (1.91, 2.28, 3.95) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.011, 0.018, 0.046)$$

$$SC_3 = (2.84, 5.62, 7.95) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.018, 0.045, 0.093)$$

$$SC_4 = (31, 41, 47) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.191, 0.326, 0.550)$$

$$SC_5 = (3.60, 5.88, 10.87) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.022, 0.047, 0.127)$$

$$SC_6 = (26.33, 37, 43) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.163, 0.294, 0.504)$$

$$SC_7 = (8.46, 14.68, 21.53) \otimes (1/161.783, 1/125.77, 1/85.4) = (0.052, 0.117, 0.252)$$

The degrees of possibility of superiority of  $SC_1$  can be calculated is denoted by  $V(SC_1 \geq SC_2)$ . Therefore, the degree of possibility of superiority for the first requirement- the values are calculated as

$$V(SC_1 \geq SC_2) = 1, \quad V(SC_1 \geq SC_3) = 1,$$

$$V(SC_1 \geq S4) = (0.191 - 0.321) / (0.153 - 0.321) - (0.326 - 0.191) = (-0.13) / (-0.303) = 0.43$$

$$V(SC_1 \geq SC_2) = 1, \quad V(SC_1 \geq SC_2) = 0.528, \quad V(SC_1 \geq SC_2) = 1$$

For the second requirement- the values are calculated as

$$V(SC_2 \geq SC_1) = 0.216, \quad V(SC_2 \geq SC_3) = 0.51, \quad V(SC_2 \geq SC_4) = 0.89$$

$$V(SC_2 \geq SC_5) = 0.453, \quad V(SC_2 \geq SC_6) = 0.736, \quad V(SC_2 \geq SC_7) = 0.0645$$

For the third requirement- the values are calculated as

$$V(SC_3 \geq SC_1) = 1, \quad V(SC_3 \geq SC_2) = 0.176, \quad V(SC_3 \geq SC_4) = 0.536$$

$$V(SC_3 \geq SC_5) = 0.973, \quad V(SC_3 \geq SC_6) = 0.391, \quad V(SC_3 \geq SC_7) = 0.363$$

For the fourth requirement- the values are calculated as

$$V(SC_4 \geq SC_1) = 1, \quad V(SC_4 \geq SC_2) = 1, \quad V(SC_4 \geq SC_4) = 1$$

$$V(SC_4 \geq SC_5) = 1, \quad V(SC_4 \geq SC_6) = 1, \quad V(SC_4 \geq SC_7) = 1$$

For the fifth requirement- the values are calculated as

$$V(SC_5 \geq SC_1) = 1, \quad V(SC_5 \geq SC_2) = 0.35, \quad V(SC_5 \geq SC_3) = 1$$

$$V(SC_5 \geq SC_4) = 0.303, \quad V(SC_5 \geq SC_6) = 0.171, \quad V(SC_5 \geq SC_7) = 0.517$$

For the sixth requirement- the values are calculated as

$$V(SC_6 \geq SC_1) = 1, \quad V(SC_6 \geq SC_2) = 1, \quad V(SC_6 \geq SC_3) = 1$$

$$V(SC_6 \geq SC_4) = 0.907, \quad V(SC_6 \geq SC_5) = 1, \quad V(SC_6 \geq SC_7) = 1$$

For the seventh requirement- the values are calculated as

$$V(SC_7 \geq SC_1) = 1, \quad V(SC_7 \geq SC_2) = 0.835, \quad V(SC_7 \geq SC_3) = 1$$

$$V(SC_7 \geq SC_4) = 0.226, \quad V(SC_7 \geq SC_5) = 1, \quad V(SC_7 \geq SC_6) = 0.335$$

The minimum degree of possibility of superiority of each criterion over another is obtained. This further decides the weight vectors of the criteria.

Therefore, the weight vector is given as

$$W' = (0.43, 0.0645, 0.176, 1, 0.171, 0.907, 0.226)$$

The normalized value of this vector decides the priority weights of each criterion over another. The normalized weight vectors are calculated as

$$W = (0.144, 0.022, 0.06, 0.336, 0.056, 0.304, 0.078)$$

The normalized weight of each success factor is depicted in Figure 4. Figure 4 shows that the criteria trust and mobility have higher priority than the other success factors.



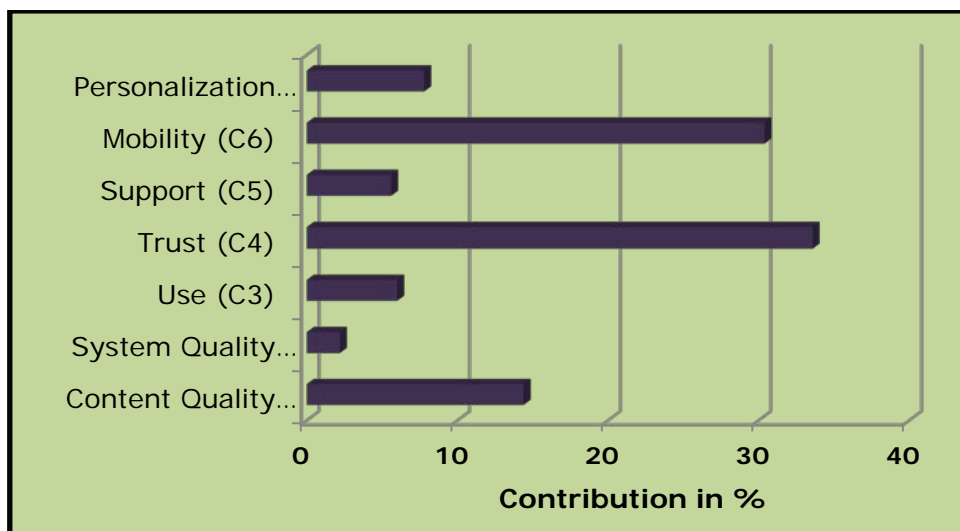


Figure 4. "Contribution of criteria in percentage for the evaluation of m-commerce".

Now the different sub-criteria are compared under each of the criterion separately by following the same procedure discussed above. The fuzzy comparison matrices and the weight vectors of each sub-criterion are shown in Tables 3-9. The priority weight of each sub-criterion has been determined following the similar procedure discussed above.

$C_1$	$S_1$	$S_2$	$S_3$	$S_4$	Weight
$S_1$	(1,1,1)	(1/9,1/9,1/7)	(1/3,1,1)	(1/7,1/5,1/3)	0.033
$S_2$	(7,9,9)	(1,1,1)	(3,5,7)	(1,1,3)	0.55
$S_3$	(1/3,1,1)	(1/7,1/5,1/3)	(1,1,1)	(1/5,1/3,1)	0.057
$S_4$	(3,5,7)	(1/3,1,1)	(1,3,5)	(1,1,1)	0.36

Table 3. "Fuzzy comparison matrix of the sub-criteria with respect to content quality".

$C_2$	$S_5$	$S_6$	$S_7$	$S_8$	Weight
$S_5$	(1,1,1)	(1/7,1/5,1/3)	(1,1,3)	(1/3,1,1)	0.157
$S_6$	(3,5,7)	(1,1,1)	(7,9,9)	(5,7,9)	0.453
$S_7$	(1/3,1,1)	(1/9,1/9,1/7)	(1,1,1)	(1/3,1,1)	0.324
$S_8$	(1,1,3)	(1/9,1/7,1/5)	(1,1,3)	(1,1,1)	0.066

Table 4. "Fuzzy comparison matrix of the sub-criteria with respect to system quality".

$C_3$	$S_9$	$S_{10}$	Weight
$S_9$	(1,1,1)	(1/5,1/3,1)	0.30
$S_{10}$	(1,3,5)	(1,1,1)	0.70

Table 5. "Fuzzy comparison matrix of the sub-criteria with respect to use".

$C_4$	$S_{11}$	$S_{12}$	Weight
$S_{11}$	(1,1,1)	(1,1,3)	0.50
$S_{12}$	(1/3,1,1)	(1,1,1)	0.50

Table 6. "Fuzzy comparison matrix of the sub-criteria with respect to trust".

$C_5$	$S_{13}$	$S_{14}$	$S_{15}$	$S_{16}$	Weight
$S_{13}$	(1,1,1)	(5,7,9)	(3,5,7)	(1,3,5)	0.463
$S_{14}$	(1/9,1/7,1/5)	(1,1,1)	(1/7,1/5,1/3)	(1/7,1/5,1/3)	0.006
$S_{15}$	(1/7,1/5,1/3)	(3,5,7)	(1,1,1)	(1/5,1/3,1)	0.21
$S_{16}$	(1/5,1/3,1)	(3,5,7)	(1,3,5)	(1,1,1)	0.321

Table 7. "Fuzzy comparison matrix of the sub-criteria with respect to support".

$C_6$	$S_{17}$	$S_{18}$	Weight
$S_{17}$	(1,1,1)	(5,7,9)	0.50
$S_{18}$	(1/9,1/7,1/5)	(1,1,1)	0.50

Table 8. "Fuzzy comparison matrix of the sub-criteria with respect to Mobility".

$C_7$	$S_{19}$	$S_{20}$	$S_{21}$	Weight
$S_{19}$	(1,1,1)	(1/7,1/5,1/3)	(1,1,3)	0.086
$S_{20}$	(3,5,7)	(1,1,1)	(3,5,7)	0.781
$S_{21}$	(1/3,1,1)	(1/7,1/5,1/3)	(1,1,1)	0.133

Table 9. "Fuzzy comparison matrix of the sub-criteria with respect to personalization".

At this stage, the relative priority weights of each criterion and each sub-criterion are calculated. The results of the instance are shown in Table 10 and Figure 5.

Criterion	Priority of criterion	Sub-criterion	Priority of sub-criterion	Final priority of sub-criterion	CR of sub-criterion	CR of criterion
C <sub>1</sub>	0.144	S <sub>1</sub>	0.033	0.0047	0.0478	0.0911
		S <sub>2</sub>	0.55	0.0792		
		S <sub>3</sub>	0.057	0.0082		
		S <sub>4</sub>	0.36	0.0518		
C <sub>2</sub>	0.022	S <sub>5</sub>	0.157	0.0034	0.0468	
		S <sub>6</sub>	0.453	0.0099		
		S <sub>7</sub>	0.324	0.0071		
		S <sub>8</sub>	0.066	0.0014		
C <sub>3</sub>	0.06	S <sub>9</sub>	0.30	0.0180	0	
		S <sub>10</sub>	0.70	0.0420		
C <sub>4</sub>	0.336	S <sub>11</sub>	0.50	0.168	0	
		S <sub>12</sub>	0.50	0.168		
C <sub>5</sub>	0.056	S <sub>13</sub>	0.463	0.0259	0.0716	
		S <sub>14</sub>	0.006	0.0003		
		S <sub>15</sub>	0.21	0.0117		
		S <sub>16</sub>	0.321	0.0179		
C <sub>6</sub>	0.304	S <sub>17</sub>	0.50	0.1520	0	
		S <sub>18</sub>	0.50	0.1520		
C <sub>7</sub>	0.078	S <sub>19</sub>	0.086	0.0067	0.0497	
		S <sub>20</sub>	0.781	0.0609		
		S <sub>21</sub>	0.133	0.1037		

Table 10. "Priority and consistency ratios for the evaluation of m-commerce".

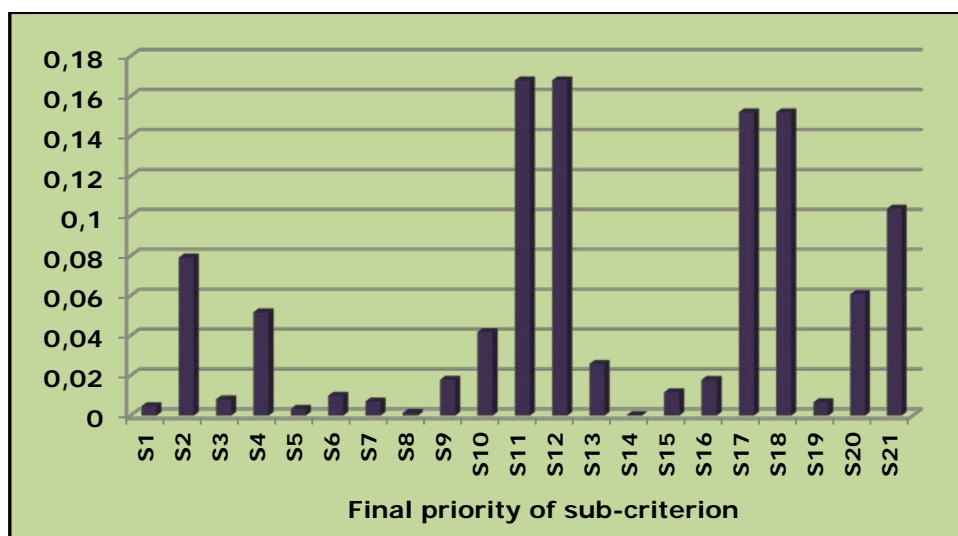


Figure 5. "Importance of sub-criterion for the evaluation of m-commerce".

## 5 Discussions

The present study extracted success factors and decision alternatives in consideration of users, systems, developers and suppliers involved in mobile commerce, and were selected from the functional, technological and market aspect. Figure 5 shows the importance of decision alternatives or sub-criteria calculated based on the importance of the success factors of mobile commerce. Table 10 shows that the trust (C4) and mobility (C6) have higher priority than the other success factors. As a result, trust and mobility are the essential factors affecting the success of mobile commerce, while security (S11) and privacy (S12) are the most critical factors within trust criteria and device (S17) and application (S18) are the most critical factors within mobility criteria (Figure 5). Through the calculation of importance in Table 10, individual preferences (S2) in personalization and understandability (S21) of content quality are also important for users to understand and use contents without difficulty. Personal satisfaction should be enhanced through easy acquisition of desired contents, and the number of transactions should be minimized. Mobile commerce users are more active than e-commerce users, and sites are visited more frequently when their contents are updated with latest data. In addition, preciseness (S4), timeliness (S20) and information (S10) were also found important. Since the consistency of all the level is less than 1.0, this set of priorities is considered acceptable.

## 6 Conclusions

With mobile and internet technologies, customers can have unlimited access to the information they require and may enjoy a wider range of choices in selecting products and services with highly competitive prices. Therefore, it is generally not easy for enterprises to gain and sustain competitive advantages based solely on a cost leadership strategy in rival-driven market. Rather, the subtle “differentiating” service quality levels of the enterprises have increasingly become a key driving force in enhancing customers’ satisfaction and in turn in expanding their customer bases.

In this paper, criteria have been proposed, for use by a company intending to launch an m-commerce business, by which customer’s interests can be assessed. Developing aspects of customer interest in the m-commerce market are the main

pointers to business success and application of the Fuzzy AHP technique provides a customer-oriented success strategy. The Fuzzy AHP technique has application in providing a structured approach to finding the best decision-making strategy in the area of Multi Criteria Decision Making. A subjective and objective integrated approach has been put forward to determine attributes weights in Fuzzy AHP problems. The main attractive factors for the customer are the trust and mobility factors. In addition, content quality, system quality, use, support, personalization factors are also important. If application of these criteria is extended to marketing in the new ubiquitous computing environment, it will become a useful assessment model for predicting and evaluating market tendencies.

Sampling is a major limitation in this study. Since the survey was conducted based on a sample in Bangladesh, the prudent reader may need to interpret the results of the study with caution, particularly with respect to the generalization of research findings to Bangladesh mobile commerce customers as a whole.

Future research should make several extensions of the current study. For future study, it is needed to measure users' satisfaction with mobile commerce using user satisfaction index and evaluate commercial activities in ubiquitous environment, which is a process in the transition of commerce, using the success factors and alternatives of mobile commerce.

## Appendices

The steps of Chang's extent analysis (Chang, 1992) can be detailed as follows (Bozbura, Beskese, & Kahraman, 2007; (Kahraman, Cebeci, & Ulukan, 2003; Kahraman, Cebeci, & Ruan, 2004):

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

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

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

$$\sum_{j=1}^m M_{g_i}^j = (\sum_{j=1}^m a_j, \sum_{j=1}^m b_j, \sum_{j=1}^m c_j)$$

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

$$\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j = (\sum_{i=1}^n a_i, \sum_{i=1}^n b_i, \sum_{i=1}^n c_i)$$

And then compute the inverse of the vector such that

$$[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j]^{-1} = \left( \frac{1}{\sum_{i=1}^n c_i}, \frac{1}{\sum_{i=1}^n b_i}, \frac{1}{\sum_{i=1}^n a_i} \right)$$

Step 2: The degree of possibility of  $M_2 = (a_2, b_2, c_2) \geq M_1 = (a_1, b_1, c_1)$  is defined as

$$V(M_2 \geq M_1) = \sup [\min (\mu_{M_1}(x), \mu_{M_2}(x))]$$

And can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = h_G = \begin{cases} 1 & \text{if } b_2 \geq b_1 \\ 0 & \text{if } a_1 \geq c_2 \\ \frac{a_1 - c_2}{(b_2 - c_2) - (b_1 - a_1)} & \text{otherwise} \end{cases}$$

where  $d$  is the ordinate of the highest intersection point  $D$  between  $\mu_{M_1}$  and  $\mu_{M_2}$  as shown in Figure 6.

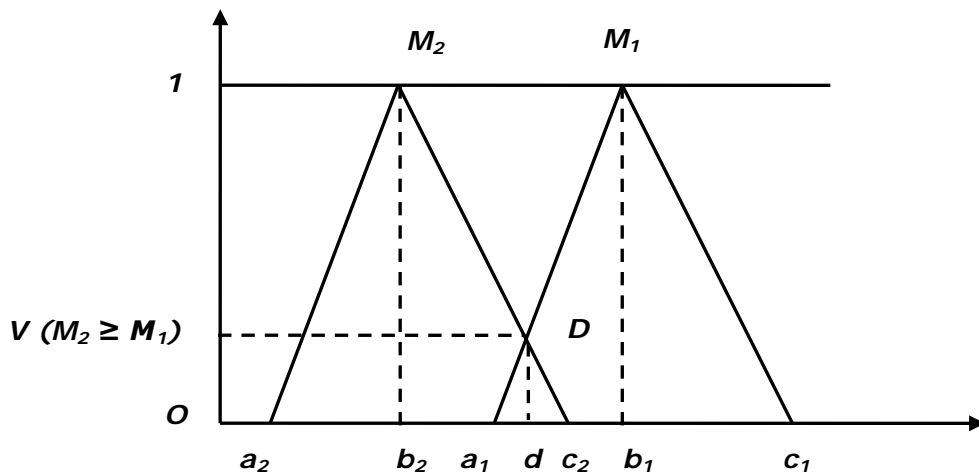


Figure 6. "The intersection between M1 and M2"

To compare  $M_1$  and  $M_2$ , both the values of  $V(M_1 \geq M_2)$  and  $V(M_2 \geq M_1)$ .

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

$$V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \dots (M \geq M_k)]$$

$$= \min V (M \geq M_i), (i = 1, 2, 3, \dots, k)$$

Assuming that

$$d' (A_i) = \min V (S_i \geq S_k)$$

for  $k = 1, 2, 3, \dots, n; k \neq i$ . Then the weight vector is given by

$$W' = (d' (A_1), d' (A_2), \dots, d' (A_n))^T$$

where  $A_i = (i = 1, 2, 3, \dots, n)$  are  $n$  elements

Step 4: By normalizing, the normalized weight vectors are

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

where  $W$  is a non-fuzzy number.

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