Performance Evaluation of Automated Teller Machine (ATM) with Fuzzy TOPSIS Using Sample Survey Results

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Abstract

The aim of this study is to propose a fuzzy multi-criterion decision model (MCDM) to evaluate the performance of ATMs of larger Pakistani banks. For this purpose six banks of Pakistani banking sector are examined and evaluated their quality performance in terms of cost-benefit criterions or factors of ATM facility. Fuzzy Technique for order performance by similarity to ideal solution (TOPSIS) is incorporated in the proposed model. Important factors of service quality are evaluated, ranked and graphically depicted. As customer's satisfaction represents a modern approach for quality in different business organizations, so in this study, we transform the decision maker's responses into direct customer's responses. Bank's performance may be evaluated in relation to a set of satisfaction factors that indicates the weak and strong points of business organizations. For this purpose we introduce the survey technique to collect the data of customer's. The study provides important results for development of banking sector.

Keywords: Performance evaluation, Multi-criterion decisions, Fuzzy,TOPSIS and Closeness Coefficient

1. Introduction

Automated Teller Machine (ATM) has become a fundamental part of banking world-wide as it is the easiest way for monetary transaction(s). There is a wide range of banks providing services of ATM by installation of ATM machines not only in their premises but off-premises-public locations. There are five main dimensions of ATM service as follows:

(a) ***Reliability****:* It relates to the accuracy, speed and 24 hours service.(b)***Tangibles****:* Must focus on the physical appearance of service (interior/exterior, decoration etc.)(c) ***Responsiveness:*** It is totally related to the bank and their staff's providing the ATMs services that how they respond to help the customer when they face the problems of card blocking/locking, machines break downs etc. (d) ***Assurance****:* It reflects the experience and knowledge of staff to overcome the technical problems. (e) ***Empathy:*** It is the judgment aspect of the customers of the banks providing the ATMs services.

All these dimensions integrate different factors of ATMs service quality. Neat and clean machines, user friendly, conveniently located, 24 hour service, correct and clear guidance machine, interbank transfer, technologically updated, quick operation machine, sufficient number of ATMs machines, waiting time, per day limit of cash withdrawal, awareness of fee charges, availability of different facilities (payment of bills), all time availability of cash, flexibility, machines breakdown and safe and secure machine etc.

Different researchers set up experimental studies for service quality of ATM's taking some of the above mentioned service quality criterions. For instance, Al-Hawari et al. (2006)studiedfive aspects of ATM i.e. user friendliness of the systems, procedures, secured, convenient locations and adequate number of ATM's. Shamsdouha et al. (2005) analyzed three service quality factors of ATM which areconvenient locations, 24 hour service and accuracy. Joseph and Stone (2003) studied the factors: user friendly, easy access to location and security that influenced the perception of customers towards the Service Quality of ATMs.Islam et al. (2005) examined level of satisfaction of ATM card holders of a top Bangladeshi bank (HBSC) by fuzzy TOPSIS.

Sun and Lin (2009) used fuzzy TOPSIS method for evaluating the competitive advantage shopping websites to select the best alternate based on 12 different criteria. Ashrafzadeh (2012) used fuzzy TOPSIS method for selection of warehouse location. Semih et.al (2009) selected shipping center site in Istanbul using combined model of fuzzy Analytical Hierarchy Process(AHP) and fuzzy TOPSIS model. In this study we incorporated fuzzy TOPSIS model for ranking service quality criterions of ATMs.

In this study we incorporated all these factors of ATMs Service Quality,analyzeand prioritizethem,using Fuzzy TOPSIS methodology. The remaining paper is organized as follows: Fuzzy TOPSIS algorithm discussed in section 2, Data collection methodology is discussed in Section 3, Results obtained using Fuzzy TOPSIS algorithm in Section4 and finally we summarized the results in Section 5.

2. Fuzzy Topsis Algorithm

Chen (2000) proposed the following algorithm of Fuzzy TOPSIS:

Step 1: firstly, decision maker's team is formed. The team has K decision makers,fuzzy rating of each decision maker D_K for (k = 1, 2…k) can be represented by triangular/quadrilateral fuzzy numbers such as $\tilde{x}_k = (k = 1, 2, ...k)$ with membership function $\tilde{\Psi}_k(x)$

Step 2: Criteria evaluation is determined.

Step 3: Choose the appropriate linguistic variables for importance weight of criteria and linguistic ratings for alternatives w.r.t criteria.

Step 4: Aggregate the performance rating of each alternatives and criteria weights as follows:

$$\tilde{w}_j = \frac{1}{k}\left(\tilde{w}_{j,1} + \tilde{w}_{j,2} + \ldots \tilde{w}_{j,k}\right)$$

$$\tilde{x}_{ij} = \frac{1}{k}\left(\tilde{x}_{ij}^{1} + \tilde{x}_{ij}^{2} + \ldots + \tilde{x}_{ij}^{k}\right)$$

Where x_{ij} and w_j are aggregated performance rating of each alternative and criteria weight, respectively.

Step 5: Construct fuzzy decision matrix $D = \left[\tilde{x}_{ij}\right]_{m*n}$ with 'n' criterions and'm' alternatives for K decision makers.

Step 6: Normalize the decision matrix.

The normalization matrix of fuzzy decision $\tilde{R}$ shownas follows

$\tilde{R} = [r_{ij}]_{m*n}$, i = 1, 2. . .m andj = 1, 2,. . . ,n

$$\tilde{R} = \begin{array}{c|ccc} & C_1 & C_j & C_n \\ \hline A_1 & r_{1,1} & r_{1,j} & r_{1,n} \\ A_i & r_{i,1} & r_{i,j} & r_{i,n} \\ A_m & r_{m,1} & r_{m,j} & r_{m,n} \end{array}$$

Here, alternative $A_i, i = 1, 2, ..., m$, criterion $C_j, j = 1, 2, ..., n$ and r_{ij}areelement of normalized decision matrix. The normalization aim isdual i.e. It ensures that all triangular fuzzy numbers are in range within interval [0, 1]. To compare heterogeneous criteria, the normalization is necessary. In the process of normalization, different equations have to be applied to cost criteria and benefit criteria. The normalization is as follows;

$$\tilde{r}_{ij} = \frac{\tilde{x}_{ij}}{c_j^+} = \left(\frac{a_{xij}}{c_j^+}; \frac{b_{xij}}{c_j^+}; \frac{c_{xij}}{c_j^+}\right) \quad j \in B \qquad (3.1)$$

Where $c_j^+ = \max(c_{xij}) \; \forall_i = 1, ..., m \in B$, and B represents the benefit criteria

$$\tilde{r}_{ij} = \frac{\bar{a}_j}{\tilde{x}_{ij}} = \left(\frac{\bar{a}_j}{c_{xij}}; \frac{\bar{a}_j}{b_{xij}}; \frac{\bar{a}_j}{a_{xij}} \right) j \in C \quad (3.2)$$

Where $\bar{a_j} = \min(a_{Xij}) \ \forall_i = 1,....,m \in C$, and C represents the cost criteria

Step 7:Compute the weighted normalized decision matrix. For this purpose, firstly, consider the different weights of each criterion,then multiplying the normalized decision matrix with weight of criteria evaluation.∇ is denoted as weighted normalized decision matrix.

$\nabla = [\tilde{v}_{ij}]_{m*n}$ i= 1,2.....m; j= 1,2.....n

$$V = \begin{array}{c|ccc} & C_1 & C_j & C_n \\ \hline A_1 & \tilde{v}_{1,1} & \tilde{v}_{1,j} & \tilde{v}_{1,n} \\ A_i & \tilde{v}_{i,1} & \tilde{v}_{i,j} & \tilde{v}_{i,n} \\ A_m & \tilde{v}_{m,1} & \tilde{v}_{m,j} & \tilde{v}_{m,n} \end{array}$$

$\forall i = 1, \ldots, m$

$\forall j = 1, \ldots, n$ (3.3)

Where $\tilde{v}_{ij} = \tilde{r}_{ij} * \tilde{w}_j$ fuzzy normalized number ranges in [0, 1].

Step 8:Determine the fuzzy positive ideal solution A^+ and fuzzy negative ideal solution A^-. After normalization, we know that each element v_{ij} of fuzzyweighted normalize matrix lies within the interval [0, 1], so the formulae defined for fuzzy positive ideal solution and fuzzy negative ideal solution are as follows:

$A^+ = (\tilde{v}_1, \tilde{v}_2, ..., \tilde{v}_j)$, Where $\tilde{v}_j = \max v_{ij}$ for Band $\min v_{ij}$ for C

$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_j^-)$, Where $\tilde{v}_j^- = \min v_{ij}$ for Band $\max v_{ij}$ for C

Or simply it can be defined as:

$A^+ = (\tilde{v}_1, \tilde{v}_2, ..., \tilde{v}_j)$, $A^- = (\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_j^-)$ (3.4)

Where $\tilde{v}_j = (1,1,1)$, $\tilde{v}_j^- = (0,0,0)$, j= 1, 2, …,n

Step 9: Compute the n-dimensional separation distances of each criterion j=1, 2… m to fuzzy positive-ideal solution $A^+$and fuzzy negative-ideal solutionA^-.

$$d_j^+ = \sum_{i=1}^{m} d(\tilde{v}_{ij}, \tilde{v}_j) \ ; \quad i= 1, 2 ...m; \quad j=1, 2 ...n (3.5)$$

$$d_j^- = \sum_{i=1}^{m} d(\tilde{v}_{ij}; \tilde{v}_j^-) \ ; i= 1, 2 ...m; \quad j=1, 2 ...n \quad (3.6)$$

$d_j^+ \in R^+, d_j^- \in R^+$

Where d_j^+ is separation distances from positive-ideal solution and d_j^- is separation distances from negative-ideal solution respectively.

Step 10: Calculate the relative 'closeness index' of each alternatives or criterion by using;

$$C_j = \frac{d_j^-}{d_j^- + d_j^+} \quad (3.7)$$

Where $C_j \in [0,1]$ is closeness index

The value of closeness index close to 1 gives the optimal alternativeor criteria. Closeness coefficient determined the ranking of alternatives. Such that the coefficient having value nearer to 1 is ranked high while value far from 1 ranked lowest.

3. Data Collection Survey

In this study survey was conducted to collect the opinions of ATM users and service provider of ATM for the ATM's Service Quality factors. For this purpose, we selected the six ATMs booths of different banks of Islamabad, the capital city of Pakistan. The findings of the study, research involves the use of questionnaire as well as structured interviews. The questionnaire was distributed using convenience sampling as well as judgmental sampling technique to a number of ATM users and to staff that are the responsible of operations of ATMs in each six banks. Convenience sampling is the type of sampling in which the sample is selected such that it is convenient to take because it is easy to use when the factor is time, location and cost. Whereas, in judgmental sampling, the sample is selected on the basis of the survey conductor (enumerator),because this is claimed that enumerator knows the units in the population. So they can determine that which unit should be included in the sample and which not. The managerial charge of ATM operations of each selected bank was targeted for the criterions weights.

3.1 Sample Size

Since the population is large sowe used the convenience/accidental sampling as well as judgmental sampling. As for qualitative research the start of sample size is typically considered to be small. So we considered the sample of 100 customers and 6 representatives from the banks. Then we divided the samples of 100 customers into sub-samples and each sub-sample contained different number of customers. For the alternatives rating, data was collected by the ATM customers. But for the criterion weights data was collected from the management of each selected bank.

3.2 Data Source and Data Collection Tool

For studying and investigation of Service Quality, different researchers have used different methods to collect the data. These methods include interview studies, experimental studies, literature review and observational studies. In this study, primary data was collected through questionnaire (see Appendix.1) from six ATM booths of selected banks.

3.3 Data Organization

We collected the opinions of customers from the 6 ATMs of different banks. Then we separated the data. In the next step, each service quality factor was chosen separately as a mode from each ATMs data (Appendix.1). Then we combined all the modes of each service quality factor for alternative rating and converted into linguistic variables. The responses from banks management are also obtained and converted into linguistic variables (Appendix.3).

4. Analysis of Data by Fuzzy TopsisAlgorithm

We consider the 17 factors (as indicated above) of service quality as criterions and responses of customers to 6 ATMs machines from different banks as an Alternatives in fuzzy TOPSIS, namely as A1, A2, A3, A4, A5, A6 respectively.

In fuzzy TOPSIS method decision makers have right to judge the importance of each criterion and as well as performance of alternative ratings. But in this study we used the customer responses and staff responses as alternative ratings and criterion weights. For alternative ratings, we already used the mode asaverage from different ATMs and then combined all of them into a matrix. So there is no need to find the aggregated mean of those alternatives. Simply we put all those opinions into linguistic variables. But for criterion weights, we need to find aggregated mean because we get all those responses from just one member of staff from each ATM.

Thus first of all, we set linguistic scales to evaluate the importance of criteria weights and alternative ratings based on opinions. The triangular fuzzy numbers for criterion and alternative rating are shown in Table 1 and Table.2 respectively by using the relation a≤ b≤ c. The criteria weights lie within the interval [0, 1] whereas; the alternative ratings lie within 1 to 10 scales (Goli, 2013).

Table.1: Linguistic Variable for Importance of Weight of Each Criterion

Linguistic variable	Triangular fuzzy numbers
Very Low (VL)	(0.0, 0.1, 0.3)
Low (L)	(0.1, 0.3, 0.5)
Medium (M)	(0.3, 0.5, 0.7)
High (H)	(0.5, 0.7, 0.9)
Very High (VH)	(0.7, 0.9, 0.9)

Table.2: Fuzzy Rating of Alternatives

Linguistic variable	Triangular fuzzy numbers
Very Poor (VP)	(1,1,3)
Poor (P)	(1,3,5)
Fair (F)	(3,5,7)
Good (G)	(5,7,9)
Very Good (VG)	(7,9,9)

Step 1.Alternative versus service quality factors was considered. The alternatives are denoted by A1, A2, A3, A4, A5, and A6 respectively.

Step2. In the next step the important criterions used for service quality factors of ATMs was identified. The 17 important criteria used in this study are:

User friendly, Neat and Clean machine,Adequate number of ATM machines, Conveniently located,Correct and Clear guidance machine,Flexibility,24 hour service,Availability of cash all the time,Quick operation machine,Safe & secure machines, per day limit of cash withdraw,Other facilities availability, Interbank transfer,Machines breakdown,Technological updating,Waiting time (queues),Awareness of fee charged and these are denoted by C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, and C17 respectively.

Step 3.The weights to the criterions of service quality were assigned by using the linguistic variables. Similarly the alternatives rating are worked out using Table.2.

Table.3: Criterion Weights Using Linguistic Variables

Criterions	Responses					
C1	VH	H	H	H	H	H
C2	H	H	M	H	VH	L
C3	H	L	H	M	H	H
C4	H	M	L	H	M	VL
C5	H	H	H	H	VH	H
C6	L	M	H	H	L	VH
C7	L	M	L	H	VL	H
C8	L	H	L	L	L	VL
C9	M	M	L	M	H	VL
C10	M	H	L	M	VH	M
C11	M	H	L	L	L	L
C12	VH	VH	H	L	H	VH
C13	M	VH	VL	H	H	VH
C14	H	VH	VH	H	VH	M
C15	VH	M	L	H	VH	M
C16	VL	H	H	H	VL	VH
C17	H	H	H	H	M	VH

Step 4. The transformation of opinions for criterion weights into linguistic variables is shown in Table.3. Then aggregated the criterion weights and the result is shown in Table .4 and the aggregated alternativerating (fuzzy decision matrix) is shown in Table.5

Table.4: Aggregated Fuzzy Weights for Criterion

Criterions	Aggregated fuzzy weights
C1	(0.53,0.73, 0.90)
C2	(0.43, 0.63, 0.80)
C3	(0.40, 0.60, 0.80)
C4	(0.66, 0.46, 0.66)
C5	(0.53, 0.73, 0.90)
C6	(0.35, 0.53, 0.70)
C7	(0.25, 0.43, 0.63)
C8	(0.15, 0.33, 0.53)
C9	(0.25, 0.43, 0.63)
C10	(0.26, 0.46, 0.66)
C11	(0.26, 0.46, 0.66)
C12	(0.53, 0.73, 0.83)
C13	(0.60, 0.80, 0.86)
C14	(0.56, 0.76, 0.86)
C15	(0.43, 0.63, 0.76)
C16	(0.36, 0.53, 0.70)
C17	(0.50, 0.70, 0.86)

Table.5 Aggregated Rating of Alternatives (Fuzzy Decision Matrix)

	A1	A2	A3	A4	A5	A6
C1	(7,9,9)	(7,9,9)	(7,9,9)	(1,3,5)	(5,7,9)	(7,9,9)
C2	(3,5,7)	(3,5,7)	(5,7,9)	(3,5,7)	(7,9,9)	(1,3,5)
C3	(1,3,5)	(5,7,9)	(3,5,7)	(1,3,5)	(5,7,9)	(5,7,9)
C4	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)
C5	(5,7,9)	(5,7,9)	((5,7,9)	(3,5,7)	(5,7,9)	(7,9,9)
C6	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(7,9,9)
C7	(1,3,5)	(1,3,5)	(3,5,7)	(1,3,5)	(5,7,9)	(1,3,5)
C8	(5,7,9)	(3,5,7)	(1,3,5)	(1,3,5)	(5,7,9)	(1,3,5)
C9	(5,7,9)	(5,7,9)	(3,5,7)	(3,5,7)	(5,7,9)	(5,7,9)
C10	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(3,5,7)
C11	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(5,7,9)	(1,3,5)
C12	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,9)	(5,7,9)	(7,9,9)
C13	(5,7,9)	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)	(5,7,9)
C14	(5,7,9)	(3,5,7)	(7,9,9)	(5,7,9)	(5,7,9)	(5,7,9)
C15	(5,7,9)	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(5,7,9)
C16	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)	(1,3,5)	(5,7,9)
C17	(3,5,7)	(5,7,9)	(7,9,9)	(5,7,9)	(3,5,7)	(7,9,9)

Step 5. The fuzzy decision matrix was normalized for benefit criterion and cost criteria usingequation(3.2) and equation(3.3) respectively. The criterions C1, C2, C3, C4, C14, and C16 are considered as cost criterion whereas C5, C6, C7, C8, C9, C10, C11, C12, C13, C15, and C17 are taken as benefit criterion. The normalized decision matrix is given in Table.6 as shown below:

Table.6: Normalized Fuzzy Decision Matrix

	A1	A2	A3	A4	A5	A6
C1	(.11,.11,0.14)	(.11,.11,.14)	(.11,.11,.14)	(.2,.33,1.0)	(.11,.14,.20)	(.11,.11,.14)
C2	(.14,.20,.33)	(.14,.20,.33)	(.11,.14,.20)	(.14,.20,.33)	(.11,.11,.14)	(.20,.33,1.0)
C3	(.20,.33,1.0)	(.11,.14,.20)	(.14,.20,.33)	(.2,.33,1.0)	(.11,.14,.20)	(.11,.14,.20)
C4	(.33,.42,.60)	(.33,.42,.60)	(.33,.42,.60)	(.33,.42,.60)	(.42,.60,1.0)	(.42,.60,1.0)
C5	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.33,.55,.77)	(.55,.77,1.0)	(.77,1.0,1.0)
C6	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.33,.55,.77)	(.55,.77,1.0)	(.77,1.0,1.0)
C7	(.11,.33,.55)	(.11,.33,.55)	(.33,.55,.77)	(.11,.33,.55)	(.55,.77,1.0)	(.11,.33,.55)
C8	(.55,.77,1.0)	(.33,.55,.77)	(.11,.33,.55)	(.11,.33,.55)	(.55,.77,1.0)	(.11,.33,.55)
C9	(.55,.77,1.0)	(.55,.77,1.0)	(.33,.55,.77)	(.33,.55,.77)	(.55,.77,1.0)	(.55,.77,1.0)
C10	(.55,.77,1.0)	(.33,.55,.77)	(.55,.77,1.0)	(.33,.55,.77)	(.33,.55,.77)	(.33,.55,.77)
C11	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.11,.33,.55)	(.55,.77,1.0)	(.11,.33,.55)
C12	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.77,1.0,1.0)	(.55,.77,1.0)	(.77,1.0,1.0)
C13	(.55,.77,1.0)	(.77,1.0,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)
C14	(.33,.42,.60)	(.42,.60,1.0)	(.33,.33,.42)	(.33,.42,.60)	(.33,.42,.60)	(.33,.42,.60)
C15	(.55,.77,1.0)	(.55,.77,1.0)	(.55,.77,1.0)	(.33,.55,.77)	(.55,.77,1.0)	(.55,.77,1.0)
C16	(.14,.20,.33)	(.11,.14,.20)	(.11,.14,.20)	(.11,.14,.20)	(.20,.33,1.0)	(.14,.20,.33)
C17	(.33,.55,.77)	(.55,.77,1.0)	(.77,1.0,1.0)	(.55,.77,1.0)	(.33,.55,.77)	(.77,1.0,1.0)

Step 6: The weighted normalized decision matrix was computed by multiplying the weights of each criterion to the values of normalized fuzzy decision matrix. The computed weighted matrix is shown in Table.7 as below:

Table.7: Weighted Normalized Decision Matrix

Criterions	A1	A2	A3
C1	(.058,.080,.126)	(.058,.080,.126)	(.058,.080,.126)
C2	(.060,.126,.264)	(.060,.126,.264)	(.047,.088,.160)
C3	(.080,0.198,.800)	(.044,.084,.160)	(.056,.120,.264)
C4	(.218,.1932,.396)	(.218,.193,.396)	(.218,.193,.396)
C5	(.292,.5621,.900)	(.2915,.5621,.900)	(.292,.562,.900)
C6	(.193,.4081,.700)	(.1925,.4081,.700)	(.193,.408,.700)
C7	(.028,.1419,.346)	(.2075,.1419,.346)	(.083,.237,.485)
C8	(.083,.2541,.530)	(.049,.1815,.408)	(.016,.1089,.291)
C9	(.138,.331,.630)	(.138,.331,.630)	(.083,.237,.485)
C10	(.143,.354,.660)	(.086,.253,.508)	(.143,.354,.660)
C11	(.143,.354,.660)	(.143,.354,.660)	(.143,.354,.660)
C12	(.292,.562,.830)	(.292,.562,.830)	(.292,.562,.830)
C13	(.330,.616,.860)	(.462,.800,.860)	(.33,.616,.860)
C14	(.185,.3192,.516)	(.235,.456,.860)	(.185,.251,.361)
C15	(.237,.485,.760)	(.237,.485,.760)	(.237,.485,.760)
C16	(.050,.106,.231)	(.039,.074,.140)	(.039,.074,.140)
C17	(.165,.385,.662)	(.275,.539,.860)	(.385,.700,.860)

	A4	A5	A6
C1	(.106,.241,.900)	(.058,.102,.180)	(.058,.080,.126)
C2	(.060,.126,.264)	(.047,.069,.112)	(.086,.208,.800)
C3	(.080,.198,.800)	(.044,.084,.160)	(.044,.084,.160)
C4	(.218,.193,.396)	(.277,.276,.660)	(.277,.276,.660)
C5	(.175,.402,.693)	(.295,.562,.900)	(.408,.730,.900)
C6	(.116,.292,.539)	(.195,.408,.700)	(.269,.530,.700)
C7	(.028,.142,.347)	(.138,.331,.630)	(.027,.141,.346)
C8	(.016,.109,.292)	(.083,.254,.53)	(.016,.108,.291)
C9	(.083,.237,.485)	(.138,.331,.63)	(.138,.331,.630)
C10	(.086,.253,.508)	(.086,.253,.508)	(.086,.253,.508)
C11	(.029,.152,.363)	(.143,.354,.660)	(.028,.152,.363)
C12	(.408,.730,.830)	(.292,.562,.830)	(.408,.730,.830)
C13	(.330,.616,.860)	(.330,.616,.860)	(.330,.616,.860)
C14	(.185,.319,.516)	(.185,.319,.516)	(.184,.319,.516)
C15	(.142,.347,.585)	(.237,.485,.760)	(.236,.485,.760)
C16	(.039,.074,.140)	(.072,.175,.700)	(.050,.106,.231)
C17	(.275,.539,.860)	(.165,.385,.662)	(.385,.700,.860)

Step 7:The fuzzy negative ideal (A^-) and fuzzy positive ideal (A^+) solution was determined. As we know the values of normalized fuzzy decision matrix lies within the interval [0, 1]. This is 0 for negative ideal solution (NIS) and 1 for positive ideal solution (PIS) using equation (3.4); the results are shown in Table.8 and Table.9.

Table.8: Fuzzy Positive Ideal Solution (A^+)

Criterions	A1	A2	A3	A4	A5	A6
C1	.9124	.9124	.9124	.6795	.9124	.9124
C2	.8542	.8542	.9082	.8542	.9243	.7077
C3	.7140	.9052	.8577	.7140	.9052	.9052
C4	.7365	.7365	.7365	.7365	.6224	.6224
C5	.4843	.4843	.4843	.6146	.4843	.3800
C6	.6034	.6034	.6034	.7063	.6034	.5305
C7	.8384	.8384	.7505	.8384	.6653	.8384
C8	.7346	.8007	.8685	.8685	.7346	.8685
C9	.6653	.6653	.7505	.7505	.6653	.6653
C10	.6498	.7383	.6498	.7383	.7383	.7383
C11	.6498	.6498	.6498	.8304	.6498	.8304
C12	.4907	.4907	.4907	.3882	.4907	.3882
C13	.4531	.3410	.4531	.4531	.4531	.4531
C14	.6738	.5478	.6738	.6738	.6738	.6738
C15	.5494	.5494	.5494	.6671	.5494	.5494
C16	.8741	.9163	.9163	.9163	.7375	.8741
C17	.6296	.5025	.4032	.5025	.6296	.4032

Table.9: Fuzzy Negative Ideal Solution (A^-)

Criterions	A1	A2	A3	A4	A5	A6
C1	.0924	.0924	.0924	.5413	.1241	.0924
C2	.1724	.1724	.1088	.1724	.0807	.4797
C3	.4780	.1073	.1705	.4780	.1073	.1073
C4	.2837	.2837	.2837	.2837	.4429	.4429
C5	.6353	.6353	.6353	.4733	.6353	.7093
C6	.4808	.4808	.4808	.3600	.4808	.5302
C7	.2167	.2167	.3152	.2167	.4185	.2167
C8	.3426	.2594	.1799	.1799	.3426	.1799
C9	.4185	.4185	.3152	.3152	.4185	.4185
C10	.4402	.3314	.4402	.3314	.3314	.3314
C11	.4402	.4402	.4402	.2277	.4402	.2277
C12	.6027	.6027	.6027	.6802	.6027	.6802
C13	.6397	.7287	.6397	.6397	.6397	.6397
C14	.3661	.5781	.3661	.3661	.3661	.3661
C15	.5381	.5381	.5381	.4011	.5381	.5381
C16	.1495	.0942	.0942	.0942	.4186	.1495
C17	.4523	.6071	.6071	.6071	.4532	.6776

Step 8: As the distances from each criterion to fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) are computed in the above step. In this step we then summed up all distances of each criterion by using equation (3.5) and (3.6) respectively and results are shown in Table.10.

Table.10: Distances ofCriterions from A^+ and A^-

Criterions	d_{j+}	d_{j-}
C1	5.2415	1.0350
C2	5.1026	1.1864
C3	5.0013	1.4484
C4	4.1908	2.0206
C5	2.9318	3.7238
C6	3.6504	2.8134
C7	4.7694	1.6005
C8	4.8754	1.4843
C9	4.1622	2.3044
C10	4.2528	2.2060
C11	4.2600	2.2162
C12	2.7392	3.7712
C13	2.6065	3.9272
C14	3.9168	2.4086
C15	3.4141	3.0916
C16	5.2346	1.0002
C17	3.0706	3.4740

Step 9: Now we calculate the criterion 'closeness coefficient index' by using the equation (3.7). Closeness coefficient value close to 1 shows the optimal criterion. Then determined the ranking of each criterion along with closeness coefficient values and the results are shown in Table.11.

Table.11: Closeness Coefficient and Ranking of Criterions

Criterions	d_{j-}	$d_{j-} + d_{j+}$	C_j	Rank
C1	1.0350	6.2765	0.1649	16
C2	1.1864	6.2890	0.1886	15
C3	1.4484	6.4497	0.2245	14
C4	2.0206	6.2114	0.3253	11
C5	3.7238	6.6556	0.5594	03
C6	2.8134	6.4638	0.4352	06
C7	1.6005	6.3699	0.2512	12
C8	1.4843	6.3597	0.2333	13
C9	2.3044	6.4666	0.3563	08
C10	2.206	6.4588	0.3415	10
C11	2.2162	6.4762	0.3422	09
C12	3.7712	6.5104	0.5792	02
C13	3.9272	6.5337	0.6010	01
C14	2.4086	6.3254	0.3807	07
C15	3.0916	6.5057	0.4752	05
C16	1.0002	6.2348	0.1604	17
C17	3.4740	6.5446	0.5308	04

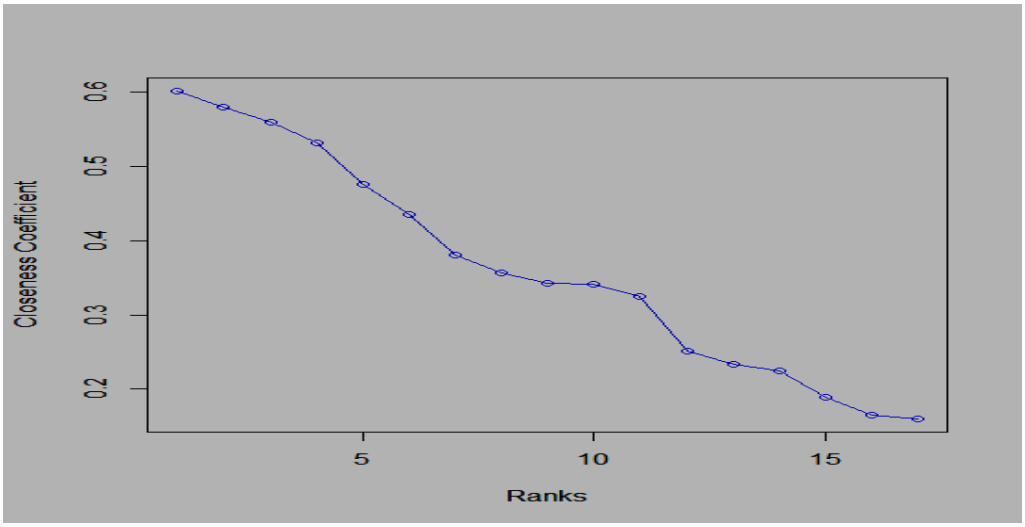
Step 10: The prioritized factors of service quality of ATMs with respect to'closeness coefficients' can be shown as in Table.12.

Table.12: Prioritized factors of Service Quality of ATMs

Rank	C_j	Factors
1	0.6010	Interbank Transfer(C13)
2	0.5792	Availability of other facilities(C12)
3	0.5594	Correct & Clear guidance(C5)
4	0.5308	Awareness of fee charged(C17)
5	0.4752	Technological updating(C15)
6	0.4352	Flexibility(C6)
7	0.3807	Machines Breakdown(C14)
8	0.3563	Quick operations(C9)
9	0.3422	Per day limit of cash(C11)
10	0.3415	Safe & secured machines(C10)
11	0.3253	Neat & clean machines(C2)
12	0.2512	Sufficient number of ATMs(C3)
13	0.2333	Availability of cash all the time(C8)
14	0.2245	24 hour service(C7)
15	0.1886	Conveniently located(C4)
16	0.1649	User friendly(C1)
17	0.1604	Waiting times(C16)

The values of closeness coefficient corresponding to ranked factors of Service Quality of ATMs can be depicted as below(Fig.1):

Fig.1:Ranks VS Closeness Coefficient



The factor C13-Interbank Transfer, ranked first as it has closeness coefficient value closer to 1 while factor C16-Waiting time, ranked the lowest and it has value of closeness coefficient closer to 0. Similarly, all other factors are ranked corresponding to their closeness coefficient values. High ranked values indicate the customer's satisfaction towards the factor(s) but lower ranked values indicate the customer's dissatisfaction. Similarly satisfaction/dissatisfaction of customers regarding remaining factors can be seen from the above exponentially decay graph (see Fig.1).

5. Conclusion and Remarks

The performance evaluation of banking sector is a multi-criteria decision-making problem including both quantitative and qualitative. In this paper, we presented a multi-criteria decision-making approach for performance evaluation of ATMs of different banks in Pakistan under fuzzy environment. The proposed approach comprises of two steps. In step 1, the criteria are identified.

These criterions are user friendly, neat and clean machine, Adequate number of ATM machines, Conveniently located, Correct and Clear guidance machine, Flexibility, 24 hour service, Availability of cash all the time, Quick operation machine, Safe & secure machines, Per day limit of cash withdraw, Other facilities availability, Interbank transfer, Machines breakdown, Technological updating, Waiting time (queues),Awareness of fee charged. In step 2, the experts and customers provided linguistic ratings to the criteria and the alternatives respectively. Fuzzy TOPSIS is used to aggregate the ratings and generate an overall performance score for measuring each alternative.

We carried out this study in Islamabad, Pakistan. The results indicate that there are some important factors that should be improved to get more satisfaction of customers such as to install more ATMs at secured area which may help to reduce the waiting time and risk in cash. Focus should be given on neatness (interior/exterior) of machines, make more user friendly, to provide the 24 hour service with quick operations and the cash availability all the times especially on weekends, ending days of month, and Eidholidays etc.The study could be helpful tointer-alia and to the banking sector of the country to make new policies, decisions and plans to improve those service quality factors that are ranked lowest to attract more customers with greater convenience.

This study may be further extended as follows:

1. Others method such as Data Envelopment Analysis(DEA) may be used to evaluate the performance and compare those results with the above study.
2. Ranking may be applied to alternatives rather than criteria
3. Performance may be evaluated using trapezoidal/quadrilateral fuzzy numbers in TOPSIS.
4. Sensitive analysis may be conducted to evaluate the influence of criteria weights on closeness coefficient(ranking).

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Appendix.1

Questionnaire

Instructions:Pleasemarkthe mostappropriateboxagainsteachquestion

LikertScale:Strongly Disagree(SD),Disagree(DA),Neutral (N),Agree(A),StronglyAgree(SA)

S.No.	Statements	SD	DA	N	A	SA
1	ATMs are more user friendly machine.					
2	The machines are neat and clean in appearance.					
3	The number of ATMs is sufficient.					
4	ATMs are located at convenient places.					
5	The functions of ATMs are easily understandable.					
6	Machine can understand customer need perfectly.					
7	Services are accessible all the times.					
8	Required amount of money are available all the time.					
9	It provides the speedy operations all the time.					
10	The risk of cash with the use of ATMs is low.					
11	The limit of cash Availability per day is satisfactory.					
12	It provides the availability of balance inquiry, mini-statement and change of personal identification number etc.					
13	It provides the facility to pay bills and transferring the funds.					
14	Have you ever faced the problem of card locking, machine breakdown etc.					
15	Do you satisfy with the technological updating for the service?					
16	Do you never wait in long queues to receive the service?					
17	Do you have an idea about the fee charged while using an ATM not owned by your bank?					

Appendix.2

Alternative.1(Respondents=15)

Q.No.	**SD**	**DA**	**N**	**A**	**SA**	**Mode**
1	-	-	1	5	9	SA=9
2	1	2	7	5	-	N=7
3	-	8	3	4	-	DA=8
4	-	4	5	6	-	A=6
5	-	2	1	8	4	A=8
6	1	3	3	6	2	A=6
7	4	5	3	3	-	DA=5
8	2	3	5	5	-	A=5
9	1	4	3	6	1	A=6
10	1	1	5	5	3	A=5
11	1	1	6	6	1	A=6
12	-	-	4	8	3	A=8
13	-	-	4	10	1	A=10
14	-	3	1	8	3	A=8
15	-	-	6	8	1	A=8
16	1	2	5	5	2	N=5
17	-	2	5	3	4	N=5

Alternative.2(Respondents=20)

Q.No.	SD	DA	N	A	SA	Mode
1	2	1	-	8	9	SA=9
2	-	2	9	8	1	N=8
3	2	4	6	8	-	A=8
4	-	3	7	8	2	A=8
5	1	-	1	10	8	A=10
6	1	-	4	10	5	A=10
7	3	8	6	2	1	DA=8
8	2	6	6	5	1	N=6
9	2	3	6	6	3	A=6
10	1	4	6	6	3	N=6
11	2	3	4	10	1	A=10
12	1	1	2	10	6	A=10
13	1	3	4	6	6	SA=6
14	2	5	6	3	4	N=6
15	1	3	5	11	-	A=11
16	1	6	3	9	1	A=9
17	4	2	-	13	1	A=13

Alternative.3(Respondents=20)

Q.No.	SD	DA	N	A	SA	Mode
1	-	-	-	8	12	SA=12
2	-	2	3	9	6	A=5
3	-	5	5	5	5	N=5
4	2	4	6	7	1	A=7
5	-	-	1	12	7	A=12
6	-	6	3	7	4	A=7
7	5	4	6	4	1	N=6
8	1	7	6	4	2	DA=7
9	1	1	9	7	2	N=9
10	1	4	5	8	2	A=8
11	1	4	6	7	2	A=7
12	-	1	4	8	7	A=8
13	1	3	2	10	4	A=10
14	3	3	3	4	7	SA=7
15	-	2	5	10	3	A=10
16	3	3	5	7	2	A=7
17	2	4	2	3	9	SA=9

Alternative.4(Respondents=12)

Q.No.	SD	DA	N	A	SA	Mode
1	1	4	3	4	-	DA=4
2	-	4	4	4	-	N=4
3	1	5	3	3	-	DA=5
4	3	3	2	4	-	A=4
5	1	2	6	2	1	N=6
6	2	1	5	4	-	N=5
7	2	8	-	1	1	DA=8
8	1	5	4	1	1	DA=5
9	2	3	5	1	1	N=5
10	-	3	5	4	-	N=5
11	1	6	2	2	1	DA=6
12	1	1	1	4	5	SA=5
13	2	2	-	5	3	A=5
14	1	-	2	8	1	A=8
15	2	3	4	3	-	N=4
16	1	2	2	4	3	A=4
17	1	1	4	4	2	A=4

Alternative.5(Respondents=10)

Q.No.	SD	DA	N	A	SA	Mode
1	-	-	-	7	3	A=7
2	1	1	3	2	3	SA=3
3	-	2	3	5	-	A=5
4	-	2	4	4	-	N=4
5	-	-	2	5	3	A=5
6	-	1	-	7	2	A=7
7	1	3	3	3	-	A=3
8	-	2	-	6	2	A=6
9	-	1	3	5	1	A=5
10	-	1	4	3	2	N=4
11	-	3	1	4	2	A=4
12	-	-	2	8	-	A=8
13	-	1	2	6	1	A=6
14	-	1	2	5	2	A=5
15	-	-	2	6	2	A=6
16	1	4	3	2	-	DA=4
17	1	5	4	-	-	N=4

Alternative.6(Respondents=20)

Q.No.	SD	DA	N	A	SA	Mode
1	-	1	2	8	9	SA=9
2	1	7	5	3	4	DA=7
3	2	5	3	8	2	A=8
4	3	4	7	3	3	N=7
5	-	3	1	8	8	SA=8
6	-	3	3	5	9	SA=9
7	3	7	4	5	1	DA=7
8	1	8	7	4	-	DA=8
9	4	3	4	7	2	A=7
10	-	1	8	7	4	N=8
11	3	7	1	7	2	DA=7
12	-	2	-	8	10	SA=10
13	-	-	1	10	9	A=10
14	1	1	3	9	6	A=9
15	-	1	4	8	7	A=8
16	3	1	6	6	4	A=6
17	3	2	2	6	7	SA=7

Appendix.3

Combined Customer's Responses for Alternatives

Criterions	A1	A2	A3	A4	A5	A6
1	SA	SA	SA	DA	A	SA
2	N	N	A	N	SA	DA
3	DA	A	N	DA	A	A
4	A	A	A	A	N	N
5	A	A	A	N	A	SA
6	A	A	A	N	A	SA
7	DA	DA	N	DA	A	DA
8	A	N	DA	DA	A	DA
9	A	A	N	N	A	A
10	A	N	A	N	N	N
11	A	A	A	DA	A	DA
12	A	A	A	SA	A	SA
13	A	SA	A	A	A	A
14	A	N	SA	A	A	A
15	A	A	A	N	A	A
16	N	A	A	A	DA	A
17	N	A	SA	A	N	SA

Transformation of combined customer's response into linguistic variable for Alternatives

Criterions	A1	A2	A3	A4	A5	A6
1	VG	VG	VG	P	G	SA
2	F	F	G	F	VG	DA
3	P	G	F	P	G	A
4	G	G	G	G	F	N
5	G	G	G	F	G	SA
6	G	G	G	F	G	SA
7	P	P	F	P	G	DA
8	G	F	P	P	G	DA
9	P	G	F	F	G	A
10	G	F	G	F	F	N
11	G	G	G	P	G	DA
12	G	G	G	VG	G	SA
13	G	VG	G	G	G	A
14	G	F	VG	G	G	A
15	G	G	G	F	G	A
16	F	G	G	G	P	A
17	F	G	VG	G	F	SA

Management responses for criterion weights with linguistics variables in parenthesis

Criterions			Responses			
1	SA(VH)	A(H)	A(H)	A(H)	A(H)	A(H)
2	A(H)	A(H)	N(M)	A(H)	SA(VH)	DA(L)
3	A(H)	DA(L)	A(H)	N(M)	A(H)	A(H)
4	A(H)	N(M)	DA(L)	A(H)	N(M)	SD(VL)
5	A(H)	A(H)	A(H)	A(H)	SA(VH)	A(H)
6	DA(L)	N(M)	A(H)	A(H)	DA(L)	SA(VH)
7	DA(L)	N(M)	DA(L)	A(H)	SD(VL)	A(H)
8	DA(L)	A(H)	DA(L)	DA(L)	DA(L)	SD(VL)
9	N(M)	N(M)	DA(L)	N(M)	A(H)	SD(VL)
10	N(M)	A(H)	DA(L)	N(M)	SA(VH)	N(M)
11	N(M)	A(H)	DA(L)	DA(L)	DA(L)	DA(L)
12	SA(VH)	SA(VH)	A(H)	DA(L)	A(H)	SA(VH)
13	N(M)	SA(VH)	SD(VL)	A(H)	A(H)	SA(VH)
14	A(H)	SA(VH)	SA(VH)	A(H)	SA(VH)	N(M)
15	SA(VH)	N(M)	DA(L)	A(H)	SA(VH)	N(M)
16	SD(VL)	A(H)	A(H)	A(H)	SD(VL)	SA(VH)
17	A(H)	A(H)	A(H)	A(H)	N(M)	SA(VH)