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Ranking E-Banking Service Quality Factors Using a Fuzzy TOPSIS Approach: A Study about Automatic Teller Machine (ATM)

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Abstract: Daily change in computer science has been shifted expectations of society from information technology. Taking the same direction for provided services to customers and their real needs can be the key factor of success in business. Rapid development in providing desirable services to customers has been changed to a principle in competitive electronic markets especially in field of electronic banking. To get more benefits from huge sector of e-banking, basic and vital customers' needs should be precisely recognized in order to provide services of the highest quality for them and providing appropriate services will satisfy customers. The Aim of this research is firstly to recognize and examine the e-service quality factors in Automated Teller Machines (ATM) by e-service quality models and secondly to prioritize them based on Fuzzy TOPSIS. Fuzzy logic provides a useful tool for dealing with decisions in which the phenomena are vague.

Key words: Automated teller machines · Electronic Banking · Electronic services quality · Fuzzy logic

INTRODUCTION

The computer technology and the Internet applications have suggested for the first time in marketing's history the possibility to collect, process, analyze and efficiently use large volumes of data and to adopt a personalized marketing approach for every customer [1].

The Internet, if properly, can be a powerful tool to increase overall service offerings and create a higher standard in various industries [2].

A relatively new phenomenon, online purchasing is increasingly became a commonplace purchasing mode. With the ever-expanding presence of information and communication technologies (ICTs), improving business service quality (BSQ) in an e-commerce environment has been increasingly viewed as an effective way of gaining and sustaining competitive advantages [3].

The service revelation has increasingly been an information revolution, information service is the highest growth area in the sector. Information service is that aspect of services in which information is the primary value exchanged between two parties- such as buyer and a seller [4].

Customers now demand new levels of convenience and flexibility in addition to powerful and easy to use financial management tools, products and services that traditional retail banking cannot offer. Internet banking has allowed banks and financial institutions to provide these services by exploiting an extensive public network infrastructure [5].

As a result, the quality of electronic banking services (e-banking) has become a major area of attention among researchers and bank managers due to its strong impact on business performance, lower costs, customer satisfaction, customer loyalty and profitability [6].

Virtual banks or "branchless banks" is a relatively new concept used to define banks that do not have a physical location such as a branch, but offer services only through the internet and ATMs to deposit or withdraw funds [7].

Self-service technology (SST) allows people to complete transactions (services) at their discretion (i.e., decide when, where and how to do them). One of the popular examples of SSTs is the ATM in the banking industry [8].

In the categorization of services in technology- based service delivery options Dabholkar (1994) suggests there are a number of relevant classifications that will apply to

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industries employing technology based service delivery. The classification analyses ``who'' delivers the service. That is, person to person, where the employee uses the technology or consumer to technology, such as the use of an ATM [9].

ATMs were initially only available at bank locations, though, by the early 1980s, shared ATM networks had been established in the U.S. and ATMs were introduced at retail locations (e.g., supermarkets and shopping malls). They appeared to provide competitive advantage, but it diminished as more banks adopted the technology and ATMs became a competitive necessity—forced to install them or risk loss of business. However, the replacement of human labor by automation certainly improved the traditional process [8].

Since the ATM is one of the major IT investments in the banking industry and also it has the highest rate of use among all e-banking services, e-service quality factors in ATMs are explored. Authors collected rich data on ATM use: in an attempt to measure importance of each indicator from the point of view of customers. Completely recognition of the clients' needs of ATMs helps to optimize infrastructure of hardware and software in ATMs.

ATM deployment in Iran has recently accelerated. The number of ATMs in Iran was around 25,000, by the end of 2008, representing an average of approximately 2800 ATMs per million people. Currently, their main functions include cash deposit and withdraw, account balance checking, transfer and bill payment.

E-Service Quality: Service quality is one of the key factors in determining the success or failure of e-commerce.An important consideration in development of any service quality measure is clearly specifying the type of service one is evaluating. Research into service quality has been popular for more than two decades, but is only recently that is has been applied to e-commerce environment.

The complex process of online customer company interaction has opened multiple possibilities for theoretical and empirical research. Some specialists focused on the categorization and definition of services, such as facilitating and supporting services [10] or supplementary services, while others are more preoccupied with the consumer evaluation of e-services technology and experience [1].

Before discussing how e-service quality might be measured it is important to define what is meant by e-service. At its simplest e-service can be defined as the electronic provision of a service to customers [11].

Boyer *et al.* (2002) define e-service as follows: The e-service encounter is the initial landing on the home page until the requested service has been completed or the final product has been delivered and is fit for use [12].

E-service can be defined as a role of service in cyberspace [4]. Zeithamel *et al.* (2002) electronic service quality as "extend to which a web site facilities efficient and effective shopping, purchasing and delivery of products and services.

The concept of service quality in e-commerce can be define as a customer's overall evaluation and judgment of the excellence and quality of e-service offering in virtual marketplace [13]. In contrast the their evaluation of traditional service, customer are less likely to evaluate each sub-process in detail during a single visit to a Web site; rather they are likely to perceive the service as an overall process and outcome [14].

In attempting to create a model of e-service quality, the starting point should be a thorough consideration of the Internet as a novel transaction channel, with specific characteristics [1]. Insights from studies dealing with people-technology interactions imply that customer evaluation of new technologies is a distinct process.

A noteworthy feature of the extant SQ literature is that it is dominated by people-delivered services. As such, whether the preceding conclusions extend to e-SQ contexts and what the similarities and differences are between the evaluative processes for SQ and e-SQ are basic issue [15].

However many various models are in traditional service quality, SERVQUAL is the most prevalent and comprehensive accepted model which uses in many various researches. But there are different sorts of e-service quality models in which varied dimension are considered. There have been various empirical researches in the area of online service quality during the last decades. Some scholars have developed scale to evaluate online services.

Dabholkar (1996) proposes that expectation of speed of delivery, ease of use, reliability, enjoyment and control will impact quality expectations for technology- base self-service option [15].

Using an online survey, Szymanski and Hise (2000) study the role that customer perceptions of online convenience, merchandising (product offerings and product information), site design and financial security play in satisfaction assessments [16].

Gefen (2002) suggests that in the evaluating online service quality the five traditional dimensions of SERVQUAL model must collapse into three: tangibles, a combined dimension of responsiveness, reliability and

assurance; and empathy [17]. And also, Cheffey and Williams Edgar (2000) examine online service using the SERVQUAL model and conclude that the constructs of SERVQUAL are valid. However they suggest that both provision of accessible and relevant information and clarity and site technical performance are important.

Yoo and Donthu (2001) develop a nine-item SITE-QUAL scale includes four dimensions: ease of use, aesthetic design, processing speed and security [18]. Zeithaml *et al.* (2002) develop a framework consist of 11 dimensions to be used in evaluating the delivery of electronic service quality. The 11 dimensions include access, ease of navigation, efficiency, flexibility, reliability, personalization, security/privacy, responsiveness, assurance/trust, site aesthetics and price knowledge [19]. Abels *et al.* (1999) propose six operational definition user criteria: use, content, structure, linkage, search and appearance [19].

Santos (2003) proposes a different model. It is proposed that e-service consist of an incubative dimension and an active dimension using time- before and after a Web site is launched- as the criterion for separating the dimensions. The incubative dimension can be developed before a Web site is launched. These include: ease of use, appearance, linkage, structure and layout and content and the active dimension consists of reliability, efficiency, support, communication, security and incentives. It can increase customer retention and encourage positive word-of-mouth referral [13].

Venus and Salehi (2002) identify effective factors in customer's trends for using ATM from the point of view of Iranian customers. It includes diversity of services, ease of use, interbank network, suitable location, Customer awareness and reliability [20].

When consider this recent part of work, several similar and common dimensions emerge that seem to be particularly relevant for online environment. Researchers perceive security/privacy to be a significant service quality dimension. Ease of use /navigation in another dimension that appears in many of studies. Another common dimension is appearance/ site aesthetics.

However, many established models of service quality have inclined to focus dimensions of e-service quality and marginalize the issue of importance which this is main question of this research [9].

Decision Making Issues: Decision making is a process which we always deal with and has a basic and significant role in different management sciences. Inasmuch as there are more than one decision maker in sophisticated issues, group decision making has become frequent.

One of the most applied branches of decision making is Multiple Criteria Decision Making which itself has divided into two branches of Multiple Attributes Decision Making and Multiple Objectives Decision Making.

MADM methods which decision making issues are mostly of this sort deal with selection principles. As a matter of fact, issues which are involved in this domain need a selection between some choices. MADM methods make it clear how the information related to the indexes is processed to get access a decision. Among the present methods for MADM issues, we can point to SAW, WPM, TOPSIS, AHP and variant methods of Out Ranking among which TOPSIS and AHP are more applied and well-known [21, 22].

TOPSIS views a multi-attribute decision-making issue with m alternatives as a geometric system with m points in the n-dimensional space. The method is based on the concept that the chosen alternative should have the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution. TOPSIS is an operational design approach that helps choose the optimal levels of service quality attributes that would facilitate the delivery of customer satisfaction. This technique can be extremely useful for service design. Similarly, loss function is better suited to highlight the future long-term damage caused by not delivering on customer-defined service standards [23].

Fuzzy Logic: There are various kinds of data and information which are frequently inaccurate and unclear; therefore, decision making on the basis of classic methods and without regarding this ambiguity in data can cause deficiency in this process. The article "Fuzzy sets" by Zadeh (1965) removed this deficiency in 1965 and presented helpful instruments in order to regard theses inaccurate and unclear data [24].

Zadeh expresses that the reason of choosing "Fuzzy" is its connection with popular feeling (Kosko, 1993) [25]. There are many unclear words in the statements which are daily used (such as much little significance, much high price, relatively satisfied) which cannot be stated with common sets and these statements must be expressed accurately. Sets which are stated accurately are called crisp sets in the fuzzy logic. Fuzzy sets confront with this inaccurate words and statements [26].

What is indeed regarded in fuzzy systems and made it invaluable is the coherence between words and sets. Fuzzy logic is capable of applying linguistic terms [25].

Fuzzy set theory is used to manage the vagueness of human thought, since it can represent vague expressions which are regarded as the natural representation of respondents' preference and judgment. Inasmuch as fuzzy data is more harmonious with real world, making decision is naturally more appropriate on the basis of fuzzy data and if we do not consider decision makers' judgment and evaluation, it will affect much in results [26].

There are two main characteristics of fuzzy systems that give them better performance for specific applications [27].

- Fuzzy systems are suitable for uncertain or approximate reasoning, especially for the system with a mathematical model that is difficult to derive; and (2) Fuzzy logic allows decision-making with estimated values under incomplete or uncertain data.

A fuzzy set is a class of objects with a connected series of membership degrees, characterized by a membership function which determines a membership grade ranging between zero and one to each object [27, 28].

A fuzzy set contains elements that have varying degrees of membership in the set. Elements of a fuzzy set are mapped to a universe of membership value using a function-theoretic form.

A fuzzy set $\tilde{a}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{a}}(x)$ which associates with each element x in X, a real number in the interval [0, 1]. The function value $\mu_{\tilde{a}}(x)$ is termed the degree of membership of x in $\tilde{a}$ [29, 24].

Among the commonly used fuzzy numbers, triangular fuzzy number (TFN) and trapezoidal fuzzy numbers (TrFN) are likely to be the most common, due to their simplicity in modeling and ease of interpretation that TFN use in this research.

A triangular fuzzy number $\tilde{a}$ can be defined by a triplet (a_1,a_2,a_3). Its mathematical form is [30].

$$\mu_{\tilde{a}}(x)=\begin{cases}0 & x\le a_1\\ \dfrac{x-a_1}{a_2-a_1} & a_1<x\le a_2\\ \dfrac{a_3-x}{a_3-a_2} & a_2<x\le a_3\\ 0 & x>a_3\end{cases}$$

If $\tilde{b}=(b_1,b_2,b_3)$, the multiplication and addition on fuzzy triangular numbers are:

$$\tilde{a}\times\tilde{b}=(a_1\times b_1,a_2\times b_2,a_3\times b_3)$$

$$\tilde{a}+\tilde{b}=(a_1+b_1,a_2+b_2,a_3+b_3)$$

Methodology: In this study for obtaining users' opinions of bank, we use a questionnaire. This contains 32 questions about importance of each indicator for increase users' satisfaction with (1-7) spectrum. Our population was containing all costumers of bank that use ATMs.

In order to determine the sample size we used Morgan Table 1 (Lkrejcie and Morgan, 1970) and consequently our sample was equal to 370 (approximately). A total of 410 questionnaires were distributed and 385 were returned completed. Cronbach's alpha coefficient calculated for total sample size is 0.889 indicating high reliability of the research questionnaire. The data concerning respondents is shown in Table 2.

The required data were collected in the form of a questionnaire asking the respondents to choose the importance of the mentioned factors based on Likert scale, with a ranking of: 1 very low, 2 low, 3 relatively low, 4 fair, 5 relatively high, 6 high and 7 very high. Prioritizing the indicators was done using the Fuzzy TOPSIS. The numerical value of each linguistic term used in the questionnaire, was determined based on Table 3 [31].

Fuzzy TOPSIS: In simultaneous fuzzy influence on science world, diverse methods of fuzzy decision making were proposed and also Fuzzy TOPSIS has different methods. Fuzzy TOPSIS method which was presented by Chen in 1997 is applied in this research. This method use normalization.

The following seven steps, based on the technique introduced by Chen (1997), are used for this research purpose in ranking e-banking service quality factors [32].

Step one: Consider a fuzzy decision matrix of respondents' ideas as follows, where i stands for the number of factors (quality factors) and j stands for the number of respondents.

Also, $\tilde{x}_{ij}$ stands for the score assigned by respondent number i for factor j. On the other hand, $\tilde{w}_{ij}$ is the importance (weight) of each respondent's ideas. It must be added that, because all the respondents are considered to have the same weight, $\tilde{w}_{ij}$ will be defined as $\tilde{w}_j=(1,1,1)$.

Table 1: Illustrates all e-indicators which extract from the e-service quality dimensions

Dimension		Factors	
Site Aesthetics:	Image	Fonts	Font color
		Graphics / Animation	Layout and format
Efficiency:	Online Registration	Quick services	Menu/ buttons
	Quick operation of ATM	Disconnected and confused connection	
Assurance/trust:	Awareness of account information changed		Update account information
	The necessary confirmations		Restrictions on the data changed
Reliability:	Continues use	Awareness of account information changed	
	Response / download time	Complete Show of account information in each use	
Ease of use:	Search Functions	Auxiliary functions	Ease of user interface
Flexibility:	Other languages	Interbank transfer	Innovative aspects
Responsiveness:	Correct and clear guidance	Ability to correct mistakes	Online help
Security/privacy:	Secure data storage		Communication Security
Access:	Complete access to all information		24 hours services
Domestic dimension:	Suitable place of ATM		Integrated interbank network

Table 1: Categorization of e-factors

Table 2: Data about respondents

Factor	Frequency	Percentage	
Gender	Male	219	57
	Female	166	43
Age	20 to 25	104	27
	25 to 30	165	43
	30 to 35	77	20
	Over 35	39	10
Using ATM	Once a month	88	23
	Once a week	166	43
	Daily	104	27
	Several time every day	27	7
Using other e-banking services			
	Homepage of bank	85	22
	Mobile banking	31	8
	Telephone banking	138	36
	POS	131	34

Table 3: Fuzzy range and numbers

Linguistic variable	Fuzzy number
Very low (VL)	(0, 0.05, 0.15)
Low (L)	(0.1, 0.2, 0.3)
Relatively low (FL)	(0.2, 0.35, 0.5)
Fair (M)	(0.3, 0.5, 0.7)
Relatively high (FH)	(0.5, 0.65, 0.8)
High (H)	(0.7, 0.8, 0.9)
Very high (VH)	(0.85, 0.95, 1)

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & - & - & - & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & - & - & - & \tilde{x}_{2n} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ \tilde{x}_{m1} & \tilde{x}_{m2} & - & - & - & \tilde{x}_{mn} \end{bmatrix}$$

$$\tilde{X} = (a_{ij}, b_{ij}, c_{ij})$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, ..., \tilde{w}_n]$$

Step Two: This step includes neutralizing the weight of decision matrix and generating fuzzy un-weighted matrix ($\tilde{R}$). To generate $\tilde{R}$, either of the following relations can be applied.

Relation 1

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}\, \tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right)$$

Where:

$$c_j^* = \max_i c$$

Relation 2

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{ca_j^-}{c_{ij}} \right)$$

Where:

$$a_j^- = \min_i a_{ij}$$

Step Three: This step includes generating fuzzy un-weighted matrix ($\tilde{V}$), while having $\tilde{w}_{ij}$ as an input for the algorithm:

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n}\, i = 1, 2, ..., m, j = 1, 2, ..., n,$$

$$\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_j.$$

Step Four: Determine positive ideal (FPIS, A+) and negative ideal (FNIS, A-) for factors:

$$A^+ = \left(\tilde{v}_1^*, \tilde{v}_2^*, ..., \tilde{v}_n^* \right)$$

$$A- = \left(\tilde{v}_1^-, \tilde{v}_2^-, ..., \tilde{v}_n^- \right)$$

In this research, the positive and negative ideas introduced by Chen (1997) are used.

$$\tilde{v}_j^* = (1,1,1) \qquad \tilde{v}_j^- = (0,0,0)$$

Step Five: In this step, we calculate the sum of distances from positive and negative ideas for each factor. For fuzzy numbers such as A and B, the difference between A and B shown as D(A,B), is determined using the following formula:

$$\tilde{A} = (a_1, b_1, c_1)$$

$$\tilde{B} = (a_2, b_2, c_2)$$

$$D(A,B) = \sqrt{\frac{1}{3}\left[(a_2 - a_1)^2 + (b_2 - b_1)^2 + (c_2 - c_1) \right]}$$

Therefore, the difference of each factor from positive and negative ideals is calculated:

$$d_i^* = \frac{\sum_{j=1}^{n} d\left(\tilde{v}_{ij} - \tilde{v}_j^* \right)}{n} i = 1, 2, ..., m$$

$$d_i^- = \frac{\sum_{j=1}^{n} d\left(\tilde{v}_{ij} - \tilde{v}_j^- \right)}{n} i = 1, 2, ..., m$$

Step Six: The adjacency of each factor to positive ideal is calculated as the following:

$$CC_i = \frac{d_i^-}{\left(d_i^* + d_i^- \right)}, i = 1, 2, 3, ..., m$$

Step Seven: This is the final step where we rank factors in a descending order of CC_i. Therefore the higher CC_i go to top.

CONCLUSION AND DISCUSSION

According to the data obtained from the questionnaire and seven steps of Fuzzy TOPSIS, the researcher calculated the weight of fuzzy numbers through software which programmed at Microsoft Excel 2007 by authors. The findings of this research shows in Table 4.

Although service quality was for a long time a matter of significance, it is always developing in order to achieve customers' satisfaction. To retain and keep competitive advantages, all banks must adopt and use technologies

Table 4: Prioritizing service quality factors of bank services

Rank	Factor	d^*_i	d^-_i	CC_i
1	Communication Security	0.168725	0.877612	0.838747
2	Secure data storage	0.176178	0.872628	0.832021
3	24 hours services	0.182377	0.86626	0.826082
4	Quick operation of machines	0.184578	0.865896	0.824291
5	Response / download time	0.193804	0.859558	0.816014
6	Disconnected and confused relationship	0.193802	0.845967	0.813611
7	Integrated interbank network	0.204976	0.84996	0.805698
8	Update account information	0.206884	0.8484	0.803954
9	Ability to correct mistakes	0.210245	0.855214	0.802672
10	The necessary confirmations	0.218809	0.835568	0.792475
11	Suitable place of ATM	0.281224	0.778867	0.734717
12	Complete access to all information	0.287223	0.778016	0.730368
13	Interbank transfer	0.287409	0.772875	0.728932
14	Ease of user interface	0.289608	0.774343	0.727799
15	Awareness of account information changed	0.300275	0.795046	0.725857
16	Complete Show of account information in each use	0.299775	0.77744	0.721713
17	Online Registration	0.29549	0.764998	0.721364
18	Correct and clear guidance	0.32469	0.7908	0.708926
19	Restrictions on the data changed	0.318258	0.750015	0.702082
20	Continues use	0.327758	0.760107	0.698714
21	Auxiliary functions	0.328553	0.74112	0.692845
22	Innovative aspects	0.346249	0.720765	0.675497
23	Menu/ buttons	0.349106	0.723395	0.674493
24	Online help	0.375364	0.696019	0.649645
25	Fonts	0.413518	0.658745	0.61435
26	Search Functions	0.422476	0.64872	0.605604
27	Size of Image	0.437788	0.635496	0.592104
28	Layout and format	0.452193	0.622206	0.57912
29	Graphics / Animation	0.486007	0.588995	0.547901
30	Font color	0.486425	0.587739	0.54716
31	Other languages	0.606223	0.461387	0.432168

effectively and efficiently. By deploying SST, bank clients can complete transactions and related services themselves without requiring assistance from employees of bank. ATMs are one of the most commonly used devices in all e-banking services. This study has two stages, firstly, identifying main e-dimension of ATM and, secondly, determining importance of each factor. This research used a questionnaire driven from e-service quality models and analyzed by Fuzzy TOPSIS methodology to review and rank the e-service quality dimensions in the ATMs.

Using Fuzzy logic and particularly considering linguistic variables in the research causes that the model becomes more flexible and ambiguous data like human judgments can be easily considered and applied results be received.

This research can be used different ways. Designers should pay particular attention to the dimensions which are more important from the clients' point of view.

Security/privacy issue (Communication Security Secure data storage) is the most significant indicators from the point of view of the users of ATMs. On the other hand, generally, research's results indicate that customers pay less attention to the whole expenses which are considered for appearance /site aesthetics factors like "font color" or "size of Image".

"Other languages" has the lowest significant e-factors form customers' viewpoint. There is a dramatic decreased in this elements, in comparison with others factors. It can be eliminated from first stage in ATMs because clients with others languages cannot use Iranian's ATMs.

"Suitable place of ATM" and "Integrated interbank network", two domestic dimensions which are used in the research, situated in top rank of table 3 so that these two factors are advantageous to increased level of customer satisfaction. Customer can use all kind of ATMs with having any debit card in an "Integrated interbank network".

Pages of ATMs are designed as static pages and all users receive a kind of e-services, one of the best ways to use these findings is personalization of ATM's pages. Customers can have its own specific pages which are designed with regard to the importance of each factor form the customer's standpoint. It can be done by neural network.

In order to make strategic decisions in future, IT managers of banks can focus on improvement of electronic service quality based of the results of this research to keep their clients and increase customers' satisfaction.

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