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Hybrid Techniques of Multi-Criteria Decision-Making for Location of Automated Teller Machines (ATMs): Shahr Bank Branches in Tehran, 1st District Municipality

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Abstract

Location is an important factor in the activity of economic enterprises. Owing to the importance, location-based sciencesought/seeks to provide the methods in order to determine and select the optimal location in the activities of enterprises. Enterprises seek to use scientific methods to maximize the services and efficiency and minimize the costs. Suitable location plays an important role in many fields such as reducing the costs and increasing the customer satisfaction. Location studies have been proposed in recent years as one of the key elements in the success and survival of industrial centers as considered at many national and international levels. This study, as an applied research, provides a new framework in location of ATMs using multi-criteria decision-making approach and fuzzy AHP and fuzzy ELECTRE III. The multi-criteria decision-making approaches were based on similar studies in other countries and viewpoints of experts and managers of Shahr Bank branches in Tehran, 1st District Municipality, and the establishment of favorable sites was identified by combining the information in order to influence the location of ATMs including competitors (0.202), price of land (0.199), access to facilities and utilities, poles and important centers of town (0.189), quality of track (0.180), security (0.120), transport and traffic (0.112), population under coverage (0.065), and regulation (0.039). At the end, the most appropriate locations of establishment of ATMs were determined to cover the demands of Tehran, 1st District Municipality using fuzzy AHP methods and ELECTRE III.

Keywords: Automated Teller Machin (ATM), Multi-Criteria Decision-Making, Analytical hierarchy process (AHP), ELECTRE III method, Fuzzytheory.

1. Introduction

One of managers' main concerns is conversion and optimization of existing capital resources appropriately with the maximum possible income through investments at the right time and place. Therefore, in today'seconomic conditions, how and where to invest will be a complex and risky issue. Location of ATMs designation has a key role in the initial investment economically. Location is one of the deepest and most interesting issues in research science of operations since early 1960. The mathematical models have been applied to find and decide on locations of factories, warehouses, hospitals, schools and maximize customer satisfaction, namely the demand side. In such issues, cost and distance traveled by the applicants areoften the most important deciding factors in the establishment or selection of one unit so that gradually other indices enter into this area in order to attempt to locate the optimal site as one of the most important concerns of scientists in the field of modeling. Location selection for ATMs is an important part of bank management. Choosing what location is better to establish an ATM is extremely difficult, since many factors and criteria are involved in this regard. Location is the perfect one for a given activity by performing a specific administrative procedure according to the criteria and factors affecting it (Fen Li, 2007). Facility location problems are among classic optimization problems with wide applications, particularly in services. These applications include health units, databases, petrol stations, police stations, and bank branches. We attempt to minimize the cost of location of the facility in order to solve this kind of problem so that it covers the entire customer demand (Aldajani andAlfares, 2009). Suitable location has an important role in competitiveness in the market, and so it should be chosen in a way that makes the strategic and competitive advantages achievable in comparison to other competitors. Negative impacts resulting from the creation and operation of the industry should be reduced to a minimum in order to achieve sustainable development. The suitable location is also a decision affecting sustainability of industrial activities and overall sustainable development in the region (Ruiz Puente et al., 2007). Given the importance of banks as well as financial and credit institutions and their increase in recent years and dependence on location, we found few studies on the importance of location decisions and their impact on the banking system. In this regard, the importance of suitable location is necessary for a bank as one of the most important service centers associated with

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population and ATMs,consequently. We can mention several cases on the location importance and necessity of ATMs including increase of profitability and investment productivity, reduction of potential losses (GodarziandZobeidi, 2008), and increase of customer satisfaction (BamdadandRafieMehrabadi, 2008).Overall, performance sustainability depending on the location decision of banks as well as financial and credit institutions requires a scientific model for location of ATMs (Fokerdi, 2005).

locating a decent and suitable locationalong withlower cost is one of the issues that has become an influential factor by the authorities and industrialists in recent years. Location of firm was at strategic decision-making levels with crucial importance in its success. Facilities location can be observed as a large body of knowledgeinvovling a variety of models, methodologies, and techniques for different solutions in various fields such as industrial engineering, operations research, operations management, urban economics, and political science (Partovi, 2006).Żak and Węgliński(2014) used the multi-criteria decision-making methods in order to locate the logistics centers. In the first step, a comprehensive analysis of areas was conducted and multiple evaluation criteria were examined, including technical standards, infrastructure, and economic, social and environmental potential. The considered criteria were ranked using ELECTRE III. Then, the used criteria and variables were defined, the preferences of decision-makers were modeled, and the results were shown in the end. Tahri et al. (2015) proposedto locate a project of renewable energy with the help of multi-criteria decision analysis using GIS. In this study, the location was conducted based on four main indicators and ranked using Analytical Hierarchy Process.

The purpose of this study is to select locations for ATMs ofShahr Bank branches in Tehran, 1st District Municipality, andit should be less expensive to build and deliver the products to customers and make the customer satisfied, reducing the costs while meeting the demands of officials both quantitatively and qualitatively. Thus, the present study seeks to answer this question: which criteria and factors are effective inlocation of Shahr Bank branches' ATMs in Tehran, 1st District Municipality and how much the degree of influence of each oneis?

The statistical population consisted of all experts and specialists in banking with more than 5 years of experience in Shahr Bank branches in Tehran, 1st District Municipality including 70 people selected using Cochran formula of 40 individuals by simple random sample. The community is analyzed statistically after completion of questionnaires and extraction of data in terms of age, marital status, gender, and education.

2. Materials and Methods

The study methodology is ofqualitative-quantitative type, initially started by identifying the most important variables of the literature, then continued with comparative studies, and eventually ended with proper analysis. The research seeks the subject to include collecting data to answer the questions concerning the current state of the subject with an applied aspect. The results of this research can be used in decision-making, policy-making and planning in banks as well as financial and credit institutions in an applied form. The present study is an applied, descriptive, and quantitative-qualitative in terms of purpose, research problem, data collection, and nature of data, respectively.

Various methods were used to collect data in this study including the internet websites, search in databases, books, papers, and domestic and foreign theses. Library method was used regarding the use of multi-criteria decision making techniques, questionnaires, and interviews to determine the impact of expert opinions on clarifying the relative importance of the research criteria and value and verbal judgments of subjects.

Data collection in this study is from interviews channels with experts, questionnaire, library studies, documentation studies, and related reports on the Internet. It is worth noting that visiting all candidate areas was one of the key actions to solve the problem of location in which valuable information can be achieved

The questionnaire of hierarchical analysis developed by the supervisor's idea, using similar theses and experts and bank officials' views and using well-known books and papers, was used to collect data in this study. Completing the questionnaires was done ina way that the questionnaires were distributed evenly between experts, and then they were asked to score and grade the criteria and write themif there were other criteria in their opinion. At the end, the results were compiled in the Matrix questionnaires and Excel software after collection.

Determining the validity of the questionnaire: validity indicates that whether our tool is able to assess and measure the variables made for it;we can consider that a study has validity when itcan measure the desired goal and there is no logic error in the study (Biabangard, 2005). Content validity and face validity are used to determine the validity of the questionnaire in this study. The study used 20 subjects of banking experts with a history of more than 5 years in the field to assess the content validity concerning the coordination of the content of this instrument and purpose. The minimum acceptable value for the CVI index is equal to 0.79. and that all questions gained this value in the study; therefore, the questionnaire was confirmed in terms of content validity.

Then, the opinions of the sample group or respondents were used to survey the face validity, and this part of validity of the test does not require the specialists' opinions. For acceptance of face validity questions, the effect score should not be less than 1.5, and questions are only acceptable in terms of face validity whose score is higher than 1.5 (Azkia and DarbanAstaneh, 2003). In this study, all questions had score more than this value; therefore, face validity of the questionnaire was confirmed.

Descriptive statistics: In this part of the study, the sample is described (respondents) using statistical analysis software SPSS, and then it checked the frequency of their response to the questionnaire. A total of 40 subjects completed the questionnaire whose average age was under 30 years (32.5%), between 31 to 40 years (35%), between 41 to 50 years (25%), and older than 51 years (7.5%). Furthermore, their average marital status showed to be22.5% single and 77.5% married. In terms of gender, 25 % and 75 % of them were female and male, respectively. Their academic status was 10% diploma, 12.5 % associate's degree, 52.5 % bachelor's degree, 15 % master's degree, and 10 % Ph.D. degree. Thus, according to the results, most of the subjects were male were less than 40 years old and married, and had mainly bachelor's degree.

The following steps are needed for the present study:

The first step: factors influencing location of ATMs are reviewed according to the previous research. The theoretical foundations of the research are obtained from the library method. Part of the necessary information is collected and research papers are used in the library method with reference to Persian and Latin books and articles.

The second step: location options will be designated for location of Shahr Bank ATMs.

The third step: weight and importance of each criterion is calculated using fuzzy AHP.

The fourth step: location options are ranked using fuzzy ELECTRE III.

In this regard, Figure 1 illustrates the research steps as a schematic.

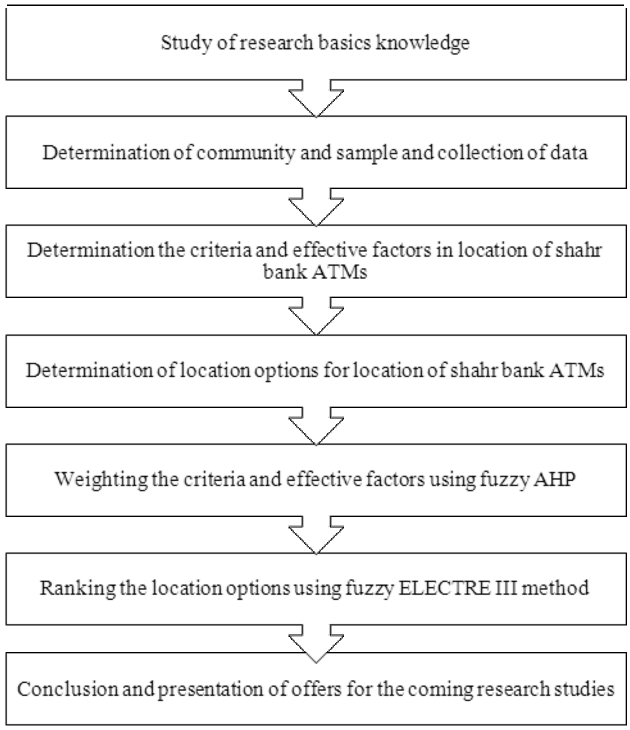

Fig.1. Steps of research

The study examined ten regions of the location of Shahr Bank branches' ATMs in Tehran, 1st District Municipality. Figure 2 shows the map of Tehran, 1st District Municipality in separate areas.

Fig. 2. Map of Tehran, 1st District Municipality

These ten regions were introduced as A, B, C, D, E, F, G, H, I, and J. Therefore, we must choose the most suitable location from Table 1.

Table 1
Areas and locating

Location	Areas	Areas
A	1	Farmanieh and Hesar Bu ali
B	2	Darakeh, Evin, Velenjak, Mahmoodieh and Zaferanieh
C	3	Golabdareh, Darband and EmamzadehQasem
D	4	Dezashib, Jamaran and Niavaran
E	5	Kashanak, Darabad and Golha
F	6	Shahrake-e Naft
G	7	BaqFerdos, Tajrish and Qeytarieh
H	8	Hekmat and Chizar
I	9	Araj and Ozgol
J	10	Shahrake-e Mahalati and Soohanak

Frequency criteria must be considered in selecting the optimum location of ATM. All effective criteria were introduced in the meetings from previous research studies, and the most important criteria for our option were selected from among all parameters introduced in the literature in categorization of early-secondary, objective-subjective, and so on. Therefore, all factors influencing the decision were identified and evaluated by respective directors and experts of different sectors to the location selection for ATM, and finally eight criteria were selected and introduced: The price of land, road quality, access to facilities and utilities, city centers, security, transport and traffic, population under coverage, competitors, laws and regulations.

Due to the nature of subjective and objective criteria and requirement in options selection or selective nature of the issue, the multiple-attribute decision-making model was selected from compensation models among various methods of suitable location. According to this model, first, the criteria were weighted using fuzzy AHP, and then the options were ranked using fuzzy ELECTRE III.

Criteria and factors influencing the location of Shahr Bank ATMs were found from authoritative articles and resources by polling experts. Each of these criteria was coded to study the research, and Table 2 shows the quality of this encoding process.

Table 2
Encoding factors

Row	Factor	Code
1	Price of land	F1
2	Quality of track	F2
3	Access to facilities and utilities, poles, and important centers of town	F3
4	Security	F4
5	Transport and Traffic	F5
6	Population under coverage	F6
7	Competitors	F7
8	Regulation	F8

In this part of the study, criteria and factors influencing location of Shahr Bank ATMs are rated using fuzzy AHP. For this purpose, the mean geometric comments were calculated according to Equation (1) after collecting the views of experts and banking experts.

$$\overline{a}_{ij} = (\pi_{k=1}^{N} a_{ij}^{(k)})^{\frac{1}{N}} \qquad (1)$$

Table 3 presents the results of this step, and Table 4 also shows the normal decision-making matrix. The average is then taken from each row whose values are listed in Table 5.

Table 3
Mean geometric comments

	F1	F2	F3	F4	F5	F6	F7	F8
F1	(1, 1, 1)	(5.17, 7.20,	(1, 1.55, 3.68)	(2.24, 4.36,	(1.08, 1.86,	(1.07, 1.60,	(0.24, 0.52,	(6.12, 7.74, 9)
F2	(0.11 ,0.14,	(1, 1, 1)	(5.72, 7.74, 9)	(0.11, 0.13,	(0.17, 0.27,	(3.68, 5.72,	(1.34, 2.38,	(3.89, 5.85,
F3	(0.27, 0.64, 1)	(0.11, 0.13,	(1, 1, 1)	(1.07, 1.49,	(3.56, 5.59,	(1, 1.24, 3.32)	(3, 5, 7)	(6.25, 8.28, 9)
F4	(0.16, 0.23,	(5.72, 7.74, 9)	(0.27, 0.67,	(1, 1, 1)	(0.25, 0.56, 1)	(1.07, 1.39,	(0.26, 0.60 ,1)	(6.54, 8.56, 9)
F5	(0.25, 0.54,	(1.55, 3.68,	(0.13, 0.18,	(1, 1.80, 3.93)	(1, 1, 1)	(4.41, 6.47,	(0.11, 0.13,	(0.17, 0.25,
F6	(0.27, 0.62 0.93)	(0.13, 0.17,	(0.30, 0.80, 1)	(0.28, 0.72,	(0.12, 0.15,	(1, 1, 1)	(0.12 0.15 , 0.23)	(6.26, 8.28, 9)
F7	(1.55, 1.90,	(0.22, 0.42,	(0.14, 0.20,	(1, 1.67, 3.81)	(5.53, 7.57,	(4.41, 6.47,	(1, 1, 1)	(4.17, 6.22,
F8	(0.11, 0.13,	(0.13, 0.17,	(0.11, 0.12,	(0.11, 0.12,	(1.80, 3.94,	(0.11, 0.12,	(0.12, 0.16,	(1, 1, 1)

Table 4
Normal decision-making matrix

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
F1	(0.11, 0.19, 0.27)	(0.20, 0.35, 0.63)	(0.06, 0.13, 0.42)	(0.11, 0.39, 0.94)	(0.04, 0.09, 0.30)	(0.03, 0.07, 0.22)	(0.02, 0.05, 0.10)	(0.11, 0.17, 0.26)
F2	(0.01, 0.03, 0.05)	(0.04, 0.05, 0.07)	(0.35, 0.63, 1.04)	(0.01, 0.01, 0.03)	(0.01, 0.01, 0.05)	(0.10, 0.24, 0.46)	(0.09, 0.24, 0.74)	(0.07, 0.13, 0.23)
F3	(0.03, 0.12, 0.27)	(0.00, 0.01, 0.01)	(0.06, 0.08, 0.12)	(0.05, 0.13, 0.53)	(0.12, 0.27, 0.56)	(0.03, 0.05, 0.20)	(0.20, 0.50, 1.13)	(0.12, 0.18, 0.26)
F4	(0.02, 0.04, 0.12)	(0.22, 0.38, 0.64)	(0.02, 0.05, 0.11)	(0.05, 0.09, 0.15)	(0.01, 0.03, 0.07)	(0.03, 0.06, 0.21)	(0.02, 0.06, 0.16)	(0.12, 0.19, 0.26)
F5	(0.03, 0.10, 0.25)	(0.06, 0.18, 0.41)	(0.01, 0.01, 0.03)	(0.05, 0.16, 0.58)	(0.03, 0.05, 0.07)	(0.12, 0.27, 0.49)	(0.01, 0.01, 0.03)	(0, 0.01, 0.02)
F6	(0.03, 0.12, 0.25)	(0, 0.01, 0.02)	(0.02, 0.07, 0.12)	(0.01, 0.06,.14)	(0.00, 0.01, 0.02)	(0.03, 0.04, 0.06)	(0.01, 0.02, 0.04)	(0.12, 0.18, 0.26)
F7	(0.17, 0.37, 1.13)	(0.01, 0.02, 0.05)	(0.01, 0.02, 0.04)	(0.05, 0.15, 0.56)	(0.19, 0.36, 0.66)	(0.12, 0.27, 0.49)	(0.07, 0.10, 0.16)	(0.08, 0.13, 0.24)
F8	(0.01, 0.02, 0.04)	(0, 0.01, 0.02)	(0.01, 0.01, 0.02)	(0.01, 0.01, 0.02)	(0.06, 0.19, 0.44)	(0, 0.01, 0.01)	(0.01, 0.02, 0.04)	(0.02, 0.02, 0.03)

Table 5
Average rows

Factor	**Average row**
F1	(0.085, 0.179, 0.396)
F2	(0.085, 0.167, 0.334)
F3	(0.077, 0.168, 0.385)
F4	(0.060, 0.112, 0.215)
F5	(0.039, 0.099, 0.235)
F6	(0.028, 0.063, 0.112)
F7	(0.087, 0.177, 0.416)
F8	(0.015, 0.036, 0.078)

Afterward, defuzzification converts the average lines into absolute numbers by using Equation (2). In addition, its values indicate the rank and weight of each factor.

$$a = \frac{a^l + 4a^m + a^u}{6} \qquad (2)$$

Table 6 shows the results of this step.

Table 6
Rank and weight factor

Factor	**Weight**	**Rank**
F1	0/199	2
F2	0/180	4
F3	0/189	3
F4	0/120	5
F5	0/112	6
F6	0/065	7
F7	0/202	1
F8	0/039	8

Thus, the criteria and factors influencing Shahr Bank ATMs location in order of priority are:

$$F_7 \rightarrow F_1 \rightarrow F_3 \rightarrow F_2 \rightarrow F_4 \rightarrow F_5 \rightarrow F_6 \rightarrow F_8$$

Nominated sites are ranked after weighting the factors affecting the location at this step. Fuzzy ELECTRE III method is used for this purpose. Table 7 shows the initial decision matrix after calculating the geometric mean comments

Table 7
Initial decision-making matrix

	F1	F2	F3	F4	F5	F6	F7	F8
A	(1, 1.55, 3.68)	(5.53, 7.57, 8.85)	(5.98, 7.61, 9)	(2.41, 4.51, 6.54)	(1.34, 2.06, 4.31)	(1.07, 1.86, 4.03)	(1.07, 1.60, 3.76)	(1.24, 1.60, 3.80)
B	(3.30, 5.41, 7.44)	(1, 1.55, 3.68)	(4.03, 5.98, 8.00)	(1.16, 2.39, 4.56)	(5.72, 7.74, 9)	(1.16, 1.43, 3.59)	(5.72, 5.72, 7.74)	(1.34, 2.38, 4.61)
C	(1, 1.44, 3.56)	(2.39, 4.56, 6.61)	(6.26, 8.28, 9)	(1.07, 1.49, 3.64)	(6.12, 8.14, 9)	(3.55, 5.59, 7.61)	(1, 1.16, 3.21)	(4.67, 6.73, 8.42)
D	(6.12, 8.14, 9)	(5.78, 7.83, 8.85)	(6.54, 8.56, 9)	(6.25, 8.28, 9)	(4.17, 6.22, 8.14)	(6.18, 8.23, .8.85)	(1.16, 1.66, 3.85)	(1, 1.34, 3.44)
E	(1, 1.55, 3.68)	(3.09, 5.17, 7.20)	(1.14, 1.80, 3.96)	(5.17, 7.20, 8.85)	(2.88, 4.94, 6.96)	(2.41, 4.51, 6.54)	(4.10, 6.25, 8.09)	(6.40, 8.42, 9)
F	(3.29, 5.46, 7.25)	(1.07, 1.38, 3.51)	(6.69, 8.70, 9)	(1.55, 3.68, 5.72)	(1, 1.55, 3.68)	(1.16, 2.39, 4.56)	(1.07, 1.29, 3.16)	(1.34, 2.38, 4.61)
G	(4.15, 6.29, 8.23)	(2.98, 5.05, 7.08)	(1.16, 2.07, 4.26)	(1.07, 1.49, 3.64)	(3.60, 5.41, 7.44)	(1.07, 1.49, 3.64)	(1.72, 3.66, 5.81)	(1.44, 1.98, 4.26)
H	(2.48, 4.03, 6.29)	(6.32, 8.37, 8.85)	(6.12, 8.14, 9)	(6.18, 8.23, 8.85)	(1, 1.44, 3.56)	(6.26, 8.28, 4.61)	(5.72, 7.74, 9)	(3.98, 6.05, 7.87)
I	(6.26, 8.28, 9)	(1.07, 1.49, 3.64)	(4.17, 6.22, 8.14)	(1.16, 1.66, 3.85)	(6.12, 8.14, 9)	(1.34, 2.38, 4.61)	(6.12, 8.14, 9)	(5.52, 7.61, 8.56)
J	(1, 1.34, 3.44)	(2.88, 4.94, 6.96)	(2.88, 4.94, 6.96)	(3.10, 5.11, 7.12)	(1, 1.55, 3.68)	(4.56, 6.62, 8.42)	(4.17, 6.22, 8.14)	(2.24, 4.36, 6.40)

After initial decision matrix with respect to other inputs of fuzzy ELECTRE III method, it is needed to recognize the importance or weight of each criteria and threshold values for each of them.

Fuzzy AHP was used to determine the weight of criteria; thresholds of indifference (q), superiority (p), and veto (v) for each criterion were directly determined by experts. Table 8 indicates the corresponding values.

Table 8
Determines the weight of criteria and thresholds of indifference, superiority, veto as follows:

Factor	Weight	Thresholds of indifference (q_j)	Thresholds of superiority (p_j)	Thresholds of veto (v_j)
F1	(0.085, 0.179, 0.396)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F2	(0.085, 0.167, 0.334)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F3	(0.077, 0.168, 0.385)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F4	(0.060, 0.112, 0.215)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F5	(0.039, 0.099, 0.235)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F6	(0.028, 0.063, 0.112)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F7	(0.087, 0.177, 0.416)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)
F8	(0.015, 0.036, 0.078)	(1, 1, 1)	(5, 5, 5)	(6, 6, 6)

Following the technical steps, ELECTRE III is explained to determine the conducted calculations framework (Figueira et al., 2005).

The first step: Calculating the coordination

If k_j is a factor of importance or specific weight to each index j.

Overall coordination parameter ($C(a,b)$) is calculated by Equation (3):

$$C(a,b) = \frac{1}{K}\sum k_j . c_j(a,b) \qquad K = \sum_{j=1}^{n} k_j \tag{3}$$

Then, it is necessary to coordinate both options to be determined for each index by Equation (4):

$$c_j(a,b)=\begin{cases}1; \; if \quad g_j(a)+q_j \geq g_j(b) \\ 0; \; if \quad g_j(a)+p_j \leq g_j(b) \\ \dfrac{p_j+g_j(a)-g_j(b)}{p_j-q_j}; \quad O.W\end{cases} \qquad (4)$$

$j=1,2,....n$

Then, in this step, first, the coordination parameter of options is calculated as paired coordination matrix presented in Table 9.

The second step: Calculating the incoordination.

Table 9
Coordination matrix (C)

	A	B	C	D	E	F	G	H	I	J
A	(1, 1, 1)	(-0.36, 0.28, 1.34)	(1, 1, 1)	(0, 0, 0)	(1, 1, 1)	(-0.31, 0.27, 1.35)	(-0.56, 0.06, 1.13)	(-0.07, 0.63, 1.55)	(0, 0, 0)	(1, 1, 1)
B	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.17, 0.57,	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.17, 0.53, 2.04)	(1, 1, 1)
C	(1, 1, 1)	(-0.36, 0.26, 1.31)	(1, 1, 1)	(0, 0, 0)	(1, 1, 1)	(-0.31, 0.24, 1.32)	(-0.56, 0.04, 1.10)	(-0.07, 0.60, 1.52)	(0, 0, 0)	(1, 1, 1)
D	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)
E	(1, 1, 1)	(-0.36, 0.28, 1.34)	(1, 1, 1)	(0, 0, 0)	(1, 1, 1)	(-0.31, 0.27, 1.35)	(-0.56, 0.06, 1.13)	(-0.07, 0.63, 1.55)	(0, 0, 0)	(1, 1, 1)
F	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.18, 0.58,	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.18, 0.54, 1.50)	(1, 1, 1)
G	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(0.04, 0.79,	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.16, 0.75, 1.74)	(1, 1, 1)
H	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.38, 0.22,	(1, 1, 1)	(1, 1, 1)	(-0.19, 0.68, 1.78)	(1, 1, 1)	(-0.44, 0.20, 1.26)	(1, 1, 1)
I	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)
J	(1, 1, 1)	(-0.36, 0.23, 1.28)	(1, 1, 1)	(0, 0, 0)	(1, 1, 1)	(-0.31, 0.22, 1.29)	(-0.56, 0.01, 1.08)	(-0.07, 0.58, 1.49)	(0, 0, 0)	(1, 1, 1)

Another threshold, named veto value, should be defined to calculate the incoordination. Veto threshold value (v_j) has this possibility to completely abolish the value of a *S*bif the relationship $g_j(b) > g_j(a)+v_j$ is established for each index j.

For both options, inconsistency index for each indicator is as in Equation (5):

$$d_j(a,b)=\begin{cases}0; \; if \quad g_j(a)+p_j \geq g_j(b) \\ 1; \; if \quad g_j(a)+v_j \leq g_j(b) \\ \dfrac{g_j(b)-g_j(a)-p_j}{v_j-p_j}; \quad O.W\end{cases} \qquad (5)$$

$j=1,2,....n$

Table 10 presents the incoordination matrix.

The third step: Surveying the credit of non-rating relation

After calculating the match and mismatch matrices, the next step is to combine the criteria of two values to determine the non-rating degree value whose credit matrix is achieved from the process. Credit rating is defined as in Equation (6):

Table 10
Incoordination matrix (D)

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
A	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.56, 1.59, 3)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.42, 1.73, 3)	(0, 0, 0)
B	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)
C	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.44, 1.70, 3)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.30, 1.84, 3)	(0, 0, 0)
D	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)
E	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.56, 1.59, 3)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.42, 1.73, 3)	(0, 0, 0)
F	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)
G	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)
H	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)
I	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)
J	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.32, 1.8, 3)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(0, 0, 0)	(-2.18, 1.94, 3)	(0, 0, 0)

$$S(a,b)=\begin{cases} C(a,b); if & d_j(a,b)\le C(a,b) \\ C(a,b).\prod\limits_{\{j\in J: d_j(a,b)>C(a,b)\}} \dfrac{1-d_j(a,b)}{1-C(a,b)}; if & d_j(a,b)>C(a,b) \end{cases} \quad (6)$$

where $j \in J$ indicates those measures that $d_j(a,b) > C(a,b)$.

Thus, matrix credit (reflecting the credit rating of superiority of one option over the other option) is obtained on the basis of all the criteria in Table 11.

Table 11
Credit matrix (S)

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
A	(1,1,1)	(-0.36, 0.28, 1.34)	(1,1,1)	(0, 0, 0)	(1,1,1)	(-0.31, 0.27, 1.35)	(-0.56, 0.06, 1.13)	(-0.07, 0.63, 1.55)	(0, 0, 0)	(1,1,1)
B	(1,1,1)	(1, 1, 1)	(1,1,1)	(-0.17, 0.57, 2.08)	(1,1,1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.17, 0.53, 2.04)	(1,1,1)
C	(1,1,1)	(-0.36, 0.26, 1.31)	(1,1,1)	(0, 0, 0)	(1,1,1)	(-0.31, 0.24, 1.32)	(-0.56, 0.04, 1.10)	(-0.07, 0.60, 1.52)	(0, 0, 0)	(1,1,1)
D	(1,1,1)	(1, 1, 1)	(1,1,1)	(1, 1, 1)	(1,1,1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1,1,1)
E	(1,1,1)	(-0.36, 0.28, 1.34)	(1,1,1)	(0, 0, 0)	(1,1,1)	(-0.31, 0.27, 1.35)	(-0.56, 0.06, 1.13)	(-0.07, 0.63, 1.55)	(0, 0, 0)	(1,1,1)
F	(1,1,1)	(1, 1, 1)	(1,1,1)	(-0.18, 0.58, 1.53)	(1,1,1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.18, 0.54, 1.50)	(1,1,1)
G	(1,1,1)	(1, 1, 1)	(1,1,1)	(0.04, 0.79, 1.78)	(1,1,1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(-0.16, 0.75, 1.74)	(1,1,1)
H	(1,1,1)	(1, 1, 1)	(1,1,1)	(-0.38, 0.22, 1.29)	(1,1,1)	(1, 1, 1)	(-0.19, 0.68, 1.78)	(1, 1, 1)	(-0.44, 0.20, 1.26)	(1,1,1)
I	(1,1,1)	(1, 1, 1)	(1,1,1)	(1, 1, 1)	(1,1,1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(1,1,1)
J	(1,1,1)	(-0.36, 0.23, 1.28)	(1,1,1)	(0, 0, 0)	(1,1,1)	(-0.31, 0.22, 1.29)	(-0.56, 0.01, 1.08)	(-0.07, 0.58, 1.49)	(0, 0, 0)	(1,1,1)

The Fourth Step: Ranking the options
The next step is to create the final rankings of options from the information contained in the credit matrix. For this purpose, parameter λ is determined by Equations (7) and (8):

$$\lambda = \begin{cases} \max S(a,b) \\ a,b \in A \end{cases} \quad (7)$$

$$\begin{aligned} \lambda &= \max S(a,b) \\ \lambda &= (0.04,\ 0.79,\ 1.78) \end{aligned} \quad (8)$$

This parameter determines the amount of credit in which only values of $S(a,b)$ close to it are considered. Values α and β , in this study, are regarded as default values equal to -0.15 and 0.3, respectively (Raimon Redondo et al., 2007). In this process, new parameter $S(\lambda)$ is introduced based on Equation (9):

$$S(\lambda) = \lambda\alpha + \beta \quad (9)$$

Finally, amount $\lambda - S(\lambda)$ should be calculated.
Accordingly, matrix T is defined as in Equation (10):

$$T(a,b) = \begin{cases} 1; if \quad S(a,b) > \lambda - S(\lambda) \\ 0; \quad O.W \end{cases} \quad (10)$$

Then, matrix T is obtained as shown in Table 12.

Table 12
Matrix T

	A	B	C	D	E	F	G	H	I	J
A	1	0	1	0	1	0	0	1	0	1
B	1	1	1	0	1	1	1	0	0	1
C	1	0	1	0	1	0	0	0	0	1
D	1	1	1	1	1	1	1	1	1	1
E	1	0	1	0	1	0	0	1	0	1
F	1	1	1	0	1	1	1	1	0	1
G	1	1	1	1	1	1	1	1	1	1
H	1	1	1	0	1	1	1	1	0	1
I	1	1	1	1	1	1	1	1	1	1
J	1	0	1	0	1	0	0	0	0	1

Then, the utility for each option (Q (A)) means the number of options overcome by option A minus the number of options superior to A. Utility is simply defined as the sum of the numbers in the row minus the sum of the numbers in the columns of matrix T for each option.
In the downside process, all options with the highest and greatest utility assign the high grade to their own after leaving options with the highest utility from the process. The process re-continues calculating λ and $S(\lambda)$ to set all the options out. The result will be the pre-ranking of Z_1 as descending ranking.

In addition, other variables are removed in the next step. The obtained alternatives ratings are based on the descending pre-rating of options (Z_1). First, it determines the options with the greatest amount of utility as shown inFigure 3.

$$Z_1 \Rightarrow \begin{Bmatrix} D \\ I \end{Bmatrix} \rightarrow \begin{Bmatrix} B \\ F \\ G \end{Bmatrix} \rightarrow \begin{Bmatrix} A \\ C \\ E \\ H \\ J \end{Bmatrix}$$

Fig. 3. Descending options ranking

Ascending results are obtained in a similar way with a difference that, firstly, the options are used with the least utility. Ranking the options (Z_2) is rated as shown inFigure 4 based on the ascending options ranking.

$$Z_2 \Rightarrow \begin{Bmatrix} D \\ G \\ I \end{Bmatrix} \rightarrow \begin{Bmatrix} B \\ F \\ H \end{Bmatrix} \rightarrow \begin{Bmatrix} A \\ E \end{Bmatrix} \rightarrow \begin{Bmatrix} C \\ J \end{Bmatrix}$$

Fig. 4. Ascending options ranking

The final ranking results of options ($Z_1 \cap Z_2$) (the combination of two pre-rating descending and ascending options) are obtained as shown in Figure 5.

$$Z_1 \cap Z_2 \Rightarrow \begin{Bmatrix} D \\ I \end{Bmatrix} \rightarrow G \rightarrow \begin{Bmatrix} B \\ F \end{Bmatrix} \rightarrow H \rightarrow \begin{Bmatrix} A \\ E \end{Bmatrix} \rightarrow \begin{Bmatrix} C \\ J \end{Bmatrix}$$

Fig. 5. Final options ranking

3. Conclusion

Obviously, research in every field has a specific purpose and motivation. However, its results and achievements are so important that they can be used to reach fruition. Furthermore, the results and suggestions are important in terms of making the study more applied and are effective in building and strengthening researchers'motivation, paving the way for other studies and research. Moreover, it is attempted to offer constructive suggestions for future research. This study investigated the problem of locating ATMs using multi-criteria decision-making techniques in Shahr Bank branchesin Tehran, 1st District Municipality.
We should always bear in mind that the information required for making a decision is not delivered to the decision-maker definitely, and in many circumstances, it includes imprecise and vague estimates. One of the common tools to explain such situations is the use of concepts of fuzzy theory. In this study, AHP and ELECTRE III methods in a fuzzy state are used to cover such situations.
In this study, after the introduction of all models of the location and the deployments of Shahr Bank ATMs, multi-criteria decision-making techniques were used for

this purpose as fuzzy. Thus, originally, factors influencing location of ATMs were encoded after the extraction from resources and papers and through surveys from experts. These factors include price of land, quality of track, access to facilities and utilities, poles and important centers of town, security, transportation and traffic, population under coverage, competitors, and regulation. In the following, these factors were ranked using fuzzy AHP regarding influencing location of Shahr Bank ATMs:Competitors (0.202), price of land (0.199), access to facilities and utilities, poles and important centers of town (0.189), quality of track (0.180), security (0.120), transport and traffic (0.112), population under coverage (0.065), and regulation (0.039).

Thus, according to the results of the fuzzy ELECTRE III method, prioritization and ranking of suitable locations for ATMs of Shahr Bank are as follows:

First priority: Dezashib, Jamaran and Niyavaran- Araj and Ozgol

Second priority: BaqFerdos, Tajrish, and Qeytariyeh

Third priority: Darake, Evin, Velenjak, Mahmoodieh, and Zaferanieh- Shahrake-e Naft

Fourth priority: Hekmat and Chizar

Fifth priority: Farmaniyeh and Hesar Bu ali- Kashank, Darabad and Golha

Sixth priority: Golabdareh, Darband and EmamzedehQasem- Shahrake-e Mahalati and Soohanak

This study attempted to extract criteria and factors affecting location of ATMs from a variety of sources. It is recommended that further studies be conducted in this area. Finally, recommendations are offered for future investigations.

• Structural equation techniques can be used to derive the relationship between the criteria and factors influencing ATMs location, specifying the impact of each factor on the location based on the statistical data.

• Conducting this research in other banks and other regions of Iran

• Conducting this research for many locations for a variety of different places and fields

• As observed in this study, linguistic variables were transformed into quantitative onesusing triangular fuzzy numbers. Then, theresearch can be conducted using trapezoidal fuzzy numbers instead of triangular fuzzy numbers.

• According to experts, paired comparisons are used in the Analytic Hierarchy Process in order to rank the options. Due to the application of Analytic Hierarchy Process, other multi-criteria decision-making methods, such as SAW, TOPSIS, VIKOR, etc., can be used to rank and prioritize criteria.

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