Fuzzy AHP and VIKOR to Select Best Location for Bank Investment: Case Study in Kurdistan Region of Iraq

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Chapter 33
Fuzzy AHP and VIKOR to Select Best Location for Bank Investment: Case Study in Kurdistan Region of Iraq

Ahmet Demir, Sarkhel Shawkat, Bzhar Nasradeen Majeed and Taylan Budur

Abstract Location selection is one of the most important decisions of the operations manager. One of the effectiveness criteria of the organizations is the correct location. And the appropriate location for the banking sector means better network to the customers and a competitive advantage in the market. The present paper investigates the best location as using the fuzzy AHP and VIKOR analysis in the Kurdistan Region of Iraq. The research revealed that "security in the region" and "willingness to work with the bank" have been the most important criterions in location strategy. These results show contrast with the developed countries.

Keywords Fuzzy AHP · Location strategy · VIKOR · MCDMA · Bank location strategy

33.1 Introduction

As long as world market keeps on expanding, global nature of every business also gains speed. From this point of view, operations manager job is harder than ever in this global acceleration. As one of the ten strategic decisions of operations managers is location strategy, it is significantly important to select initially where to locate a firm.

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A poor location strategy may increase transportation cost, cause losing competitive advantage, and consequently impact the overall success of the business [19, 50]. Beside this, good location strategy may affect overall costs of a firm up to 50% [25].

Although there are many location selection strategies and methods such as integer programming [35], multiple regression analysis [38], and branch and bound methods [16], multi-dimensional decision-making analysis is a method that calculates all complex criterions and provides a solution for decision-maker. However, there is a general flow of location selection process such as determining the main and subcriterions for location strategy, specifying the alternatives to be selected among, and using a specific model to calculate all criterions with the values of alternatives in a rank so that one of the alternatives can be chosen. Multi-criteria decision-making analysis can be proposed for all decision types as well as banking business location strategy.

Over decades, there are many changes have been in banking business market. As the acceleration in all over the global market pressures banks as well as many other sectors, it became vitally important to decide strategically at every operations' issue. Due to the location strategic decision is important for the quality of network, competitive advantage in the market, and being closer to the customers, managers must select best location for a bank. This importance brought the issue interesting for the researchers.

There are many researches which have been studied in location strategy. Those researchers have proposed various techniques of multi-criteria decision-making analysis such as analytic hierarchy process (AHP) [53], analytic network process (ANP) [17], DEMATEL [51], SWARA, WASPAS [56], TOPSIS, ELECTRE, Grey Theory [41], and fuzzy models [18]. Beside this, there are only a few or no researches have studied VIKOR method in integration with the fuzzy analytic hierarchy process in banking business location strategy. Secondly, we believe that due to Kurdistan Region of Iraq is newly being adopted with the banking system, there are special criterions such as "security" and "willingness of society to work with banks" in the region. This might not be the case in developed countries. Third, the location selection via multi-criteria decision-making analysis is a new approach in Kurdistan Region of Iraq, and the investors are not very familiar with the method while selecting the best location for their business. From these aspects, this research is important to show a methodology of location selection to the practitioners in the region.

The current study is intended to analyze main and subcriterions for bank location strategy in Kurdistan Region of Iraq. To do this, we have determined the main and subcriterions for bank location selection from the literature [12, 36, 37, 43, 54] and banking experts. Beside what we have found from the literature, experts have determined that "willingness of customers" and "security" are also important aspects which determine the best location in the region. Therefore, we have added two new criterions to the bank location decision. Secondly, we have arranged a meeting with three bank experts to evaluate the importance of each criterion comparing to each other. After the results of discussions, we have investigated the national–international reports to obtain real values for each criterion. Further, we have proposed fuzzy AHP with VIKOR method to calculate the best alternative. The results show that Erbil is the best alternative as initial location for bank investors.

33.2 Literature Review

33.2.1 Location Strategy

Any organization that wants to expand to a new site is faced with the challenge of selecting an appropriate location. Out of all of the criteria necessary for the success and survival of a firm, location seems to be the most important criterion [8, 15, 18, 22, 23]. Therefore, a great deal of thought should be given to the decision-making process for selecting a spot, because unlike other criteria, location cannot be easily changed [15, 22]. Pointing out the importance of location in the retailing industry, Jain and Mahajat [27] stated "in the development of competitive strategies, prices can be matched, services can be extended and improved, but a retailer's location advantages are difficult to assail or neutralize." Location is a particularly important contributor to the profitability and success in the banking industry [23]. Further emphasizing this importance, Fung [21] noted that 39% of customers choose their banks primarily due to the convenience of their locations.

Selecting a location for a new bank branch is not without its challenges. What makes selecting a new branch location so challenging is the multi-criteria nature of the problem and the fuzziness of some of its main determinants [15, 18]. Adding to the complexity of the problem is the fact that, depending on their strategies, different banks will consider different criteria in their decision to select a location for a new branch [9, 10, 54]. Perhaps this is the reason for why there is no consensus in the literature as to the exact number of factors that affect the performance of bank branches.

Vafadarnikjoo et al. [51] consider competition, access to public facilities, demographic attributes, cost and flexibility, and transportation as some of the most important criteria when selecting location for a new branch. Allahi et al. [4] utilize cost, access to public facilities, transportation, demographic attributes, flexibility, and competition in their model for selecting the optimal bank branch location. Cinar and Ahiska [18] use demographic, sectoral employment, socio-economic, trade potential, and banking criteria in their model for selecting a location for a new bank branch, whereas Gorener et al. [23] used demographic, economic, and investment and banking criteria in their model for selecting a bank branch location. Abbasi [1] divides the factors that affect the bank location selection into three main categories, namely general factors, business-related factors, and population-related factors, while Başar et al. [9] proposed a methodology for identifying the most important criteria and their properties for the location problem, namely number of potential customers, social potential, competition, easement of access, socio-economic situation, commercial potential, financial situation, and growth potential. But for Brealey and Kaplanis

[13], size of trade or foreign direct investment (FDI) is one of the reasons for favoring a location over another when a bank wants to open a branch in a foreign country.

Although there is no fixed set of determinants or criteria for selecting a new location, it can be drawn from the literature that demographic, economic, and competition are some of the most considered factors in the location selection problem. So, it would be a mistake from our side not to consider these factors in our study.

The problem of site selection for new branches in the banking industry has received considerable attention in the literature (see [1, 4, 9, 10, 12, 13, 15, 18, 23, 24, 33, 51]). Consequently, a variety of models and/or strategies have been developed to deal with the issue.

In their paper, Lord and Wright [33] outlined three unique strategies when it comes to selecting a location for opening a new branch in the banking industry, namely defensive, offensive, and follow-the-leader. Defensive is when the bank branch joins a cluster of other bank branches not because they want to capture new customers, but because they fear losing their existing customers. Offensive is when a firm selects a location where there are no competitors. This strategy is suitable for market leaders rather than small firms, due to the risky nature of such strategy. Finally, follow-the-leader strategy is used by smaller firms who follow a market leader to a location in hopes of capturing the attention of some of the market leader's customers.

Boufounou [12] developed a model for identifying the best location for a new bank branch using regression analysis. They found out that criteria like average household size, domestic per capita income, position of competitors, total population, and population growth rate are critical determinant of success for bank branches. Therefore, they can be used as factors affecting the location selection problem. Abbasi [1] built a decision support system (DSS) to aid the banking industry decision-makers in their struggle to find the optimal location for new branches. After defining the five most important factors in selecting a location for a new bank branch, Cinar and Ahiska [18] used fuzzy analytical hierarchy process (AHP) to establish a decision support model (DSM) that could help the banking industry firms in deciding where to place their new branches. Similarly, after consulting with experts in the banking industry, Vafadarnikjoo et al. [51] identified the most important determinants in selecting bank branch location and then used intuitionistic fuzzy set theory in combination with decision-making trial and evaluation laboratory (DEMATEL) model to prioritize the criteria that affect the decision for choosing a new bank branch. Having not found a "one-size-fits-all" procedure for selecting a new bank branch location, Cabello [15] attempted to produce a model that would suit the maximum number of situation when dealing with the location problem.

Having studied relative literature on the location selection problem in the banking industry, it was seen that location selection problem is a multi-criteria problem, as such multiple criteria decision model (MCDM) and fuzzy set theory are among the very commonly used models for solving the location problem in the banking industry [9]. Secondly, depending on the banking strategy, different banks will consider different criteria to solve their location problem. Finally, there is no one model that will be suitable for every location problem scenario. Consequently, different banking firms should consider different criteria when dealing with the location problem.

33.2.2 Fuzzy AHP Model

33.2.2.1 Fuzzy Set Theory

According to Zimmerman [55], fuzzy set theory helps to understand complex phenomena through rigid mathematical guidelines. Similarly, Wu et al. [52] noted vague expressions of people like "not very clear, probably so, and very likely" could be analyzed by fuzzy set model. Fuzzy set theory is a crucial method to measure the uncertain events related to the human beings [47].

For instance, Kwong and Bai [32] have used AHP and fuzzy AHP model to define the importance of degrees of customer requirements for product planning. Kahraman et al. [28] have used fuzzy AHP model to select the best supplier firm according to service importance weights. Similarly, Ly et al. [34] have used the same model to predict the effective impact indicators on Internet of things (IoT) system for related companies. In addition, Sanayei et al. [46] have used VIKOR analysis to determine the eligible supplier in the supply chain of a company. Further, newly Abdel-Basset and his associates have used VIKOR model to analyze the government Web sites according to quality, security, and accessibility [2].

33.2.2.2 Fuzzy Number Set

Fuzzy numbers, which defined as triangular and trapezoidal, are the subset of real numbers. The widely used one is the triangular numbers. In this study, the triangular numbers are produced through linguistic assessments of the bank managers and construct the pairwise comparison for the model [6, 20].

A triangular fuzzy number can be shown as $M = (l, m, u)$. Its membership function $\mu_M(x)$: R $\to$ [0, 1] is equal to

$$\mu_M(x) = \begin{pmatrix} \left(\frac{x}{m-l} - \frac{l}{m-l}, & x \in [\boldsymbol{l}, \mathbf{m}] \\ \frac{x}{m-u} - \frac{u}{m-u}, & x \in [\boldsymbol{l}, \mathbf{u}] \\ 0, & \text{otherweise} \end{pmatrix}$$

where $l \leq m \leq u$, the triangular numbers are: l is lower, m is mid, and u is the upper values for the support of M. When $l = m = u$, it is a non-fuzzy number by convention. The main operational laws for two triangular fuzzy numbers $M1$ and $M2$ are as follows [29]:

$$\begin{aligned} &M_1 + M_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \\ &M_1 \otimes M_2 \approx (l_1 l_2, m_1 m_2, u_1 u_2) \\ &\lambda \otimes M_1 = (\lambda l_1, \lambda m_1, \lambda u_1), \quad \lambda > 0, \quad \lambda \in \mathrm{R} \\ &M_1^{-1} \approx (1/u_1, 1/m_1, 1/l_1) \end{aligned}$$

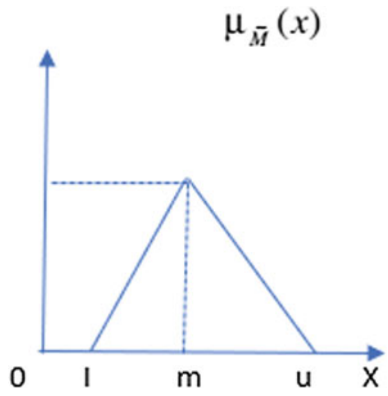

Fig. 33.1 Triangular fuzzy number

A triangular membership function is illustrated in Fig. 33.1.

33.2.2.3 Fuzzy AHP

Analytic hierarchy process (AHP) is one of the broadly used decision-making method, which was improved by Saaty in 1980 [45, 47]. According to the method, there are three categories to make the decision, which are the creation of hierarchies, determination of superiority, and providing logical and numerical consistency [30]. Criterions are hierarchically structured for the calculation and divided into importance levels, and finally, according to importance weights' best results reached through analysis. But because of the imprecise behaviors of the person, different kinds of multi-criteria calculation methods, such as fuzzy AHP and VIKOR, might be used as an integrated model with AHP [5, 47]. Steps of fuzzy AHP can be sequenced as:

Determining the fuzzy weights of each variable. To do this, the following formula has been used;

$$FW_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[\sum_{j=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \quad (33.1)$$

in order to obtain $\sum_{j=1}^{m} M_{gi}^{j}$, the fuzzy summation of m extent values for a specific matrix can be calculated as;

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad (33.2)$$

Further,

$$\left[\sum_{j=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

can be obtained via summation of M_{gi}^{j} ($j = 1, 2, 3 \ldots m$) numeric values proposed such as

$$\sum_{j=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{33.3}$$

And then, the inverse of the vector can be computed such as dividing each summation by one.

33.2.3 VIKOR

VIKOR method is one of the multi-criteria decision-making analysis that determines the compromise ranking list of alternatives, compromise solutions for complex problems, and the weight stability intervals for choice stability of the compromise solution obtained with the initial given weights [40]. The model gives best alternative as solution that is closest to the ideal [39]. Steps for the VIKOR calculation are as follows [40, 48]:

1. Determine the best (f_i^*) and the worst (f_i^-) values among all alternatives ($j = 1, 2, 3, \ldots m$) and by each criterion ($i = 1, 2, 3, \ldots n$).
   a. If it is a benefit criterion that is to be maximized: $f_i^* = \text{Max}_j f_{ij}$
   b. If it is a benefit criterion that is to be minimized: $f_i^- = \text{Min}_j f_{ij}$.
2. Compute S_j (Eq. 33.1) and R_j (Eq. 33.2) for $j = 1, 2, 3 \ldots m$. S_j and R_j, respectively, represent utility and regret measures for alternative.

$$S_i = \sum_{j=1}^{n}\left[w_i\left(\frac{f_i^* - f_{ij}}{f_i^* - f_i^-}\right)\right] \tag{33.4}$$

$$R_j = \sum_{j=1}^{n}\max_j\left[w_i\left(\frac{f_i^* - f_{ij}}{f_i^* - f_i^-}\right)\right] \tag{33.5}$$

   where W_i is the weight of the criterion.
3. Compute Q_j (Eq. 33.3) for $j = 1, 2, 3 \ldots, m$
   where $S^* = \min S_j$, $S^- = \max S_j$, $R^* = \min R_j$, $R^- = \max R_j$, v is the weight for the decision-making strategy of the maximum group utility, and $(1-v)$ is the

weight of the individual regret; generally, v is assumed equal 0.5 corresponding to the consensus.

$$Q_i = \sum_{j=1}^{n}\left[v\left(\frac{S_i - S_i^-}{S_i^* - S_i^-}\right) + (1-v)\left(\frac{R_i - R^-}{R^* - R^-}\right)\right] \tag{33.6}$$

4. Rank the alternatives by the values S, R, and Q in ascending order by forming three ranking lists such that the lower the value, the better the alternative.
5. Propose the alternative a' as a compromise solution which is ranked the best by the minimum value of Q if the following two conditions are satisfied:

   Condition 1. Acceptable advantage: $Q(a'') - Q(a') \geq DQ$ where a'' is the alternative which is ranked second by Q and $DQ = 1/(m-1)$.
   Condition 2. Acceptable stability in decision making: Alternative a' must also be the best ranked by S or/and R.

6. If one of the conditions in Step 5 is not satisfied, propose a set of compromise solutions which include:

   - Alternatives a' and a'' if only Condition 2 is not satisfied, or
   - Alternatives a', a'', …, $a(n)$ if only Condition 1 is not satisfied; the closeness of the alternative $a(n)$ ranked nth by Q is determined by $Q(a(n)) - Q(a') < DQ$.

33.3 Materials and Methods

This study aims to propose multi-dimensional decision-making analysis to understand the best location for bank investment. To do this, we have initially prepared a questionnaire that contains criterions for bank location selection. The criterions have been abstracted from the current literature studied by various researchers. The criterions have been mainly demographic, socio-economic, sectoral employment, banking, trade potential, willingness to work with banks, and security in the region. Consequently, the subcriterions of the main ones also have been determined.

The structured criterions have been discussed with the experts in the banking sector. We have met three banking experts separately and asked them the importance of each criterions comparing to one another. The answers of each expert have been discussed with four academics from the finance, economics, and operations management fields. The answers of each expert have been entered in the "expert choice" analytic hierarchy process software in order to calculate the inconsistency levels. As it has been seen that all inconsistency levels were below 0.10, it was concluded that all answers have been consistent.

Initially, global weights of each main criterions (demographic, socio-economic, sectoral employment, banking, trade potential, willingness to work with banks, and security in the region) have been calculated. Secondly, weights of subcriterions have been calculated comparing to each other. As the last step of analytic hierarchy process, we have multiplied the weight score of each subcriterion with global weight of the concerning main criterion. By this way, we have obtained the real weights of each subcriterions via analytic hierarchy process.

After calculating the importance weights of each subcriterions, we have proposed VIKOR method to calculate the minimum utility regret for each city and find the best location for start banking business. Doing this, we have initially determined the values of each subcriterions. For example, the first criterion under demographic was total population.

We have determined the demographic information from the Kurdistan Region Statistical Office and International Organization for Immigration [26]. Values for socio-economic criterion have been obtained from BBC News, facts [7], Kurdistan Region Statistical Office [31], Socio-economic monitoring system report [49]. Sectoral employment and trade potential values have been received from Boi [11]. Finally, banking criterion's real values have been determined by Abdullah [3]. The values of all subcriterions have been obtained from various national and international reports. Beside this, willingness to work with banks and security in the region criterions unfortunately did not have any value. Instead, we have asked those criterions to experts in the region to rate from one to ten for Erbil, Sulaimani, and Dohuk. The nominal values for those two main criterions have been used in the current study.

Calculating VIKOR method, obtained values have been used. First of all, best value (f_i^*) and the worst value (f_i^-) for each subcriterions, starting from the total population of each city, have been selected. Secondly, relative S_j and R_j values have been calculated for each criterions. Finally, global S_j, R_j, and Q_j values have been calculated consequently in order to select the best decision among three cities of Kurdistan Region of Iraq.

33.3.1 Findings

33.3.1.1 Fuzzy AHP

While conducting multi-criteria decision-making analysis, it is very important to structure decision criteria in a hierarchical form (Fig. 33.2). By this way, importance of each subcriteria comparing to another is calculated. Moreover, success of a decision analysis initially and strongly depends on this process [44]. By this way, overall view of very complex relations between each subcriterion can be determined. On the other hand, there is no consensus among researchers about how to structure the hierarchy of criterions among each other (Kannan). Therefore, as many authors did in their past studies [42], we have constructed the hierarchy discussing with the three experts in the banking field and four academics in finance, economics, and operations management fields.

Table 33.1 shows the fuzzy pairwise comparison weights of main criterions. Initially, three banking experts have discussed together to compare each main criterion with another by using Saaty's 1–9 scale. Later, fuzzy theory has been conducted

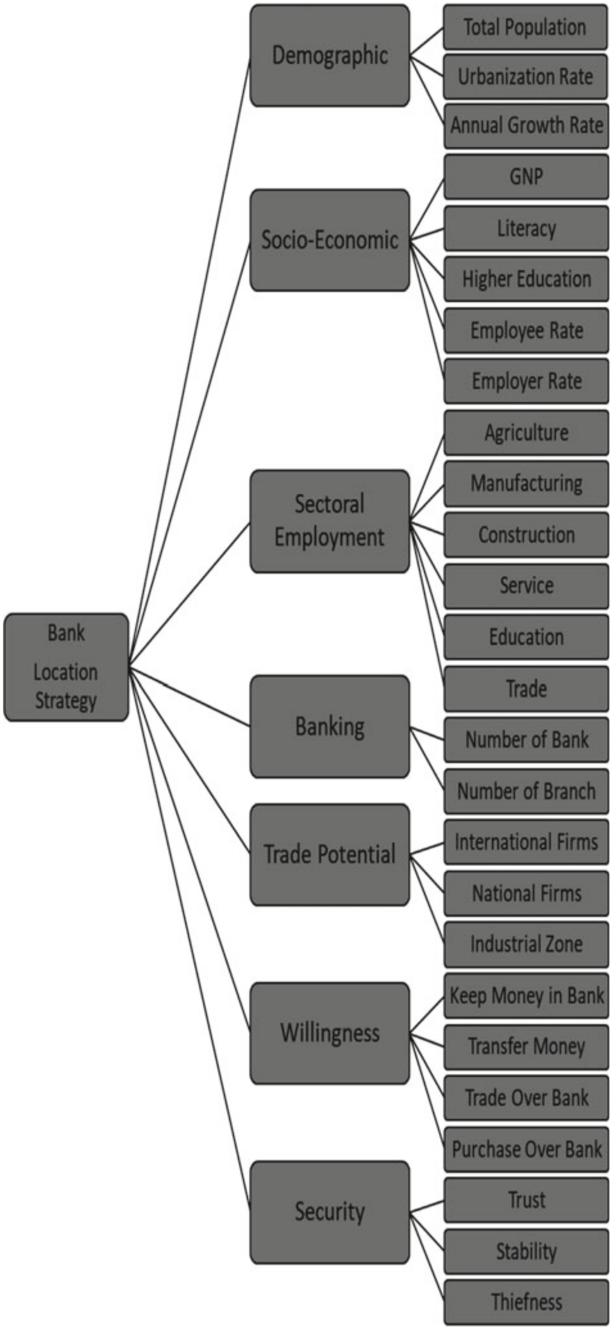

Fig. 33.2 The model of multi-criteria decision-making analysis

to create fuzzy pairwise comparison matrix. By this way, we have converted basic comparison values of the criterions into triangular fuzzy numbers in Table 33.1.

1. **Step**: From Table 33.1, fuzzy geometric mean of each variable with respect to main goal is calculated by using formula [14]:

Fuzzy geometric mean $(S_i) = (l_1, m_1, u_1,)^{1/n} * (l_2, m_2, u_2,)^{1/n} * (l_3, m_3, u_3,)^{1/n}$ where n is number of criterions.

$$\begin{aligned}
S_D &= (1 * 1/2 * 1/2 * 1/4 * 1/4 * 1/4 * 1/6)^{1/7}, \\
&\quad (1 * 1/3 * 1/3 * 1/5 * 1/5 * 1/5 * 1/7)^{1/7}, \\
&\quad (1 * 1/4 * 1/4 * 1/6 * 1/6 * 1/6 * 1/8)^{1/7} = (0.42, 0.28, 0.23) \\
S_{SE} &= (2 * 1 * 1 * 1/2 * 1/2 * 1/2 * 1/2)^{1/7}, \\
&\quad (3 * 1 * 1/2 * 1/3 * 1/3 * 1/3 * 1/3)^{1/7}, \\
&\quad (4 * 1 * 1/3 * 1/4 * 1/4 * 1/4 * 1/4) = (0.74, 0.57, 0.47) \\
S_{SEM} &= (2 * 1 * 1 * 1/2 * 1 * 1 * 1/2)^{1/7}, (3 * 2 * 1 * 1/3 * 1/2 * 1 * 1/3)^{1/7}, \\
&\quad (4 * 3 * 1 * 1/4 * 1/3 * 1 * 1/4)^{1/7} = (0.91, 0.85, 0.82) \\
S_B &= (4 * 2 * 1 * 1/2 * 1 * 2 * 1)^{1/7}, (5 * 3 * 2 * 1/3 * 1 * 3 * 1/2)^{1/7}, \\
&\quad (6 * 4 * 3 * 1/4 * 1 * 4 * 1/3)^{1/7} = (1.35, 1.47, 1.64) \\
S_{TP} &= (4 * 2 * 1 * 1/2 * 1/2 * 1 * 1/2)^{1/7}, (5 * 3 * 1 * 1/3 * 1/3 * 1 * 1/3)^{1/7}, \\
&\quad (6 * 4 * 1 * 1/4 * 1/4 * 1 * 1/4)^{1/7} = (1, 0.92, 0.87) \\
S_W &= (4 * 2 * 2 * 1/2 * 1 * 2 * 1)^{1/7}, (5 * 3 * 3 * 1/3 * 2 * 3 * 1)^{1/7},
\end{aligned}$$

Table 33.1 Fuzzy pairwise comparison matrix

	D	SE	SEM	SEC	B	TP	WILL
D	1, 1, 1	1/2, 1/3, 1/4	1/2, 1/3, 1/4	1/6,1/7, 1/8	1/4, 1/5, 1/6	1/4, 1/5, 1/6	1/4, 1/5, 1/6
SE	2, 3, 4	1, 1, 1	1, 1/2, 1/3	1/2, 1/3, 1/4	1/2, 1/3, 1/4	1/2, 1/3, 1/4	1/2, 1/3, 1/4
SEM	2, 3, 4	1, 2, 3	1, 1, 1	1/2, 1/3, 1/4	1, 1/2, 1/3	1, 1, 1	1/2, 1/3, 1/4
B	4, 5, 6	2, 3, 4	1, 2, 3	1/2, 1/3, 1/4	1, 1, 1	2, 3, 4	1, 1/2, 1/3
TP	4, 5, 6	2, 3, 4	1, 1, 1	1/2, 1/3, 1/4	1/2, 1/3, 1/4	1, 1, 1	1/2,1/3,1/4
W	4, 5, 6	2, 3, 4	2, 3, 4	1/2, 1/3, 1/4	1, 2, 3	2, 3, 4	1, 1, 1
SEC	6, 7, 8	2, 3, 4	2, 3, 4	1, 1, 1	2, 3, 4	2, 3, 4	2, 3, 4

Note: *D* demographic distributions; *SE* socio-economic situation; *SEM* sectoral employment; *B* banking; *TP* trade potential; *W* willingness to work with banks; *SEC* security in the region

$$(6 * 4 * 4 * 1/4 * 3 * 4 * 1) = (1.49, 1.90, 2.25)$$

$$S_{\mathrm{SEC}} = (6 * 2 * 2 * 1 * 2 * 2 * 2)^{1/7}, (7 * 3 * 3 * 1 * 3 * 3 * 3)^{1/7},$$
$$(8 * 4 * 4 * 1 * 4 * 4 * 4) = (2.13, 2.89, 3.62)$$

After those calculations, the fuzzy geometric means have been represented on Table 33.2.

2. **Step**: Determining the fuzzy weights of each variable. To do this, the following formula has been used;

$$FW_i = \sum_{j=1}^{m} M_{gi}^{j} * \left[\sum_{j=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \tag{33.7}$$

in order to obtain $\sum_{j=1}^{m} M_{gi}^{j}$, the fuzzy summation of m extent values for a specific matrix can be calculated as;

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{33.8}$$

Further,

$$\left[\sum_{j=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

can be obtained via summation of M_{gi}^{j} $(j = 1, 2, 3 \ldots m)$ numeric values proposed such as

$$\sum_{j=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{33.9}$$

Table 33.2 Fuzzy geometric means

Demographic	0.42	0.28	0.23
Socio-economic	0.74	0.57	0.47
Sectoral employment	0.91	0.85	0.82
Banking	1.35	1.47	1.64
Trade potential	1.00	0.92	0.87
Willingness	1.49	1.90	2.25
Security	2.12	2.89	3.62

And then the inverse of the vector can be computed such as dividing each summation by one. After all calculations, fuzzy weights and the defuzzied weights are shown in Table 33.3;

3. **Step**: Center of gravity. Fuzzy weights have been calculated by the formulas which have been introduced above. Further, in order to calculate the final weights of the fuzzy analytic hierarchy process, we need to propose center of gravity function which is

$$W_i = \frac{l + m + u}{3} \tag{33.10}$$

where lower, medium, and upper values are summed up and divided by three. The results show that the most important parameter among bank location selection criterions is security. The importance percentage of the criterion is 32% as the biggest value comparing to others. This result shows that the most secure city has competitive advantage among others. Secondly, willingness to work with a bank (21%), banking (17%), trade potential of the city (11%), and sectoral employment (10%) are other important criterions, respectively, while selecting the best location for a banking business. Finally, it has been observed that socio-economic situation of the city (7%) and demographic (4%) are the least important criterions.

Based on the importance weights of each criterion, the importance of the subcriterions has been also calculated in the same methodology. For example, demographic has three subcriterions in total. Further, the subcriterions also have already been evaluated by the same expert group. The results are shown in Table 33.4.

Table 33.4 shows the normalized important weights of each subcriterion. Beside this, those weights are still need to be processed and calculated to distribute the importance weights of main criterions conveniently to the subcriterions.

There are mainly three subcriterions under demographic criterion. The normalized weights of those subcriterions (total population, urbanization rate, and annual population growth rate) are 0.28, 0.64, and 0.07, respectively. On the other hand, these are the values which have been calculated before taking main criterions into account. By

Table 33.3 Importance weights matrix

	Fuzzy weights			Defuzzied weights
Demographic	0.05	0.03	0.02	0.04
Socio-economic	0.09	0.06	0.05	0.07
Sectoral employment	0.11	0.10	0.08	0.10
Banking	0.17	0.17	0.17	0.17
Trade potential	0.13	0.10	0.09	0.11
Willingness	0.19	0.21	0.23	0.21
Security	0.27	0.33	0.37	0.32
Inconsistency: 0.05				

Table 33.4 Importance weights matrix of subcriterions

Variables		Fuzzy weights			Defuzzied weights
Demographic	Total population	0.32	0.28	0.25	0.28
	Urbanization rate	0.59	0.65	0.69	0.64
	Annual population growth	0.09	0.07	0.06	0.07
Socio-economic	GNP	0.44	0.49	0.52	0.48
	Literacy rate	0.08	0.07	0.06	0.07
	Higher education	0.07	0.05	0.04	0.06
	Employee rate	0.27	0.26	0.26	0.27
	Employer rate	0.14	0.13	0.12	0.13
Sectoral employment	Agriculture	0.08	0.06	0.05	0.06
	Manufacturing	0.12	0.12	0.12	0.12
	Construction	0.28	0.28	0.27	0.28
	Service	0.04	0.03	0.02	0.03
	Education	0.09	0.08	0.07	0.08
	Trade	0.39	0.43	0.46	0.43
Banking	Number of bank	0.50	0.67	0.75	0.64
	Number of branch	0.22	0.14	0.10	0.15
Trade potential	International firms	0.71	0.74	0.76	0.74
	National firms	0.15	0.17	0.17	0.16
	Industrial zone	0.14	0.09	0.07	0.10
Willingness	Keep money in bank	0.26	0.18	0.15	0.20
	Transfer money	0.34	0.46	0.52	0.44
	Trade over bank	0.31	0.30	0.28	0.30
	Purchase over bank	0.08	0.06	0.05	0.06
Security	Trust	0.61	0.67	0.71	0.66
	Stability	0.27	0.24	0.22	0.24
	Robbery	0.12	0.09	0.07	0.09

another meaning, those values are relative importance weights of each subcriterion only comparing to each other. Further, by multiplying the normalized weights of main criterions with each subcriterions, we will obtain the final importance weight of each subcriterion comparing to the all subcriterions (Table 33.5).

The other relative weights of subcriterions have been calculated by the same methodology. The table below shows the results of all subcriterions (Table 33.6).

Table 33.6 shows the relative priority within the concerning criterion. To expand the explanation, there are mainly three criterions for security. Perceived trust of the society to the banks, security in the region, and the robbery rate in the region have been discussed by the three banking experts and have been evaluated. Further, they have

Table 33.5 Relative weights of subcriterions under demographic

Variable name	Subcriterion weight	Operation	Weight of demographic	Relative weights of subcriterions
Total population	0.28	×	0.04	0.009
Urbanization rate	0.64	×	0.04	0.021
Annual population growth	0.07	×	0.04	0.002

rated the comparative importance of each criterion to one another. Secondly, using the fuzzy AHP methodology, we have calculated the weights of each subcriterion. After that, we have multiplied the normalized weight of security criterion (0.319) by each subcriterion (0.664, 0.245, and 0.092), and the relative weights have been 0.21, 0.08, and 0.03, respectively. The other relative weights have been calculated with the same methodology.

33.3.1.2 VIKOR

In order to select the best place for banking business investment, we have explained the methodology how the weights have been calculated by using fuzzy analytic hierarchy process. However, in this section, we have proposed VIKOR method in

Table 33.6 Relative weights of AHP

Criterion	Subcriterion	Global weights	Weights of subcriterion	Relative weights of subcriterion
Demographic (*D*)	Total population (*D*1)	0.033	0.284	0.009
	Urbanization rate (*D*2)	0.033	0.643	0.021
	Annual population growth rate (*D*3)	0.033	0.074	0.002
	Inconsistency: 0.06			
Socio-economic (SE)	Gross national product per capita (SE1)	0.068	0.484	0.033
	Literacy rate (SE2)	0.068	0.068	0.005
	Rate of population with higher education (SE3)	0.068	0.057	0.004

(continued)

Table 33.6 (continued)

Criterion	Subcriterion	Global weights	Weights of subcriterion	Relative weights of subcriterion
	Employee rate (SE4)	0.068	0.265	0.018
	Employer rate (SE5)	0.068	0.126	0.009
	Inconsistency: 0.04			
Sectoral employment (SEM)	Agricultural employment rate (SEM1)	0.098	0.063	0.006
	Manufacturing employment rate (SEM2)	0.098	0.121	0.012
	Construction employment rate (SEM3)	0.098	0.276	0.027
	Services employment rate (SEM4)	0.098	0.033	0.003
	Education sector employment rate (SEM5)	0.098	0.080	0.008
	Trade sector employment rate (SEM6)	0.098	0.426	0.042
	Inconsistency: 0.05			
Banking (*B*)	Number of bank (*B*1)	0.167	0.639	0.107
	Number of branch (*B*2)	0.167	0.155	0.026
	Inconsistency: 0.00			
Trade potential (TP)	Number of international firms (TP1)	0.106	0.737	0.078
	Number of national firms (TP2)	0.106	0.163	0.017
	Number of industrial zones (TP3)	0.106	0.101	0.011
	Inconsistency: 0.01			

(continued)

Table 33.6 (continued)

Criterion	Subcriterion	Global weights	Weights of subcriterion	Relative weights of subcriterion
Willingness (W)	Willingness to keep money in banks ($W1$)	0.209	0.198	0.041
	Willingness to transfer money over banks ($W2$)	0.209	0.441	0.092
	Willingness to trade over banks ($W3$)	0.209	0.296	0.062
	Willingness to purchase over banks ($W4$)	0.209	0.065	0.014
Inconsistency: 0.02				
Security (SEC)	Perceived trust of society to the banks (SEC1)	0.319	0.664	0.212
	Security in the region (SEC2)	0.319	0.245	0.078
	Robbery rate in the region (SEC3)	0.319	0.092	0.029
Inconsistency: 0.01				

order to find the minimum utility regret and the opportunity cost. To do this, in order to use the values in the concerning VIKOR formulas, we have investigated the national and international reports to find the required values for demographic, socio-economic, sectoral employment, trade potential, and banking criterions. Further, due to there is no information about willingness of society to work with the banks and security in the region, we have used nominal values which have been evaluated by the three banking experts. They have rated the values of three subcriterions of security and four subcriterions of willingness for each region from one up to ten. The values for each city have been used like a data in the concerning formulas of VIKOR method.

VIKOR is a multi-criteria decision-making analysis method which has been found by Serafim Opricovic in order to solve highly complex conflicts by selecting the choice which is closest to the ideal. In order to propose VIKOR, the best (f_i^*) and the worst (f_i^-) values for each criterion have been determined. S_j and R_j values for each alternative have been calculated by proposing the Eqs. (33.4) and (33.5), respectively (Table 33.7).

As a result of these calculations, relative utility regret (RS_j) has been obtained. The relative utility regret shows how much the users would be regretful for the concerning alternative in case they select. For example, perceived trust of society to

Table 33.7 S_j and R_j values of service providers at each subcriterion

CR	SC	City	Value	GWC	GWSC	RWSC	f_i^*	f_i^-	RS_j
Demographic (*D*)	*D*1	E	2,190,738	0.03	0.28	0.009	2,190,738	1527,413	0.00
		S	2,157,832	0.03	0.28	0.009	2,190,738	1,527,413	0.00
		D	1,527,413	0.03	0.28	0.009	2,190,738	1,527,413	0.01
	*D*2	E	1,789,395	0.03	0.64	0.021	1,789,395	1,247,591	0.00
		S	1,762,517	0.03	0.64	0.021	1,789,395	1,247,591	0.00
		D	1,247,591	0.03	0.64	0.021	1,789,395	1,247,591	0.02
	*D*3	E	2.48	0.03	0.07	0.002	4.17	2.48	0.00
		S	3.46	0.03	0.07	0.002	4.17	2.48	0.00
		D	4.17	0.03	0.07	0.002	4.17	2.48	0.00
Socio-economic (SE)	SE1	E	9,858,322	0.07	0.48	0.033	9,858,322	6,873,357	0.00
		S	9,710,245	0.07	0.48	0.033	9,858,322	6,873,357	0.00
		D	6,873,357	0.07	0.48	0.033	9,858,322	6,873,357	0.03
	SE2	E	78.65	0.07	0.07	0.005	80.4	76.6	0.00
		S	80.4	0.07	0.07	0.005	80.4	76.6	0.00
		D	76.6	0.07	0.07	0.005	80.4	76.6	0.00
	SE3	E	1.4	0.07	0.06	0.004	1.7	1.075	0.00
		S	1.7	0.07	0.06	0.004	1.7	1.075	0.00
		D	1.075	0.07	0.06	0.004	1.7	1.075	0.00
	SE4	E	50.2	0.07	0.27	0.018	55	50.2	0.02
		S	55	0.07	0.27	0.018	55	50.2	0.00

(continued)

Table 33.7 (continued)

CR	SC	City	Value	GWC	GWSC	RWSC	f_i^*	f_i^-	RS_j
		D	51	0.07	0.27	0.018	55	50.2	0.02
	SE5	E	2.4	0.07	0.13	0.009	4.7	2.4	0.01
		S	4.7	0.07	0.13	0.009	4.7	2.4	0.00
		D	4.5	0.07	0.13	0.009	4.7	2.4	0.00
Sectoral employment (SEM)	SEM1	E	5	0.10	0.06	0.006	16	5	0.01
		S	16	0.10	0.06	0.006	16	5	0.00
		D	9	0.10	0.06	0.006	16	5	0.00
	SEM2	E	54	0.10	0.12	0.012	87	54	0.01
		S	87	0.10	0.12	0.012	87	54	0.00
		D	60	0.10	0.12	0.012	87	54	0.01
	SEM3	E	50	0.10	0.28	0.027	81	36	0.02
		S	81	0.10	0.28	0.027	81	36	0.00
		D	36	0.10	0.28	0.027	81	36	0.03
	SEM4	E	4	0.10	0.03	0.003	4	0	0.00
		S	3	0.10	0.03	0.003	4	0	0.00
		D	0	0.10	0.03	0.003	4	0	0.00
	SEM5	E	6	0.10	0.08	0.008	11	6	0.01
		S	8	0.10	0.08	0.008	11	6	0.00
		D	11	0.10	0.08	0.008	11	6	0.00
	SEM6	E	59	0.10	0.43	0.042	59	35	0.00
		S	39	0.10	0.43	0.042	59	35	0.03

(continued)

Table 33.7 (continued)

CR	SC	City	Value	GWC	GWSC	RWSC	f_i^*	f_i^-	RS_j
		D	35	0.10	0.43	0.042	59	35	0.04
Banking (*B*)	B1	E	11	0.17	0.64	0.107	20	6	0.07
		S	10	0.17	0.64	0.107	20	6	0.08
		D	4	0.17	0.64	0.107	20	6	0.12
	B2	E	6	0.17	0.15	0.026	10	2	0.01
		S	10	0.17	0.15	0.026	10	2	0.00
		D	2	0.17	0.15	0.026	10	2	0.03
Trade potential (TP)	TP1	E	11	0.11	0.74	0.078	47	11	0.08
		S	47	0.11	0.74	0.078	47	11	0.00
		D	19	0.11	0.74	0.078	47	11	0.06
	TP2	E	203	0.11	0.16	0.017	298	203	0.02
		S	298	0.11	0.16	0.017	298	203	0.00
		D	211	0.11	0.16	0.017	298	203	0.02
	TP3	E	1530	0.11	0.10	0.011	3100	1530	0.01
		S	3100	0.11	0.10	0.011	3100	1530	0.00
		D	420	0.11	0.10	0.011	3100	1530	0.02
Willingness (*W*)	W1	E	8	0.21	0.20	0.041	8	6	0.00
		S	6	0.21	0.20	0.041	8	6	0.04
		D	7	0.21	0.20	0.041	8	6	0.02
	W2	E	9	0.21	0.44	0.092	9	7	0.00
		S	8	0.21	0.44	0.092	9	7	0.05

(continued)

Table 33.7 (continued)

CR	SC	City	Value	GWC	GWSC	RWSC	f_i^*	f_i^-	RS_j
		D	7	0.21	0.44	0.092	9	7	0.09
	W3	E	8	0.21	0.30	0.062	8	6	0.00
		S	6	0.21	0.30	0.062	8	6	0.06
		D	6	0.21	0.30	0.062	8	6	0.06
	W4	E	7	0.21	0.06	0.014	7	5	0.00
		S	5	0.21	0.06	0.014	7	5	0.01
		D	6	0.21	0.06	0.014	7	5	0.01
Security (SEC)	SEC1	E	8	0.32	0.66	0.212	8	7	0.00
		S	7	0.32	0.66	0.212	8	7	0.21
		D	7	0.32	0.66	0.212	8	7	0.21
	SEC2	E	9	0.32	0.24	0.078	9	8	0.00
		S	8	0.32	0.24	0.078	9	8	0.08
		D	8	0.32	0.24	0.078	9	8	0.08
	SEC3	E	8	0.32	0.09	0.029	8	7	0.00
		S	7	0.32	0.09	0.029	8	7	0.03
		D	7	0.32	0.09	0.029	8	7	0.03

Note: *E* Erbil, *S* Sulaimani, *D* Dohuk, *CR* criterion, *SC* subcriterion, *GWC* global weight of criterion, *GWSC* global weight of subcriterion, *RWSC* relative weight of subcriterion, f_i^* best value among alternatives, f_i^- worst value among alternatives, *RSj* relative weights for utility regret

Table 33.8 Final values of alternatives for location strategy

	S_j	R_j	s_j^*	s_j^-	R_j^*	R_j^-	Q_j
Erbil	0.283	0.078	0.283	0.917	0.078	0.212	0.000
Sulaimani	0.603	0.212					0.752
Dohuk	0.917	0.212					1.000

the banks (SEC1) is a criterion which relatively important for customers. Considering alternatives, Erbil, Sulaimani, and Dohuk, it was observed that utility regret values were 0.00, 0.21, 0.21, respectively. It shows that the investor, who selects Erbil, would have the least utility regret about trust of society to the banks. The result shows that Erbil promises the least utility regret about trust with the value 0.00 regret which is lower than Sulaimani (0.21) and Dohuk (0.21). All utility regret values have been calculated and evaluated the same methodology. The details are in Table 33.7.

Secondly, global S_j and global R_j values have been calculated by adding up all S_j values for each alternative at each subcriterion and R_j values for each alternative at each subcriterion. For example, in order to calculate S_j value for Erbil alternative, we have added up all S_j values of Erbil under each subcriterion in the table above. Further, for the R_j values, we have selected maximum values among all S_j values of the alternatives from the same table. Other S_j and R_j values for each alternative have been calculated by the same methodology. Finally, Q_j values for each alternative have been calculated by using Eq. (33.6). For this calculation, we have used "V" vector value as 0.5 like other authors [40, 48]. The results of the calculations can be observed in Table 33.8.

The results of global utility regret (S_j) and (R_j) values show consistency with the maximum utility (Q_j) that Erbil is the best location for investment on banking business rather than Sulaimani and Dohuk based on the evaluation of all locations. However, $C1$ ($Q_{\text{Erbil}} - Q_{\text{Sulaimani}} \geq 1/3 - 1$) and the $C2$ (that Erbil is best alternative based on S_j and R_j values) criteria have been satisfied.

33.4 Practical Implications

There are several implications of the current research for the practitioners and theorists. First, by using the current study, public and private business investors in Kurdistan Region of Iraq may understand a method of decision making about location selection at the beginning of their investments. Such a methodology in location strategy is a new concept for the region, and the study plays an important role from this point of view.

Secondly, the study added two more important criterions (willingness and security) to the location selection problem in banking sector. It shows that for some geographies, such as Kurdistan Region of Iraq, some particular variables may play more important role rather than they do in developed countries. From this point of view, the study contributes both theoretically and practically to the literature from some specific aspects of the location problem. On the one hand, investors may use those two new criterions for the further decision analysis in order to increase the precision in location selection. On the other hand, theoretically new criterions have been added to the problem.

Third implication of the study is that the current bank investors and managers may evaluate their location performances using the current study in the region. For example, any investment started in different city than Erbil can evaluate what are the advantages and disadvantages for their location decisions. This may help them evaluate the future strategies on location selection.

Location strategy is important for businesses as it is a structural decision area which is long term and costly to change. From this point of view, investors must evaluate location analysis critically in order to increase the business performance and decrease the total costs.

This research has studied some special criterions of bank location strategies; beside, it has reused the existing criterions in the literature. The results show that the most important criterion for location selection is security in Kurdistan Region of Iraq. Secondly, willingness of the society to work with the banks plays an important role in location problems' solutions. It has been seen that rather than any other developed countries, there are some particular aspects that determine where to locate the investment. Moreover, other criterions, such as socio-economic, sectoral employment, trade potential, banking, and demography, play less importance than the security and willingness. The reason might be the society is newly getting integrated with the banks and interact in their businesses.

Results show that Erbil is the best location currently to start investment in banking business comparing to Sulaimani and Dohuk. The results show that from the willingness of the society to work with the banks and security in the city, Erbil is the best location. Further, Sulaimani is the second, and the Dohuk is the last option for the bank investment.

As all researches, this study also has some limitations. Initially, it would be beneficial to discuss the limitations of data in the region. For example, Cinar and Ahiska [18] have studied "banking deposit per branch, credits per branch, credit per capita, and bank deposit per capita" in their researches. On the other hand, we have excluded the concerning parts as we are unable to obtain the concerning data in the region. This might be the first limitation of the study. Secondly, we have used the nominal values which have been evaluated by the banking experts in order to compare security and willingness of societies in three cities of the region. Beside this, we could propose a survey questionnaire among three cities' societies in order to contribute more realistic values for the willingness and security perception of populations in the concerning regions.

In the current study, we have focused on different cities to select the best of them. Further, the future studies may focus on the inside city location strategies to select best location in a city. By this way, the further researches may increase the number of detailed researches in the current literature.

33.5 Conclusions, Limitations, and Directions for the Future Studies

This research have studied some special criterions of bank location strategies beside it has reused the existing criterions in the literature. The results shows that the most important criterion for location selection is security in the region were society trust banks. Secondly, willingness of the society to work with the banks play an important role in location problems' solutions. It has been seen that rather than any other developed countries, there are some particular aspects that determines where to locate the investment. Moreover, other criterions such as socio-economic, sectoral employment, trade potential, banking, and demography plays less importance than the security and willingness. The reason might be the society is newly getting integrated with the banks and interact in their businesses.

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