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Application of Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) Method for Bank Branch Location Selection

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Abstract

Location selection problem in banking is an important issue for the commercial success in competitive environment. There is a strategic fit between the location selection decision and overall performance of a new branch. Providing physical service in requested location as well as alternative distribution channels to meet profitable client needs is the current problematic to achieve the competitive advantage over the rivalry in financial system. In this paper, an integrated model has been developed to support in the decision of branch location selection for a new bank branch. Analytic Hierarchy Process (AHP) technique has been conducted to prioritize of evaluation criteria, and multi-objective optimization on the basis of ratio analysis (MOORA) method has been applied to rank location alternatives of bank branch.

Keywords: Location selection; Banking; Bank Branch; AHP; MOORA

1. Introduction

Many countries before globalization strictly regulated the financial system, permitted limitedly to open branch abroad and restricted the international financial transactions in the worldwide. In this case, the competition in the financial system remained in the local area and new service & products of the banking sector were provided for only national clients. The revealed situations such as incomparable pricing mechanism for particularly have given global services and were unable to get the most profitable global customers. These were the main problems in the lack of the global competition. By the globalization process, the productivity and efficiency in production economies has become an important concern to ensure the competitive advantage. Especially, the new economy process emerged by the 1990s requires to consider the strategic thinking such as competitive pricing, providing the service just in time and changing demand according the customer needs. Although all of the items are significantly related to the customer-oriented beneficial determinants, the main problem for the firms is to find the strategies that reducing operational costs and determining attractive location as well as providing customer satisfaction.

Bank branch location is one of the most important strategic issues in the complex market competitiveness. Increasing new service facilities and internet-based banking applications force the firms to give face to face services more efficiently than competitors. That's why the nearest locations should be found to provide the most profitable and productive services for conscious customers.

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In this study, bank branch determinants have been revealed and related demographic, economic and investment parameters have been determined to find out the best branch location. AHP and MOORA method also have been considered to evaluate the best bank branch location in inter-country comparison.

2. Bank Branch Location Selection

It is necessary to focus on the productivity-enhancing strategies in order to achieve profitability in banking transactions. There are lots of items to get the productivity and efficiency in financial institutions. However, the branch location selection is the prominent issue in banking sector to increase the productivity and gains. Although gigantic empirical studies on efficiency and productivity of the banking sector, most of them only get weight to the internal and organizational factors to evaluate the branch performance. Also, they generally use the data envelopment analysis to appraise internal inputs. The selected studies on bank branch are seen in table 1.

Table 1. Selected Studies on Bank Branch

Authors	Main Determinants	Methods	Goals
Boufounou, 1995	Deposits, population, households, employment, firms in the trade sector, income, characteristics of the owners' and competitors' bank branches,	Regression model	Bank branch planning,
Athanassopoulos, 1997	Employees, computers, ATM, transactions, deposits and loans	Data envelopment analysis	Service quality and efficiency,
Hirtle, 2007	Deposits, loans, return on equity, market return, assests, capital ratio, entities, Herfindahl-Hirschmann Index	Regression	Impact of network and bank performance
Liang, Ching, Chan, 2013	Return on asset, return on equity, tobin's Q, net interest marjin ratio, cost ratio, characteristics of the branch and representative office, control variables	Regression analysis	European Banks and representative offices performance
Giokas, 2008	Personel costs, operating costs, interest and non-interest costs, loans, deposits,interest and non-interest income	Data envelopment analysis	Efficiency
Berger, Leusner, Mingo, 1997	Operating costs, interest costs, consumer and business transactions, closed and opened accounts, credits, debits,	Panel data	Merger and efficiency
Cerutti, Ariccia, Peria, 2007	Internationalization strategy, size, business orientation, regulations, entry,	Probit model	organizational form
Dekker, Post, 2001	Personell, workspace, loans, mortgages, insurance, computers, demographics, competition	Data envelopment analysis	Production technology
Shyu, Chiang, 2012	Staff, business personel, office rent, operating expenses, net interest spread income, net fee income	Data envelopment analysis	Managerial efficiency and environment variables
Manandhar, Tang, 2002	Personnel expenses, supplies, office space, technology, labor, deposits and loans, interest and non-interest expenses	Data envelopment analysis	Effiency, internal service quality, benchmarking
Paradi, Rouatt, Zhu, 2011	Personal and commercial relationship, specialist, manager, transactions	Data envelopment analysis	Bank branch network
Paradi, Zhu, Edelstein, 2012	Sales, service, management, day-day banking, borrowing, investment, transactions	Data envelopment analysis	Branch Management
Ramirez, 2003	Assests, capital, deposit, risky assests, failure rate, market power, establishment, population, illiteracy rate, manufacturing	Logit regression	Bank failures, unit banks
Spyropoulos, Balaras, 2011	Construction details and annual energy consumption	Sensitivity Analysis	Energy consumption and office buildings
Meepadung, Tang, Khang, 2009	Labor, empoyees, interest and non-interest expenses, deposit, loans, IT-based transaction, interest and non-interest income	Data envelopment analysis	Efficiency and IT-based technology
Wu, Yang, Liang, 2006	Personel, equipment, occupancy, expenses, income, population, density, economy, deposits, loans	Data envelopment analysis	The efficiency of Cross-region bank branches

The focus points of the bank branch-based studies can be listed as the planning, managerial issues and service quality in the efficiency, technology and network etc. Nevertheless, the evaluation criteria in the branch selection generally omit the external factors on the basis of the economics and investment. The methods are mostly limited to the regression and data envelopment analysis. In this study, comprehensive framework for inter-country bank branch location is conducted. However, banking and investment-based parameters as well as economic and demographic criteria in the target countries are considered for the branch location selection.

2.1. Evaluation framework

In this study, our location selection model contains three main criteria with eleven sub-criteria. Demographic criteria (C_1) include three sub-criteria; total population (C_{11}), literacy rate (C_{12}) and urbanization rate (C_{13}). Economic criteria (C_2) contain four sub-criteria namely gross domestic product (C_{21}), spending on education (C_{22}), employment rate (C_{23}) and inflation rate in consumer prices (C_{24}) Investment and banking criteria (C_3) consist four criteria namely total business spending on investment (C_{31}), number of domestic companies listed on the stock exchange (C_{32}), Bank capital to assests ratio (C_{33}) and domestic credit by banking sector (C_{34}).

Table 2. List of evaluation criteria for bank branch location selection

Main Criteria	**Sub-Criteria**
C_1-Demographic criteria	C_{11}-Total population
	C_{12}-Literacy rate (%)
	C_{13}-Urbanization rate (%)
C_2- Economic criteria	C_{21}-Gross domestic product (millions of US $)
	C_{22}-Spending on education (% of GDP)
	C_{23}-Employment rate (%)
	C_{24}-Inflation rate in consumer prices(%)
C_3- Investment and Banking criteria	C_{31}-Total business spending on investment (% of GDP)
	C_{32}-Number of domestic companies listed on the stock exchange
	C_{33}-Bank capital to assests ratio (%)
	C_{34}-Domestic credit by banking sector (% of GDP)

Four possible location alternatives (L_1, L_2, L_3 and L_4) are determined as alternatives by the XYZ Corp. to open its new bank branch. Hierarchical structure of location selection problem is given in Figure 1.

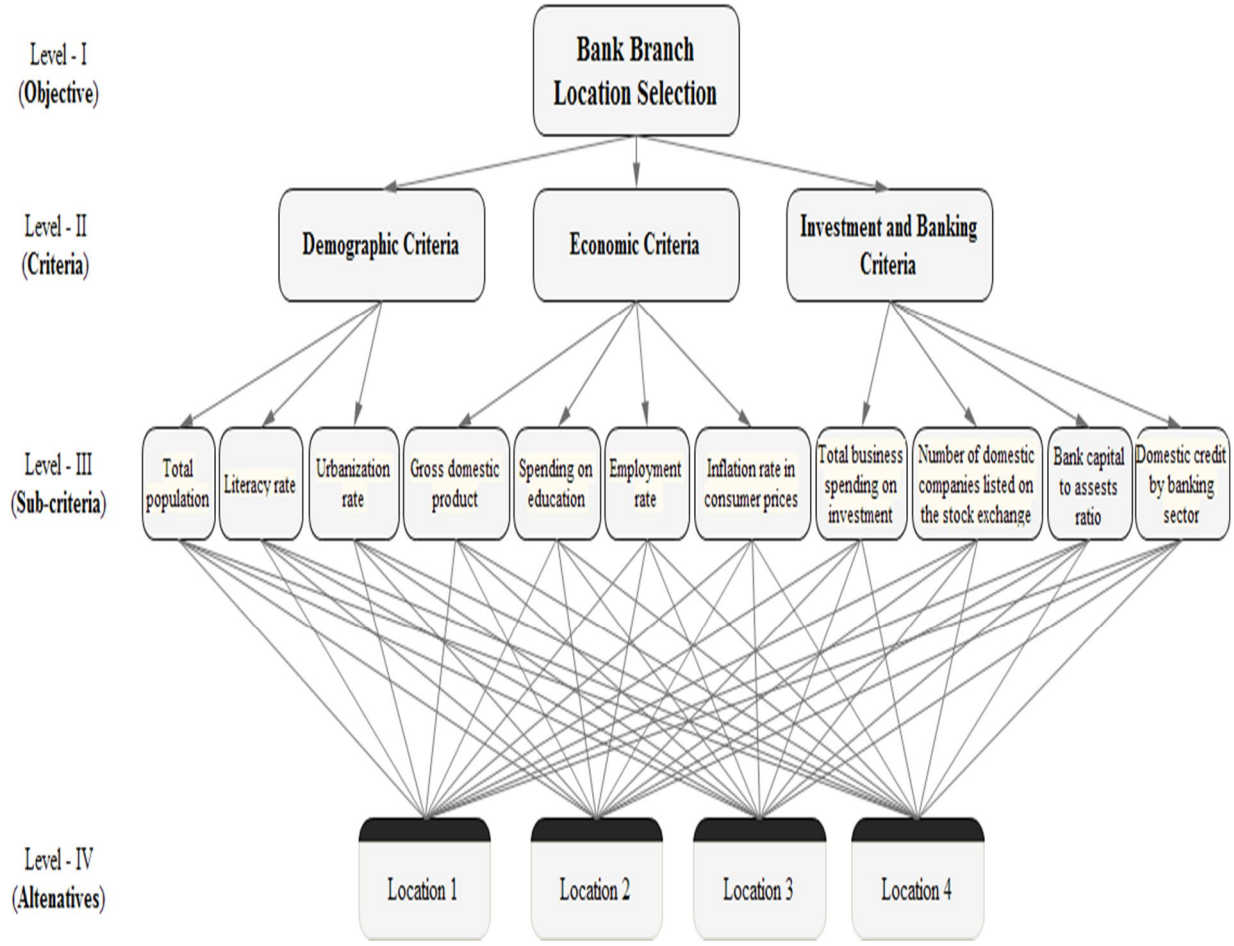

Figure 1. Location selection problem hierarchy

3. Research Methods

3.1 AHP Method

The AHP is an effective decision making method to solve multi-dimensional and complex problems. AHP performs pairwise comparison matrices to decompose and solve a multiple criteria decision making problems with different and conflicting criteria. AHP method is based on three main principles: structure of the model; comparative judgment of the criteria and/or alternatives; synthesis of the priorities.

Steps of the AHP method as follows (Saaty, 1980, 1990, 2008):

Step 1: Developing the hierarchical structure.

A decision problem is structured as a hierarchy. With the AHP, the goal, decision criteria and alternatives are arranged in a hierarchical structure similar to a family tree (Albayrak and Erensal, 2004; Liu et al., 2012).

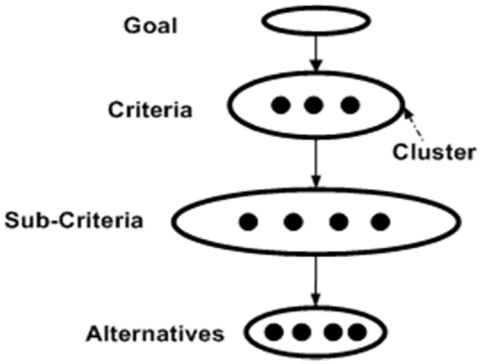

Figure 2. Hierarchical structure of AHP

Step 2: Perform the pairwise comparisons.

In this step, comparison matrices are formed and pairwise comparisons are conducted. Decision criteria are compared in the corresponding level using fundemental comparison scale. The table below shows the comparison scale used by AHP.

Table 2. The fundamental scale for pairwise comparison

Intensity of importance	Explanation
1	Two activities or criteria contribute equally to the objective
3	Experience and judgement slightly favor one over another
5	Experience and judgment strongly favor one over another
7	An activity or criteria is strongly favored and its dominance is demonstrated in practice
9	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	When compromise is needed

This pairwise comparison can be shown by a square and reciprocal matrix, (see Eq. (1)). The result of the pairwise comparison on *n* criteria can be summarized in an (*n* x *n*) evaluation matrix.

$$A = \left(a_{ij}\right)_{nxn} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ a_{n1} & a_{n2} & . & a_{nn} \end{bmatrix} \quad (1)$$

Step 3: Calculating the relative importance weights.

In the last step, each matrix is normalized and perform calculations to check consistency. Via normalization, the normalized weight vectors and priority of criteria can be obtained.

The number 0.1 is the accepted upper limit for consistency ratio (CR) (Dağdeviren et al., 2009). The CR is calculated as the ratio of the consistency index (CI) and the random index (RI). The CI and CR can be computed with the use of following equations:

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{2}$$

$$CR = \frac{CI}{RI} \tag{3}$$

Table 3. Random index (Saaty, 1980)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41

3.2 MOORA Method

The MOORA method, first used by Brauers (2003), is relatively new multi-criteria decision making method. The method based on ratio system and dimemsionless measurement (Brauers et al., 2008, 2010).

MOORA method is composed of five major steps (Brauers and Zavadskas, 2006; Chakraborty, 2011; Gadakh, 2011; El-Santawy and Ahmed, 2012):

Step 1: Creating the decision matrix.

The method starts with a decision matrix of responses of different alternatives to evaluation criteria.

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \tag{4}$$

where x_{ij} is the performance measure of ith alternative on jth criteria, m is the number of alternatives, and n is the number of criteria.

Step 2: Normalization procedure.

MOORA refers to a ratio system in which each response of an alternative on criteria is compared to a denominator, which is representative for all alternatives concerning that objective. This ratio can be expressed as below:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \qquad (j = 1, 2, \dots, n) \tag{5}$$

where x_{ij}^{*} is a dimensionless number which belongs to the interval [0, 1] representing the normalized performance of ith alternative on jth criteria.

Step 3: Evaluation of positive and negative effects.

For optimization, these normalized performances are added in case of maximization (for beneficial criteria) and subtracted in case of minimization (for nonbeneficial or cost criteria) by solving the following equation:

$$y_i = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \tag{6}$$

where g is the number of criteria to be maximized, (n−g) is the number of criteria to be minimized, and y_i is the normalized assessment value of *i*th alternative with respect to all the criteria.

Step 4: Determine the weighted assessment value.

Generally, it is often observed that some decision criteria are more important than the others. In order to increase priority of criteria, it could be multiplied with its weight. When these criteria weights are taken into consideration, Eq. 7 becomes as follows:

$$y_i^* = \sum_{j=1}^{g} w_j \, x_{ij}^* - \sum_{j=g+1}^{n} w_j \, x_{ij}^* \qquad (j = 1, 2, \ldots, n) \tag{7}$$

where w_j is the priority of *j*th criteria, which can be assigned using different multi-criteria decision making method.

Step 5: Ranking of alternatives.

Decision alternatives should be ranked the preference order according to decreasing values of y_i^*. Assessment value can be positive or negative depending of criteria situation and priority values.

4. The Application for Bank Branch Location Selection

In order to solve the bank branch location selection problems and rank the location alternatives, integrated AHP-MOORA model is proposed. The general structure of our methodology is given in the Figure 3.

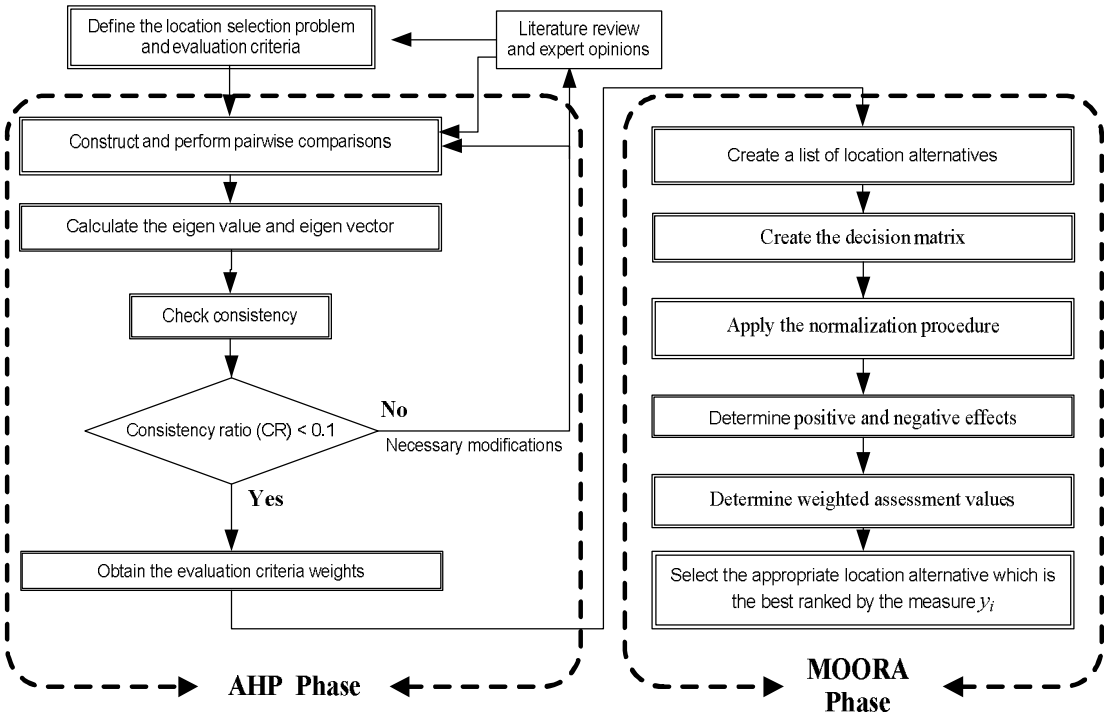

Figure 3. General structure of the location selection framework

4.1 Determining priorities of evaluation criteria

In the first step of the solution, AHP is applied to assign priorities of criteria. To construct the pairwise comparison matrices for the evaluation criteria, an expert team constituted. Three decision makers from XYZ Bank, namely general manager, head of branch network development department, head of strategic planning department, and two academician from department of banking and capital markets constructed an expert team for determine consensus criteria priorities. Comparison matrices of main and sub-criteria and global priority weights of evaluation criteria and their ranking have been presented in Table 4-8.

Table 4. The pairwise comparison matrix of the main criteria

Criteria	C_1	C_2	C_3	Weights
C_1 Demographic criteria	1	1/3	1/5	0.115
C_2 Economic criteria	3	1	1	0.405
C_3 Investment and Banking criteria	5	1	1	0.480
CR = 0.025				

Table 5. The pairwise comparison matrix of the demographic criteria

Criteria	C_1	C_2	C_3	Weights
C_{11} Total population	1	2	1	0.411
C_{12} Literacy rate	1/2	1	1	0.261
C_{13} Urbanization rate	1	1	1	0.328
CR = 0.046				

Table 6. The pairwise comparison matrix of the economic criteria

Criteria	C_{11}	C_{12}	C_{13}	C_{14}	Weights
C_{21} Gross domestic product	1	1/2	3	1/3	0.461
C_{22} Spending on education	2	1	6	1	0.073
C_{23} Employment rate	1/3	1/6	1	1/3	0.310
C_{24} Inflation rate in consumer prices	3	1	3	1	0.156
CR = 0.044					

Table 7. The pairwise comparison matrix of investment and banking criteria

Criteria	C_{11}	C_{12}	C_{13}	C_{14}	Weights
C_{21} Total business spending on investment	1	3	5	2	0.456
C_{22} Number of domestic companies listed on the stock exchange	1/3	1	3	1/3	0.152
C_{23} Bank capital to assests ratio	1/5	1/3	1	1/5	0.068
C_{24} Domestic credit by banking sector	1/2	3	5	1	0.324
CR = 0.039					

Table 8. Overall priority weights of evaluation criteria

Main Criteria	Priority	Sub-Criteria	Priority within the Cluster	Overall Priority
Demographic criteria	0.115	Total population	0.411	0.047
		Literacy rate	0.261	0.030
		Urbanization rate	0.328	0.038
Economic criteria	0.405	Gross domestic product	0.461	**0.187**
		Spending on education	0.073	0.029
		Employment rate	0.310	**0.126**
		Inflation rate in consumer prices	0.156	0.063
Investment and Banking criteria	0.480	Total business spending on investment	0.456	**0.219**
		Number of domestic companies listed on the stock exchange	0.152	0.073
		Bank capital to assests ratio	0.068	0.033
		Domestic credit by banking sector	0.324	**0.155**

According to AHP result XYZ Bank give more importance to "total business spending on investment", "gross domestic product", "domestic credit by banking sector" and "employment rate" in determining the best location alternative.

4.2 Ranking of the location alternatives

After the pairwise comparisons and determine of the weights of criteria with respect to the goal, alternatives are evaluated with criteria values of location alternatives by MOORA method. Four possible country location alternatives (L_1, L_2, L_3 and L_4) are evaluated to open new bank branch. Decision matrix includes values for evaluation criteria to alternative locations are given in Table 9.

Table 9. Values for evaluation criteria to alternative locations

Evaluation Criteria	Alternative Locations			
	L_1	L_2	L_3	L_4
Total population	7400000	33500000	10850000	29200
Literacy rate (%)	98.4	78.2	96.0	86.6
Urbanization rate (%)	73.1	66.5	61.4	82.3
Gross domestic product (millions of US $)	50800	144600	255000	657000
Spending on education (% of GDP)	4.1	4.1	4.0	5.6
Employment rate	90.1	84.0	75.6	89.3
Inflation rate in consumer prices	2.4	6.4	1.1	4.6
Total business spending on investment (% of GDP)	20.4	10.1	10.4	21.5
Number of domestic companies listed on the stock exchange	393	347	275	150
Bank capital to assests ratio (%)	10.6	8.0	6.3	12.9

Table 10. Dimensionless number (x_{ij}^*) for each location alternative

	C_{11}	C_{12}	C_{13}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}	C_{34}
Location 1	0.206	0.546	0.513	0.070	0.456	0.530	0.289	0.618	0.643	0.542	0.373
Location 2	0.931	0.434	0.467	0.200	0.456	0.494	0.770	0.306	0.568	0.409	0.195
Location 3	0.302	0.532	0.431	0.354	0.444	0.445	0.132	0.315	0.450	0.322	0.801
Location 4	0.001	0.480	0.578	0.911	0.622	0.526	0.553	0.652	0.246	0.660	0.426
Criteria Weight	*0.047*	*0.030*	*0.038*	*0.187*	*0.029*	*0.126*	*0.063*	*0.219*	*0.073*	*0.033*	*0.155*
Criteria Situation	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(+)	(+)

Table 11. Weighted assessment values (y_i^*) and ranking for location selection problem

Alternative	Benefit Criteria	Cost Criteria	y_i^*	Rank
Location 1	0.397	0.018	0.379	3
Location 2	0.340	0.049	0.291	4
Location 3	0.418	0.008	0.410	2
Location 4	0.539	0.035	0.504	**1**

Based on evaluation criteria weights obtained by AHP, the results of MOORA, as present in Table 10, occur the ranking of alternatives as L_4, L_3, L_1 and L_2. Decision matrix for MOORA method with criteria weight and dimensionless number calculations are presented in Table 9. In Table 10, the benefit, cost, and weighted assessment values are listed for all location alternatives MOORA ranking results show that Location-4 is the best choice among the four location alternatives.

5. Conclusions

Bank branch location is a critical issue to evaluate the banking performance. Although, there are a lot of studies on the bank branch performance, comprehensive parameters on the international branch location are so limited for the best location selection. The study covers the banking-based determinants as well as investment, economic and demographic factors. In this study, AHP method has been used to construct the weights of decision criteria and MOORA has been also applied to determine the best alternative for the new bank branch location. The empirical study shows that the most important criteria is determined as "total business spending on investment" and Location-4 is chosen among the four branch location alternatives. According to the weights of criteria, overall priority of demographic factors is relatively less than other main criteria. However, Experts' choices indicate that investment and banking criteria have a strategic role in the best location selection decision. Especially, spending on investment, domestic product and credit demand have the first three ranks in the weights of criteria. The result demonstrates that domestic credit demand may enhance due to the increasing investment and production in the target location, thus the bank branch can get more profitable and productive than other locations.

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