H.A.D.N.C Seneviratne[(1)], P.J.Paranamana[(2)] and S.S.N. Perera[(3)]

A Decision Index to Locate a New Commercial Bank Branch

(1), (2), (3) Research & Development Centre for Mathematical Modeling, Department of Mathematics, University of Colombo, Colombo 03, Sri Lanka.
(email: pushpij@yahoo.com)

Abstract: In this study main objective is to build a decision model to find best location for new bank branch in Sri Lanka. The decision criteria consists eight main factors Demography, Facilities, Socio-Economy, Sectoral Employment, Trade Potential, Banking & Finance, Geography, Safety & Security and decomposed into sub factors. Fuzzy AHP is used to weight the criteria. The TOPSIS method is used to rank the alternative locations. Using the model, locations can be compared simultaneously and identify the best solution.

Keywords: TFN, AHP, fuzzy AHP, TOPSIS

Introduction

For a company's performance and competitiveness, establishing it in a proper location has a strategic importance. Although the decision may vary according to the business strategies and missions, branch and its location is very significant for the whole banking system as it is costly and difficult to reverse. Therefore selecting the ideal location gives the maximum benefit to both the bank and the customers. (Heizer and Render, 2001).

Since several quantitative and qualitative factors should be considered to find the best location, it is a multi-staged process having many criteria in each level. As the fuzziness of human thinking is involved, problem becomes more complex.

Globally different approaches are used to solve this kind of problems such as feasibility studies and some advanced networking methods. In the Sri Lankan context, conducting feasibility studies is the only technique to select the location for a new bank branch. This strategy is expensive concerning about the time and cost since it has to be repeated for each separate alternative location. For a competitive business world, a more advanced and a clear method is required.

Yet the globally used models cannot be directly incorporated to Sri Lanka as the country's socio-economic aspects, monetary policies, government regulations and other factors are different. The expected model should reflect the country's socio-economic environment. The main objective of this research is to construct a model to find the best location for a new bank branch based on Sri Lankan background. The strength of the proposed model is that it can be used to compare any number of location alternatives simultaneously so that the most appropriate location can be identified.

In literature a lot of approaches are available to address multi criteria problems. One method is the Analytic Hierarchy Process (AHP) developed by Saaty (Saaty, 1980), which arranges the multi criteria hierarchically and combines the results at the each level of hierarchy. But this requires the exact decisions without any fuzziness. To overcome problems due to uncertainty, fuzzy AHP models developed by Laarhoven and Pedrycyz (Van Laarhoven and Pedrcyz, 1983), Buckley (Buckley, 1985; Buckley *et al*., 2001), Chang (Chang, 1996), Leung and Cao method (Leung and Cao, 1996) can be used. The proposed model was constructed using Chang's Extent Analysis method, Geometric Mean Method of Buckley and TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) method (Hwang and Yoon, 1981; Chen *et al.,* 2006; Chen, 2000).

Material and Methods

Triangular Fuzzy Numbers: A fuzzy number is an extension of a regular number which doesn't refer to one single value but rather to a connected set of possible values where each possible value has its own weight 0 to 1.

A Triangular Fuzzy Number (TFN) is represented as $\tilde{A} = (a_1, a_2, a_3)$ where a_1, a_2, a_3 represents lower, middle and the upper value of the TFN respectively.

Geometric Mean Method: Consider a fuzzified reciprocal $n \times n$. judgment matrix containing all pair wise comparisons $\tilde{a}_{ij}$ between elements i and j for all $i,j \in \{1,2,\ldots,n\}$ where $\tilde{a}_{ij}$ are TFNs. Suppose there are m decision makers. Let $\tilde{a}_{ijk} = (l_{ijk}, m_{ijk}, u_{ijk})$ be the fuzzy evaluation of the k^{th} decision maker ($k=1,2,\ldots m$) for comparison for i^{th} and j^{th} factors.

Then the aggregated response using Geometric Mean Method is

$$\tilde{a}_{ij}=(l_{ij},m_{ij},u_{ij})=\{(\prod_{k=1}^{m} l_{ijk})^{1/m},(\prod_{k=1}^{m} m_{ijk})^{1/m},(\prod_{k=1}^{m} u_{ijk})^{1/m}\} \qquad (1)$$

Chang's Extent Analysis Method: Let $X=\{x_1,x_2,\ldots,x_n\}$ and $G = \{g_1,g_2,\ldots g_m\}$ be an object set and a goal set respectively. Then each object is taken and extent analysis is performed for each goal. Then the obtained m extent analysis values for each object can be represented as follows.

$M_{g_i}^1, M_{g_i}^2, \ldots M_{g_i}^m$; $i=1,2,\ldots,n$ where $M_{g_i}^j$ $j=1,2,\ldots,m$ all are TFNs.

The Chang's Extent Analysis Method is described as follows.

Step 1: The value of fuzzy synthetic extent with respect to the i^{th} object is defined as

$$S_i=\sum_{j=1}^{m} M_{gi}^j \times [\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j]^{-1}. \qquad (2)$$

Step 2: Let $M_1= (l_1,m_1,u_1)$ and $M_2= (l_2,m_2,u_2)$ be TFNs. The degree of possibility of $M_2 \geq M_1$ is defined as

$$V(M_2 \geq M_1)= \begin{cases} 1 & ,\text{if } m_2 \geq m_1 \\ 0 & ,\text{if } l_1 \geq u_2 \\ \frac{l_1-u_2}{(m_2-u_2)-(m_1-l_1)} & ,\text{otherwise}. \end{cases} \qquad (3)$$

Step 3: Let $d'(A_i)$ be the corresponding weight for i^{th} object

$$d'(A_i)=\min\{V(S_i \geq S_k)\}; \quad k=1,2,\ldots,n \quad \& \quad k \neq i \qquad (4)$$

Then the weight vector is

$$W'=d'(A_1),d'(A_2),\ldots,d'(A_i)\ldots,d'(A_n)]^T. \qquad (5)$$

where A_i are n elements for $i=1,2,\ldots,n$

Step 4: Via normalization, the normalized weight vector is obtained.

$$\bar{W}=[d(A_1),d(A_2),\ldots,d(A_i)\ldots,d(A_n)]^T \qquad (6)$$

where $d(A_i) = \frac{d'(A_i)}{\sum_{i=1}^{n} d'(A_i)}$

Geometric Mean Method of Buckley: Consider an aggregated $n \times n$ judgment matrix containing all pair wise comparisons $\tilde{p}_{ij}$ between elements i and j for all

i and j for all $i, j \in \{1, 2,\ldots, n\}$ where $\tilde{p}_{ij}$ are TFNs.

Let $\tilde{p}_{ij} = (l_{ij}, m_{ij}, u_{ij})$

Then

$$\tilde{r}_i=(\prod_{j=1}^{n} \tilde{p}_{ij})^{1/n} \qquad (7)$$

And

$$\tilde{w}_i=\tilde{r}_i \otimes (\sum_{i=1}^{n} \tilde{r}_i)^{-1}; i=1,2\ldots n \qquad (8)$$

Since is fuzzy number lets denote $\tilde{w}_i = (l_i', m_i', u_i')$. Then using simple centroid method is defuzzified and obtained the final weight of the i^{th} factor.

$$\tilde{w}_i' = \frac{l_i+m_i+u_i}{3} \qquad (9)$$

Let $\tilde{w}_i' = a_i'$

Then the normalized weight vector for all $i=1,2,\ldots,n$ is

$$W=(a_1, a_2, \ldots, a_n)^T.$$

where $a_i = \frac{a_i'}{\sum_{i=1}^{n} a_i'}$ (10)

The Proposed Model: The proposed model is based on Chang's Extent Analysis Method, Geometric Mean Method of Buckley and the practical aspects regarding location selection.

Suppose there are n factors in the j^{th} criteria set and let $f_1, f_2, \ldots, f_n$ be the factors.

Let, $\bar{A}_j,\bar{B}_j$ be the normalized weight vectors obtained from Chang's Extent Analysis Method, Geometric Mean Method of Buckley respectively and $\bar{P}_j$ be the normalized weight vector of n factors in j^{th} criteria set of the proposed model.

Then

$$\bar{P}_j=\alpha_j\bar{A}_j+(1-\alpha_j)\bar{B}_j \quad (11)$$

$$\text{where}\ \alpha_j=\begin{cases}\frac{2}{3};\ \text{if } \bar{A}_j \text{ satisfies the condition}\\ \frac{1}{3};\ \text{if } \bar{B}_j \text{ satisfies the condition}\\ \frac{1}{2};\ \text{if no condition}.\end{cases}$$

and α_j is defined on the conditions of $\bar{A}_j$, and $\bar{B}_j$

Then

$$\bar{P}_j=\begin{cases}\frac{2}{3}\bar{A}_j+\frac{1}{3}\bar{B}_j;\ if\,\alpha_j=2/3\\ \frac{1}{3}\bar{A}_j+\frac{2}{3}\bar{B}_j;\ if\,\alpha_j=1/3\\ \frac{\bar{A}_j+\bar{B}_j}{2};\ if\,\alpha_j=\frac{1}{2}.\end{cases} \quad (12)$$

TOPSIS Method: TOPSIS method is used to determine the final ranking of the alternatives. It is based on the concept that the best selection should have the shortest geometric distance from positive ideal solution (PIS) that maximizes the benefit and minimizes the cost and the largest geometric distance from the negative ideal solution (NIS) that minimizes the benefit and maximizes the cost.

Step 1: Let $B=\left\{v_{ij}\right\}_{nm}$ where v_{ij} is the value for the j^{th} factor for i^{th} alternative. Where $i=1,2,\ldots n$ and $j=1,2,\ldots m$

Then B_N is the normalized matrix of B where

$$B_N=\left\{v_{ij}^{*}\right\}_{nm} \quad (13)$$

where $v_{ij}^{*}=\frac{v_{ij}}{\sqrt{\sum_{j=1}^{n}v_{ij}^{2}}}$ for $i=1,2,\ldots,n$ and $j=1,2,\ldots,m$

Step2: Using B_N and normalized and weight vector $W=(w_1,w_2,\ldots,w_m)_{m\times 1}$, the weighted normalized matrix W_N is obtained.

$$W_N=\{w_{ij}^{*}\}_{n\times m}. \quad (14)$$

where $w_{ij}^{*}=w_i\times v_{ij}^{*}$ for $i=1,2,\ldots,n$ and $j=1,2,\ldots,m$

Step 3: Let

$$w_j^{*}=\max\{w_{ij}^{*}\ ;\ \forall i\in\{1,2,\ldots,n\}\}. \quad (15)$$

$$w_j^{-}=\min\{w_{ij}^{*}\ ;\ \forall i\in\{1,2,\ldots,n\}\}. \quad (16)$$

Then

$$\text{PIS}A^{*}=\{w_1^{*},w_2^{*},\ldots.w_m^{*}\}. \quad (17)$$

$$\text{NIS}A^{-}=\{w_1^{-},w_2^{-},\ldots.w_m^{-}\}. \quad (18)$$

Step 4: The distance of i^{th} alternative from PIS and NIS

$$d_i^{*}=\sqrt{\sum_{j=1}^{m}(w_{ij}^{*}-w_j^{*})^2}\ ;\ i=1,2,\ldots,n. \quad (19)$$

$$d_i^{-}=\sqrt{\sum_{j=1}^{m}(w_{ij}^{*}-w_j^{-})^2}\ ;\ i=1,2,\ldots,n. \quad (20)$$

Step 5: The closeness coefficient of i^{th} alternative is,

$$CC_i=\frac{d_i^{-}}{d_i^{*}+d_i^{-}}\ ;\ i=1,2,\ldots,n \quad (21)$$

By comparing CC_i values alternatives are ranked.

Developing a decision support model for bank branch location selection: After reviewing the literature (Cinar, 2009; VBoufounou, 1995; Willer, 1990; Min, 1989; Ravallion and Wodon, 2000; Zhao *et al.,* 2004) and obtaining expertise ideas, the evaluation criteria of location selection was decided.

Table 1: The Hierarchical Structure of the Selection Criteria

Hierachy level			
Main factors(level-1)	Subfacors(level-2)	Subfactors(level-3)	Subfactors(level-4)
Demorgraphic	Total population	Gender	Male
			Female
		Age	Kids
			Youth
			Middle Aged
			Senior citizen
	Population growth rate		
	Population density		
	Number of housing units		
Facilities	Trasportation	Road kilometerage	
		Number of registered vehicles	Buses
			Taxies
			Other private vehicles
	Communication	Number of post offices	
		Telecommunication	Telephone facilities availability
			Internet facilites availability
	Medical	Number of government hospitals	
		Number of private hospitals	
	Education	Number of schools	
Socio-Economic	Household income		
	Literacy rate		
	Beneflecieries	Public assistance	
		Samurdhi	
Sectoral employment	Agriculture employment rate		
	Industry employment rate		
	Services employment rate		
Trade potential	Number of registered commercial establishments		
	Number of manufacturing industries		
Banking and finance	Number of banks		
	Number of branches		
	Number of other financial institutions		
	Average deposits per branch		
	Average credits per branch		
Geography	Size of the area		
Safety and security	Number of police stations		

Note:

1) Average bank deposit/credit per branch measured in Rs millions.
2) In telecommunication telephone and internet facilities availability in the area is denoted by 1 (if available), 0 (if not available).

A survey was conducted among expertise of banking sector to obtain information. The obtained responses were aggregated and constructed the result using the geometric mean method. It gives the comparison of each main factors and sub factors for evaluating the candidate cities to find the weights.

Then Fuzzy AHP techniques were used to find the weights of the multi criteria. The study was pursued using both Chang's extent analysis method and Geometric Mean method of Buckley and further a new method was proposed by combining the above two.

The conditions which are the base to define α_j in proposed model are described as follows.

Let $\bar{X}_j \in \{\bar{A}_j, \bar{B}_j\}$

<u>01: If the j</u>

01: If the j^{th} criteria = Main Criteria.

$\bar{X}_j$ takes the

finance factor.

02: If the j^{th} criteria = Demography Sub Criteria.

$\bar{X}_j$ takes the hi

03: If the j^{th} criteria = Facilities Sub Criteria.

$\bar{X}_j$ takes the highest value for the sum of the values of transportation and communication.

04: If the j^{th} criteria = Communication Sub Criteria.

$\bar{X}_j$ takes the highest value for teecommunication.

05: If the j^{th} criteria = Socio Economy Sub Criteria.

$\bar{X}_j$ takes the highest value for household income.

06: If the j^{th} criteria = Sectoral Employment Sub Criteria.

$\bar{X}_j$ has the minimum variance between the weights of three sub factors in sectoral employment.

07: If the j^{th} criteria = Banking and Finance Sub Criteria.

$\bar{X}_j$ has the minimum variance between the weights of the five sub factors in banking and finance.

08: If the j^{th} criteria = Trade Potential Sub Criteria.

$\bar{X}_j$ has the minimum variance between the weights of the two sub factors in trade potential.

09: All other Criteria.

No condition.

The α_j values for each condition:

Main Criteria: $\alpha_j = \frac{2}{3}$, Demography Sub Criteria: $\alpha_j = \frac{2}{3}$, Facilities Sub Criteria: $\alpha_j = \frac{2}{3}$, Communication Sub Criteria: $\alpha_j = \frac{2}{3}$, Scio Economy Sub Criteria: a: $\alpha_j = \frac{2}{3}$, Sectoral Employment Sub Criteria: a: $\alpha_j = \frac{1}{3}$, Banking and Finance Sub Criteria: $\alpha_j = \frac{1}{3}$, Trade Potential Sub Criteria: $\alpha_j = \frac{1}{3}$, All other factor sets: $\alpha_j = \frac{1}{2}$

Four districts in SriLanka, Gampaha, Kandy, Badulla, Hambanthota and two district secretariat divisions were chosen as the location alternatives for the branch opening. To rank the candidate locations using weighted criteria, the necessary data of each criterion for each location were collected from Department of census and statistics-district statistical handbooks, Central bank Sri Lanka- annual report.

Using the obtained weights and collected data the location alternatives were evaluated and ranked using TOPSIS method.Then calculations of each method were programmed in excel and aggregated into one system, so the locations will be ranked as the data of alternative locations and responses of the decision makers were input. MS excel mathematical functions, cell reference techniques, and excel VBA with Macro were used to develop the system.

Results and Discussion

Table 2: Distribution of the weights in each method with respect to main factor.

Main Factors	Chang's Method	Buckley's Method	Proposed Method
Demography	0.1528	0.1382	0.4179
Facilities	0.0592	0.0652	0.0612
Socio-Economy	0.1929	0.1697	0.1852
Sectoral Employment	0.1659	0.1372	0.1563
Trade Potential	0.2126	0.1666	0.1972
Banking & Finance	0.2166	0.1743	0.2025
Geography	0	0.0943	0.0314
Safety & Security	0	0.0545	0.0182

When all the factor sets are considered, in Chang's Extent Analysis method there are zeros and ones as weights. Zero weights force the factors to vanish from the decision criteria which is the main weakness of the Chang's method. This information loss problem was eliminated in the new model by combining the two methods by a weighted average technique. The model obtained from Buckley's method has a little variance for the weights. The variability of the proposed model is higher than the Buckley's method so that the accuracy is improved. Another benefit is that the new model was constructed considering the practical aspects of location selection which leads to a more reliable solution.

Theoretical aspects of the procedure alone do not guarantee the success of the project. Experimental procedure, the data collection and mainly the survey carries a great weight on the success. Thus the responses of the decision makers have a high influence on the final weights of the criteria. The correctness of the results prevails on the accuracy of the pair wise comparison of each factor. Therefore decision makers should know their priority properly to determine the weights of the criteria.

The accuracy and the scope of the project is limited by the availability of the required data. As long as data is available for each criterion and for each location, they can be evaluated.

Conclusion

In Sri Lanka, location selection for a new bank branch limits to a feasibility study which needs to be repeated for each new location. The constructed model compares the suitability of a given set of locations for a new bank branch simultaneously and can be used to find the most suitable location. Considering the results obtained, the Banking and Finance is the most important main criterion. Safety and Security has the lowest priority. According to the case study that was carried out to demonstrate the results, Biyagama is found to be the most suitable solution among alternatives and followed by Kundasale, Badulla, Dompe, Tangalle, Madadumbara, and Lunugala respectively.

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