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A mathematical model for facility location in banking industry

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C H R O N I C L E

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A B S T R A C T

This paper presents an empirical investigation to determine the efficient locations of bank branch as well as automated banking machine. The study develops a mathematical model to minimize the cost of facility establishment subject to some constraints, which are associated with the population, accessibility of facilities, etc. All input parameters are considered in terms of triangular fuzzy numbers and using some methods, they numbers are converted into crisp values. The method has been applied for four cities in province of Seman, Iran and using WinQSB, the efficient locations of the facilities for a private bank named Samen have been determined.

1. Introduction

During the past few years, there has been growing interest in private banking development in Iran. Most banks try to find appropriate places for lower expenses to generate more revenue (Craig, 1984; Al-Hanbali, 2003). There are literally many studies associated with facility locations of banks. Aldajani and Alfares (2009) considered the problem of determining the optimum number and locations of banking automatic teller machines (ATMs). The objective of the survey was to minimize the total number of ATMs to cover all customer demands within a given geographical area. Almossawi (2001) concentrated on determining the bank selection criteria in Bahrain. The survey examination depended on 30 selection factors extracted from relevant literature, personal experience and interviews with some bank officials and college students. They reported that the chief factors determining college students' bank selection could include bank's reputation, availability of parking space near the bank, friendliness of bank personnel, and availability and location of automated teller machines (ATM). Kaynak and Harcar (2005) showed the application of geodemographic segmentation to the service industry by applying commercial banking as a case example. They reported that there were substantial differences between customers of local and national US banks in their evaluation of the relative importance of bank service charges and overall confidence in the bank. Miliotis et al. (2002) showed how demand–covering models could be combined with geographical

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information systems (GIS) to detect the optimal location of bank branches, taking into account the different factors that characterize local conditions within the demand area.

2. The proposed study

The proposed model of this paper plans to locate the places of banks and ATM in 58 different locations. Let P be the population of the province and P_r be the population of each alternative location, respectively. In addition, let m_j be the defuzzify coefficient associated with population of each alternative. Therefore, for each alternative we define a utility parameter a_j as follows,

$$a_j^1 = \frac{m_j P_r}{\sum_{j=1}^{n} m_j \sum_{j=1}^{s} P_r} \quad \forall j = 1, \cdots, n; r = 1, \cdots, s \tag{1}$$

Let x_j be a binary variable, which is one when a facility is located in place j and zero, otherwise. Let c_j and d_j be the cost of each square meter of land dedicated to place j and the distance of facility from the center of service, respectively.

2.1. The objective functions

There are two objective functions associated with the proposed study, one associated with the place a branch of bank is located as follows,

$$\min z_1 = \sum_{j=1}^{n} c_j x_j \ . \tag{2}$$

In addition, the study minimizes the cost of allocating ATM to a particular place as follows,

$$\min z_2 = \sum_{j=1}^{n} d_j x_j \ , \tag{3}$$

where d_j is the distance from each service facility.

2.2. Constraints

The first constraint is associated with the portion of covering set of population as follows,

$$\sum_{j=1}^{n} -\ln\left(-\ln\left(1-a_j^1\right)\right) x_j \geq -\ln\left(1-\alpha\right), \tag{4}$$

where α is the level of uncertainty. Next constraint considers the level of wealth distribution.

$$\sum_{j=1}^{n} -\ln\left(-\ln\left(1-a_j^2\right)\right) x_j \geq -\ln\left(1-\alpha\right), \tag{5}$$

where a_j^2 is associated with wealth distribution and is defined as follows,

$$a_j^2 = \frac{r_j F_r}{\sum_{j=1}^{n} r_j \sum_{j=1}^{s} F_j} \quad \forall j = 1, \cdots, n; r = 1, \cdots, s \tag{6}$$

where r_j and F_j are defuzzify ratio of wealth and availability of money in each location, respectively. Depending on the position of each alternative, we have

$$\sum_{j=1}^{n} \left(-\ln\left(a_j^i\right)\right) x_j \geq -\ln\left(1-\alpha\right) \tag{7}$$

where

$$a_j^i = L + \Delta \times \frac{(m-L)(\Delta+u-m)^2(R-\lambda)+(u-L)^2(\Delta+m-\lambda)^2}{(\Delta+m-\lambda)(\Delta+u-m)^2(R-\lambda)+(u-L)(\Delta+u-m)}, \tag{8}$$

where $\tilde{a}_j^i$ is a triangular fuzzy number defined as $\tilde{a}_j^i = \left(\lambda_j, m_j, u_j\right)$, $L = \min\left(\lambda_j\right), R = \max\left(u_j\right)$ and $\Delta = R - L$, (Zadeh, 1965; Opricovic & Tzeng, 2003). We consider some constraint similar to what we have in Eq. (7) for infrastructure with $a_j^i = \frac{I_j}{\sum_{j=1}^{n} I_j} \forall i, j$. Finally, we consider similar constraints as we introduced in Eq. (7) and Eq. (8) for the level of easy access to facilities.

3. The results

The proposed model of this paper, which was formulated as a mixed integer nonlinear optimization has been coded in WinQSB software package. In our survey, there were 4 cities located in province of Semnan, Iran. In addition, we have detected 58 alternative locations for facility establishment. Fig. 1 demonstrates the position of each bank and ATM facilities located for each city.

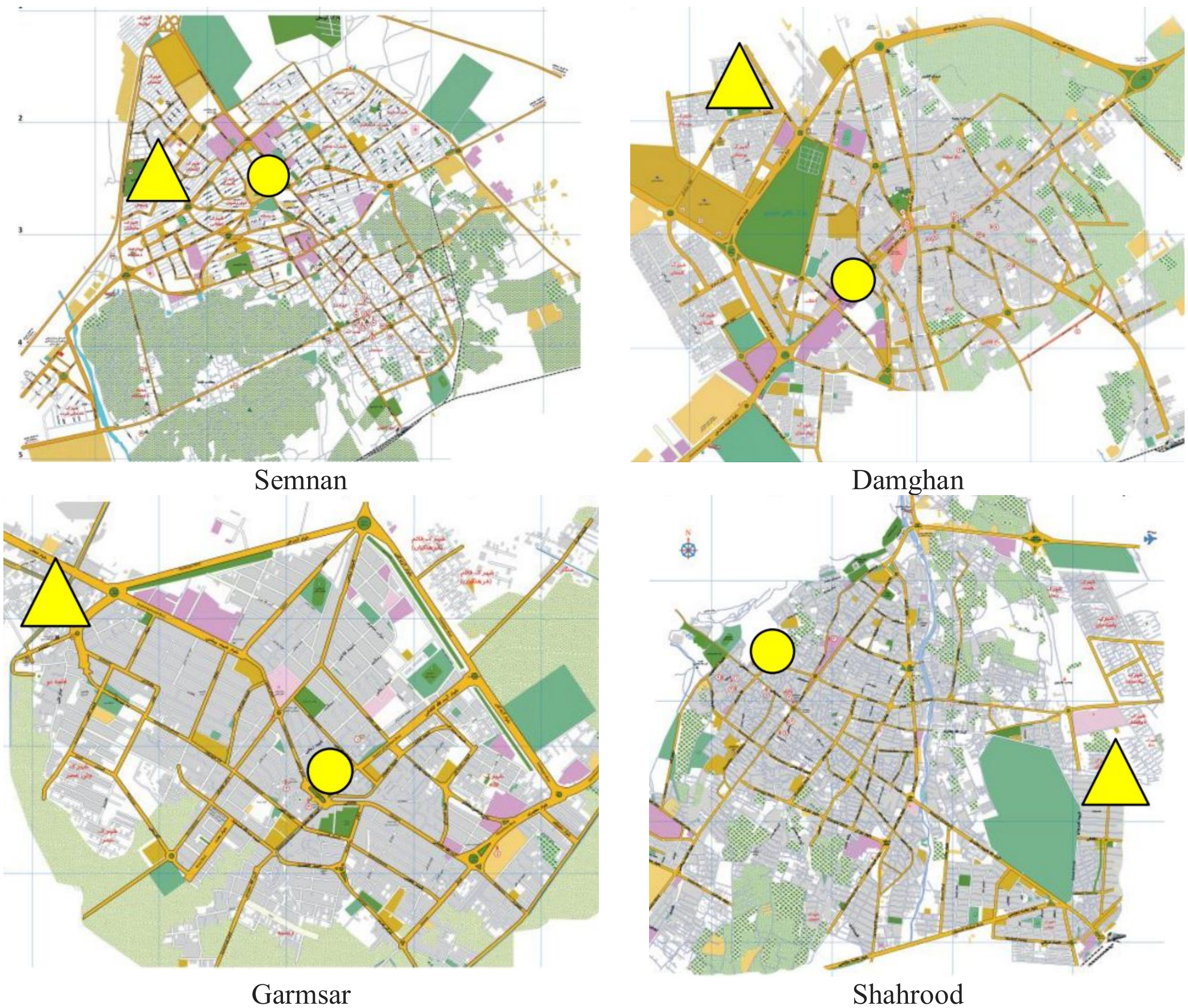

Fig. 2. The results of facility location

Bank

ATM

4. Conclusion

During the past few years, there has been growing trends on banking industry in Iran due to massive deregulation, which has facilitated the emerge of private banks. In this paper, we have presented a mathematical model to determine the optimal locations of bank branch and ATM in four cities in province of Semnan, Iran. The proposed study has implemented fuzzy logic to handle any uncertainty associated with input parameters. The preliminary results indicate that the proposed study has capable of locating new alternatives, effectively.

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