Bank attractiveness evaluation method based on soft computing in the analytic hierarchy process

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Abstract. The article offers a methodology for solving the problem of allocating investments to optimize the work of the bank. For this, a hierarchy of criteria is formed based on the use of expert information. After that, a formalized presentation of the problem is given: how to allocate the amount of investment according to the criteria in the optimal way. Due to the fact that the evaluation criteria are contradictory, a utility function is built on the basis of the mathematical apparatus of fuzzy sets to solve the problem. The result of the work is a mathematical model for solving the problem of distribution of investments.

Keywords: Analytic Hierarchy Process, Soft Computing, Bank Evaluation

1 The roots of the problems of bank attractiveness evaluation

Over the past few years the state of Ukraine's financial system has changed significantly. This seriously affected banking sector. As follows from the statistics of the Ministry of Finance [1], over the last 2 years the number of commercial banks in Ukraine has decreased by 26%. Also, the National Bank of Ukraine implements a policy aimed at improving the quality of banking services by raising the standards of information security. This affects the work of banks. Therefore, today, bank executives are interested in optimizing the activities of their organizations. By optimization, in the context of this work, we should understand the attraction of new customers and the retention of old ones. To do this, it is necessary to understand what customers are guided by when choosing a bank, what criteria are used, and how to invest in these criteria with maximum efficiency.

1.1 Related works, research and publications

The problem of assessing the attractiveness of the bank can be considered from different points of view. In particular, it can be considered as an attraction with regard to a consumer of banking services (order) and investment attractiveness, that is, in terms

of another financial institution. For instance, N. Jaremenko [2] states that an investment attractiveness of the bank is evaluated for merger or acquisition. The study proposes the sequence of formed steps to evaluate the attractiveness of the bank and a quantitative method of evaluation. For this purpose, the authors define a number of criteria for evaluating the investment attractiveness of the bank. It should also be noted that in some cases, the evaluation of the bank divisions (offices) is the main subject of the work. This research evaluates the attractiveness of the branch from the bank point of view, that is, evaluating the efficiency of the banking department. In this regard the authors also propose a number of steps for quantitative evaluation and suggest a group of criteria for evaluating the effectiveness of the banking department which were developed by them.

At the same time the attractiveness of the bank from the perspective of private clients and the attractiveness from the point of view of corporate clients are different concepts because they use different criteria for the evaluation of the bank. Also objectives of the bank attractiveness evaluation should be distinguished. Above all it can be an attraction of new customers or retention of existing ones. The work [3] clearly states that retaining existing customers unambiguously costs the bank cheaper and more profitable than attracting new ones. In this work not so much the attractiveness of the bank as the client's satisfaction with banking services is estimated. At the same time in a number of Russian-language research (i.e., closer to the realities of Ukraine) it is argued that the banking market is now saturated and the main struggle is being fought for keeping customers. All the studies are united by the fact that to evaluate the attractiveness of banks the evaluation criteria are used. For instance, in [3] the RATER model is used for service quality evaluation, which contains such groups of criteria:

- reliability,
- confidence (quality of service based on the ability to inspire confidence),
- tangibles (criteria which physically present the service),
- emotional impression,
- responsiveness

And also negative criteria are introduced (which reduce the level of satisfaction with banking services).

In a number of studies, the notion of bank attractiveness is being investigated among a specific group of clients (social, age, etc.). For example, the research [4] provides the criteria for selecting a bank among transport workers in one of the cities of Nigeria. In this work based on a survey of respondents, the criteria for bank evaluation were defined, and their importance was also determined. The most important criteria in the study are reliability, reputation of the bank, courtesy of the staff. And the least important criteria for this group of customers were free cash delivery to the house, the availability of Internet banking and the presence of an overdraft. The main criteria for bank evaluation for transport workers will be significantly different from the criteria of businessmen, workers, students. Research [5] contains a list of possible positions on which a set of bank customers can be divided: this is the age segment, geographic, behavioral, social, and so on). This survey makes the evaluation of the bank among students of South Africa. As a result of the study it was concluded that the most im-

portant factors for bank evaluation for students are the ease of a bank account opening, the financial stability of the bank and the location of ATMs. At the same time the least important criteria are the availability of parking spaces, the teachers' influence and free gifts for customers.
It is possible to note the similarity in the studies: they all use some set of evaluation criteria, and a mathematical model for determining the quantitative measure of the attractiveness of the bank and determining the value criteria impact on the evaluation. Some surveys suggest a study of the attractiveness of the bank from the customers' point of view which is the purpose of this work. Also, several studies analyze the attractiveness of the bank within a particular group of respondents (students, transport workers ...). Based on the literature review and the experts' survey, a number of criteria for evaluating the bank by private clients will be selected regardless of the user segment.

1.2 Research aims

For the first time in the work [6] an effort was made to formalize the term of the bank's attractiveness from the customer's side. A model is developed in that work. On the basis of this model an algorithm for optimizing the distribution of financial resources aimed at increasing the attractiveness of the bank is proposed, since the bank attractiveness influences in growth of its revenues. The essence of the model and the algorithm is as follows. Based on the analytic hierarchy process, and on open statistics and expert opinions, a hierarchy of criteria has been developed, in which the focus of the problem is on the first level, which is formulated as a bank's attractiveness. At the second level there are three complex criteria on which the focus of the problem depends: reliability, quality of service, range of services. Further on, the third level reveals the individual components of these complex indicators. For example, for the bank's reliability criteria such indicators are: the volume of the authorized capital, the volume of assets, the rates for deposits, and so on. At the next level of the hierarchy there are separate alternatives. These are competing banks for which, based on the experts' opinion, the procedure of the AHP is conducted, and their weighting factors are determined from the point of view of the main problem focus - the attractiveness of the bank. Next, a parametric analysis of the degree of influence of each third-level criteria on the problem focus is made by investing in certain areas of the bank's activities: increase of the authorized capital, change rates on loans (deposits), and so on. On the basis of this analysis, certain utility functions (bank attractiveness) are synthesized depending on the financial resources being invested and a mathematical model of their optimal distribution is formulated. The objective function of the model is additive. Each component determines the utility in terms of criteria for the third level of the hierarchy. However, in [6] the concept of attractiveness does not take into account many aspects that allow us to consider the proposed model and algorithm as some guide to action. Therefore, the goal of this paper is to evaluate a number of factors that will allow us to develop a method based on the model and algorithm that are more applicable in the real situation. Let's emphasize the main tasks that will make possible to achieve the goal:

- Accounting for the decision-making distribution ;
- Use of fuzzy sets in Saaty's paired comparison method on which the AHP is based.

2 Mathematical model for evaluation of the bank attractiveness

2.1 Decision making distribution

Assume that the proposed method is intended for a fairly large bank which functions at least at the state level. Then, the concept of distribution in this paper is treated as follows. The fact is that the influence of the criteria of the third level of the hierarchy in the AHP on the concept of a bank attractiveness is different. We introduce the concept of their influence at the global, regional levels and at the level of individual clusters of entities that are potential customers of a bank. In accordance with this, all the criteria of the third level of the hierarchy are divided into four groups. The criteria affecting the bank attractiveness:

- All clusters within the entire territory of the bank's operation;
- A separate type of cluster within the entire territory of a bank's operation;
- All clusters within the region;
- A separate cluster type within the region.

For the criteria of the first group, as previously, 4 levels of the hierarchy are used [7]. For the second and third groups, the criteria of the third level of the hierarchy give rise to the fourth. For each criterion of the second group, these are sub-criteria considered at the level of an individual cluster type, and for the third group, these are sub-criteria considered at the level of a particular region. Criteria of the fourth group generate the fourth and fifth levels of the hierarchy. The fourth is the level of regions, and the fifth is the level of individual clusters of the region.
Figure 1 presents a visual interpretation of the distributed hierarchical decision support system, where $G^k = \{G_1^k, G_2^k, G_3^k, G_4^k\}, k = \overline{1,3}$ is a set of criteria groups for the k -th complex criterion of the third level of the hierarchy; $I = \{I_1..I_M\}$ - a set of regions; $T = \{T_1..T_N\}$ - a set of clusters; $\overline{T}(I_l), l = \overline{1,M}$ - a set of clusters in the l -th region, and the universal set of banks $B = \{B_1, B_2, ..., B_L\}$.

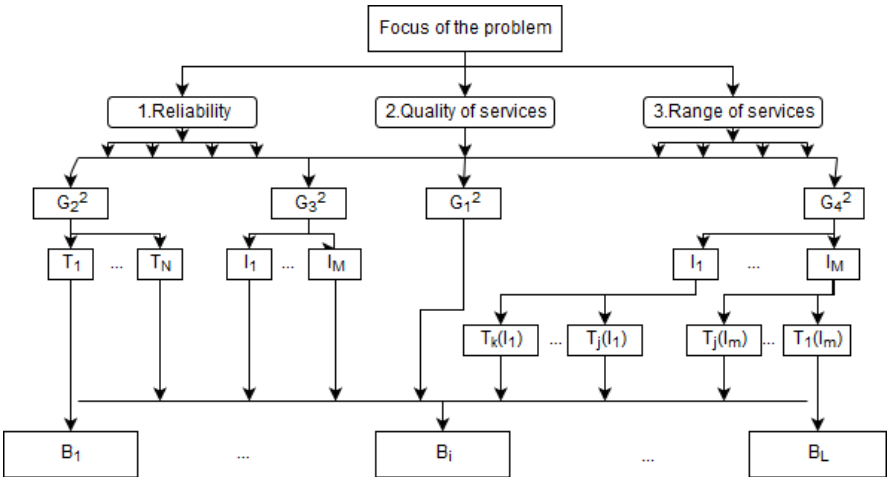

Fig. 1. Distribution of the decision making

2.2 Fuzzy sets in AHP

In this paper unlike the traditional approach [8] it is suggested within the AHP method to consider criteria as fuzzy sets that are defined on universal sets of variants by means of membership function. Let's examine this approach as the fragment of the example shown in Figure 1. Let the third group of criteria G_3^2 be considered in the complex criteria "Quality of Service", and there are such sub-criteria as "Number of ATMs" in it. Then the criteria of the fifth level $I_1, I_2 ..., I_M$ will characterize the attractiveness of the bank in the i-th region, $i = \overline{1..M}$, and be fuzzy sets on the universal set of banks $B = \{B_1, B_2, ..., B_L\}$.

If we assume that the $\lambda_i(B_l) \in [0,1]$ characterizes the evaluation of the B_l-th bank according to the I_i-th criteria, then the fuzzy criteria $I_i = \{[B_1, \lambda_i(B_1)], [B_2, \lambda_i(B_2)] ... [B_L, \lambda_i(B_L)]\}$, where $\lambda_i(B_i)$ is the membership function to the fuzzy set I_i. Using the Saaty's method of paired comparisons with the nine-point scale, $\lambda_i^*(B_l)$ numbers that characterize the rating of the l-th bank on the i-th criteria are defined. And $\sum_{l=1}^{L} \lambda_i^*(B_l) = 1, i = \overline{1,M}$. According to the Bellman-Zade approach [9], a fuzzy solution of the problem of achieving fuzzy goals is determined by their intersection. That is, on a fuzzy set $\tilde{I} = \bigcap_{i=1}^{M} I_i$, the membership function of which is determined as a minimum of the membership function to

an individual criterion. However, the criteria $\bar{I}_i, i=\overline{1,M}$ have the certain importance. Suppose that it is determined by the weighting coefficients $\rho_i \geq 0, \sum_{i=1}^{M} \rho_i = 1$, which values can be determined by the method of paired comparisons using the Saaty nine-point scale. Then the fuzzy set of intersection of fuzzy goals has the formula (1) and the alternative with the maximum value of the membership function is considered to be the best.

$$\tilde{I} = \{[B_1, \min(\lambda_i^*(B_1))^{\rho_i}], [B_2, \min(\lambda_i^*(B_2))^{\rho_i}], ..., [B_L, \min(\lambda_i^*(B_L))^{\rho_i}]\} \quad (1)$$

3 Method for increasing bank attractiveness in terms of limited resources

An offered method is based on the results of research [5] and on this survey. It is presented as a sequence of steps.

First step. A set of lower-level criteria X is formed based on the hierarchy (Fig.1). This set characterizes bank attractiveness from the customer's point of view. Each criterion has certain indicators which affect bank attractiveness. For instance, in group 3 (Range of Services) there is a criterion "Remote banking services". It has such indicators as availability of mobile applications (for different OS: Android, iOS, WP, etc.), availability of remote banking service for companies, quality of these services, level of support responsiveness, etc.

Second step. For each criterion from X, an evaluation of indicators which characterize an attractiveness of the bank from B (a set of alternatives – different banks) is made by experts. Assume that for each l-th bank, $l \in \overline{1,L}$, a set of these evaluations is X_l^*.

Third step. Based on sets X_l^*, $l \in \overline{1,L}$, and hierarchy of criteria used AHP (Section 2.2) importance of weighting factors $\gamma_l(X_l^*)$ are formed. These factors are formed from their attractiveness point of view, and satisfy $\gamma_l(X_l^*) \geq 0, l \in \overline{1,L}$. Also $\sum_{l \in 1}^{L} \gamma_l(X_l^*) = 1$.

Fourth step. Variation of evaluations X_l^* from the set X to increase the l-th bank importance of weighting factor requires certain financial costs. Let y_{l_j} financial costs of l-th bank used for the correction of j-th evaluation $x_{l_j}^* \in X_l^*$, and m_{l_j} - limit value of y_{l_j} which is determined by the bank experts.

Fifth step. For j-th criteria of l-th bank a set of experiments is made. In these experiments y_{l_j} varies in the range $0 < y_{l_j} \le m_{l_j}$, and the importance weighting factor $\gamma_l(\overline{X}^*_l)$ based on AHP is determined, where $\overline{X}^*_l = \{x^*_{l_1},...,\overline{x}^*_{l_j},...,x^*_{l_S}\}$, $S = |X|$, and $\overline{x}^*_{l_j}$ is a corrected evaluation of indicator of j-th criteria of l-th bank connected with financial costs y_{l_j}.

Sixth step. A function of the impact of financial costs for the correction of indicators j-th criteria of l-th bank on the importance of weighting factor of l-th bank is formed based on a set of experiments.

$$\gamma_l(\overline{X}^*_l) = F_{l_j}(y_{l_j}) \tag{2}$$

Seventh step. After the analysis of function $F_{l_j}(y_{l_j})$, some subsets of criteria are ignored, which are not sufficient or do not have any influence on the importance of weighting factor (2). Next step will deal with a subset $X^C \subseteq X$ of existing criteria.

Eighth step. Let *K* is an amount of costs which the bank can spend for increasing its attractiveness from the customer's point of view. Then the rational distribution of these costs is determined on the basis of the solution of the following problem: find such value of vector $y_l = \{y^*_{l_j}\}$, which ensures maximum value of target function:

$$F_l(y_l) = \sum_{j \in X^C} F_{l_j}(y_{l_j}) \tag{3}$$

, with conditions:

$$0 < y_{l_j} \le m_{l_j}, j \in X^C \tag{4}$$

$$\sum_{j \in X^C} y_{l_j} \le K. \tag{5}$$

Based on solution of (3-5), the rational distribution of financial costs *K* is determined. This distribution ensures the increasing of a bank attractiveness from the customers' side.

In this research we assumed that the function (3) is an additive function to functions (2).

4 Conclusions and future work

The paper describes the process of evaluation and a bank development management in terms of its attractiveness using the distributions of this concept at the level of individual regions and user clusters, and offers method for amount distribution for increasing attractiveness based on AHP. The problem of the application of soft computations in the AHP is considered due to the "blurring" of the criteria for all levels of the hierarchy and the introduction of fuzzy sets at different levels. This approach is an alternative to the traditional AHP algorithm. Further research will be devoted to comparing the traditional AHP algorithm, and based on soft computing, as well as the validity of applying one or another approach in different situations.

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