ASSESSING THE QUALITY OF BANKING SERVICES BASED ON FUZZY LOGIC METHOD

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The study analyzed the existing mathematical methods and models for assessing the quality of banking services. It is determined that they have the following disadvantages: consumers evaluate services in the form of the score, which is a complex process for them and characterized by subjectivism; the weights of the criteria of quality are not considered. Therefore, it is decided to carry out an expert survey, where the criteria are qualitative assessments. Further, by using the fuzzy inference system, a vector of quantitative estimates is formed. In addition, a method for calculating criteria weights was proposed, on the basis of which a general assessment of the quality of banking services can be obtained. As a result of applying this method, the bank receives a quantitative assessment of the quality of the provided services. This assessment will make it possible to identify the strengths and weaknesses of the bank and, based on the results obtained, to develop a strategy for improving the quality of services in the bank.

Keywords: *bank, banking services, quality of services, expert survey, fuzzy sets, fuzzy inference system.*

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ОЦІНЮВАННЯ ЯКОСТІ БАНКІВСЬКИХ ПОСЛУГ
ІЗ ЗАСТОСУВАННЯМ ІНСТРУМЕНТАРІЮ НЕЧІТКОЇ ЛОГІКИ

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У статті проведено аналіз існуючих математичних методів і моделей оцінювання якості банківських послуг. Визначено, що наявні методи мають ряд недоліків, зокрема: клієнти банку оцінюють послуги у вигляді конкретного балу, що вносить значну частку суб'єктивізму; запропоновані методи не враховують вагомості різних критеріїв якості в загальній оцінці. В результаті у статті вирішено проводити експертне оцінювання на основі якісних характеристик. На їх основі з використанням апарату нечіткого логічного виведення утворюється вектор кількісних оцінок і здійснюється розрахунок вагових коефіцієнтів критеріїв якості. У результаті застосування даного методу банк отримує кількісну оцінку якості пропонованих послуг. Таке оцінювання дозволить банку визначити сильні та слабкі сторони та на їх основі розробити стратегію покращення якості послуг банку.

Ключові слова: *банк, банківські послуги, якість послуг, експертне опитування, нечіткі множини, система нечіткого логічного виведення.*

ОЦЕНИВАНИЕ КАЧЕСТВА БАНКОВСКИХ УСЛУГ С ПРИМЕНЕНИЕМ ИНСТРУМЕНТАРИЯ НЕЧЕТКОЙ ЛОГИКИ

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В статье проведен анализ существующих математических методов и моделей оценки качества банковских услуг. Выявлено, что данные методы имеют ряд недостатков, в частности: клиенты банка оценивают услуги в виде конкретного балла, что вносит в расчеты значительную долю субъективизма; предложенные методы не учитывают значимости различных критериев качества в общей оценке. В результате в статье решено проводить экспертное оценивание с учетом качественных характеристик. На их основе с использованием аппарата нечеткого логического вывода формируется вектор количественных оценок и осуществляется расчет весовых коэффициентов критериев качества. В результате применения данного метода банк получает количественную оценку качества предлагаемых услуг. Такая оценка позволит банку определить сильные и слабые стороны и, на их основе разработать стратегию улучшения качества услуг банка.

Ключевые слова: *банк, банковские услуги, качество услуг, экспертное оценивание, нечеткие множества, система нечеткого логического вывода.*

Introduction

The service sector today is a dynamic part of the economy. This applies to the banking sector, where the success of the bank and its competitiveness are determined not only by price factors, but also by qualitative characteristics, one of which is the quality of banking services. Based on the analysis, it was found that existing quality assessment methods are based on an expert survey of consumers. As part of this assessment, the client should provide a quantitative quality score. But, as practice shows, it is difficult for clients to put a specific point that would characterize a particular issue that describes the quality of the service. It is easier for consumers to evaluate the quality at the level of «low» or «high», etc. Therefore, in the paper a model for assessing the quality of banking services based on fuzzy sets methods is proposed. The model will turn the qualitative rating categories into quantitative ones.

Literature Review

The analysis of literature showed that there is a classic definition of the concept of quality as a difference between expectations and perceptions of consumers [1].

Modern scientists distinguish 3 basic methods for assessing the quality of banking services: SERVPERF, SERVQUAL, method of calculating the customer satisfaction index.

SERVPERF method is based on a questionnaire survey of service users. The questionnaire contains a list of subcriteria, grouped according to the criteria for assessing the quality of banking services. Consumers are asked to express their opinion on each of the subcriteria for the subject of the study (bank) on the five or seven-point Likert scale (completely disagree – completely agree). After completing the questionnaire, the average number of «execution» (perception) of each subcriteria is calculated [2, 3].

The development of this method was the SERVQUAL, which is expressed in the form of the «expectance minus perception» algorithm (E-P). Expectations are described as «consumer desires», as a standard in the creation of services. Perception in the method is considered as a measured consumer attitude to a real service [4, 5].

Since 1985, the initial concept has undergone a number of transformations and has been developed in a number of new methods.

Thus, the method of calculating the «customer satisfaction index» (CSI) is widely used to assess the quality of bank services. This method reflects the attitude of customers and allows to identify the reasons for satisfaction (dissatisfaction) of consumers with the service or product, which, accordingly, affects their degree of loyalty. The CSI method involves the preliminary formulation of the problem, the definition of the main components, the preparatory process (the development of questionnaires), the holding an opinion poll, processing and analysis of the accumulated information, as well as the calculation of the CSI values and the preparation of conclusions. After receiving the CSI it is possible to study the services offered by the bank, the attitude to work with specific clients, revealing «non-working» internal processes, the identification of bottlenecks at each stage and the management of the bank as a whole. Thus, CSI is a tool for managing not only the quality of banking services, but also loyalty and customer satisfaction [6, 7].

Reviewed methods of assessing the quality of banking services have the following significant disadvantages:

− the existing approaches offer the client to assess the quality of banking services in the form of a certain score, which is rather difficult for the client and, as a result, may lead to distortion of the results;

− modern methods do not consider the weight of the quality criteria of banking services in the overall assessment, which significantly changes the final result, because there are aspects that require more attention and, accordingly, they should be weightier in the evaluation process [8].

Thus, there is a need to build a substantially new model, which would include correction of these disadvantages. So the main aim of this research is to propose a new method for assessing the quality of banking services, which is based not on quantitative but on qualitative assessments by the clients of the bank.

1. Method

From the literature review we can see that all methods and models are based on an expert survey. Indeed, the most reliable way to determine whether a client is satisfied with the quality of services provided by the bank is to ask his opinion.

At the same time, it was found that the client can't assess banking services in the form of a specific score, as usually happens in banks. It is easier for the client to evaluate the criteria as «high» or «low» to provide

a linguistic assessment of the quality of banking services. Accordingly, the model must take into account this specificity of expert evaluation.

Speaking about the quality assessment, it is clear that for the evaluation of this characteristic it is necessary to develop a system of certain criteria. The basic feature of banking services is that it is impossible to determine a single criterion for assessing their quality. The process of assessing the quality of banking services can be presented as a hierarchical tree (Figure 1).
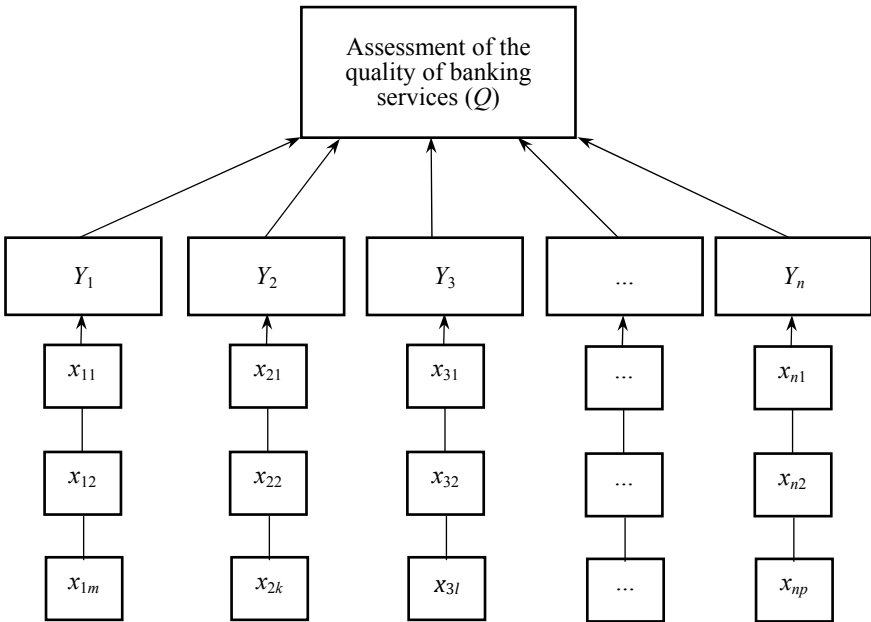

Figure 1. Hierarchical tree for assessing the quality of banking services

According to the given tree, we have a general assessment of the quality of services of the banking institution – Q, the calculation of which is the final aim of this investigation. The Q score is formed from the estimates for each criterion Y_j, $j = \overline{1, n}$. In turn, each criterion consists of a certain number of x_{ji} indicators that are included in the expert evaluation questionnaire.

According to the difficulty for the consumer to provide a quantitative assessment of quality of banking services the results of an

expert evaluation on the selected quality indicators will be obtained in a linguistic form, that is, the level of the indicator will be characterized, for example, as «high». Based on received expert opinions, we are faced with the task of turning them into a quantitative assessment of the quality criterion.

To processing of linguistic and qualitative information, methods of fuzzy sets theory can be successfully used. The study is based on the usage of Fuzzy Inference System (FIS-structure). The FIS-structure contains all the necessary characteristics for the implementation of the functional visualization of «input-output», which is shown in Fig. 2.
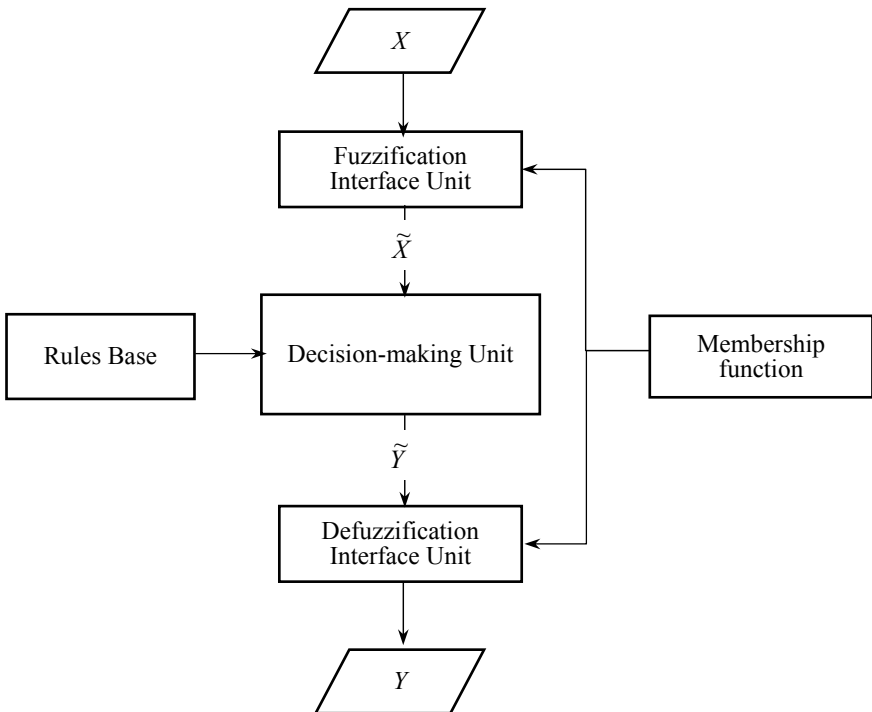

Figure 2. Fuzzy Inference System

In fig. 2: X – the input vector; $\widetilde{X}$ – a vector of fuzzy sets corresponding to the input vector X; $\widetilde{Y}$ – result of decision-making unit in the form of a fuzzy set vector; Y – the output quantitative vector $\{Y_1, \ldots, Y_n\}$.

Based on the result obtained through the FIS, we can calculate the final assessment of the quality of banking services.

As mentioned above, the model for assessing the quality of banking services should consider the weight of the criteria on which the evaluation is carried out. If we denote the weight factor as *k*, then based on the method of linear consideration of priority, we will receive the following model of quality assessment services of banking institutions:

$$Q = \sum_{j=1}^{n} Y_j \cdot k_j$$

$$\begin{cases} Y_j \in [0;100], \\ k_j \in [0;1], \\ \sum_{j=1}^{n} k_j = 1, \end{cases} \tag{1}$$

where Y_j – quantitative assessment of the quality criteria of banking institutions;

k_j – weighting coefficient of criteria;

n – number of criteria.

Based on these calculations, a general assessment of the quality of banking services *Q* will be obtained.

2. Results

The main stage in the assessment of the quality of banking services is the development of a system of criteria and subcriteria that will be estimated in the expert survey. Of course, each bank can independently develop a system of criteria that will be adapted to the specifics of providing services. However, in this study we offer our own system of criteria and indicators.

On the basis of the analyzed literature, practical observations and specifics of the banking services market in Ukraine, it is proposed to use the following criteria and indicators, selected for the purpose of the research: the first criterion is «reliability» (Y_1), which is characterized by such indicators as «time preparation» (x_{11}) – the time

required to start the service, «execution time» (x_{12}) – the time at which the customer is fully provided with the offered service; the second criterion is «practicality» (Y_2), characterized by the «learning opportunity» (x_{21}) – the complexity and length of the study of the service, «easy adaptability» (x_{22}) – the ease of managing functions and comfort in work, and the «completeness and correctness of the documentation» (x_{23}) – availability of the complete package of documents and compliance with the current legislation; the third criterion is «mobility» (Y_3) is characterized by indicators of «software availability» (x_{31}) – the availability of mobile applications, «software clarity» (x_{32}) – providing clear work with the software application, and «ease of use of software» (x_{33}) – the ability to use the software applications in a convenient format at any time; the fourth criterion is «accompaniment» (Y_4), which is characterized by such indicators as «the possibility of analysis» (x_{41}) – the ability to follow all stages of obtaining a service, and «stability» (x_{42}) – resistance to negative manipulations with changes; the fifth criterion is «confidence» (Y_5) is characterized by the following indicators: «customer satisfaction» (x_{51}) – providing customers with a sense of confidence in the service provided, «bank rating» (x_{52}) – clients assessment of the level of a particular bank among others institutions and «assessment of service level» (x_{53}) – the better the assessment, the higher the quality of service according to this criterion.

Based on this system of criteria an expert survey is carried out in the form given in Table 1.

Table 1

AN EXAMPLE OF THE RESULTS OF AN EXPERT SURVEY

	High	Medium	Low
Indicator 1 (x_{11})	x		
Indicator 2 (x_{12})			x
Indicator 3 (x_{21})		x	
…	…	…	…
Indicator 13 (x_{53})		x	

You can see that the survey is conducted in the form proposed in the study – the result will be given in a linguistic form, not in the form of specific points.

Approbation of the developed method was carried out on the basis of banking services of PJSC «OTP Bank». The first step was to conduct a survey. 150 clients of the bank took part in the assessment. Each respondent rated the proposed banking service for the developed system of criteria for three levels: high, medium and low. The overall interpretive survey is presented in Table 2.

Table 2

**RESULTS OF THE SURVEY ON THE ASSESSMENT
OF BANKING SERVICES OF PJSC «OTP BANK»**

Level	Votes for Level of Indicator, %							
	x_{11}	x_{12}	x_{21}	x_{22}	x_{23}	x_{31}	x_{32}	x_{33}
High	86,67	82,00	60,00	0,00	0,00	0,00	26,00	0,00
Medium	13,33	18,00	38,00	64,00	16,00	7,33	68,67	38,00
Low	0,00	0,00	2,00	36,00	84,00	92,67	5,33	62,00
Level	Votes for Level of Indicator, %				
	x_{41}		x_{42}	x_{51}	x_{52}	x_{53}
High	37,33	0,00	0,00	0,00	0,00
Medium	46,00	20,00	12,00	37,33	27,33
Low	16,67	80,00	88,00	62,67	72,67

Based on the conducted survey, FIS in Matlab package was used. System parameters are listed below:
– output variable – a quantitative quality criterion, the value of which is from 0 to 100;
– input variables – indicators that make up this criterion (the value varies from 0 to 100);
– type of membership function – trapezoidal;
– the number of terms – 3, «low», «medium» and «high» levels of the indicator;
– fuzzy rules base – results of expert evaluation; Mamdani type rules;
– the method of defuzzification – the center of gravity.
An example of a fuzzy rules base is shown in Fig. 3. Based on it, we can calculate the quantitative value of the criterion Y_1, taking into account the results of the expert survey (Fig. 4).
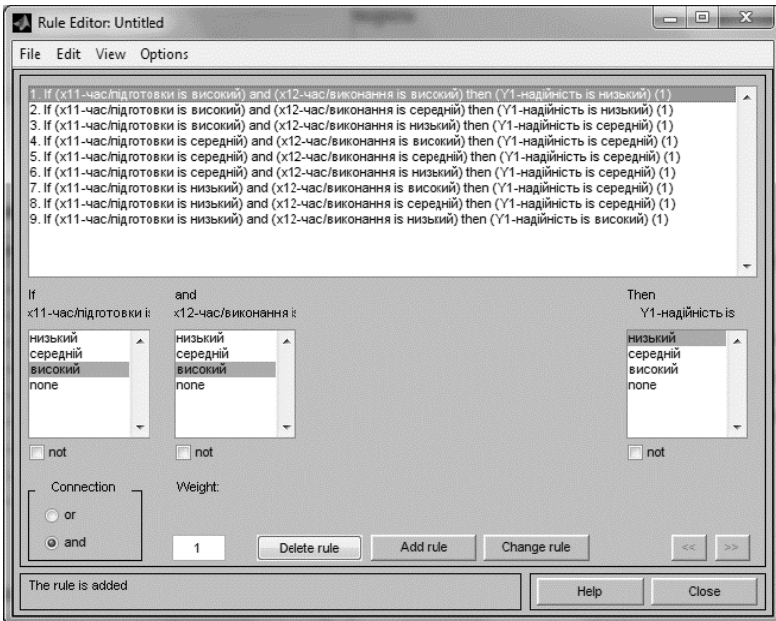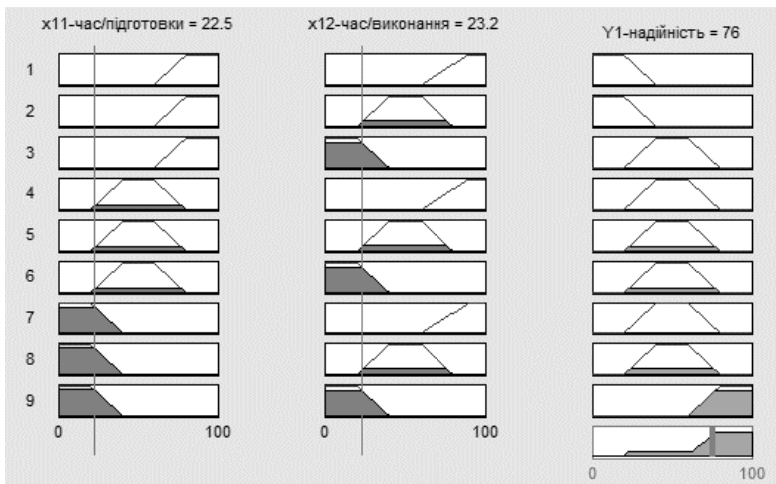
Figure 3. Fuzzy Rules Base for Y_1

Figure 4. The Result of Defuzzification

As a result of applying FIS, we obtain the following quantitative assessments of the quality criteria: $Y_1 = 76,00$, $Y_2 = 68,80$, $Y_3 = 62,20$, $Y_4 = 68,30$, $Y_5 = 71,50$.

In accordance with the developed method, it is necessary to calculate weights of the criteria. Up to this, we apply the method of Saati pair comparisons [9]. The distribution of the importance of the criteria is given in Table 3.

Table 3

PAIR COMPARISON OF CRITERIA

№ of criteria	Condition	№ of criteria	Condition	№ of criteria	Condition	№ of criteria	Condition	№ of criteria
Y_3	>>	Y_5	>=	Y_1	>	Y_2	>=	Y_4

According to the Saati pair comparisons, we received the following weights of the criteria and an overall assessment of the quality of banking services:

$$Q_{OTP} = 0,2 \cdot 76,00 + 0,11 \cdot 68,80 + 0,38 \cdot 62,20 +$$
$$+ 0,1 \cdot 68,30 + 0,21 \cdot 71,50 = 68,26.$$

Within the framework of the method the scale was developed on which we can interpret obtained results (Table 4).

Table 4

INTERPRETATION OF THE RESULTS OF ASSESSMENT

The Range of Values Q	Quality of Banking Services
[0, 20)	Very low
[21, 40)	Unsatisfactory
[41, 60)	Satisfactory
[61, 80)	Good
[81, 100]	High

Thus, the quality of the services of PJSC «OTP Bank» can be estimated as good. In addition, the developed method allows the bank to analyze the quality of banking services in the context of each criterion. So, for the «OTP Bank» the weak point is the absence of a mobile banking and an extremely inconvenient, from the client's point of view, Internet banking (criterion 3). Thus, the bank needs to pay special attention to the development and improvement of mobile applications.

Thus, the developed model and method of assessing the quality of banking services will allow a quantitative assessment of quality based on input linguistic information.

Conclusion

In this research the method for assessing the quality of banking services using fuzzy logic tools is proposed. It allows assessing the quality of banking services, which, as a result, will provide an opportunity for the bank to analyze in more detail the advantages and disadvantages of its services. Therefore, the results of this analysis can be applied to improve the quality of banking services. The developed method allows to consider the features of providing banking services and, as a consequence, increase the competitiveness of the bank in the market. The proposed method for assessing the quality of banking services can be used by consumers to compare similar services provided by different banks in order to compare their level of quality and to choose the best bank with the highest quality of services provided, as well as for the direct analysis of their services by banks in order to improve their position on the market.

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