Journal of Information Technology Management

Print ISSN: 2008-5893

Online ISSN: 2423-5059

Hierarchical Fuzzy Method of Comparing Bank Products with Complex Tariff Packages

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Abstract

The article considers a method for solving an information asymmetry problem that is relevant for the banking sector. The authors compare bank products and services in which tariff packages are consist of different informational components. The principal feature of the proposed method is to

focus on obtaining a subjective evaluation of the attractiveness of the Bank's offers for specific target groups. This makes the proposed method relevant for Central and commercial banks, as well as for consumers of banking products. Since complex tariff packages of different banks contain not only many indicators but also different sets, it is impossible to directly compare them. The proposed method allows solving the main informational problems of traditional methods for comparing banking products. Using the Fuzzy Inference System (FIS) allows a flexible approach to the aggregation of singular indicators of tariff packages and simplifies the expert procedures. To make rules for fuzzy inference, linguistic constructions close to the natural language can be used. This makes it easier to fill the knowledge base. To solve the set tasks, a methodology for constructing hierarchical FIS is used. In comparison with non-hierarchical FIS it can reduce the requirements to the number of rules in fuzzy inference rule base and system implementation time. The experiments with the fuzzy inference system, which implements a corporate credit cards tariff packages comparison of four Ukrainian banks, showed the effectiveness of the proposed approach. The obtained numerical results are adequately interpreted for the highlighted groups of banking product consumers.

Keywords: Comparison indicators, Packages information, Bank tariff, Fuzzy Inference System (FIS), Fuzzy logic.

DOI: 10.22059/jitm.2021.82607 Document Type: Research Paper

Introduction

Nowadays some researchers argue that Bank competition has mainly non-price character and is connected primarily with the quality of bank product and services (Carbó et al, 2009, Braun, & Deeg, 2019). But, when quality is equal, the price of the product has a decisive influence on consumer choices.

For traditional bank services, such as credit, deposit, and accounting transactions, the price could be directly determined and compared with competitors based on the bank's tariffs. Thus, the price of credit and deposit services is traditionally considered to be the interest rate. But since the 1970s commercial banks have significantly expanded both the range of products and the structure of each of them (Amel & Jacowski, 1989). Therefore, at present, some researchers suppose the price of a bank product to be a broader category, which is close to the concept of the "cost of ownership" (Authority for the Financial Markets, 2012).

However, this approach has a sense only if all expenses or incomes related to the analyzed bank product are deterministic, which is true as for accounting transactions (Vovk et al., 2020). In case the client's outlays for the bank services are partially probabilistic, the cost of ownership

determination also becomes impossible. Tariff packages that contain such outlay we will call "complex tariff packages". This term was first introduced by Malolli (Malolli, 2017) but has not received further development, although in our opinion it very aptly describes the economic essence of the processes under consideration.

Since complex tariff packages of different banks, as a rule, contain not only many components but also different sets, it is impossible to make a direct comparison of these tariff rates. Thus, another symptom of a complex tariff package is the inability to highlight the main indicator to rate them.

The purpose of this article is to develop a method to compare bank products with complex tariff packages.

The task of comparing bank products is one of the most important in bank marketing (Brescia & Scunziano, 2017; Soukal, 2018). It is indispensable in determining the competitiveness of products in market segmentation, strategic planning, and optimal price search.

The solution to this problem was studied by many researchers. So, Guo et al., (2008) proposed the method of comparison and measurement of service quality in the Chinese corporate banking market. Methods of bank charges comparison in different bank services markets were analyzed by Soukal, Hedvičáková & Draessler (2012) and Soukal (2012). The method for analysis of bank products competitiveness, based on the numerical score, was proposed by Mints (2010). But this method has several disadvantages, it works only with quantitative indicators. This limits its accuracy and scope. Thus, the formulated problem still does not have an adequate universal solution.

Methdology

Analysis of existing research relating to the fuzzy inference systems (Dubois & Prade, 2012; Rodríguez et al., 2013; Shtovba, 2007), econometrics, and machine learning methods (Babenko et al., 2019; 2021), allow us to identify the general sequence of constructing the FIS which can be used to compare bank products with complex tariff packages.

1. Determining basic parameters of a fuzzy knowledge base. The goal of this phase is to determine the quantity and structure of variables in the knowledge base, the number of terms for each of the input and output variables, and so on.

Initially, based on the total analysis of comparable tariff packages, there are several groups of parameters, corresponding to different aspects of the assessment of bank products. As follows from (Miller, 1956), during the knowledge base filling and subsequent use of the method one should focus on the fact that the number of groups G was in the following range $G \in \{2..7\}$.

The number of fuzzy terms used in the description of each variable is selected based on the following assumptions (Dubois & Prade, 2012): the more terms mean the more complex dependencies can be described in terms of the fuzzy inference system; the more terms mean the greater the number of rules required for the adequate formation of the knowledge base system.

If we deal with not very complex dependencies in fuzzy inference systems for input variables, we can use only three linguistic terms – High (H), Medium (M), and Low (L).

The output variable can be mapped to five linguistic terms – Very High (VH), High (H), Medium (M), Low (L), and Very Low (VL). It practically will not affect the number of fuzzy knowledge bases but will improve the accuracy of the results.

2. The structure formation of fuzzy inference system. The classic FIS implies the existence of a single knowledge base. This works well with a relatively small number of variables. In practice, when the number of variables is more than 5, the formation of the fuzzy knowledge base is considerably more complicated (Shtovba, 2007), because the full set of the rules is determined by the formula:

$$R_{fs} = V^N, \tag{2}$$

\where N – the number of variables;

V – the number of different values that can take each variables.

Although in the FIS there will be fewer rules in the fuzzy output database than was specified in formula (1), the form of dependence is maintained. Thus, in a fuzzy system that uses 10 indicators, each assigned to 3 terms, the number of rules in the full knowledge base should be 3^{10} = 59049. Even with the empirical estimations of the adequacy of the fuzzy knowledge base described by Shtovba (Shtovba, 2007), the minimum required several rules for its formation can be estimated at 600-1000 level, and most of the rules should cover all eight variables, rules of thumb determining the size of the fuzzy knowledge base.

Methods of solving this problem are *the aggregation* of indicators and the transition to *the hierarchical* structure of the knowledge base.

Aggregation is an expression of some set of characteristics of the tariff packages through a single figure, determined by experts. This is advisable in cases when each element of the set itself has little effect on the overall rating, or when a direct comparison is not possible due to different characteristics. In the given method *other financial terms* and *nonfinancial terms* are evaluated in the same way.

The hierarchical structure of the system is based on the calculation of fuzzy benchmarks

which allows reducing the dimension of the knowledge bases. The methodology of constructing and using hierarchical fuzzy inference systems is described in (Shtovba, 2007).

3. The definition of the procedures of fuzzification variables and defuzzification results. The solution to the problem in fuzzy terms involves adding the stages of fuzzification and defuzzification to the basic procedure of evaluation. In the process of fuzzification the converting of input data, expressed in numerical form to fuzzy logic terms, takes place. That is, each variable is assigned to a function that determines the degree of values belonging of this variable to the fuzzy terms. The procedure of defuzzification completes the process of fuzzy inference and involves the transformation of fuzzy sets into a crisp number.

4. The formation and filling of a fuzzy knowledge base. The knowledge base of FIS is generated using a survey of experts, or by a formalization in terms of fuzzy logic knowledge of a system developer. A significant advantage of fuzzy logic systems is that expert assessments can be entered into the database and be used even without the procedure of harmonization of various experts' opinions. The structure of the fuzzy knowledge base follows the structure of the truth tables of the binary logic operators, but as was already mentioned, the filling of all possible combinations of the independent variables is not mandatory.

5. Implementation of fuzzy inference system in the chosen software environment. Currently, the following software concepts for the implementation of fuzzy logic systems are used. The use of specialized software packages (MatLab, FuzzyTech, etc.). This approach allows to reduce development time and modernize the system but requires additional financial investments for the software package (Perevozova et al., 2019). In addition, it complicates the integration of the developed system into the existing IT infrastructure. Implementation using programming languages of general-purpose, with the use of specialized software libraries. It is time-consuming to development but simplifies integration and reduces the cost of implementing a fuzzy system since software libraries are usually freely available. Hardware implementation. It is used in technical systems and this study is impractical.

Choosing the program concept is due to objective factors, including the cost of purchasing the software product and the requirements for its integration, and subjective factors, including the preferences of the developer.

6. Checking the fuzzy inference system on real data and, if necessary, its adjustment. This phase provides feedback to the development process, FIS, and allows you to identify the errors and omissions of the previous stages.

Results and Descussion

The analysis of the existing research suggests that their authors made the fundamental error – the assumption about the possibility to obtain an objective evaluation of the complex tariff packages.

The impossibility of obtaining such evaluation is confirmed by numerous studies, which proved the subjectivity of decision making by economic agents (Kahneman & Tversky, 2000; Arena & Larrouy, 2016; Robins, 2019; He et al., 2018).

Therefore, when comparing complex tariff packages, you need to consciously move away from attempts to obtain an objective evaluation. On the contrary, you need to focus on obtaining subjective evaluation, which will reflect the needs of specific decision-makers and the specifics of their company with the bank product. Therefore, one of the requirements to the newly created method is a simplification of the task of subjective rules and criteria.

The best way for the above-mentioned requirements is the mathematical apparatus of fuzzy logic. The advantages of this approach are the ability to use natural linguistic structures for building the fuzzy inference system. This allows you to consider quality parameters of tariff packages along with the quantitative ones, to consider different points of the client's view on the priority of the parameters; it speeds up the process of development (compared to point methods of comparable accuracy) and facilitates adjustment of the system.

Following the basic concepts of fuzzy logic (Dubois & Prade, 2012), fuzzy set of $\overline{A}$ elements on X is defined as

$$\overline{A} = \{(x, \mu_A(x)) \mid x \in X\}; \mu_A(x) : x \to [0,1], \quad (1)$$

where $\mu A\ (x)$ is the membership function of the fuzzy set.

According to the approach, proposed by Zadeh (Zadeh, 1965), the degree of element's membership to a set can acquire any values in the range [0; 1], not only "0" or "1". Thus, element x may be a member of the set A to a small degree ($\mu A\ (x)$ approaches 0), to a large degree ($\mu A\ (x)$ approaches 1), not to be a member of a set ($\mu A\ (x) = 0$), or be a member of A ($\mu A\ (x) = 1$).

Each element can simultaneously belong to various categories with different degrees of membership. This allows us to significantly reduce the number of rules, necessary for designing fuzzy inference systems in comparison with traditional expert systems.

Each element can simultaneously belong to various categories with different degrees of membership. This allows us to significantly reduce the number of rules, necessary for designing fuzzy inference systems in comparison with traditional expert systems.

To illustrate the proposed method, let's consider its practical application concerning the comparison of commercial banks' tariff packages of Ukraine on the issue of corporate plastic cards, which are used to pay the costs of enterprises of commercial and main activities.

Let us consider the implementation of the above stages concerning the task.

1. In the analysis of corporate cards tariff packages, it is necessary to distinguish the following three groups:

I. Basic financial terms

II. Other financial terms

III. Non-financial terms

Group I. includes the main financial characteristics of the analyzed product, which are in the tariff packages of many banks. In this case, it is the cost of annual servicing of the card, the cost of withdrawals in Ukraine and abroad, the cost of credit card recharge, rules of credit limit use.

Group II. Includes other financial terms that can occur in tariff packages of individual banks but are significantly less important for the client than the terms of group I, since the probability of occurrence of relevant circumstances is also low. Such terms include, for example, fees for urgent cards issue and reissue, all statements, rates related to specific bank services, and others.

Group III includes the factors of work comfort with the bank associated with the choice of a particular product. For example, the size and availability of branch and ATM networks of the bank, quality of service, availability of customer-specific proposals, and other terms that can't be directly included in the tariff packages but will affect the client's choice.

Table.1 shows the analysis results which are based on the tariff packages of four Ukrainian banks – *Privatbank*, *Oschadbank*, *Prominvestbank*, and *Ukrgasbank*. The names of the banks hereinafter are replaced into "Bank1"..."Bank4".

To determine subjective evaluations of the attractiveness of tariffs, it is necessary to formulate the characteristic features of customers target groups. Depending on this, the group of indicators that are included in group I and II is determined.

Let us select two target groups:

Group A – industrial enterprises operating in the domestic market. Cards are used mostly for travel expenses. Officers regularly travel within the country. Occasionally the need for the use of cards abroad arises.

Lots of parameters from table 1 for group A might look like this:

$$A^{I} = \{p_1, p_2, p_3, p_4\};\ A^{II} = \{p_5, p_7, p_9, p_{11}, p_{12}, p_{13}\}.$$

Group B – trade enterprises using cards for domestic payments within the country and sometimes

for travel expenses. The use of cards abroad is not expected.

Table 1. Indicators of tariff packages of the analyzed commercial banks

Indicator (*p*)	**Bank 1**	**Bank 2**	**Bank 2**	**Bank 4**
The cost (per year)	100	100	200	250
Withdrawals (Ukraine)	0,80%	0,15-0,75-1,5%	0,5-1,5%	0,7-1%
Withdrawals (other countries)	2%	1,5% + 35UAH	1,5% min 24 UAH	2.2% min $8
The fee for conversion of funds	0%	1%	1,5%	0%
Withdrawal of funds due to the credit limit	3%	n/a	n/a	4,50%
Card recharge	*0*	0	n/d	*0*
Currencies	UAH, USD, EUR, RUR	UAH, USD, EUR	UAH, USD, EUR, RUR	UAH, USD, EUR
Statement methods	SMS, ATM, Internet	SMS, ATM	personally, ATM	personally, e-mail, ATM
Reissue (client-initiated)	100	50	40	250
Additional card	100	impossible	100	50
Minimum balance	0	0	100	2% balance +5 UAH
% for unauth overdraft	200	60	n/a	48
Transfer from card	0,3%-?	0,1-2%	n/a	0,5%-?

A lot of parameters from table 1 for group B might look like this:

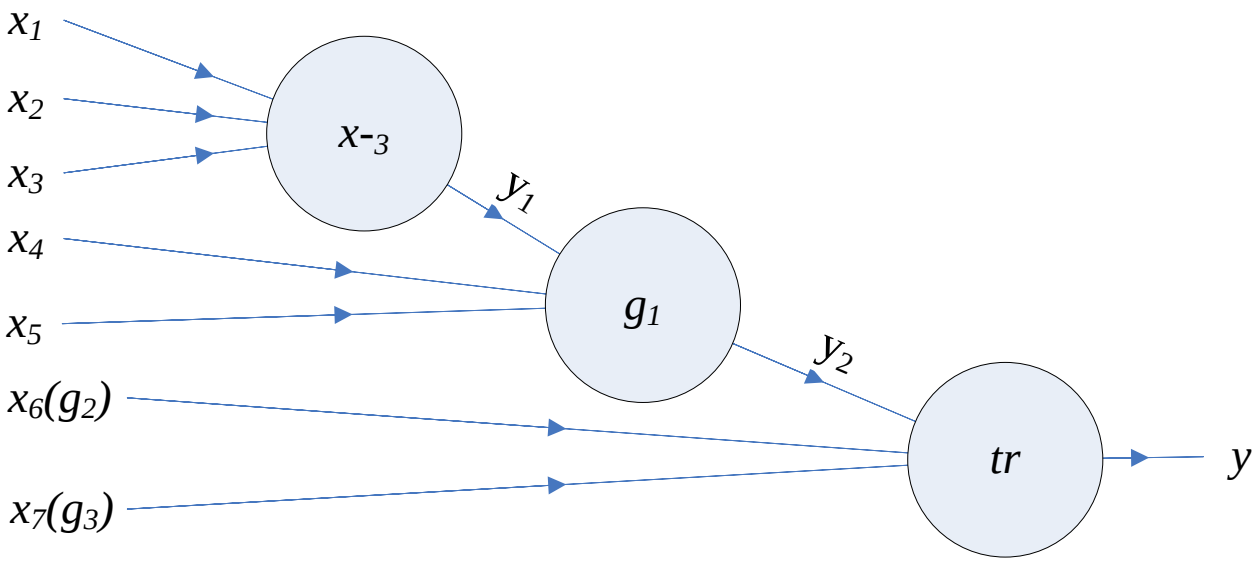
$B^I = \{p_1, p_2, p_5\}$; $B^{II} = \{p_8, p_9, p_{11}, p_{12}, p_{13}\}$.

Next, for each group of parameters the evaluation method is determined. You can also use the evaluation based on individual parameters (numeric or non-numeric), or a general expert evaluation group.

In this example, parameters of group I are considered by a FIS using their numerical characteristics. Parameters of group II are aggregated from the standpoint of their significance to the client, by language evaluation. Parameters of group III are also characterized by linguistic evaluation.

2. Fig. 1. shows the structure of the proposed fuzzy inference system. The renumbering of the indicators for *Table 1* is due to the peculiarities of the implementation of the hierarchical fuzzy system output.

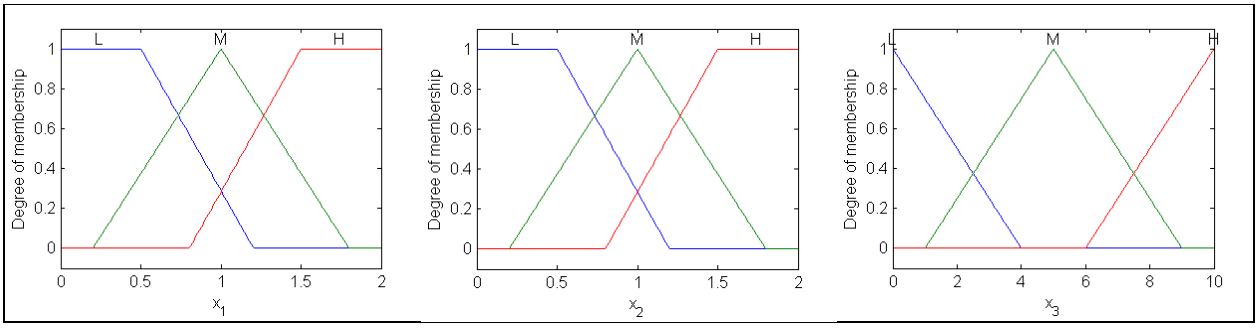
As can be seen from Fig. 1, a hierarchical subsystem was used to estimate the cost of withdrawal in Ukraine, as most banks differentiate rates for withdrawing money depending on ATM supplies, or banks. Another fuzzy hierarchical subsystem evaluates the performance of group I. Other groups are evaluated in total based on the subjective criteria of the target group users.



x_1 – the commission for withdrawing money at an ATM;
x_2 – the commission for withdrawing money in other banks of Ukraine;
x_3 – score number of ATMs and Bank branches;
x_4 – the cost of opening the card;
x_5 – the cost of withdrawing money abroad;
x_6 – other financial terms (evaluation);
x_7 – non-financial terms (evaluation).

Fig. 1. The structure of a hierarchical FIS for the evaluation of tariff packages of commercial banks to issue corporate cards

3. There are two main methods to define membership functions – analytical and graphical, among which there is one-to-one correspondence. Graphic representation of membership functions of input and output variables of the fuzzy model is shown in Fig. 2.



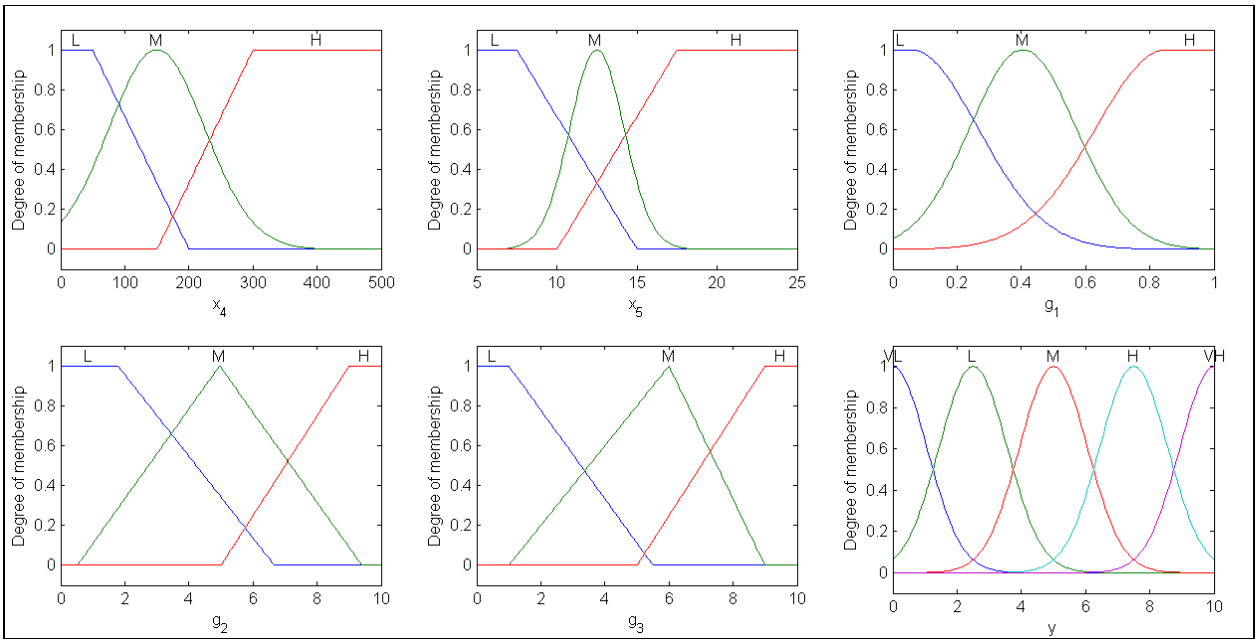


Fig. 2. Membership Functions Family of described hierarchical FIS

4. Knowledge base of solved tasks is shown in Tables 2-4.

Table 2. Knowledge matrix of the FIS gx3

In			**Out**
L		H	L
M		H	M
L	H	M	M
	H	L	H
	M	L	M
L	M	M	M
M	H	M	M
L	L	M	L
M	M		M
H	H		H
L	L	H	L
L	M	H	L
L	H	M	M
L	H	L	H

Table 3. Knowledge matrix of the FIS g1

In			**Out**
		H	L
L		L	H
M	L	L	H
M	M	L	H
		not H	M
H	H	not L	L

Table 4. Knowledge matrix of the FIS y

In			Out
H	H	H	VH
L	L	L	VL
not L	not L	H	H
not L	not L	M	M
not L	not L	L	L
L	not L	M	M
not L	L	M	M
not H	not H	L	L
H	H	L	M
H	H	not L	M
not H	M	H	H
not H	L	H	M
	H	H	H
	H	M	H
	H	H	VH

5. Implementation of hierarchical FIS was carried out in the MatLab using Fuzzy Logic Tolbox and add-on to the fuzzy inference on the hierarchical knowledge bases developed by Shtovba (Shtovba, 2007). This add-on allows you to combine several fuzzy systems within the same hierarchy without the procedures of fuzzification/defuzzification of intermediate variables.

6. The input data for the ranking of tariff packages of commercial banks from the point of view of the target client group A are shown in Table 5.

It should be noted that Table 5 contains data of different nature. Among them there is an absolute value in monetary terms (x4, x5), the percentage (x1, x2), estimated values (x3, x6, x7). x5 (the cost of withdrawing money abroad) means the cost of withdrawal at a foreign ATM, the equivalent of $500, which can be considered typical for the target group of customers. In other cases, different techniques can be required for data preparation.

From the obtained results (table. 3) we can conclude that the most attractive for the target group A are the tariffs of Bank 1. The tariff packages evaluations of other banks are far enough from one another that does not allow to improve competitiveness by making small changes.

Table 5. Input and output of FIS for the target group A

Var	Bank 1	Bank 2	Bank 3	Bank 4
Input variables				
x1	0.8	0.75	0.5	0.7
x2	0.8	1.5	1.5	2
x3	10	4	2	2
x4	100	100	200	250
x5	10	14	15	11
x6	9	5	5	7
x7	9	8	8	6
Defuzzificated fuzzy output values				
g1	0.5874	0.5000	0.4019	0.4019
y	6.5192	6.2790	5.0000	4.5387

After carrying out the similar work on tariff packages analysis of the target clients of group B, other evaluations were received (Table 6).

Table 6. The results of the fuzzy estimation system of tariff packages for the target group B

Var	Bank 1	Bank 2	Bank 3	Bank 4
Defuzzificated fuzzy output values				
y	5.7272	3.6241	2.5361	2.5338

It can be noted that ratings of banks 3 and 4 are very close, which makes them roughly equivalent to the customers. In such cases, relatively small changes in tariffs can significantly improve the competitiveness of bank products. For Bank 4 these changes can reduce the tariffs for corporate cards issue, as well as improve the services of remote customer service

Conclusion

As already noted, the considered method is advisable to use in cases when the tariff packages of the analyzed products have many components, and the total cost of product ownership is partially probabilistic. Additional conditions are the relatively low cost of the product, as well as many competitors and consumers in the market. Banking products and services meet these conditions most fully.

As our research suggests, a direct comparison of innovative banking products with complex tariff packages is almost impossible. We have defined complex tariff packages for commercial banks through the concept of the cost of ownership of banking services. The tariff package we will call “complex”, if the consumer’s spending for paying for the bank’s services are partially probabilistic and depend on the model of using the banking services by its consumer.

Our research shows the inexpediency of attempts to create a universal method for rating banking products with complex tariff packages, since different groups of banking services consumers are differently evaluating various components of tariff packages. But the calculation of subjective product rating for each group of clients based on the numerical scoring method is difficult or completely impossible.

Analysis of the complex tariff packages in existing banks let us highlight the following problems of traditional methods for comparing banking products: many components of the tariff package. For some banking products (for example, credit cards), their number can reach 30-40; different composition of tariff package components, which exclude their direct comparison. For example, one bank can set a cash withdrawal rate of 2% for any transactions, and another can specify 3% for amounts up to $ 500 and 1% for amounts over $ 500; finding the weight coefficients in numerical scoring methods requires the involvement of experts and the implementation of a rather complicated and expensive rating assessment procedure.

The proposed method allows us to solve the above problems using the fuzzy inference system. Fuzzy methods allow a flexible approach to the aggregation of individual components of tariff packages and simplify the expert procedures. For making rules of fuzzy inference can be used linguistic constructions which are close to natural language. This makes it easier to fill the

knowledge base. The hierarchical structure is a feature of the proposed fuzzy inference system. It allows us to reduce the requirements for the size of the knowledge base and further simplify the process of filling it.

The experiments with the fuzzy inference system, which implements a corporate credit cards tariff packages comparison of four Ukrainian banks, showed the effectiveness of the proposed approach. The obtained numerical results can be adequately interpreted from the point of view of highlighted groups of banking product consumers.

We recommend using the proposed methods for comparing products with complex tariff packages for banks, where they can be used by marketing departments, and for enterprises while choosing a partner bank. Moreover, in the latter case, the assessment base can be increased to a whole set of banking services that are necessary for the enterprise.

The disadvantages of the system include the relatively high requirements for the qualifications of persons, who are filling the knowledge base and setting up fuzzy inference parameters. Therefore, in the commercial implementation of this fuzzy inference system, we propose adding features that allow users to interactively edit the knowledge base, configure system parameters, and generate reports. This could reduce the qualifications requirements.

The proposed method allows performing a comparative analysis of bank products with complex tariff packages, which include, for example, bank cards, with minimal cost to the collection and processing of information. It can be used: by Central Bank-to prevent unfair competition between commercial banks; by Commercial banks - for marketing optimization; by Consumers of banking products - while choosing the optimal product for them.

The specificity of the method allows to identify the factors that have the greatest impact on competitiveness and define methods of its improvement. Possible ways of method development are clarifying the inference rule base for the analysis of other bank products with complex tariff packages.

References

Amel, D. F., & Jacowski, M. J. (1989). Trends in banking structure since the mid-1970s. *Fed. Res. Bull., 75*, 120.

Arena, R., & Larrouy, L. (2016). Subjectivity and Coordination in Economic Analysis. *OEconomia*, (6-2), 201–233. doi:10.4000/oeconomia.2348.

Authority for the Financial Markets (2012) Total cost of ownership in investment services. *Retrieved from*: https://www.afm.nl/~/profmedia/files/rapporten/2012/tco-beleggingsdienstverlening-en.pdf. Last accessed: 20-12-2019.

Babenko, V., Panchyshyn, A., Zomchak, L., Nehrey, M., Artym-Drohomyretska, Z., Lahotskyi, T. (2021). Classical Machine Learning Methods in Economics Research: Macro and Micro Level Example. *WSEAS Transactions on Business and Economics*, Vol. 18, Art. #22, pp. 209-217. https://doi.org/10.37394/23207.2021.18.22

Babenko, V., Lomovskykh, L., Oriekhova, A., Korchynska, L., Krutko, M., Koniaieva, Y. (2019). Features of methods and models in risk management of IT projects, *Periodicals of Engineering and Natural Sciences*, vol. 7, no. 2, pp. 629-636. http://dx.doi.org/10.21533/pen.v7i2.558

Braun, B., & Deeg, R. (2019). Strong Firms, Weak Banks: The Financial Consequences of Germany's Export-Led Growth Model. *German Politics,* 1–24. doi:10.1080/09644008.2019.1701657.

Brescia, R. H., & Scunziano, R. (2017). Ranking New York's Banks: Comparing the Products and Services of the Nineteen Largest Banks Serving Consumers in the Empire State. *Albany Law School Research Paper*, (8). doi:10.2139/ssrn.2937793.

Carbó, S., de Guevara, J. F., Humphrey, D., & Maudos, J. (2009) Estimating the intensity of price and non-price competition in banking. *Journal of Banks and Bank Systems, 4*(2), 4-19.

Dubois, D., & Prade, H. (Eds.). (2012). *Fundamentals of fuzzy sets* (Vol. 7). Springer Science & Business Media.

Guo, X., Duff A. & Hair, M. (2008) Service quality measurement in the Chinese corporate banking market. *International Journal of Bank Marketing*, *26*(5), 305-327. doi:10.1108/02652320810894389.

He, Z., Chan, F. T. S., & Jiang, W. (2018). A quantum framework for modelling subjectivity in multi-attribute group decision making. *Computers & Industrial Engineering*, 124, 560–572. doi:10.1016/j.cie.2018.08.001.

Kahneman, D., & Tversky, A. (Eds.). (2000). *Choices, Values, and Frames*. doi:10.1017/cbo9780511803475.

Malolli, I. (2017). Pricing policies for high demand data communications, the case of Albania. *CBU International Conference Proceedings*, 5, 300-306. doi:10.12955/cbup.v5.942.

Miller, G. A. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review, 63*(2), 81–97. doi:10.1037/h0043158.

Mints, A.Y. (2010) A formalized method for analyzing the competitiveness of bank payment cards. *Visnyk PDTU*, 20, 96-101.

Robins, D. (2018). Imagining London: The role of the geographical imagination in migrant subjectivity and decision□making. *Area, 51*(4), 728–735. doi:10.1111/area.12519

Rodríguez, R. M., Martínez, L., & Herrera, F. (2013). A group decision making model dealing with comparative linguistic expressions based on hesitant fuzzy linguistic term sets. *Information Sciences*, 241, 28–42. doi:10.1016/j.ins.2013.04.006.

Perevozova, I., Daliak, N., Babenko, V. (2019). Modeling of Financial Support for the Competitiveness of Employees in the Mining Industry. *CEUR Workshop Proceedings*, vol. 2422, pp. 444-454. URL: http://ceur-ws.org/Vol-2422/paper36.pdf

Shtovba, S.D. (2007) Design of fuzzy systems by means of MATLAB, *Hotline–Telecom*, Moscow, 288 p.

Soukal, I. (2019). The Novel Online Comparison Tool for Bank Charges with User-Friendly Approach. *Lecture Notes in Business Information Processing*, 211–224. doi:10.1007/978-3-030-11395-7_19.

Soukal, I., Hedvičáková M. & Draessler J. (2012) Probabilistic model of optimal price search on the retail core banking services market. *Int. J. Math. Models Methods Appl. Sci*., *6*(2), 386–393.

Vovk, V, Zhezherun, Y, Bilovodska, O, Babenko, V, Biriukova, A. (2020). Financial Monitoring in the Bank as a Market Instrument in the Conditions of Innovative Development and Digitalization of Economy: Management and Legal Aspects of the Risk-Based Approach. *IJIEPR*. 31 (4), 559-570. https://doi.org/10.22068/ijiepr.31.4.559

Zadeh, L. A. (1965). Fuzzy sets. *Information and Control, 8*(3), 338–353. doi:10.1016/s0019-9958(65)90241-x.

Bibliographic information of this paper for citing:

Mints, A., Zherlitsyn, D., Khadzhynova, O., Kamyshnykova, E. & Kalinin, O. (2021). Hierarchical fuzzy method of comparing bank products with complex tariff packages. *Journal of Information Technology Management*, Special Issue, 66-80.