На основі застосування теорії нечітких множин розроблено підхід до діагностики комплексної лояльності споживача автотранспортних послуг за сприйманими та поведінковими характеристиками. Діагностика рівня лояльності споживачів виступає основою циклічного процесу управління лояльністю споживачів автотранспортного підприємства (АТП) в сфері вантажних перевезень. Формування лояльності пов'язано з суб'єктивними уявленнями споживача, тому звичайні кількісні методи аналізу не ефективні в умовах нечіткої (неповної) інформації. Застосування результатів теорії нечітких множин до аналізу й оцінки лояльності споживача дає змогу одержати принципово нові моделі й методи аналізу.

Метод агрегування даних на основі нечіткого класифікатора дозволяє переходити від кількісних і якісних значень окремих показників сприйняття та поведінки споживача до комплексних показників лояльності. Емпіричні дані, використані в представленому дослідженні, були отримані шляхом опитування споживачів та на основі фактичних даних підприємства щодо перевезень вантажів по кожному клієнту. Кількісну оцінку інтегральних факторів сприйманої, поведінкової та загальної лояльності споживачів проведено за стандартною матричною схемою оцінювання. Для розпізнавання рівня цих факторів застосовано трирівневу класифікацію з підмножинами-термами «Низький рівень, Середній рівень, Високий рівень» лінгвістичної змінної «Рівень лояльності». В результаті оцінювання рівня лояльності споживачів автотранспортного підприємства було виявлено, що більшість клієнтів мають середній та високий рівень лояльності до АТП.

Використання апарату нечітких множин дозволяє комплексно виявити взаємний вплив сприйманих та поведінкових факторів на формування загальної лояльності споживача, а також моделювати різні ситуації залежно від передбачуваних показників взаємодії зі споживачем. Це складає передумови для розвитку лояльності споживачів автотранспортних послуг за рахунок розробки програм лояльності та індивідуальних стратегій взаємодії

Ключові слова: нечіткі множини, лінгвістична змінна, функція приналежності, сприймана лояльність, поведінкова лояльність

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USING THE ELEMENTS FROM A FUZZY SETS THEORY IN THE PROCESS OF DIAGNOSING THE LOYALTY OF CONSUMERS OF MOTOR TRANSPORT SERVICES

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1. Introduction

Motor transport companies (MTC) can no longer focus solely on market growth and the continued attraction of new customers under conditions of the increasing competition in the market of transport and logistics services and a limited range of consumers. The problem of marketing development in transport and logistics systems relates to the need to pay great attention to meeting needs of consumers [1]. The maintenance of existing consumers is becoming increasingly important. It means stimulation of repeated purchases combined with creation of emotional attachment to a company and its services, that is, formation of the consumer loyalty.

Obtaining competitive advantages in the long run depends largely on how a company builds relationships with consumers [2]. There is a challenge in front of MTC that relates not so much to the conquest and retention of customers, but to the achievement of a long-term partnership on mutually beneficial terms. MTC needs to pay attention to formation and development of the customer loyalty, which is not possible without estimation and analysis of loyalty indicators, to solve this problem. The study of the loyalty of a consumer of motor

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transport services necessitates the development of effective, easy-to-use tools and techniques, which give possibility for a motor transport company to estimate a level of the consumer loyalty to MTC with the highest degree of objectivity.

Numerous marketing studies [3–5] showed that satisfaction is an important prerequisite for the consumer loyalty. The consumer loyalty is the attitude and behavior of a consumer in relation to a specific service company, despite various services offered by competitors in the market [6]. That is, a loyal customer is a customer satisfied with services and prices of a company, he interacts with a company regularly, he has the high level of trust and plans to cooperate in the future, despite the attractive offers of competitors.

Diagnosing consumer loyalty level is one of the main stages of the cyclical process of managing the customer loyalty of a motor transport company. At the same time, we should perform diagnosing based on definition of a type of loyalty to be diagnosed, since it depends on all subsequent measures for its development.

Enterprises, organizations and individuals are consumers of MTC in the market of transport and logistics services for the transportation of goods. Most companies operate under conditions of VUCA (volatility, uncertainty, complexity, ambiguity) [7], which require timely management system transformations and formation of high flexibility of structures and processes. Authors of paper [7] emphasize a necessity to consider broader issues in meeting consumer needs. Thus, dynamically changing market conditions and the constant growth of competition in the market of transport and logistics services require continuation of the research in the part of the theoretical substantiation of tools for diagnosing customer loyalty in an uncertain environment. However, most commonly accepted approaches to estimation of the consumer loyalty use quantitative methods, which makes impossible to operate under conditions of uncertainty. Loyalty relates to subjective representations of a consumer, therefore, the usual quantitative methods of analysis are not effective in the analysis of complex systems, where the essential role belongs to judgments, perceptions and knowledge of a person. Therefore, the process of analytical support and justification of the methodology for estimation of a level of loyalty of consumers of motor transport services faces the need to use diagnostic models based on fuzzy-plural descriptions in motor transport companies.

The presence of a wide range of theoretical and practical problems connected with necessity of simulation of the process of diagnosing the customer loyalty of motor transport companies under conditions of fuzzy (incomplete) information determined the relevance of the study topic. The researchers face the task of creation and justification of a model of fuzzy estimation of the loyalty of customers of motor transport services. The decision of this task becomes of special significance for MTC, which provide transportation services, since there are numerous risks in their activities in a changing environment. In addition, the existing methods of diagnosing the consumer loyalty are applicable in certain industries, but they do not take into account the specifics of motor transport in the field of freight traffic.

2. Literature review and problem statement

There are different approaches to measurement of the consumer loyalty. Most of the proposed techniques use ballroom loyalty estimation methods followed by the calculation of the arithmetic mean or certain loyalty indices, or there are linear and regressive dynamic loyalty models constructed on this basis. Thus, an author of work [8] noted that the key to measurement of the customer loyalty is to give priority to the most satisfied customers and suggested to measure the consumer loyalty with NPS (Net Promoter Score) final promoter index. This technique is too simple; one indicator of intentions to recommend a service cannot reflect a complex process of assessment of the loyalty.

In this regard, the best approach to determination of the customer loyalty is study [9]. It proposed to consider the loyalty as a combination of behavioral and perceptual characteristics. The behavior of a consumer when making purchase determines the behavioral loyalty. Preferences of consumers create the perceptual (attitudinal) loyalty. It includes satisfaction and awareness. We determine a complex indicator of the consumer loyalty based on the segment analysis and Bayesian approach. The methodology gives possibility to estimate the customer loyalty in different directions, in a complex way, but authors have difficulties in measurement of the perception of consumers.

Another approach to measurement of loyalty [10] makes it possible to mark out two groups of indicators, which correspond to behavioral and perceptual (attitudinal) loyalty to some extent. It is interesting to divide indicators by the type of measurement: direct one and indirect one. However, this approach is quite complicated for quantitative measurement and it does not make it possible to determine a level of the customer loyalty. Paper [11] proposed the method of assessment of the loyalty in the form of RAPID (retention, advocacy and purchasing loyalty indexes) model. The author summarized the results of the study based on the factor analysis. A rather significant disadvantage of this approach is impossibility of definition of a complex indicator of the consumer loyalty.

Some authors [12] suggested application of the method of multiple regression analysis to construct a multi-factor consumer loyalty model. The model included quality of service, customer satisfaction and other factors. However, the model almost did not take into account a behavioral component expressed in the volume and regularity of purchases. Authors of paper [13] proposed estimation of consumer satisfaction based on the multi-attributive model of factors, which influence the customer loyalty. The paper revealed the main factors of the customer loyalty in the context of 7P marketing mix. However, the proposed factors did not give possibility to identify individual directions of consumer satisfaction and his intentions and to analyze his behavior in making purchases.

Most of the indicators have specifics of the industries where they were created in the developed customer loyalty methodologies and models. Therefore, it is quite difficult to apply them for MTC.

Let us consider the methods of estimation of the consumer loyalty in the field of transport and logistics services. Author of paper [14] compared and categorized transport companies of Poland in a few years with the help of regression analysis. The disadvantage of this approach is that the aim of the study was investigation of an impact of NPS on the growth and profitability of Polish transport companies, not taking into account consumer satisfaction and their attitude to services.

Paper [15] proposed an interesting method based on nonlinear modeling and application of a fuzzy system to han-

dle customer complaints, namely, the approach of an adaptive neuro-fuzzy output system (ANFIS). Authors figured out the relationship between customer satisfaction and the main relevant variables in transport and logistics companies in ports. The positive point is application of fuzzy descriptions, but the technique uses insufficient indicators to assess the consumer loyalty.

Authors [16, 17] proposed creation of loyalty models for public transport clients. They used factor analysis and structural equation modeling (SEM). The models investigated interconnections between different factors and customer loyalty. However, these models relate to passenger transport, and we cannot use them in the field of freight traffic. Study [18] also used structural equation modeling (SEM), dispersion analysis and least squares (PLS) method. A comprehensive assessment of consumers' perceptions in rental of vehicles is interesting, but the model does not consider behavioral characteristics of customers.

Authors of paper [19] described the loyalty model and examined its application in transport, using the example of consumer choice between two types of transport. There were component factors of the loyalty model determined based on the factor analysis. However, the questions included in the questionnaire are not suitable for the study of the loyalty of consumers of freight MTC.

One of the first studies of the consumer loyalty in the field of logistics outsourcing was work [20]. The authors performed the empirical loyalty study using structural equation modeling, but indicators of loyalty to outsourcing services did not correspond to the chosen topic of the study. Article [21] analyzed a quality, satisfaction and loyalty in the context of implementation of logistics services using the factor analysis. It proposed to determine satisfaction based on three elements: a quality of services, prices and relations between a supplier and a consumer. The disadvantage of the model is that it did not study behavior and emotional attitude of a client to services, in addition, factor analysis did not make it possible to estimate information uncertainty.

Authors of paper [22] carried out the most comprehensive study in the field of transport and logistic services [22]. They focused on analysis of an impact of determinants of satisfaction on the customer loyalty to freight transport providers. They evaluated the model using least squares (PLS) method and dispersion analysis (ANOVA) method. This study confirmed that there are significant differences in quality and levels of satisfaction between types of transport. However, these methods also do not give possibility to operate with uncertainty.

An overview of the most common models and methods for measurement of the consumer loyalty [8–22] showed that these models do not take into account different directions of its formation; and they are too generalized in most cases. In addition, their basis is various traditional statistical methods of analysis, such as factor analysis, regression analysis, least squares, structural equations, and others, that is, they describe the existing level of information uncertainty inadequately. The fuzziness used often to describe some sides and characteristics of the consumer loyalty and related to decision-making by a person is insufficiently studied.

During the last years, theoretical positions of modeling of the process of diagnosing the consumer loyalty under conditions of incomplete (fuzzy) information are actively developing. Thus, authors of [23] offered a new direction in air travel research, using SEM analytical approach and artificial neural networks to analyze an impact of SERVPERF (Service Performance) model on customer satisfaction and loyalty. However, this model has a narrow direction in assessment of perception of airline service by customers. Work [24] proposed the similar method. It used artificial neural networks and linear regression to model customer loyalty in insurance companies. The disadvantage of this approach is that it estimates consumer perception without paying attention to behavioral characteristics. Work [25] proposed using simple nonlinear adaptive models with relevant key factors to overcome limitations of linear regression models for estimation of the customer loyalty. Authors of paper [26] used a polarization index to measure the consumer loyalty. It reflected a degree of loyalty to repeated discrete choices. However, this index measures the behavioral loyalty of a consumer only almost without examining the perceptual loyalty.

Some authors used elements of the theory of fuzzy sets to analyze and estimate the consumer's attitude to a company and its services expressed by the indicator of loyalty. Therefore, in order to determine loyalty and customer satisfaction in the mobile communications market, paper [27] proposed to use NPS indicator and to construct a fuzzy logic model. Authors chose the FPA (Fast Prototyping Algorithm) method based on the least-square method. Other authors [28] suggested ranging the consumer loyalty based on the TOPSIS (technique for order preference by similarity to ideal solution) method. The disadvantage of these approaches is that their aim is determination of the loyalty in the mobile services market only, and we cannot use them to diagnose the loyalty in the freight transport market.

We recognize the importance of studies carried out. However, we cannot consider the scientific development of the problem of diagnosing the loyalty of customers of motor transport companies, which provide services for transportation of goods, to be sufficient. There is no unity of opinion regarding criteria and methods for measurement of the consumer loyalty in modern literature sources [8–28]. In addition, indicators used do not reflect components of the process of creation of loyalty of consumers of motor transport services fully. The above prevents the diagnosing of the consumer loyalty.

Imperfection of methodical approaches and models of research of loyalty of MTC consumers requires their scientific improvement and development, as they do not take into account peculiarities of the process of provision of motor transport services fully. Therefore, a scientific task arises in development of a methodological approach to the diagnosing of the loyalty of consumers of motor transport services. Since the process of determination of a level of the consumer loyalty to MTC and its services are related to human perception, theories, which consider peculiarities of reasoning with inaccurate concepts, are necessary for analysis and evaluation of the loyalty. One of the approaches to description of such complex systems is the use of a fuzzy set of devices and construction of fuzzy models based on it.

3. The aim and objectives of the study

The objective of this study is to develop a methodological approach to the diagnosing the complex loyalty of a consumer of motor transport services by perceptual (attitudinal) and behavioral characteristics, using elements of the theory of fuzzy sets.

We set the following tasks to achieve the objective:

– proposition of directions and groups of factors for diagnosing of loyalty of users of motor transport services;

– formation of a model of the process of diagnosing loyalty of consumers of motor transport services and generalization of the algorithm of fuzzy assessment of the customer loyalty to services;

– diagnosing the level of loyalty of MTC consumers based on the use of fuzzy sets.

4. Formation of a methodical approach to diagnosing the level of customer loyalty using a fuzzy sets theory

Since the existing scientific methods for assessment of the consumer loyalty are apparently insufficient, it is necessary to develop a fundamentally new model of loyalty diagnostics, which functions under conditions of significant uncertainty. The fuzzy set theory [29–31] can greatly contribute to formation of this model. It gives possibility to analyze the process (phenomenon) without finding a functional dependence between variables. The presence of mathematical means of reflection of the fuzziness of source information enables us to construct a model that is adequate to reality. This leads to the study of the applied aspect of the use of fuzzy logic techniques in the process of diagnosing the consumer loyalty.

At the same time, application of the results of the theory of fuzzy sets to the analysis and assessment of the system of formation of consumer loyalty makes it possible to obtain fundamentally new models and methods of analysis. It provides the opportunity to perform a reasonable transition from classical probabilistic models and expert assessments to fuzzy-plural descriptions. Thus, we can replace the classical probabilistic distribution by a probabilistic distribution with fuzzy parameters in a model, and we can interpret a set of expert assessments by a set of membership functions formed by a fuzzy classifier.

Papers [30, 31] proposed to apply the theory of fuzzy sets for the quantitative assessment of the integral indicator of the loyalty of a consumer of motor transport services. It gives possibility to take into account and to compare measured and hardly measurable indicators of the consumer's attitude to MTC and its services.

Fuzzy sets are widely used to formalize linguistic knowledge. The following five objects represent the linguistic variable

$$\{Y, T, X, G, M\}, \quad (1)$$

where Y is the name of a linguistic variable; T is the term-set, which is a name of fuzzy variables whose domain definition is X set; G is the syntactic procedure, which describes the process of creation of new terms; M is the semantic procedure for creation of new terms.

The implementation of the fuzzy algorithm consists of three stages [32, 33]:

1) fuzzification – transition from the exact output data of the solvable problem to fuzzy ones based on the input membership functions;

2) solving the problem using fuzzy instructions (fuzzy logic, linguistic rules);

3) defuzzification – transition from fuzzy instructions (fuzzy instructions, linguistic rules) to clear decisions based on the output membership functions.

Let us apply the method of multicriteria choice of alternatives based on the compositional rule of aggregation of alternatives descriptions with information on benefits of a person, who makes decisions given in the form of fuzzy judgments, to assess the loyalty of company's customers as noted above.

4. 1. Determination of directions and groups of factors for diagnosing a level of the loyalty of consumers of services based on the apparatus of the theory of fuzzy sets

Taking into account the essence of loyalty and taking into account the analysis of the approaches of different authors to its assessment [10, 14–17], it is expedient to assess two interrelated components, such as perceptual (attitudinal) loyalty and behavioral loyalty, in order to determine a level of the complex loyalty. It is necessary to determine indicators separately for each of them, because there are always both emotional and functional components in the relationship of a consumer with a company. Consumer loyalty indicators consist of several subgroups of indicators and have different levels of measurement. Therefore, it is more appropriate to consider these indicators as linguistic variables with corresponding term sets. According to above, we also consider the notion of "loyalty" as a linguistic variable and use the apparatus of fuzzy sets for its assessment.

In order to recognize a level of these factors, we suggest introducing the "Factor level" linguistic variable with the following subsets: "Low level, Average level, High level" terms. We also introduce x carrier, which is a segment of the transversal [0, 1] axis [0, 1] and define the set of membership functions from all selected subsets of the "Factor level" linguistic variable on it. There is a transition from the existing scales of measurement of factors to a scale from 0 to 1 based on a simple linear transformation. There are values of the membership function, which reflect fuzzy consumer assessments in [0, 1] interval.

The methodology proposes two directions of diagnosing of the complex consumer loyalty; they are perceptual (attitudinal) loyalty and behavioral loyalty. The following main variables are linguistic variables:

Y_1 – level of the consumer perceptual (attitudinal) loyalty (AL);

Y_2 – level of the consumer behavioral loyalty (BL);

Y_3 – level of the complex consumer loyalty (L).

The model for assessment of a level of the complex customer loyalty will be as follows:

$$L = F_1(AL, BL). \quad (2)$$

We propose the following structure of indicators of perceptual (attitudinal) and behavioral loyalty of consumers of motor transport services of freight MTC based on the analysis of various authors' studies on the customer loyalty assessment [10, 14–17, 19–24]. Preferences and thoughts of a consumer form the perceptual loyalty. We measure it using the following basic factors: customer satisfaction with quality, customer satisfaction with value of service, intentions of cooperation and consumer's attitude. But the specifics of transport services are measurements of their quality from the point of view of the quality of given service and the quality of the service process [34]. Therefore, we propose to assess the satisfaction with the quality of given services based on the result obtained by a consumer. We can determine satisfaction with the quality of the service process based on

the satisfaction with the technical and functional features of services and contacts with the staff. The consumer attitude to MTC also has emotional and rational components.

We determine the behavioral loyalty by the behavior of a consumer when making purchase and measure it based on the following indicators: increased purchases, maintaining the achieved level of interaction, a share in the business of a client, regularity of purchases and a level of duration of business relations.

The level of the perceptual (attitudinal) loyalty takes the following form:

$$AL = F_2(SQS, SQP, SVS, RAI, EAC), \quad (3)$$

where *SQS* is satisfaction with the quality of a given service; *SQP* is satisfaction with the quality of the service process; *SVS* is satisfaction with the value of the service; *RAI* is the rational attitude and intentions of a consumer; *EAC* is the emotional attitude of a consumer.

There are more details of satisfaction and consumer attitude below:

$$SQS=F_4(X_{11}...X_{15});\ SQP=F_5(X_{21}, X_{22}, X_{31}...X_{39});$$

$$SVS=F_6(X_{41}...X_{45});\ RAI=F_7(X_{51}, X_{52}, X_{61}, X_{62});$$

$$EAC=F_8(X_{71}...X_{75}). \quad (4)$$

An integral indicator of the behavioral loyalty represents the second set of indicators, which reflects the behavior of a consumer:

$$BL = F_3(X_{81}\ldots X_{85}), \quad (5)$$

where X_{81} is the increase in purchases (a share of increase of the volume of transportations); X_{82} is the support of achieved level of interaction (relative stability of the amount of purchases); X_{83} is the share in the business of a client (a specific weight of freight transported by MTC in the total volume of freight required for a consumer); X_{84} is the regularity (periodicity) of purchases (stability of transportations for this client); X_{85} is the level of duration of business relationship with a consumer.

The proposed model of the loyalty assessment helps to determine how different groups of factors influence the customer loyalty and which reserves need to be put into effect in order to increase the loyalty of a consumer of motor transport services.

4. 2. Formation of a model and algorithm for diagnosing of a level of the customer loyalty to services based on the theory of fuzzy sets

To solve a given problem using the theory of fuzzy sets, let us suppose that the set of solutions has the following set of criteria X_1, X_2, ..., X_j given on the following basic sets u_1, u_2, ... u_p. Accordingly: u_1 – is a consumer 1, u_2 – is a consumer 2, u_3 – is a consumer 3, etc.

Then we need to begin to describe the hypothesis. A group of experts formulates hypotheses based on a survey of consumer preferences and own opinions. A person, who makes decisions in accordance with the purposes of analysis and evaluation, specifies the hypotheses.

Here is an example of the formulation of hypotheses for Y_3 indicator "A level of the complex consumer loyalty":

d_1: "If a consumer is completely satisfied with the service and he has a high emotional attachment to a company, as well as high behavioral loyalty, then he has a high level of the complex loyalty";

d_2: "If a consumer has a good attitude and intentions in addition to d_1 conditions, he also has a high level of the complex loyalty";

d_3: "If a consumer does not have emotional attachment and has a low rational attitude, then he has an average level of the complex loyalty even for all other high indicators";

d_4: "If a consumer is not satisfied with the value of service and has low behavioral loyalty, then, he has an average level of the complex loyalty even for all other good indicators";

d_5: "If a consumer is not satisfied with the quality of service and the process of service, and has no emotional attachment in addition to d_4 conditions, he has a low level of the complex loyalty";

d_6 "If a consumer is not completely satisfied with the quality of service and has a negative attitude to MTC and its services, as well as low level of the behavioral loyalty, then he has a low level of the complex loyalty."

Analysis of the above information slices and allocation of assessment units makes it possible to identify the following factors, which influence a level of the complex loyalty: X_1 – SQS, X_2 – SQP, X_3 – SVS, X_4 – RAI, X_5 – EAC, X_6 – BL, Y_3 – L.

It is necessary to determine possible values of Y_n and X_j linguistic variables for the formulation of rules. We will use the variables to assess various groups of factors that affect the complex customer loyalty:

d_1: «If X_1=HIGH, X_2=HIGH, X_3=HIGH, X_5=STRONG, X_6=HIGH, then Y_3=HIGH»;

d_2: «If X_1=HIGH, X_2=HIGH, X_3=HIGH, X_4=GOOD, X_5=STRONG, X_6=HIGH, then Y_3=HIGH»;

d_3: «If X_1=HIGH, X_2=HIGH, X_3=HIGH, X_4=BAD, X_5=WEAK, X_6=HIGH, then Y_3=AVERAGE»;

d_4: «If X_1=HIGH, X_2=HIGH, X_3=LOW, X_4=GOOD, X_5=STRONG, X_6=LOW, then Y_3=AVERAGE»;

d_5: «If X_1=LOW, X_2=LOW, X_3=LOW, X_4=GOOD, X_5=WEAK, X_6=LOW, then Y_3=LOW»;

d_6: «If X_1=LOW, X_2=LOW, X_3=LOW, X_4=BAD, X_5=WEAK, X_6=LOW, then Y_3=LOW».

We describe Y_3 linguistic variable as the truth variable given on the base set: J={0; 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 0.9; 1}. The functions of membership to the new terms of the "Level of the complex loyalty" linguistic variable have the following rules:

$$VS\text{=HIGH defined as} - \mu_{VS}(j) = x^2,\ x \in J; \quad (6)$$

$$P\text{=AVERAGE} - \mu_P(j) = x,\ x \in J; \quad (7)$$

$$MS\text{=LOW} - \mu_{MS}(j) = \sqrt{x},\ x \in J. \quad (8)$$

The same group of experts determines $\mu_{Yni(j)}$ values. A person, who makes decisions, specifies them in accordance with the objectives of the analysis if necessary.

The loyalty assessment occurs for all consumers of MTC on the following set $U=\{u_1, u_2, u_3, u_4, u_5, ...,u_p\}$.

To bring the hypothesis to a mathematical form, let us denote high indicator of SQS as *A*, high SQP – as *B*, high SVS – as *C*, good RAI – as *D*, strong EAC – as *E*, high BL – as *F*.

Taking into account the implemented notations, the rules take the following form:

d_1: «If X=A and B, and C, and E, and F, then Y_3=VS»;

d_2: «If X=A and B, and C, and D, and E, and F, then Y_3=VS»;

d_3: «If X= A, and B, and C, and not D, and not E, and F, then Y_3=P»;

d_4: «If X=A and B, and not C, and D, and E, and not F, then Y_3=P»;

d_5: «If X=not A, and not B, and not C, and D, and not E, and not F, then Y_3=MS»;

d_6: «If X=not A, and not B, and not C, and not D, and not E, and not F, and not G, then Y_3=MS».

Let us define the functions of membership of μ_{Mi} for these rules:

for d_1: $\mu_{M1}(u_p)=$
$=\min(\mu_A(u_p), \mu_B(u_p), \mu_C(u_p), \mu_E(u_p), \mu_F(u_p))$;

for d_2: $\mu_{M2}(u_p)=$
$=\min(\mu_A(u_p), \mu_B(u_p), \mu_C(u_p), \mu_D(u_p), \mu_E(u_p), \mu_F(u_p))$;

for d_3: $\mu_{M3}(u_p)=$
$=\min(\mu_A(u_p), \mu_B(u_p), \mu_C(u_p), 1-\mu_D(u_p), 1-\mu_E(u_p), \mu_F(u_p))$;

for d_4: $\mu_{M4}(u_p)=$
$=\min(\mu_A(u_p), \mu_B(u_p), 1-\mu_C(u_p), \mu_D(u_p), \mu_E(u_p), 1-\mu_F(u_p))$;

for d_5: $\mu_{M5}(u_p)=$
$=\min(1-\mu_A(u_p), 1-\mu_B(u_p), 1-\mu_C(u_p), \mu_D(u_p), 1-\mu_E(u_p), 1-\mu_F(u_p))$;

for d_6: $\mu_{M6}(u_p)=$
$=\min(1-\mu_A(u_p), 1-\mu_B(u_p), 1-\mu_C(u_p), 1-\mu_D(u_p), 1-\mu_E(u_p), 1-\mu_F(u_p))$.

Now rules we can record the rules as follows:

d_1: «If X=M_1, then Y_3=VS»;

d_2: «If X=M_2, then Y_3=VS»;

d_3: «If X=M_3, then Y_3=P»;

d_4: «If X=M_4, then Y_3=P»;

d_5: «If X=M_5, then Y_3=MS»;

d_6: «If X=M_6, then Y_3=MS».

We use Lukasiewicz's implication transformed by the introduced notations for the transformation of the rules of the form: "If X=M_i, then Y=VS or P or MS". This operation makes it possible to switch from a descriptive form to the formalized mathematical form. Fuzzy implication takes the form:

$$\mu_{Dk}(u,j)=\min(1,1-\mu_{Mij}(u_j)+\mu_{Yni}(j)), \quad (9)$$

where D_k is the fuzzy subset of $U\times J$, $(u,j)\in U\times J$; U is the basic set of service consumers; $\mu_{Dk}(u,j)$ is the value of the function of membership of the k-th statement for the u-th consumer and a value of the j-th indicator, which affects the linguistic variable; $\mu_{Yni}(j)$ is the set of expert assessments of X_{ij} priorities of i-th linguistic variable of n-th level.

For each $(u,j)\in U\times J$, we get $U\times J$ fuzzy relations.

Similarly, d_1, d_2, ..., d_q expressions will transform to H_1, H_2, ..., H_q... set. Their intersection is D set:

$$D=H_1\bigcap H_2\bigcap ...\bigcap H_q, \quad (10)$$

and for each $(u,j)\in U\times J$

$$\mu_D(u,j)=\min(\mu_{Dk}(u,j)),\ k=\overline{1,q}. \quad (11)$$

We obtain matrices for each statement separately, as well as the complex matrix of the final D solution.

We use the composition rule of the conclusion in the fuzzy environment to calculate a level of the loyalty of each consumer:

$$E_k=G_k\circ D, \quad (12)$$

where E_k is a degree of satisfaction of k alternative; G_k is the reflection of k alternative in the form of a fuzzy subset by U; D is the general functional solution. Then

$$\mu_{E_k}(i)=\max_{u\in U}(\min(\mu_{G_k}(u),\mu_D(u))). \quad (13)$$

In addition, in this case

$$\mu_{Gk}(u)=0;\ u\neq u_k;\ \mu_{Gk}(u)=1;\ u=u_k.$$

Hence,

$$\mu_{Ek}(i)=\mu_D(u_k,i).$$

In other words, E_k is the k-th line in D matrix.

Comparison of alternatives occurs based on point assessments. We determine α-level ($\alpha\in[0, 1]$) set for $E\in I$ fuzzy set:

$$E_\alpha=\left\{i\middle|\mu_E(i)\right|\geq\alpha,\ i\in I\}. \quad (14)$$

We calculate E_α level sets and an average number of elements $M(E_\alpha)$ for each consumer from formula:

$$M(E_{j\alpha})=\sum_{i=1}^{n}\frac{x_i}{n}. \quad (15)$$

Then, we can calculate a point estimate of the level of the consumer loyalty from formula:

$$F(E_{j\alpha})=\frac{1}{\alpha_{\max}}\int_0^{\alpha_{\max}}M(E_{j\alpha})\mathrm{d}\alpha. \quad (16)$$

where $\alpha_{\max}$ is the maximum value for E set.

We chose the highest level of the loyalty with the highest point estimate as the best one.

Similarly, we can construct hypotheses, determine membership functions, and determine a level of perceptual and behavioral loyalty.

Given the main elements of the theory of fuzzy sets presented in the form of a list of successive actions and factors, which affect a level of the consumer loyalty, we can propose the consumer loyalty algorithm (Fig. 1).

The algorithm of fuzzy estimation of the consumer loyalty to services makes it possible to determine separately levels of perceptual and behavioral consumer loyalty and generalize them into a complex indicator based on fuzzy-plural descriptions. The offered approach gives possibility to receive the quantitative estimation of the integral index of a level of the complex loyalty of a consumer. It gives an opportunity to build models of dependence of the consumer loyalty on various factors in further studies. There are software tools developed in the MS Excel 2016 environment based on fuzzy-plural descriptions for calculation of the end-result of estimation of the level of the consumer loyalty.

5. Results of approbation of the developed model of diagnosing the level of consumer service loyalty

Let us consider PJSC "MTC-16363" (Kharkiv, Ukraine) involved in the transportation of goods as an example of implementation of the method of diagnosing of loyalty of consumers of motor transport services using the theory of fuzzy sets. We collected the source data using questionnaires for 56 consumers of MTC to calculate the loyalty of consumers to PJSC "MTC-16363". For a clear example of customer loyalty diagnosing, we give detailed calculations for the following five key service consumers: PJSC "SanInBev Ukraine" (u_1), PJSC "Philip Morris Ukraine" (u_2), State Enterprise "Lactalis-Ukraine" (u_3), LLC "Expansion" (u_{55}), PJSC "Kharkov biscuit factory" (u_{56}). We obtained the empirical data used in the present study by consumer surveys and based on the company's actual data on freight traffic for each customer. We listed them on a scale from 0 to 1.

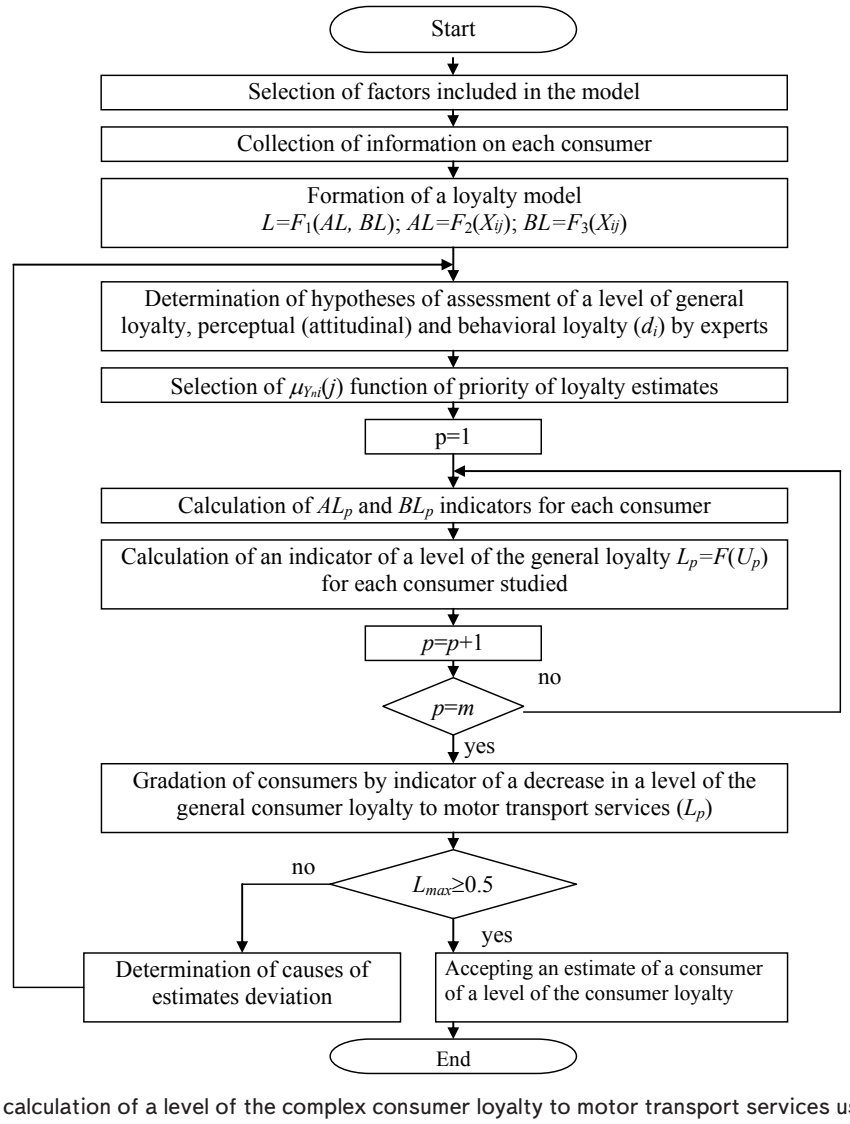

Fig. 1. Algorithm for calculation of a level of the complex consumer loyalty to motor transport services using the apparatus of fuzzy sets: L – level of the complex consumer loyalty; AL – level of the perceptual (attitudinal) loyalty; BL – level of the behavioral loyalty; U_p – specific values of X_{ij} characteristics of p-th consumer; m – the number of consumers studied; X_{ij} – the j-th estimate of i-th characteristic of the parameter of the consumer loyalty level; d_i – a hypothesis, which determines the ratio of X_{ij} estimates to Y_n linguistic variable; n – a list of qualitative estimates of a level of the consumer loyalty (high, medium, low); Y_n – linguistic variable of a certain number of X_{ij} variables, it determines a level of the consumer loyalty; $\mu_{Yn}(j)$ – a set of expert estimates of X_{ij} priorities

We constructed hypotheses and membership functions and calculated point estimates for each perceptual loyalty block (*SQS*, *SQP*, *SVS*, *RAI*, *EAC*) and behavioral loyalty according to the example in the previous section. We obtained matrices separately for each statement, as well as a general matrix of the final D solution in a certain group of indicators based on formulas (9) to (11). We calculated the point estimate of the consumer loyalty level for each group of factors and in general $F(E_{j\alpha})$, by formulas (12) to (16). We performed similar calculations for each MTC consumer.

Table 1 shows an example of calculation of perceptual and behavioral loyalty indicators by a consumer.

Table 1

Calculation of perceptible and behavioral consumer loyalty of PJSC "SanInBev Ukraine" (u1)

No.	Indicators of diagnosing	Output data for estimation per quarter				Per year	Loyalty level ($F(E_{j\alpha})$)
		1	2	3	4		
Perceptual (attitudinal) loyalty (*AL*)							
Satisfaction with the quality of service (*SQS*)							
X_{11}	Comfort of using	0.6	0.6	0.7	0.7	0.65	0.747
X_{12}	Safety of transportation	0.8	0.8	0.8	0.8	0.8	
X_{13}	Preservation of cargo	0.9	0.9	0.9	0.9	0.9	
X_{14}	Timeliness of delivery	0.9	0.9	0.9	0.9	0.9	
X_{15}	Accuracy of transportation	0.7	0.8	0.8	0.8	0.775	
Satisfaction with the quality of the service process (*SQP*)							
X_{21}	Material-and-technical equipment of motor car park	0.8	0.8	0.8	0.8	0.8	0.640
X_{22}	Motor car park capacity	0.7	0.7	0.8	0.7	0.725	
X_{31}	Material situation	0.9	0.9	1	1	0.95	
X_{32}	Professionalism of the staff	0.7	0.7	0.8	0.8	0.75	
X_{33}	Staff reaction	0.6	0.6	0.6	0.7	0.625	
X_{34}	Politeness of the staff	0.5	0.5	0.4	0.5	0.475	
X_{35}	Staff competence	0.6	0.6	0.5	0.5	0.55	
X_{36}	Staff compassion	0.6	0.6	0.6	0.6	0.6	
X_{37}	Communication level	0.5	0.5	0.5	0.6	0.525	
X_{38}	Form and method of maintenance of customer relations	0.6	0.6	0.6	0.5	0.575	
X_{39}	Level of individual work with a consumer	0.5	0.6	0.6	0.7	0.6	
Satisfaction with a value of service (*SVS*)							
X_{41}	Cost of services	0.7	0.7	0.7	0.7	0.7	0.571
X_{42}	Warranty service	0.9	0.9	0.9	0.9	0.9	
X_{43}	Consent of a consumer with a price level of services	0.1	0.15	0.15	0.17	0.143	
X_{44}	Price tolerance	0.25	0.25	0.25	0.25	0.25	
X_{45}	Sensitivity to price actions of competitors	0.33	0.33	0.33	0.33	0.33	
Rational attitude and intentions of a consumer (*RAI*)							
X_{51}	Awareness of alternative offers	0.16	0.16	0.12	0.12	0.14	0.575
X_{52}	Barriers to change supplier	1	1	1	1	1	
X_{61}	Intent on further cooperation	1	1	1	1	1	
X_{62}	Intention to recommend services	0.5	0.5	0.5	0.5	0.5	
Emotional attitude of a consumer (*EAC*)							
X_{71}	Respect for MTC staff	1	1	1	1	1	0.640
X_{72}	Friendship with MTC staff	0.6	0.6	0.7	0.7	0.65	
X_{73}	Trust to MTC staff	0.8	0.8	0.8	0.8	0.8	
X_{74}	Habit of using MTC services	0.5	0.5	0.5	0.6	0.525	
X_{75}	Advantage over other MTC	0.8	0.8	0.8	0.8	0.8	
Behavioral loyalty (*BL*)							
X_{81}	Increase in purchases	0.55	0.61	0.54	0.52	0.55	0.646
X_{82}	Support for the achieved level of interaction	0.52	0.88	0.74	0.35	0.623	
X_{83}	Share in client business	0.52	0.54	0.54	0.56	0.54	
X_{84}	Regularity of purchases	0.62	0.68	0.71	0.54	0.638	
X_{85}	Length of the business relationship with a consumer	0.19	0.19	0.19	0.19	0.19	

It is possible to calculate a generalized indicator of the consumer loyalty based on individual loyalty indicators.

We define the membership function μ_{Mi} for these rules based on previously formed hypotheses. We obtain an estimate for assigning each of the selected factors to the corresponding subset of fuzzy terms (linguistic variables) from experts. We calculate the membership function for each group of perceptual loyalty factors (SQS, SQP, SVS, RAI, EAC), as well as for generalized indicators of perceptual (AL) and behavioral loyalty (BL), and for the overall loyalty indicator (L). Table 2 presents the degree of membership to the corresponding subset-terms according to indicators of perceptual, behavioral and complex customer loyalty.

Table 2

Value of membership functions of generalized indicators of the consumer loyalty to subset-terms

Diagnosing indicators	Set of terms	Condit. notation	Value of the membership function by consumers					
			u_1	u_2	u_3	...	u_{55}	u_{56}
Perceptual (attitudinal) loyalty (*AL*)	High level (VS)	μ_{M1}	0.571	0.63	0.577	...	0.551	0.547
		μ_{M2}	0.571	0.63	0.577	...	0.551	0.547
	Average level (P)	μ_{M3}	0.253	0.276	0.287	...	0.265	0.242
		μ_{M4}	0.36	0.143	0.287	...	0.265	0.33
	Low level (MS)	μ_{M5}	0.253	0.143	0.287	...	0.265	0.242
		μ_{M6}	0.253	0.143	0.287	...	0.265	0.242
Behavioral loyalty (*BL*)	High level (VS)	μ_{M1}	0.54	0.543	0.493	...	0.325	0.395
		μ_{M2}	0.54	0.333	0.493	...	0.325	0.395
	Average level (P)	μ_{M3}	0.378	0.458	0.453	...	0.325	0.395
		μ_{M4}	0.363	0.245	0.358	...	0.243	0.393
	Low level (MS)	μ_{M5}	0.363	0.245	0.358	...	0.243	0.393
		μ_{M6}	0.19	0.142	0.203	...	0.16	0.26
General loyalty (*L*)	High level (VS)	μ_{M1}	0.571	0.630	0.577	...	0.551	0.547
		μ_{M2}	0.571	0.630	0.577	...	0.551	0.547
	Average level (P)	μ_{M3}	0.360	0.143	0.287	...	0.265	0.242
		μ_{M4}	0.354	0.354	0.370	...	0.370	0.370
	Low level (MS)	μ_{M5}	0.253	0.143	0.287	...	0.265	0.242
		μ_{M6}	0.253	0.143	0.287	...	0.265	0.242

We performed calculations of point estimates of the level of the customer loyalty based on the formed hypotheses, membership functions for the terms of the "Level of complex loyalty" linguistic variable and on formulas (9) to (16). Table 3 presents the calculation of the total integral indicator of loyalty.

These calculations give a possibility to determine the loyalty of a consumer of motor transport services, to compare their estimates and to find indicators, which have the greatest impact on the customer loyalty.

Table 3 shows that almost all consumers show slightly higher than average level of the loyalty. The most loyal is PJSC "Philip Morris Ukraine" (u_2), the least loyal consumer in this example is PJSC "Kharkiv Biscuit Factory" (u_{56}). The behavioral loyalty is lower for all studied consumers.

A diagnosis of loyalty of 56 consumers of PJSC "MTC-16363" carried out according to the proposed methodology made it possible to obtain results and conclude that most consumers are loyal to MTC. Loyalty rates range from 0.511 to 0.739. Only 7 clients have the high level of loyalty, all others – the average level. Absence of consumers with low loyalty level evidences that MTC pays great attention to building and development of relationships with their customers.

Table 3

Calculation of the complex indicator of loyalty of MTC consumers

Indicators of loyalty by groups	Cond. notation of a group	Point estimate of the loyalty level by consumers ($F(E_{j\alpha})$)					
		u_1	u_2	u_3	...	u_{55}	u_{56}
Satisfaction with the quality of service (*SQS*)	*A*	0.747	0.724	0.713	...	0.735	0.758
Satisfaction with the quality of the service process (*SQP*)	*B*	0.64	0.64	0.67	...	0.67	0.65
Satisfaction with a value of service (*SVS*)	*C*	0.571	0.629	0.577	...	0.551	0.547
Rational attitude and intentions of a consumer (*RAI*)	*D*	0.575	0.63	0.63	...	0.63	0.63
Emotional attitude of a consumer (*EAC*)	*E*	0.64	0.857	0.713	...	0.735	0.67
Perceptual (attitudinal) loyalty (*AL*)	Y_1	0.658	0.682	0.661	...	0.650	0.649
Behavioral loyalty (*BL*)	$F(Y_2)$	0.646	0.647	0.627	...	0.570	0.593
General loyalty (*L*)	Y_3	0.658	0.682	0.661	...	0.650	0.649

Analyzing the results, we can conclude that it is necessary to introduce loyalty programs, which stimulate behavioral loyalty, to increase the level of the consumer loyalty. These programs increase a value of service, and affect the quality of the customer service process through stimulation of contact staff.

According to the results of the diagnosing of the customer loyalty, management of the company makes decisions on the need for its strengthening and directions of influence on it. Thus, regular implementation of diagnosing of the consumer loyalty will provide the basis for timely development of measures for its development, which will help to increase efficiency of enterprises and formation of long-term relationships.

6. Discussion of results of constructing a model for diagnosing the level of loyalty by service consumers using the theory of fuzzy sets

The results of the study evidence that fuzzy-plural descriptions are the most justified mathematical apparatus for modeling of the process of diagnosing the consumer loyalty. The formed decomposition of the model of the customer loyalty diagnostics gave possibility to substantiate the composition of indicators, which affect formation of the customer loyalty. The matrix data aggregation method based on the fuzzy classifier makes it possible to move from quantitative and qualitative values of individual indicators of the consumer loyalty to complex loyalty indicators.

Given the perceptual and behavioral loyalty calculations, we can determine to what level of loyalty consumers

have. The testing of the model of loyalty diagnosing helps to determine how different groups of factors affect the customer loyalty, which reserves need to be put into effect in order to increase the customer loyalty.

In general, the use of the mathematical apparatus of the theory of fuzzy sets in the process of diagnosing the customer loyalty gave possibility to build models that are adequate to reality. The offered model of customer loyalty diagnosing based on fuzzy-multiple descriptions satisfies the requirements of universality, accounting of multi-criteria choice under conditions of uncertainty, simplicity of preparation and processing of expert information. The possibility of study of combinations of various factors, which affect the proposed comprehensive indicator of the consumer loyalty, is particularly interesting.

Traditional approaches to estimation of the consumer loyalty, unlike the proposed ones, did not take into account the specifics of transport and logistics companies in the field of freight traffic. The developed methodical approach to the diagnosing the consumer loyalty to services makes it possible to consider the specificity of freight motor transport in general. We can use the current diagnosing model for other modes of transport present in the freight transport market also.

The disadvantage of the application of the developed model is some estimation subjectivity, since we get hypotheses based on the opinion of experts.

The offered approach gives possibility to receive a quantitative estimation of the integral index of the level of the complex loyalty of a consumer. It makes it possible further studies on construction of models of dependence of the consumer loyalty on various factors. In addition, there is possibility to simulate different situations, depending on the expected indicators of interaction with a consumer due to implementation of individual strategies of relationships and to plan loyalty programs.

Further development and improvement of the study is possible in the direction of development of the use of intelligent and information systems to diagnose the consumer loyalty in the field of multimodal transportations.

7. Conclusions

1. We formed the composition of indicators for diagnosing of the loyalty of motor transport consumers based on the allocation of components of the process of loyalty formation. We proposed to use two integral indicators, such as perceptual (attitudinal) and behavioral loyalty to determine the overall consumer loyalty index. Preferences and thoughts of a consumer form the perceptual loyalty. We can measure it based on the following factors: customer satisfaction with quality, technical and functional features, value of service, and intentions of cooperation and emotional attitude of a consumer. Behavior of a consumer when making purchase determines the behavioral loyalty. We can measure it based on the following indicators: increased purchases, maintenance of the achieved level of interaction, a share in the business of a client, regularity of purchases and a level of duration of business relations. The proposed indicators reflect the components of the process of formation of the loyalty of motor transport consumers fully.

2. We proposed the methodical approach to diagnosing the complex consumer loyalty according to perceptual and behavioral characteristics of a client with application of elements of the theory of fuzzy sets. We developed an algorithmic procedure for fuzzy estimation of customer service loyalty. Unlike existing ones, it makes it possible to evaluate and compare consumer perceptions with its behavior in relation to MTC comprehensively, as well as to combine these indicators to obtain a complex loyalty indicator.

3. We calculated the level of perceptual (attitudinal), behavioral and complex loyalty of MTC services consumers using the fuzzy sets apparatus based on the current model of consumer loyalty diagnosing. The proposed model, unlike the other models, takes into account the specifics of provision of motor transport services. We can use it to diagnose the consumer loyalty in the freight transport market. Such approach gives possibility to get a quantitative assessment of indicators of the level of the complex loyalty of consumers of a motor transport enterprise and to determine directions of development of the consumer loyalty.

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