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Assessing the quality of international trade and economic relations in the agricultural sector

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Abstract. *Purpose of the research*. The main purpose of the article is to improve the methodical support for assessing the quality of international trade and economic relations in the agricultural sector. *Methodology.* In the course of the research, the following methods were applied: fuzzy logic inference, generalization, comparison, graphical, expert assessments, etc. *Results*. The role of international trade and economic relations in the development of the domestic economy has been substantiated. The expediency of using forecasting as a tool for assessing the prospects for expanding cooperation in the field of agriculture with other countries has been proved. The main indicators have been determined that are used in the process of measuring the relationships quality. The necessity of developing tools for assessing the quality of international trade and economic relations has been substantiated. It has been proposed to carry out an assessment using the fuzzy sets theory based on the formed thesaurus, which includes a fuzzy set, membership function, fuzzy variable, linguistic variable, fuzzy knowledge base, fuzzy logic inference. The scheme of the procedure for assessing the quality of international trade and economic relations using the method of fuzzy logic inference and description of the fuzzy system for assessing the quality of international trade and economic relations of the agricultural sector of Ukraine have been developed. An analysis has been carried out within the research framework of bilateral agreements between Ukraine and partners in the field of agriculture and it has been determined that an example of high-quality international trade and economic relations is cooperation with China, India, Germany, the United Arab Emirates; moderate – with Georgia, Poland, France, Korea; low – with Japan, Iran, Kazakhstan, etc. *Practical meaning.* Based on the results of the assessment, in accordance with the quality level of international trade and economic relations, priority areas of cooperation for Ukraine with partner countries to promote the development of its economy have been identified. *Prospects for further research* by the author are to develop a mechanism for increasing the quality of international trade and economic relations between Ukraine and partner countries.

Keyword: international trade, agriculture, fuzzy set theory, development, forecasting.

JEL Classification: C53, F13, F17, F47, Q18.

Number of references: **21**; *number of tables*: **3**; *number of figures*: **4**; *number of formulas*: **0**.

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Оцінювання якості міжнародних торговельно-економічних відносин в аграрному секторі

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Анотація. *Мета дослідження*. Головна мета статті полягає в удосконаленні методичного забезпечення оцінки якості міжнародних торговельно-економічних відносин в аграрному секторі. *Методологія*. У ході дослідження застосовано такі методи: нечіткого логічного висновку, узагальнення, порівняння, графічного, експертних оцінок тощо. *Результати*. Обґрунтовано роль міжнародних торговельно-економічних відносин у розвитку вітчизняного господарства. Доведено доцільність використання прогнозування як інструменту для оцінки перспектив розширення співпраці у галузі сільського господарства з іноземними країнами. Визначено основні показники, які використовуються у процесі вимірювання якості взаємовідносин. Обґрунтовано необхідність розвитку інструментарію оцінювання якості міжнародних торговельно-економічних відносин. Запропоновано здійснювати оцінювання з використанням теорії нечітких множин на основі сформованого тезаурусу, до складу якого входять нечітка множина, функція приналежності, нечітка змінна, лінгвістична змінна, нечітка база знань, нечіткий логічний висновок. Розроблено схему процедури оцінювання якості міжнародних торговельно-економічних відносин з використанням методу нечіткого логічного висновку та опис нечіткої системи оцінювання якості міжнародних торговельно-економічних відносин аграрного сектору України. Здійснено аналіз в рамках дослідження двосторонніх угод України з країнами-партнерами в сфері сільського господарства та визначено, що прикладом високої якості міжнародних торговельно-економічних відносин є співпраця з Китаєм, Індією, Німеччиною, ОАЕ; помірної – з Грузією, Польщею, Францією, Кореєю; низької – з Японією, Іраном, Казахстаном та ін. *Практичне значення*. За результатами оцінювання відповідно до рівня якості міжнародних торговельно-економічних відносин виділено пріоритетні напрями співробітництва для України з країнами-партнерами, що сприятиме розвитку її економіки. *Перспективи подальших досліджень* автора полягають у розробленні механізму зростання якості міжнародних торговельно-економічних відносин між Україною та кранами-партнерами.

Ключові слова: міжнародна торгівля, сільське господарство, теорія нечітких множин, розвиток, прогнозування.

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1. Introduction.

International trade and economic relations are historically conditioned and socially necessary within the framework of interaction between countries and nations for the joint achievement of mutually beneficial results. The problem of the quality of trade and economic relations between Ukraine and partner countries does not lose its relevance. There is a huge untapped potential for the comprehensive development of international trade and economic relations in the agricultural sector. Despite the fact that in recent years the trade turnover between Ukraine and the countries of the world in the field of agriculture has had positive trends, the absolute figures of indicators are not satisfactory enough based on the potential opportunities for mutual trade.

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A detailed analysis of the trade and economic relations of Ukraine with the countries of the world in the field of agriculture confirmed that Ukraine is one of the main partners of many countries. Therefore, to assess the prospects for further expansion of mutually beneficial trade and economic relations, forecasting is a very urgent and extremely important task. Forecasting provides for the determination of possible states of the object in the future and the identification of alternative scenarios, its practical importance should be determined due to the ability to take into account possible qualitative and/or quantitative changes in the state, the results of relations between countries in the future, as well as alternative ways and timing of achieving the expected state. So, the construction of economic forecasts by assessing the quality of international trade and economic relations will allow solving the following tasks: to determine the prospects for the development of trade and economic relations of Ukraine in the field of agriculture with other countries of the world; identify the current state of relations and highlight the most likely options in the time perspective; substantiate the main directions of measures for effective cooperation.

2. Literature review.

The theoretical, methodical and practical aspects of international trade are disclosed in the works of such scientists as: J. Giles and C. Williams (*2000*), F. Rassekh (*2004*), J. Reyes (*2010*), E. Saveliev (*2014*), A. Holikov (*Holikov et al., 2015*), J. Jamel (*2015*), L. Mykhailyshyn (*2016*), A. Shnyrkov (*2016*), V. Fomishyna (*2017*), N. Kazakova (*2018*), M. Kuzminov (*2018*), B. Mazorodze (*2019*), A. Ovcharenko (*2019*), T. Ruban (*2019*), H. Davydenko (*2019*), etc. However, given the significant scientific potential on this issue, the aspects of assessment in the spheres of international trade and economic relations remain insufficiently disclosed.

3. Methods.

In the course of the research, the following methods were applied: fuzzy logic inference, generalization, comparison, graphical, expert assessments, etc.

4. Research objectives.

The main purpose of the article is to improve the methodical support for assessing the quality of international trade and economic relations in the agricultural sector.

5. Results and discussions.

It should be noted that in the conditions of rapid changes taking place in science, politics, society, corresponding transformations are taking place in the economy, dictating the development direction of management systems. The modern economy determines the quality of international trade and economic relations from the standpoint of the presence of trade and economic links and active cooperation. But it should be understood that determining the quality of international trade and economic relations is a rather complex multicriteria task. Despite the fact that the definition of the value and quality of relationships has become an urgent scientific problem, experts still note the lack of theoretical and practical research devoted to these problems. In addition, the definition of the content of the concept of the value of relationships, and the development of a method for its assessment remain debatable. The integration of this concept has led to the emergence of a large number of approaches to its analysis. The difference between the benefits and costs of building and maintaining relationships is commonly used as an indicator of the value of relationships. Meanwhile, in the works written within the framework of the concept of international relations, the concept of value is interpreted more broadly. The approaches research to the analysis of the relationships value allows us to distinguish two groups of indicators that are most often proposed by foreign researchers to measure the quality of relationships:

1. Economic (monetary) indicators measured in monetary terms. Examples of economic indicators are increased sales, increased profits, decreased interaction costs, and etc.

2. Non-monetary (strategic and social indicators), have a qualitative dimension, among them – level of satisfaction, trust, affection, level of cooperation and partnership, growth of innovative potential, etc.

So, the economic indicators in the research framework were chosen: development level of international trade and economic relations, which was identified in the second chapter of the research; foreign trade balance, which will allow to determine the prevalence of agricultural exports over imports; growth rate of turnover, which will characterize the dynamics of growth in sales of agricultural products. The presence of interdepartmental bodies of bilateral cooperation is proposed as a non-monetary indicator, which will allow examining the level of cooperation and partnership between the studied countries.

It should be emphasized that the expansion of the substantive content of the tasks of assessing the quality of international trade and economic relations makes it difficult to use traditional methods of assessment. As a result, the problem arises of finding tools that can take into account not only the intellectual nature, but also the speed of the changes taking place. In such a situation, attention should be paid to the proposal for the use of fuzzy logic tools (Mamdani's fuzzy algorithm) in the problems of assessing the quality of international trade and economic relations. Actually, fuzzy methods of multicriteria alternatives assessment are gaining intensive use abroad. As the development of computer technology and computer networks makes it possible to significantly simplify the acquisition of expert opinions from a wide range of specialists on various aspects of international trade and economic relations. Valuable information from an expert can be an assessment of the degree of his confidence that the assessment takes on one or another meaning. The apparatus of the theory of fuzzy sets is suitable for such estimates.

It should be emphasized that the founder of the conceptual foundations of the fuzzy sets and fuzzy logic theory is the American mathematician Lotfi Zaden, who first introduced the concept of fuzzy logic in his work "Fuzzy sets" (1965) (*Zade, 1976*). As noted, the "dissatisfaction" with classical mathematics, which requires precision in solving complex socio-economic problems, became the reason for the attention of this theory to the peculiarities of intellectual considerations (*Jager, 1986, p. 351*). The use of fuzzy set theory in decision making has enjoyed growing popularity in recent decades. The constructed model makes it possible to automatically evaluate an arbitrary number of alternatives. The advantage of this method is the ability to: build membership functions of alternatives; apply both clear and fuzzy values of the criteria at the input of the multi-criteria assessment model; determine the fuzzy dominance relation for all pairs of alternatives to obtain the final ranking of alternatives. In order to formalize fuzzy information for the construction of mathematical models in theory, the concept of a fuzzy set, the membership function of an arbitrary element of a universal set to a fuzzy set, was considered and introduced. In addition, the concepts of fuzzy and linguistic variables, fuzzy knowledge base and fuzzy logic inference were included in the thesaurus of the theory of fuzzy sets and fuzzy logic (*Table 1*).

The toolkit entered the thesaurus, formalized linguistic variables as fuzzy, opened up the possibility of performing customary logical operations in the form of fuzzy logic inference. The main algorithms of fuzzy inference were developed (Mamdani, Tsukamoto, Larsen, Sugeno), including some specified parameters, made it possible to implement its stages in an ambiguous way (*Leonenkov, 2005; Pegat, 2013*).

It should be noted when determining the specifics of the criterial issues space of assessing the quality of international trade and economic relations, associated with the incompleteness, inconsistency and ambiguity of the components, the subjective, qualitative nature of management decisions, it was noted that traditional methods with the established practice of solving such problems do not always allow taking into account the speed of the changes taking place.

Table 1. **Thesaurus of fuzzy set and fuzzy logic theory**

Category	Contents
Fuzzy set	The set of pairs A = {μA (x), x}, where μA (x) is the belonging degree of the element x ϵ X to the fuzzy set A.
Membership function	The belonging degree of an arbitrary element of the universal set x ϵ X to the fuzzy set A, μA (x) ϵ [0, 1].
Fuzzy variable	Tuple <α, X, A (α)>, where α is the variable name; X is the domain of fuzzy variable α (basic, universal set); A (α) = {μA (x) / x ϵ X} is a fuzzy subset of the set X, which describes the constraint on the possible values of the variable α.
Linguistic variable	Set <β, T (β), X, G, M>, where β is the name of the linguistic variable; T (β) is the values set of the linguistic variable β (term set); X is a universal set (domain β); G is the syntactic rules, often in the form of grammar, generating the name of the term; M is the semantic rules that define the membership functions of fuzzy terms generated by syntactic rules.
Fuzzy knowledge base	Set of fuzzy production rules PR = {pr1, pr2, ... prs} of the form "if – that", formed in linguistic form
Fuzzy logic inference	The general logical scheme of the logic inference includes: fuzzification; fuzzy implication; fuzzy composition; defuzzification

Source: (Krichevskij, 2005, p. 100; Uskov and Kuzmin, 2004, p. 57)

In such a situation, to determine the quality of international trade and economic relations, the method of fuzzy logic inference was chosen, the Mamdani fuzzy algorithm of which made it possible to demonstrate its capabilities and the correctness of the choice made in the context of the rapid expansion of international relations. The scheme for assessing the quality of international trade and economic relations using the method of fuzzy logic inference is shown in *Figure 1*.

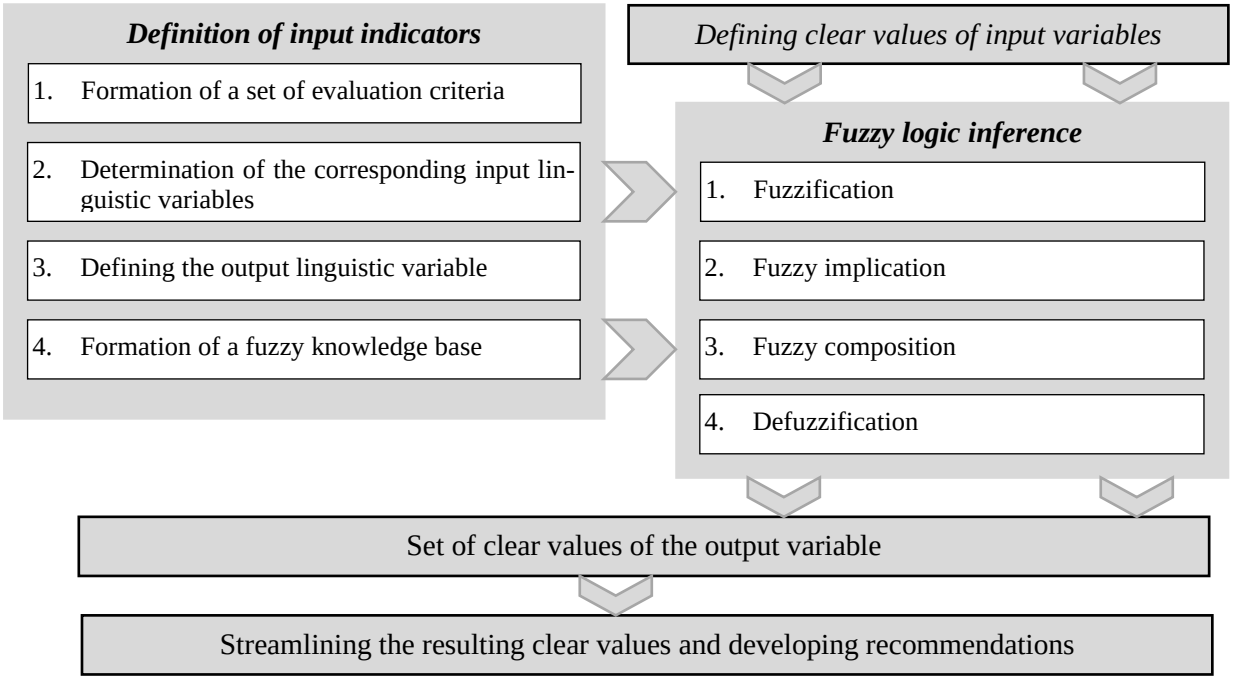

Fig. 1. **Scheme of the procedure for assessing the quality of international trade and economic relations using the fuzzy logic inference method**

Source: author's development.

It should be noted that the definition of input indicators is an important priority step in the proposed scheme. Thus, the work carried out a detailed analysis of the development

level of international trade and economic relations in the context of such components as the development level of international trade; development level of the international division of labor; development level of international capital flows; development level of international labor migration; development level of international monetary and financial and credit facilities. The following are also highlighted as important input linguistic variables: foreign trade balance (will allow to determine the prevalence of agricultural exports over imports); growth rate of trade turnover (reflect the dynamics of growth in sales of agricultural products); presence of interdepartmental bodies of bilateral cooperation (to help identify the level of cooperation and cooperation between the studied countries).

It should be noted that the use of the development level of international trade and economic relations, the assessment of which in Chapter 2 made it possible to draw conclusions, is an extremely necessary component in the framework of the implementation of the fuzzy sets method, as it helps to justify the fuzziness for the absence of assessments scale of this level and specific values.

That is, this indicator has no clear boundaries, they are uncertain, which confirms the possibility of using fuzzy sets in the research.

The analysis was carried out within the research framework of bilateral agreements between Ukraine and partners countries in the field of agriculture. Description of the fuzzy system for assessing the quality of international trade and economic relations, which are presented in *Figure 2*, visualize the available inputs and outputs, the selected membership functions for fuzzy variables and reasonable rules for the system operation.

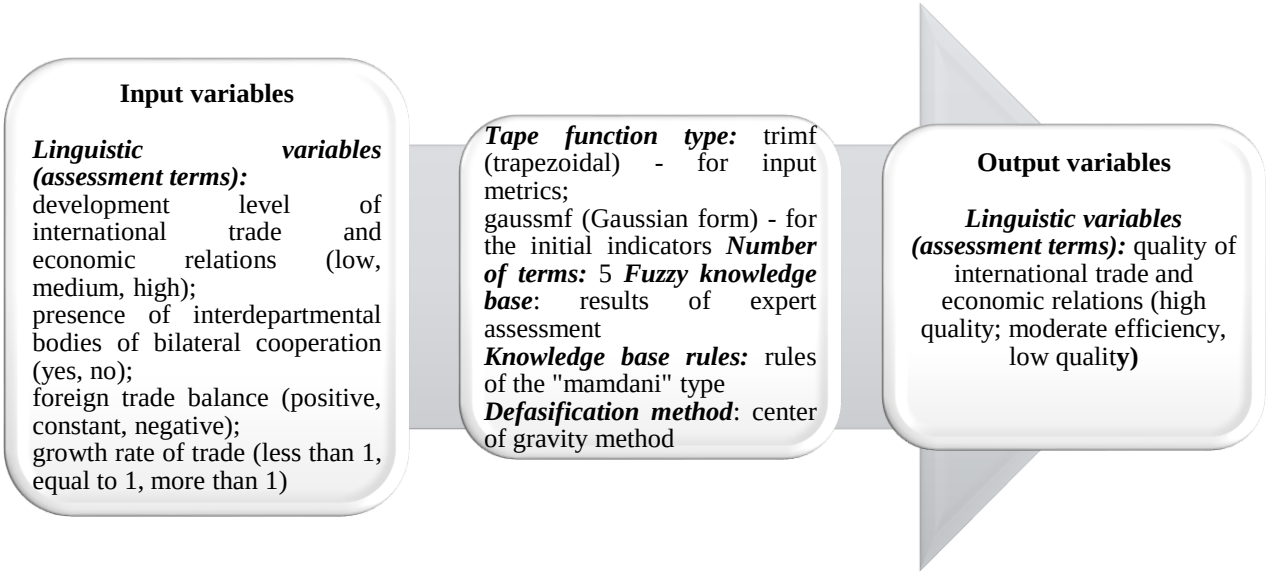

Fig. 2. **Description of a fuzzy system for assessing the quality of international trade and economic relations of the agricultural sector of Ukraine**

Source: author's development.

So, the input indicators of the fuzzy inference system are 4 fuzzy linguistic variables: P – development level of international trade and economic relations (low, medium, high); M – presence of interdepartmental bodies of bilateral cooperation (yes, no); C – foreign trade balance (positive, unchanged, negative); T – growth rate of trade turnover (less than 1, equal to 1, more than 1). The output indicator is the linguistic variable "I" – quality of international trade and economic relations (high quality, moderate quality, low quality of international trade and economic relations). With the help of the MatLab "Fuzzy Logic Toolbox" software package, the graphical interface of the FIS editor was obtained as part of the research. To construct it, membership functions for fuzzy variables were determined, the rules

of the system's operation were substantiated, the corresponding type of the membership function was identified, the rules of the knowledge base of the "mamdani" type were substantiated, and the center of gravity was chosen as the defuzzification method. An important and next step is the indicators adjustment of the fuzzy model: the choice of the membership function, the substantiation of the terms and the determination of the range of values for the input and output variables. The next step in building a fuzzy model is the formation of a rule base that takes into account the assessments of competent experts.

Note that specialists were selected as experts who not only have an understanding of the specifics of international trade and economic relations, but also have formalized assessment tools.

Note also that the logical operation "and" and the principle "IF – THEN" were chosen to link the incoming indicators. So, the fuzzy base of rules for determining the quality of international trade and economic relations is presented in *Table 2*.

Table 2. **Fuzzy base of rules for determining the quality of international trade and economic relations**

IF					**THEN**
P	M	C	T		I
high	no	positive	more than 1		high
high	no	unchanged	more than 1		average
high	no	negative	more than 1		average
average	no	positive	more than 1		average
average	no	unchanged	more than 1		average
average	no	negative	more than 1		average
low	no	positive	more than 1		average
low	no	unchanged	more than 1		average
low	no	negative	more than 1		low
high	yes	positive	more than 1		high
high	yes	unchanged	more than 1		high
high	yes	negative	more than 1		high
average	yes	positive	more than 1		high
average	yes	unchanged	more than 1		high
average	yes	negative	more than 1		average
low	yes	positive	more than 1		high
low	yes	unchanged	more than 1		average
low	yes	negative	more than 1		average
high	no	positive	equal to 1		average
high	no	unchanged	equal to 1		average
high	no	negative	equal to 1		average
average	no	positive	equal to 1		average
average	no	unchanged	equal to 1		average
average	no	negative	equal to 1		low
low	no	positive	equal to 1		average
low	no	unchanged	equal to 1		low
low	no	negative	equal to 1		low
high	yes	positive	equal to 1		high
high	yes	unchanged	equal to 1		high
high	yes	negative	equal to 1		average
average	yes	positive	equal to 1		high
average	yes	unchanged	equal to 1		average
average	yes	negative	equal to 1		average

Continuation of Table 2

IF					THEN
P	M	C	T		I
low	yes	positive	equal to 1		average
low	yes	unchanged	equal to 1		average
low	yes	negative	equal to 1		average
high	no	positive	less than 1		average
high	no	unchanged	less than 1		average
high	no	negative	less than 1		low
average	no	positive	less than 1		average
average	no	unchanged	less than 1		low
average	no	negative	less than 1		low
low	no	positive	less than 1		low
low	no	unchanged	less than 1		low
low	no	negative	less than 1		low
high	yes	positive	less than 1		high
high	yes	unchanged	less than 1		average
high	yes	negative	less than 1		average
average	yes	positive	less than 1		average
average	yes	unchanged	less than 1		average
average	yes	negative	less than 1		average
low	yes	positive	less than 1		average
low	yes	unchanged	less than 1		average
low	yes	negative	less than 1		low

The visualization of the obtained data, reflecting the dependence of the indicator "quality of international trade and economic relations" on the input variables, is shown in *Figure 3*. The implementation of Mamdani's fuzzy inference in MATLAB for assessing the quality of international trade and economic relations in the agricultural sector for the countries "Ukraine – China" is as follows – *Figure 4*. .

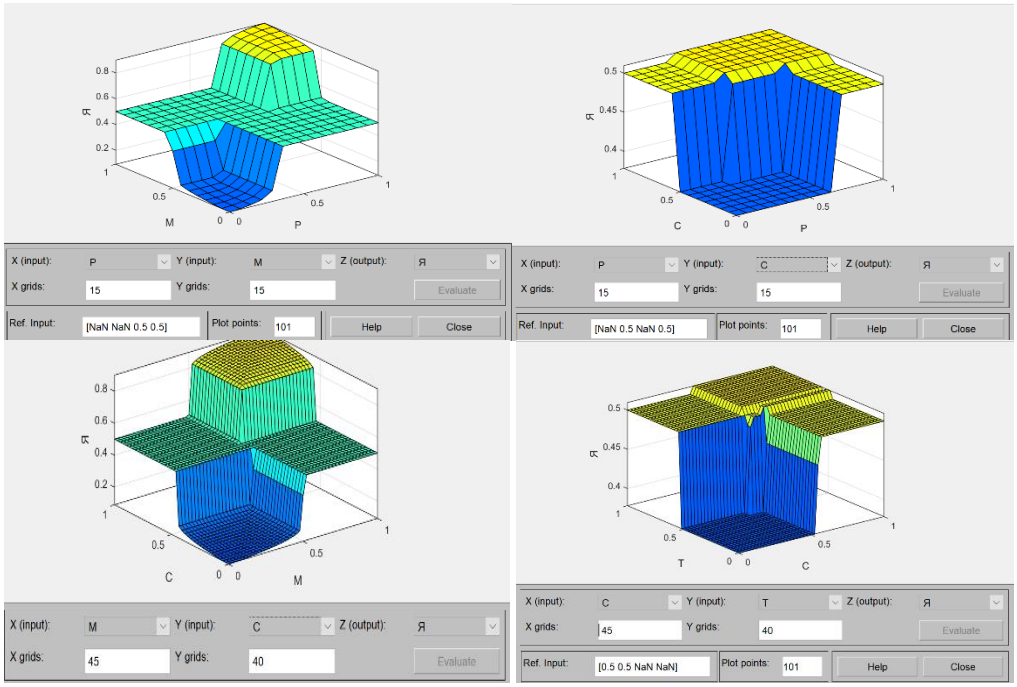

Fig. 3. **Dependence of the quality of international trade and economic relations on input variables**

Source: author's development.

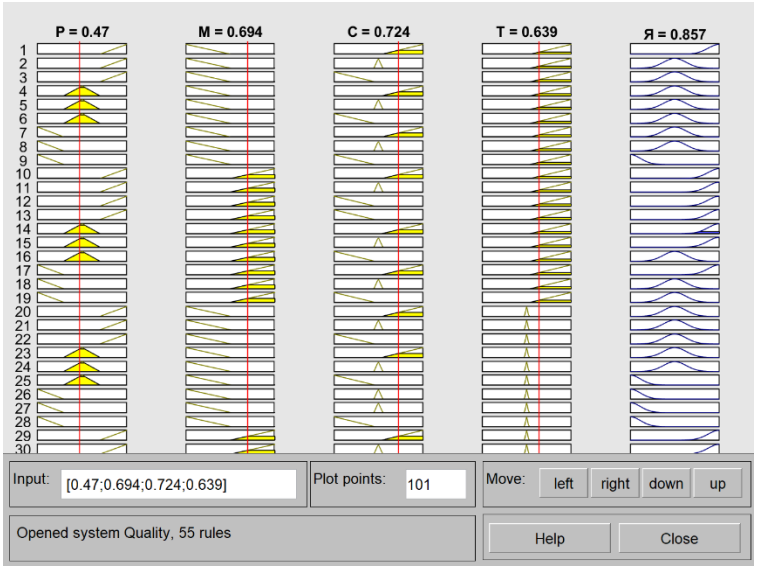

Fig. 4. **Defuzzification process in MATLAB environment ("Ukraine – China")**
Source: author's development.

Interpretation of the results obtained is as follows: due to the average development level of international trade and economic relations, presence of interdepartmental bodies of bilateral cooperation, a positive balance of foreign trade, the rate of growth of trade, a high quality of international trade and economic relations was obtained.

It should be noted that the last stage is the generalization of the data obtained and the development of recommendations to increase the quality of international trade and economic relations. Systematization of the results obtained and taking into account the analysis of trends in international trade and economic relations in the agricultural sector made it possible to develop a plan of measures to improve the quality of international trade and economic relations (*Table 3*), which has a recommendatory nature, with a justification of priority areas of cooperation.

Over the past decade, trade turnover between Ukraine and other partner countries in the field of agriculture has been characterized by positive growth dynamics, however, the absolute expression of foreign trade turnover, taking into account the potential, as well as the absence of interdepartmental bodies of bilateral cooperation with some countries, reflects the low level of cooperation between countries.

The problem is mainly a lack of understanding of the partners potential capabilities. Therefore, in order to build capacity, it is important to overestimate the structural orientation of trade between countries. In addition, it is important to level the problem of dependence on intermediary services from third countries in the transportation of goods. In this context, it is important to establish a direct exchange of goods, which will help reduce the risk of loss or delay of cargo during transportation.

6. Conclusions.

So, the biggest obstacle for the further expansion of the presence of Ukrainian companies in the agricultural market is the lack of ways to carry out international banking settlements, as well as high rates of import duties.

An important direction for improving the quality of international trade and economic relations in the agricultural sector: development of agricultural infrastructure and improvement of storage and transportation of grain; increasing the volume and expanding the commodity range of agricultural exports; the use of innovative technologies in agriculture; investment cooperation.

In addition, in the context of the strengthening of the role of Ukraine in ensuring global food security, the Export Development Strategy of agricultural products, food and

processing industries of Ukraine for the period up to 2026 is being developed. It is inextricably linked with the expansion of Ukraine's participation in achieving the UN Sustainable Development Goals, one of which is to promote sustainable agricultural development with the activation of production and export potential.

Table 3. **Directions for improving the quality of international trade and economic relations**

Bilateral trade in agricultural products	Results of the analysis of the quality level of international trade and economic relations	Priority areas for cooperation	Recommendations and measures
Ukraine – China Ukraine – India Ukraine – UAE Ukraine –Netherlands Ukraine – Germany Ukraine – Belarus Ukraine – Egypt	High quality	scientific and technological cooperation (among the promising areas: animal husbandry, crop production, irrigation, means of production for agriculture, biotechnology, food and packaging technologies, etc.); using the country's potential as a logistics hub to enter other markets.	development of agricultural infrastructure and improvement of storage and transportation of grain; application of innovative technologies in agriculture; investment cooperation.
Ukraine – Azerbaijan Ukraine – Georgia Ukraine – Israel Ukraine – Estonia Ukraine – Korea Ukraine – Turkey Ukraine – Lithuania Ukraine – Italy Ukraine – Moldova Ukraine – Poland Ukraine – France	Moderate quality	deepening mutually beneficial trade in the agro-industrial complex, comprehensive assistance in maintaining stable and timely mutual deliveries of products; interaction between the competent authorities on the coordination of veterinary, phytosanitary and sanitary requirements for trade in agricultural products; continuation of cooperation in the field of selection and seed production, viticulture and winemaking, as well as in the scientific and technological sphere; establishment of cooperation on industrial cooperation in the field of agricultural engineering, the opening of joint agricultural enterprises.	increasing the volume and expanding the commodity range of agricultural exports; levelling the problems of dependence on intermediary services of third countries in the transportation of goods; establishment of direct commodity exchange, which will help reduce the risk of loss or delay of cargo during transportation; reduction of high rates of import duties
Ukraine – Kazakhstan Ukraine – Latvia Ukraine – Iran Ukraine – Vietnam Ukraine – Saudi Arabia Ukraine – Hungary Ukraine – Japan	Low quality	increasing the turnover of agricultural products, organization and mutual participation in specialized exhibitions, organization of B2B events; The Vietnamese market is considered by Ukrainian specialized associations as promising and potentially attractive for domestic exports of a number of agricultural products); development of the legal framework for cooperation in the agricultural sector.	reassessment of the structural orientation of trade between countries; search for ways to carry out international banking settlements

Source: author's development.

Thus, the implementation of the proposed methodical support for determining the quality of international trade and economic relations in the agrarian sector involves the construction of a fuzzy model based on a certain system of indicators. The use of this scheme will contribute to a more thorough choice of tools for managing trade and economic relations.

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