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USING OF FUZZY MODELLING IN ANTI-CRISIS MANAGEMENT OF AGRICULTURAL ENTERPRISES

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ABSTRACT

The article systematizes the different views of scientists in relation to the anti-crisis management of enterprises and emphasizes the importance of its use in enterprises. There was noted the necessity to introduce the perspective directions of economic activity of the enterprise, forming its image, ensuring competitiveness, profitability, and development. In order to make effective management decisions under uncertain dynamic environment, it is suggested to use fuzzy modelling for the prevention of the crisis occurrence. In order to present the possibility of using such an approach in the practical activity of agricultural enterprises, in particular which are engaged in dairy farming, we proposed an informational and logical model for determining the forecast average price of milk, taking into account the indicators of its quality, that is based on the theory of fuzzy sets and fuzzy logic. In the context of anti-crisis management, there was substantiated the possibility of using the proposed model, as a basic one, in any agricultural enterprise in order to improve its activities.

Key words: anti-crisis management, agricultural enterprise, quality, products, fuzzy logic, fuzzy modelling
JEL codes: C45, L26, L15, O13, Q19

INTRODUCTION

In the current conditions of globalization, the issues of providing high-quality food products to the population, creating a high-quality raw material base for industries, forming export potential and food supply of the state are crucial. Agricultural production is an important sector of the Ukrainian economy, it plays a key role in assuring the food security. In Ukraine in 2017 there functioned 45,558 agricultural enterprises of various organizational and legal forms of management, in the general structure of which 74.9% were farms. At the same time, these agricultural enterprises produced 56.4% of total volume of agricultural products (including 8.7%, which was produced in farms) and the rest 43.6% was produced by households. The households – producers executing their economic activity for both purposes – self-sufficiency by foodstuff and production of commodity agricultural output. This category of producers also

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includes entrepreneurs working in the agricultural field (State Statistics Service of Ukraine, 2018). But households are not accounted as farms. It was only in July 2018 that the Verkhovna Rada adopted a special Law of Ukraine on amendments to the Tax Code of Ukraine and certain laws of Ukraine on promoting the establishment and activity of family farms, which provides the regulation of issues related to the activity of family farms. However, there are still many unsolved issues.

It should be noted that a significant number of Ukrainian agricultural enterprises are loss-making (their share in the total number of enterprises in 2017 was more than 13%) (State Statistics Service of Ukraine, 2018). Overcoming such a situation requires the application of the appropriate anti-crisis management measures. Modern anti-crisis management involves not only eliminating measures, but first of all, the preventing ones. It means, that the system of anti-crisis management should contain three elements: implementation of measures to overcome the crisis; prevention of the crisis; forecasting the crisis (Adamska, 2018).

There is no single approach among experts for content interpreting of the anti-crisis management and the nature of the crisis. Usually the term "crisis" is understood as a difficult and problem situation. In the modern sense, the crisis is often seen as the extreme aggravation of contradictions in the socio--economic system (organization), which threatens its sustainability in the environment (Korotkov, 2010).

Anti-crisis management is a system of strategic measures aimed at preventing a crisis situation, and in case of its emergence – a system of measures to overcome the crisis, taking into account all the available opportunities with minimal losses and future positive result achievement (Korotkova and Yehorova, 2011). Groh (2014) states that crisis strategic management is a special type of management, which has common management features and non-specific characteristics. Its principles are: the early diagnosis of the crisis in the financial activity of the firm, the speed of the reaction to the crisis phenomena, the adequacy of the reactions to the real threats to financial wealth, and the achievement of total potential in order to overcome the crisis. Some authors argue that for anti-crisis management, it is essential to ensure such conditions that financial difficulties could not be of a permanent and stable nature (Goodhart, 2006; Bragg, 2012; Brauer, 2013). The issue of anti-crisis management was reasonably characterized by Lihonenko (2001). He believes that one has to understand the anti-crisis management as a continuous process of identifying the signs of crisis phenomena and also as the implementation of the general plan to prevent the spread of these phenomena together with the stagnation of the business entity throughout the period of its functioning. It means, that anti-crisis management is a special, constantly organized management aimed at the most prompt detection of the crisis situation signs and the creation of appropriate prerequisites for its timely overcoming in order to ensure the viability of the business entity, preventing the emergence of its bankruptcy.

Anti-crisis management is aimed at adapting the activities of enterprises to the constantly changing environment and benefiting from new opportunities. At the same time, the main factor in the implementation of such management is the rejection of unpredictable entity activities directions and the identification of the most promising ones that ensure its competitiveness, profitability and development.

Agricultural enterprises associate their production activities with the introduction of new approaches to business planning and product quality management. Quite often, business executives do not have enough reliable information. Under such conditions, it is expedient to use fuzzy modelling. Fuzzy logic, which is the basis for the implementation of fuzzy control methods, describes the nature of human thinking and the course of thought more accurately than the traditional formal-logical systems.

The American mathematician Zade (1976) invited a formal apparatus of fuzzy algebra and fuzzy logic to solve logic processing issues in the early 1970s. This contributed to the development of a flexible scientific approach to the modelling of complex systems, whose predicted behaviour is better described by linguistic than numerical variables.

Leonenkov (2005) considered fuzzy simulation tools to solve specific practical problems in the MATLAB environment and fuzzy TECH. Under fuzzy simulation, he understands the information-logical model of the system, which is based on the theory of fuzzy sets and fuzzy logic.

The question of modelling the development of enterprises with using fuzzy multiple approaches in the context of introducing fuzzy technologies into brand management was thoroughly investigated by Rotshtein (1999) and Shtovba (2007).

Protsjuk (2007) considered the using of a fuzzy logic apparatus for modelling a product quality management system in agricultural enterprises.

However, the analysis of the scientific papers proves that little attention is paid to the study of using the fuzzy modelling possibility in the process of anti--crisis management in agricultural enterprises.

Dairy cattle breeding traditionally is one of the most important branches of agriculture in Ukraine. Favourable climatic conditions and the availability of land use by agricultural producers of 42.7 million ha of agricultural land and 32.5 million ha of arable land give rise to the potential for the production of high-quality milk and dairy products. But taking into account that the functioning of agricultural enterprises under current conditions of economic activity is characterized by crisis features, it is necessary to take into account aspects of anti-crisis management when planning and developing measures at all stages of the enterprise's activity.

It is especially important to take it into account at the stage of formation of the indicators of milk quality in agricultural enterprises, since in the conditions of Ukraine's integration with the EU, the requirements for the indicators of milk quality have significantly increased. In accordance to the current standards of Ukraine, the milk received for processing is divided into the following classes: extra, higher, first, second. In 2018, Ukraine produced 2,755.7 t of milk, the average price of which amounted to 7,385.9 UAH per 1 t, which is 4.6% more than in 2017.

The consequences of reforming the agrarian sector, changes in the system of pricing and deterioration of the demographic situation in the countryside have led to the fact that agricultural enterprises have become unprofitable for milk production, and as a result there has been a reduction in their number. Under such conditions, the producer should be able to predict the average price of milk and, accordingly, the performance of the enterprise in order to make optimal managerial decisions.

The purpose of this study is to determine the role and justification of the expediency of fuzzy modelling in anti-crisis management at agricultural enterprises to increase their competitiveness in conditions of uncertainty using the example of Ukrainian enterprises.

MATERIALS AND METHODS

In the course of the study, a dialectical method of cognition was used to collect, analyse, evaluate information and formulate conclusions, also we used monographic and fuzzy modelling methods.

On the basis of fuzzy logic, fuzzy analogues of all mathematical concepts can be built and the necessary formal apparatus for modelling human reasoning and the human way of solving problems can be created. The theory of fuzzy sets operates with the human knowledge, which is called the expert information (Zade, 1976; Rotshtein, 1999; Leonenkov, 2005).

Fuzzy control provides a formal methodology for representing, manipulating and implementing the heuristic knowledge of a person on how to manage a system.

A fuzzy set $\tilde{A}$ on the universal set U is a collection of pairs $(\mu_A(u),u)$, where $\mu_A(u)$ is the degree of the membership of the element $u \in u$ to the fuzzy set $\tilde{A}$. The degree of affiliation is the number that is in the range [0, 1]. The higher the degree of affiliation, the greater the element of the universal set corresponds to the properties of the fuzzy set. The membership function (FN) (membership function) allows for an arbitrary element of a universal set to calculate the degree of its membership in a fuzzy set. If the universal set is finite $u = \{u_1, u_2, \ldots, u_k\}$, then the fuzzy set is written in the form of the formula (1) (Shtovba, 2007):

$$\tilde{A} = \sum_{i=1}^{k} \mu_A(u_i)/u_i$$

or (1)

$$\tilde{A} = \left(\mu_A(u_1)/u_1,\ \mu_A(u_2)/u_2,\ \ldots,\ \mu_A(u_k)/u_k\right)$$

The fuzzy system has four main components: "fuzzy knowledge base" in the form of a set of fuzzy rules; mechanism of the conclusion; a fuzzification unit and a block of defuzzification (Leonenkov, 2005).

To develop the model, the Fuzzy Logic package of MATLAB engineering and scientific calculations and Simulink dynamic systems developed by MathWorks were used.

There are certain advantages in developing a fuzzy system. The first is that the rules of fuzzy control, being conditional expressions such as IF – THEN, are logical. The use of rules is carried out through the mechanism of logical conclusions. Logical management means that the logic of expert management is easy to represent, and a variety of prerequisites can be brought into line with some action. The second feature is to display the model not using one formula (classical methods), but using a large number of private rules with the help of fuzzy logic. Each rule operates in a specific area of the information space used in development. When developing a fuzzy system, one can successfully consider all the various options for a given task, and even those that are mutually contradictory. The third feature of developing a fuzzy system is that it is possible to organize management in the form of dialogue with an expert, since the rules of management are written in the form of expressions IF – THEN (Rotshtein, 1999).

The linguistic variable is called a variable whose values may be words or phrases of a certain natural language, and its value is determined by a set of verbal (that is, verbal) characteristics of some property (Leonenkov, 2005).

The term set is the set of all possible values of the linguistic variable. The term is any element of the term set. In the theory of fuzzy sets, the term is formalized by a fuzzy set using the membership function (Shtovba, 2007).

Thus, fuzzy logic provides the opportunity to successfully present a person's thinking, namely, ways of making decisions by a person and ways of modelling complex objects using natural language. The model allows to combine the using of quantitative data expressed by numbers, as well as – fuzzy, based on expert information under uncertainty.

RESEARCH RESULTS AND DISCUSSION

To present the possibility of using fuzzy modelling in the practical activity of agricultural enterprises, there was proposed an informational and logical model for determining the forecast average price for milk taking into account the indicators of its quality. It is based on the theory of fuzzy sets and fuzzy logic. The modelling was carried out on the materials of agricultural enterprises that are located in Khmelnytskyi region, Ukraine. These enterprises produce different agricultural products including milk.

When developing the model, it was stated that various factors influence the price of milk: the amount of milk sold as the higher class, the first or the second class; the content of fat and protein. That is why the idea of developing a fuzzy model for estimating the possibility of high prices depending on the discounts and allowances for milk classes is proposed in order to make decisions on improving the economic efficiency of the enterprise functioning. In this case, we use a fuzzy input system with subsequent input and output variables as a fuzzy logic model.

The meaningful interpretation of the fuzzy model implies the choice and specification of the input and output variables of the corresponding fuzzy system (Protsjuk, 2007).

In this case, there are used five input variables and one output variable in the fuzzy model. The first input variable is the quantity of higher quality milk sold, which directly evaluates the profitability of the enterprise, taking into account the quantity of milk sold by a particular enterprise. Obviously, the higher this estimate is, the higher the price is. The second input variable is the quantity of milk sold as first class. The third input variable is the quantity of milk sold as the second class. The fourth input variable is the fat content in milk. This variable is closely related to the milk quality parameters. The fifth input variable is the protein content in milk.

The starting variable is the price of milk which is the basis for decision making by the heads of enterprises on the development of measures on how to improve the quality of milk.

Fuzzification of input and output variables is made. The system state parameters are considered to be linguistic variables. It was evaluated with the help of verbal terms at five and three levels:

$$higher\ class = \begin{cases} very\ low\ (VLT\ class) \\ low\ (Lclass) \\ medium\ (Mclass) \\ high\ (Hclass) \\ very\ high\ (VHclass) \end{cases}, \quad 1^{st}\ class = \begin{cases} very\ low\ (VL\ 1^{st}\ class) \\ low\ (L\ 1^{st}\ class) \\ medium\ (M\ 1^{st}\ class) \\ high\ (H\ 1^{st}\ class) \\ very\ high\ (VH\ 1^{st}\ class) \end{cases}$$

$$2^{nd}\ class = \begin{cases} low\ (L\ 2^{nd}\ class) \\ medium\ (M\ 2^{nd}\ class) \\ high\ (H\ 2^{nd}\ class) \end{cases}, \quad fat\ content = \begin{cases} low\ (Lfc) \\ medium\ (Mfc) \\ high\ (Hfc) \end{cases}$$

$$protein\ content = \begin{cases} low\ (Lpc) \\ medium\ (Mpc) \\ high\ (Hpc) \end{cases}, \quad price = \begin{cases} very\ low\ (VLp) \\ low\ (Lp) \\ medium\ (Mp) \\ high\ (Hp) \\ very\ high\ (VHp) \end{cases}$$

In the fuzzy knowledge base a functional dependence is obtained (formula (2)):

$$price = f\,(higher\ class,\ 1^{st}\ class,\ 2^{nd}\ class,\ fat\ content,\ protein\ content) \qquad (2)$$

The use of fuzzy logic equations implies the presence of membership functions (FN) of fuzzy terms that make a part of the knowledge base. The most widespread fuzzy sets in the theory of functions have membership functions in the form of triangles (Leonenkov, 2005).

To simplify the problem, the necessary membership functions are given in the form of triangles. In order to obtain the possibility to prove the solution to the numbers, it is provided that the variables measurement ranges (universal sets) "H class", "1st class", "2nd class", "fat content", "protein content", "price" make up [0 ... 10,000], [0 ... 3,000], [0 ... 400], [1 ... 5], [1 ... 5], [0 ... 150] respectively.

As a term set of the first input variable, the "V class" there is used the set T1 = {"very low", "low", "medium", "high", "very high"} or in the symbolic form T1 = {DNVg, NVg, SVg, VVg, DVVg} with the term membership functions.

As a term set of the source linguistic variable "price", there is used the set T6 = {"very low", "low", "average", "high", "very high"} or in the symbol form T6 = {DNs, Ns, Sc , Vc, DVc} with term membership functions.

An important stage in the construction of the model was the formation of the rules base of the fuzzy logical conclusion system. Thus, 83 fuzzy rules were used during the study.

For example, IF the class is medium AND the first class is very high AND the second class is very low AND the fat content is high AND the protein content is very high, THEN the price is very high.

IF the higher class is low AND the first class is very high AND the second class is low AND the fat content is average AND the protein content is average, THEN the price is average.

IF the higher class is very low AND the first class is very low AND the second class is low AND the fat content is average AND the content of the protein is average, THEN the price is low.

As a scheme of fuzzy conclusion, the method of Mamdani is used, so the activation method will be MIN, which is calculated by the formula (3) (Leonenkov, 2005):

$$\mu' = (y) = \min\{c_i, \mu(y)\} \tag{3}$$

As a method of defuzzification, the method of the gravity centre, which is calculated by the formula (4), is applied:

$$y = \frac{\int_{\min}^{\max} x \cdot \mu(x)\,dx}{\int_{\min}^{\max} \mu(x)\,dx} \tag{4}$$

where:

y – result of defuzzification;

x – variable corresponding to the original linguistic variable;

$\mu(x)$ – function of the fuzzy set belonging to the output variable after the accumulation phase;

min, max – the left and the right points of the interval of the fuzzy set, which is considered by the output variable.

Once the knowledge base has been introduced, the rules of the fuzzy system are obtained. At the next stage, there was formed an intellectual system for predicting the prices for milk according to the quality indicators in agricultural enterprises of the Khmelnytskyi region. Milk was used for processing by higher, the first second class in the studied aggregate of enterprises in 2018. Then a decision block was created, in which the developed Fuzzy Logic Controller is located.

The Fuzzy Logic Controller includes a pre-designed FIS FILE named FuzzyMatMod. This regulator contains a set of rules that were formed during the system training. Accordingly, blocks Rule 1, Rule 2, etc. are implemented. The COA defaulted block converts the fuzzy logical output of the system into a clear numerical representation of the price. As a result, a model based on the method of fuzzy modelling was obtained, and the price of milk of each agricultural enterprise was obtained in aggregate (Fig. 1). At the same time, changing at least one of the input parameters of any enterprise, immediately gets a new value of the price. Accordingly, the influence of milk quality parameters (H class, 1st class, 2nd class, fat content, protein content) on the average price of milk and on each enterprise is also observed.

The research was conducted on data of 11 agricultural enterprises, which are located in Polonskyi and Shepetivskyi districts of Khmelnytskyi region of Ukraine. These enterprises are selected for research, as they are engaged in dairy farming and each of them has more than 50 cows. In this region there is one branch Polonsky dairy processing factory PPKF Prometheus, which buys milk from local agricultural enterprises and households. The milk processing enterprise forms the purchase prices of milk depending on its classes.

As an example of the implementation of this model, the situation regarding the implementation of milk at agricultural enterprise Kolos of the Khmelnytskyi region was described. This company in 2018 sold for the processing 2,020.71 kg of milk with the highest class, the first – 506.21 kg, the second – 24.01 with a fat content of 3.55% and protein – 2.95%. At the same time, the average price of milk was 8.82 UAH per 1 kg, which is 0.87 UAH less than the average milk price for the studied aggregate of enterprises. According to the developed model, the average price of milk corresponds to real indicators of this enterprise, which testifies to the adequacy of the model, it characterizes the lower competitive positions of Kolos, in comparison with other milk suppliers to the processing enterprise, and determines the reserves for increasing the profitability of the enterprise by improving the structure of milk classes.

CONCLUSIONS

In market conditions, the price of milk is formed depending on the ratio of demand and supply over the periods of the year.

The processing enterprises of Ukraine set the purchase price for each class of milk. The average price for the agricultural enterprise is formed depending on

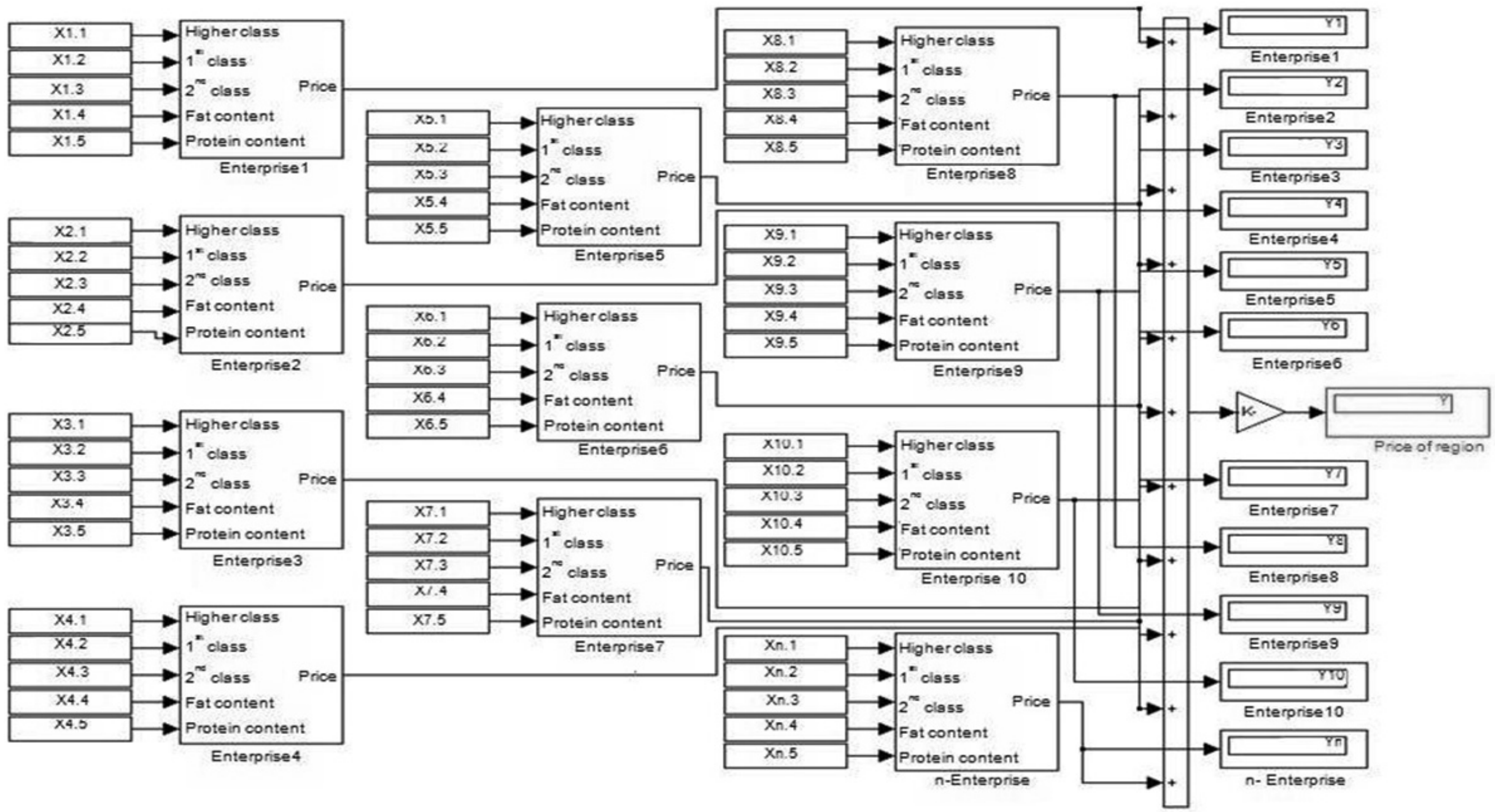

Figure 1. Information-logical model of determining the price of milk taking into account the indicators of its quality in agricultural enterprises

the milk quantity of each class that is sold. Therefore, the forecast average price for an agricultural enterprise, on the one hand, shows to it the limits of costs, and also what reserves need to be sought in order to raise this average price, that is to look for ways to improve the qualitative parameters of milk (in particular, improvement of feeding rations, technology of animal retention, milking technology etc.). On the other hand, comparing the average price of an agricultural enterprise with the average price of aggregate, the agricultural enterprise can estimate its competitive positions on the market.

On the basis of using the fuzzy sets and fuzzy logic theory in determining the average price of milk while taking into account the parameters of its quality, it is proposed to improve the processes of making managerial decisions for improving the economic activity of agricultural enterprises.

This informational and logical model of determination of the forecast average price of milk sales taking into account its quality indicators is basic and adapted to modern economic conditions. Potentially it can be used for any number of agricultural enterprises. Agricultural enterprises can use this price as a benchmark.

Therefore using fuzzy simulations in anti-crisis management of agricultural enterprises can help them to make informed decisions in a changing and uncertain environment, which will increase their efficiency and competitiveness.

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