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Automatic Information System of Risk Assessment for Agricultural Enterprises of Ukraine

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ABSTRACT

An information system (IS) for analyzing, assessing risks and their impact on the economic activity of agribusiness in Ukraine is developed. The Global Administrative Risk Management System can use this information system or its parts as a component. A new method for designing IS for risk analysis and assessment in the sphere of agriculture is suggested. An original mathematical model of such an IP is used. This mathematical model is specifically designed to reduce the IS resources' expenditures. A significant reduction in the volume of calculations per unit of time has made it possible to significantly simplify IS and to reduce the price of hardware and standard IS software. This makes the information system an affordable budget option for information support of small and medium-sized agricultural enterprises in Ukraine. To create a risk management model, it is suggested to separate the system of management and decision making and the system of risk monitoring. These two systems have different tasks and are implemented by fundamentally different mathematical algorithms. The risks of most agricultural projects have a high degree of uncertainty. Therefore, even the composition of the risks' set is dynamic. All possible risks are suggested to be passed through the monitoring procedure. To do this, a separate software unit with an autonomous security system should be used. Models of the codomain of risk change are presented where the specified region is a non-stationary scalar or vector field. An improved scheme of designing AIS for analysis and risk assessment in agriculture was suggested, which allowed significantly reducing the IS resources expenditures. Significant decrease in the volume of calculations per unit of time allowed significantly simplifying and cheapening the hardware part of the AIS. This made the use of AIS an affordable budget option for the information support for small and medium-sized farms in Ukraine. The developed AIS for the risks analysis and assessment and of their impact on the economic activity of the agro-enterprise was tested in Odessa and Mykolaiv regions.

INTRODUCTION

The analysis of risks for agricultural enterprises is somehow different from the same work for other spheres of economic activity. In addition to certain common macroeconomic risks, different clusters of other types of risk are inherent in various sectors of the economy. For example, weather related risks: grad, storm, early frosts, excessive or too low precipitations, etc. Obviously, this type of risk, which has a fundamental impact on agricultural production, is insignificant in most other areas of human activity. It is also necessary to point out the significant impact of seasonal factors in agriculture. Seasonality almost does not affect most other types of human activities. However, this is seasonality that creates new types of risks or another weight of risks in agriculture. One example of this is a big time lag between work requiring the use of all types of resources (seeding), in particular, financial, before receiving income from the products sale. As these revenues could be got only after harvesting.

The situation is complicated by the fact that the impact of certain joint macroeconomic risks on agriculture in Ukraine has a different character and another dimension in comparison with that on agrarian production of other countries of the world. For example, for Ukraine, the degree of risk in the agricultural sector is so high that it threatens investors. In some cases, foreign investment in Ukrainian agriculture is impossible. Therefore, the direct use of automated information systems for risk analysis and forecasting and optimal management actions, that are successfully used in other countries, are not possible in Ukraine. As the experience of adapting such systems to Ukrainian conditions has shown, despite the considerable amount of money spent on it, the use of such systems in Ukraine is extremely limited.

The negative factor that is not inherent in most other countries is that Ukrainian agribusinesses is more susceptible to macroeconomic stress than, for example, the banking sector. Therefore, the degree of some risks in agriculture is so threatening for a producer that it puts agricultural production at the brink of bankruptcy. This is so prominent that it negatively affects the entire economy of the country. Agriculture is one of the most important sectors of the country forming its budget. And the biggest share in commodity production of industry is belonged to the SMEs, the state of which is the most fragile, the most sensitive to these stressful situations. In addition, this factor is determinant for the emergence of other problems, for example, the problems of employment of the population.

Ukrainian agro-producers, especially small and medium-sized farms, still rely more on their own experience and traditions than on modern risk management technologies. Nowadays this is a serious problem taking into account all-planetary climate change. In such circumstances, relying on experience and traditions can lead to fatal mistakes in making a managerial decision. Of course, this is also one of the aspects of increasing the risk of bankruptcy for Ukrainian agrarian farms. On the other hand, the process of risk management in agriculture in Ukraine needs a technological breakthrough. Because the reliance on experience and tradition is sometimes a forced step, which is caused by the lack of access to modern information technology of risk management. The experience of other countries shows that it is extremely difficult to assess the impact of the risks on the agribusinesses without the use of modern information tools and, moreover, of all aspects of such means. There is a need not only for the creation of algorithms and software, adapted simultaneously in Ukraine as a whole and in its regions.

Automatic information systems for analysis, risk assessment are not able to work without accumulating, evaluating, processing information about factors that affect the risks. This work should be carried out continuously and, preferably, in automatic mode. This is primarily due to the large volumes of volatile information, constantly changing trends, which are sometimes changing to the opposite, and so on. In developed countries, the database of factors affecting the risks of agricultural production has been formed over many decades. These bases are gathered not only at the state level in general but also in separate regions. Unfortunately, in Ukraine the only database that is systematically filled up and maintained at the state level is a database on weather factors. Therefore, there is a need for both the application of the automatic information system (hereinafter – AIS) of analysis, and assessment of risks and their impact on the economic activity of Ukrainian agribusiness enterprises and for the development of databases on the factors by their influence on various types of risk.

1. ANALYSIS OF RESEARCH AND PROBLEM STATEMENT

For other types of non-agricultural business, we have a different set of risks. This complicates the use of risk analysis tools that have proven successful in other sectors. The relative weight of risks, that have a greater impact on the activity of the enterprise, is different for agrobusiness, e.g. the risk of uneven cash flows. On the contrary, in most cases the seasonal unevenness of cash inflows is inherent for agriculture. This creates certain requirements for the planning of costs, the need to take into account the risks associated with the seasonal character of production. Such a tool as futures sales are not yet widespread in the economic activities of agribusinesses, so they do not remove the problem of seasonal nature of proceeds.

The theory of risk, of the agribusiness risk has a solid scientific grounds. Many scientific works are devoted to the problems of risk, economics and mathematical modeling, in the agricultural sector, in particular. Inter alia, scientific researches of O. Bakaev, L. Bazhan L., Yu. Yermoliev, I. Lyashko, V. Vitslinsky. and of other scientists are known (Bakaev, Bazhan and Kaydan, 2008; Yermoliev, Liashko and Mykhalevych, 1979; Vitlinskiy and Velikoivanenko, 2008; Yastremskiy, 1992; Machina, 2003; Illyashenko, 2004; Neacsu et al., 2018). O. Bakaev O developed methodological aspects of modeling of complex economic systems, formed approaches to the analysis of factors influencing the functioning of complex economic structures. He analyzed not only macroeconomic systems but also microeconomic ones, and one of his works is devoted precisely to the peculiarities of the introduction of information technologies into the microeconomic modeling (Bakaev, Bazhan and Kaydan, 2008). This is an extremely interesting general theoretical work. We noted the contribution of Bazhan L.I. to scientific achievements (Ibid.).

u. Yermoliev, Lyashkoand Mykhalevych (1979) published in collaboration extremely interesting works, in particular in the field of mathematical methods of investigation of operations. They have studied in detail modern models and methods of finding effective solutions using various mathematical and programmatic approaches. Yermoliev, Lyashko and Mykhalevych analysed in detail various aspects of models and methods of stochastic programming, in particular, the choice of solutions in the presence of risks and uncertainties, described methods for solving stochastic programming problems. The researchers analyzed step-by-step approaches to solving problems under uncertainty. Their description of approaches to stochastic approximation under conditions of incomplete information about the values of stochastic functions was used in our work. The search for the best solutions under uncertainty is a very complicated task and the approaches of scientists Yermoliev Lyashko and Mykhalevych (Ibid.) to solve extreme problems using the apparatus of mathematical statistics have also been used by us. Particularly interesting was the Yermoliev et al. study of quasigradiant methods with the use of memory. This opened up new possibilities for finding the best solution when classical methods, such as the method of hill climbing or steepest descent, can not be used in the absence of information on the risk factors, and the use of the pinch method is unattainable under the conditions of a limited resources. Methods for finding the optimal solution are often used in the assumption of time discreteness. Yermoliev et al. analyzed methods with a continuous time function. In order to solve the problems of finding an optimal solution for continuous time, Yermoliev et al. used the mathematical apparatus of the variation calculus. It was also used in our work. The use of mathematical apparatus of vector analysis for multicriteria optimization by scientists made it possible to search for the best solutions under conditions when the argument – the factor of influence on risk – is not a scalar value (Ibid.).

The works of Vitlinsky V.V. devoted to modeling of economics, risk in management, to the analysis of economic risks, methods of their evaluation and modeling are fundamental and well-known. In particular, his work, in collaboration with Velikoivanenko G.I., is devoted to "risk in economics and entrepreneurship, methods, models and information technologies in the management of economic systems of different levels of the hierarchy" (Vitlinskiy and Velikoivanenko, 2008). In works (Bakaev, Bazhan and Kaydan, 2008; Yermoliev, Liashko and Mykhalevych, 1979; Vitlinskiy and Velikoivanenko, 2008; Yastremskiy, 1992; Machina, 2003; Illyashenko, 2004; Balezentis, Novickyte, 2018; Spicas et al, 2018) and others, the methodological basis of the system of analysis and risk management was developed taking into account the circumstances and peculiarities of conducting activities in the sector, in particular, of agricultur al production. The main disadvantage of these scientific studies is their general theoretical approach without specific recommendations for the formation of automatic algorithms for risk analysis. The works devoted to optimization of risks in other branches is considered. The most detailed risk optimization approach has appeared in relation to the financial and banking sectors.

The theory of G. Markowitz is widely used in the financial and banking sectors, as well as its application in financial risks optimization (Machina, 2003; Illyashenko, 2004; Chodnicka-Jaworska et al., 2017). It was Markovitz, who for the first time considered the formation of an investment portfolio in two stages, the first of which was the analysis of available data and the formation of expectations and the second one is the decision-making. This global approach was used in various applications by Markovitz successors. In particular, the application of the Markovitz theory to optimizing the sales portfolio alongside with minimizing the risk level, determined by the variance in the existing constraints, proved to be successful. At the same time to calculate the optimal value of the portfolio the sum of covariances of each of its components is used. For this purpose, the relation of these components is determined by their specific weight.

Thus, the basis of strategic planning of the enterprise is set. This became the basis of the applied work of N. Mashina (2003) which used it for the mathematical analysis of economic risk and methods for measuring it and the classical work of S. Ilyashenko (2004) on economic risk. Ilyashenko has devoted his work to the methodology of the theory of risks and methods of quantitative analysis of the risk portfolio, methods of its inclusion into the practical activities of enterprises. He took into account that most of the risks of this portfolio depend on factors that can not be fully determined. He used methods of work under conditions of uncertainty of risk factors and developed the probability methods of risk analysis. It is precisely the use of qualitative not quantitative methods for assessing the risks presented in the work of Ilyashenko, not only determined but also probabilistic, which made it possible to algorithmize the factors of influence on certain types of risks. Risk management uses not only the classical classification: risk insurance, risk sharing, risk pooling, diversification and risk hedging, risk reduction by collecting additional information, reserving funds to cover unforeseen events, but is also providing certain methods for doing so. Ilyashenko pointed to the relationship of risk and profit and, also, the use of different methods in determining the indicator of systematic risk. In our opinion, the use of decision-making methods under conditions of non-complete certainty and risk management methods in a context of active counteraction to the economic environment is also interesting. We used the methods described in the work of Ilyashenko (Ibid.) in the calculation of risk, called "country", to adapt some modern algorithms not to the countries where they are successfully used, but to the Ukrainian realities.

Unfortunately, the applied aspects of the algorithmization of his techniques remained beyond the attention of the researcher. The indicated extremely valuable experience cannot be fully applied for designing the AIS for risk analysis in the agribusiness, but certain fragments, in particular, finding the weight of a particular risk in the set of risks, were used by us as an element of AIS designing. The fundamental work of Globynets G.I. is of particular interest. Using methods of the risks theory, G. Globynets (2006) has developed general approaches to the analysis of risks in agrarian production. The scientist has elaborated a step-by-step approach in shaping the algorithm of risk management. Basing on the works of well-known scholars, in particular, V. Vitlinsky, O. Bakayev, L. Bazhan, Ll. Lyashko and others (Bakaev, Bazhan and Kaydan, 2008; Yermoliev, Liashko and Mykhalevych, 1979; Vitlinskiy and Velikoivanenko, 2008; Yastremskiy, 1992; Machina, 2003; Illyashenko, 2004), she formulated the general classification of risks in agricultural production. The approaches of G. Globynets are used in our research. It is Globynets who seems to have for the first time emphasized the need to introduce a system of monitoring the factors affecting the risks of agrarian production. Unfortunately, the monitoring system was used by a scientist only as a risk management control tool to determine the effectiveness of this management exclusively. Of course, determining the effectiveness of risk management is not the main task of the monitoring system. The disadvantage of the approach of Globynets (2006) is that she narrowly focused on the methodological substantiation of the organization of work of a structural unit which main task is risk management. That is, the analysis of the assessment of the impact of risks on real-time economic activity lies outside the scientific interests of Globynets (Ibid.). In addition, the economic state of most Ukrainian agroenterprises, unfortunately, does not allow the formation of a separate unit within their administrative structure, the main task of which would be the risk management only. However, thanking to the detailed analysis of scientific work of Globynets, we set a goal to maximize the simplicity of the interface and to adapt it to Ukrainian realities, as well as to minimize operational costs on the creation of information system for risk analysis and assessment.

While designing the AIS for risk analysis in the agro industry, one of the goals was to minimize the associated losses and to minimize the number of employees needed for its maintenance via maximization of the automation of AIS processes. The portfolio of risks, inherent to agricultural production, methods of their analysis, are described in detail in the works of O. Makolova, T. Chudaeva, L. Kudriaeva (2008) O. Nichiporuka (2002), and F. Aliu et al. (2017). Some aspects of their methods of forming a portfolio of risks, assessment of their weights were applied in the design of the AIS. The research of Makolova and her colleagues is entirely devoted to the adaptation of agricultural producers to the risks. In particular, in the work of O. Makolova et al. the necessity of taking into account losses that affect the trends of such risks is pointed out: the risk of increasing the main expenses of the agricultural producer for the production of agricultural products per hundred hectares of areas subject to processing, and the risk of reducing the amount of revenues from the sale of products per hundred hectares of areas to be processed. But, in our opinion, the recommendations of Makolova, Chudaeva and Kudriaeva (2008) on the necessity of establishing regional consulting centers seem to be wrong. Each manufacturer has a set of risks inherent to him, and he can not wait for the maintenance support at a regional center in a line.

The work of O. Nichiporuk (2002) is devoted to the risks of agriculture, in particular, in crop production. His approach to risk assessment and risk diversification as the main risk management tool is interesting. The scientist developed a method of diversification of agricultural production taking into account the advantages and threats of this process for a particular manufacturer. This technique allows you determining the level of risk and the impact on the specified level of risk diversification (Ibid.). Still it's more about risk management than about its analysis.

The PhD thesis of V. Chepurko (2001) "Economic risk of agrarian production" is devoted to this subject under the study. His thesis was based upon the assumption that agro-production is a complex dynamic system that is uncertain under the influence of stochastic factors. Chepurko applied systematic analysis and stratification of risks for the stratification of the economy as a system factor. He referred to agro-industrial integration as a risk reducing factor for the production of agricultural products. Chepurko V.V. used an aspect approach to the classification of risks, and, from our point of view, this approach among others was extremely productive. The scientist developed an approach to the classification of agricultural production risks. The method of assessing the reciprocal of additivity and non-repeatability are its base. This is a very interesting approach. The paper also mentions an important problem of the agrarian sector of Ukraine. As the set of operational risks and factors, that directly affect the decision-making process, are compounded and exacerbated by the risks of the management system and system-wide factors (Ibid.). The presence of so-called risks of "*higher object levels*" (Chepurko, 2001) leads to a multiplier effect and a change in "*local and integrated risk assessment, as well as to the formation of a hierarchical risk management system of agrarian production*". In our work some methodological approaches and conclusions of this research are used, in particular: the hierarchical approach to risk identification as well as the "*matrix-network principle of systematization of risk factors in agrarian production*". However, the aspect approach, as declared by the author (Ibid.) as unconditional, was rejected by us. As the aspect approach is rather phenomenological and can not be used in a rigidly formalized model. And when designing AIS, for which there are automatic processes of information processing, the use of non-formalized methods and models is impossible. The idea of an adaptive approach (Ibid. in the portfolio of risks. In general, unfortunately, the mathematical apparatus (Ibid.) was not suitable for the design of the AIS. Therefore, there was a need to construct own mathematical apparatus for risks analysis and their mathematical processing.

The purpose of the article is to develop its own mathematical apparatus for risks analysis and their mathematical processing. An improved scheme for designing the AIS for risk analysis and risk assessment in agriculture should be suggested. The design of the AIS should be carried out in such a way as to reduce the cost of the information system resources, and to reduce the cost of the hardware part of the AIS. Developed AIS should become affordable budget option for the information support for small and medium-sized farms of Ukraine.

2. METHODOLOGY

To formalize the methodological approach, we introduce the concept of "risk area". Why do we use the concept of domain, and not, let's say, a "figure"?

The "figure" will mean that the risk parameter is a scalar value, and this happens quite rarely. Therefore, it is better to immediately consider a set of parameters for the risk of a vector, which, under certain circumstances, can be interpreted as a scalar when, for example, a group of factors, except one, is equal to zero. The parameters of the impact on the risk, of course, will vary within certain intervals, which will allow the formation of a limited spatial area, that is the area of risk change

The area of risk change will be the geometric place of points in the space of f-dimension

$$\mathrm{f} = (j+1) \tag{1}$$

where j – the number of parameters on which the specified risk depends.

Let the set of risks be represented by *M*. In this case, each of the possible values of risk belongs to a certain area of *F* and it can be described by a set of variables $x_1, x_2, x_{3,\dots\dots} x_j$.

$$\mathrm{M}\left(x_1, x_2, x_{3,\dots\dots} x_j\right) \in \mathrm{F} \tag{2}$$

The specified parameters generate a discrete group, because in this case there are no parameters that are non-discrete. In addition, the group of risk exposure parameters is not an elementary group. Then, for the description of this set, we can use the inequality of Jorgensen (Mittal and Mehar, 2013; Voronich, Nikolaychuk and Gladuk, 2012; Gumenniy and Zastavny, 2014). Let's consider a separate case where the specified region is a scalar field. A scalar field is a geometric place of points, each dot of which corresponds to a certain real number. In our case, such a number is the number M. It is already determined that this region can be considered in Cartesian coordinates (Kasyanchuk, Yakimenko and Pazdriy, 2015; Nycolaychuk, Humenniy, Alishov and Hladyuk, 2013).

Then the surface of a given region can be described by the surface equation.

$$U\,(x_1, x_2, x_{3,\dots\dots}\, x_j) = C \quad (3)$$

Obviously, for this surface, inequality is carried out

$$\left(\frac{\partial U}{\partial x_1}\right)^2 + \left(\frac{\partial U}{\partial x_2}\right)^2 + \left(\frac{\partial U}{\partial x_3}\right)^2 + \dots + \left(\frac{\partial U}{\partial x_j}\right)^2 > 0 \quad (4)$$

that is, partial derivatives $\frac{\partial U}{\partial x_1}, \frac{\partial U}{\partial x_2}, \frac{\partial U}{\partial x_3} \dots \frac{\partial U}{\partial x_j}$ simultaneously do not equal zero.

This representation has several advantages. For example, it can be used for analytical representation of risk from its parameters $x_1, x_2, x_{3,\dots\dots}\, x_j$. derivative in the direction of the scalar field

$$\frac{dU}{dx} = \frac{\partial U}{\partial x_1}\frac{dx_1}{dt} + \frac{\partial U}{\partial x_2}\frac{dx_2}{dt} + \frac{\partial U}{\partial x_3}\frac{dx_3}{dt} + \dots + \frac{\partial U}{\partial x_j}\frac{dx_j}{dt} \quad (5)$$

where t – oriented vector.

This approach allows us finding not only the trend of changing a certain risk, but also its predictive value. The concept of the derivative in the direction of the scalar field is invariant to the coordinate system. Definition (5) allows finding the rate of risk change in the direction of the scalar field. This definition formulates the analytical form for the specified change. But, most importantly, it provides the opportunity to use standard programs to find the rate of change in risk and accurately determine the direction of this change (obviously the direction of change coincides with the direction of the vector t).

Not all types of risks can be considered as scalars. In this case, it is necessary to consider the risk representation aside from its parameters as a vector field. As you know, a vector field is a geometric point of points, each dot of which, in the general case, corresponds to a vector $(\vec{a})$.

$$\vec{a} = + P_3\left(x_1, x_2, x_{3,\dots\dots}\, x_j\right) * \overrightarrow{\imath_3} + \dots + P_j\left(x_1, x_2, x_{3,\dots\dots}\, x_j\right) * \overrightarrow{\imath_j} \quad (6)$$

where $\overrightarrow{\imath_1}, \overrightarrow{\imath_2}, \overrightarrow{\imath_3}, \dots \overrightarrow{\imath_j}$ – vectors-orts of coordinate axes.

The geometric feature of the vector field of risk for an agro enterprise will be the so-called power lines of the vector field. This makes it possible to construct an attractor of risk. The advantage is that usually complicated task of constructing a risk attractor in a multidimensional space is reduced to the use of a standard program for calculating the power lines of a vector field. Obviously, the specified vector field can not be stationary. Then, again using the standard program you can find the rate of risk change. You can also use the standard procedure to find the gradient of the vector field. Risk leveling costs, or risk-taking costs, can be found as some kind of F-Force's work on a risk taker.According to the mathematical definition, the limit of this work exists and it can not reach infinity, as indicated in the scientific work of Ya. Nikolaychuk and N. Alishov (2013). Obviously, the indicated surface can be designed for each coordinate plane. As a consequence of this, it is possible to obtain the projection of the attractor on each coordinate plane. This, in turn, gives the opportunity to get an analytical expression for each type of risk from each of the parameters.

It is known that any curve, the attractor can be designed into which, can be described as a polynomial of the seventh degree. Then, the analytic dependence of the risk Q_j on the parameter x_j can be represented by the analytic equation of the following form

$$Q = \sum_{1}^{7} b_r * x_r{}^r \tag{7}$$

where b_r – set of seven numerical coefficients of the parameter x_j in the appropriate degrees from the first to the seventh.

And then, the system of algebraic equations of the following form would be the mathematical apparatus for describing each risk:

$$Q_1 = \sum_{1}^{7} b_r * x_{1r}{}^r$$

$$Q_2 = \sum_{1}^{7} b_r * x_{2r}{}^r \tag{8}$$

$$Q_j = \sum_{1}^{7} b_r * x_{jr}{}^r$$

The indicated numerical coefficients for the corresponding degrees of the parameter are found by processing the projection of the attractor on the corresponding coordinate plane with the standard program of processing polynomial SP-07. The degree of the parameter x_j can take zero-value. Thus, you can get all analytical expressions for each type of risk. Each of the analytical expressions has the form of a seventh degree polynomial. This processing, meaning obtaining of analytical expressions, significantly reduces the volume of calculations and the time spent on each procedure.

Instead of looking for the value of each risk, it is only necessary to check how the changes of individual parameters within the time affect the polynomial coefficients. The application of technology of polynomial expressions makes it possible to work efficiently without the use of significant amounts of computer equipment resources. This leads to a significant reduction in the cost of the AIS. In reality of the application of risk analysis to agribusiness, architecture of specified AIS may allow using even just one PC when using cloud resources for the deployment of databases and monitoring systems of risk.

3. RESEARCH RESULTS

To create a risk management model, we suggest to formally and programmatically separate the risk management and devision-making system and risk monitoring system. These two systems have different tasks and are implemented via fundamentally different mathematical algorithms. Besides other advantages, this allows you reducing the memory load and the use of other computer resources. As a consequence, there is, in particular, a decrease in the requirements for computer equipment and, accordingly, a reduction in prices for AIS.

As for most agricultural projects the risks are subject to a high degree of uncertainty, this leads not only to the dynamic change in risk parameters, but even to the dynamic change in the composition of the set of risks. Therefore, all possible risks must be passed through the monitoring procedure. To do this, a separate software unit with an autonomous security system should be used. The database system will be one of the main specified blocks. Dynamic changes in risk parameters will require frequent database updates. At specified time intervals that will be different for each of the risks, information about them, including the degree of risk, risk parameters, limits of its possible changes, the nature of the risk, its descriptive function of probability, etc., should be sent to the risk monitoring system. The information provided should be analyzed, validated and verified. On the basis of this the decision is to be made to include the risk to the set of risks to be taken into account or, in view of the insignificance of the risk, it should be excluded from the analysis for that period of time. The final composition of the set of risks should be transferred to the control system and decision-making.

Since it comes to the creation of a configurable AIS, one of the main tasks is the creation and maintenance of flexible database structures. One of the methods for creating and maintaining flexible database structures is the construction of structurally independent information databases. This leads to the need to use the EAV data model. EAV is an abbreviation of "entity-attribute-value". The unconditional advantage of the EAV data model is that the data structure in the database is greatly simplified, which ensures maximum flexibility in case of need to make adjustments to the logical data schema. Since, according to the database definition, risk factors require not only frequent replenishment but also changes, the use of the EAV data model becomes a necessary tool in implementing the technology of updated information structures. We used not the standard EAV, but its modified version – EAV which uses classes and relations.

This option is called EAV / CR (English Entity-Atribute-Value with Classes and Relations). It allows characterizing each information essence, for example, the parameter on which the risk depends, belonging to a certain class. This allows you to prevent logical mistakes in the formation of an information request. When using EAV / CR, the query may be limited to the choice of the essence of only particular class. Besides, the relations between risk parameters can be formulated explicitly, and the structure that supports the communications is unified according to the defined methodology.

Integrity requirements can be now supported at meta-level. For this we have formed a subprogram – a trigger of metadata tables. The EAV / CR data model, as it was demonstrated by the experience of its use, is a reliable one in the conditions of uncertainty surrounding the very structure of the information bases.

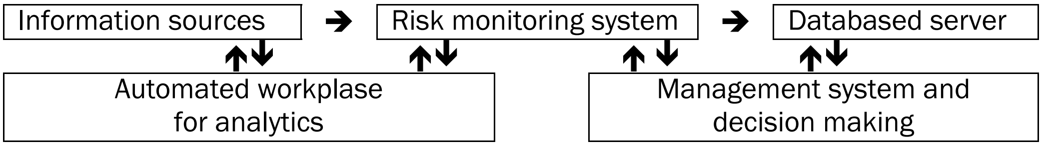
As one could know, the principle of the EAV / CR data model is the use of a stable substructure of "substance-attribute value". Such construction of databases ensures the stability of the physical data structure, because it is invariant to the structure, form and dynamic change of information. To define such databases, an established term is used – "structurally independent". Even if the information has the form of metadata, it is entered in the database directly in its original form with the use of a model which is named "logical". This approach allows us to use databases as classical relational ones. And the structure of the used metadata can be arbitrary. This can be achieved via using meta-level.

We carefully analyzed the advantages and disadvantages of the EAV / CR data model. The advantages include:

- already mentioned data flexibility;
- effective data updating in the conditions of fast-moving time;
- significant unification of the database structure;
- the ability to use consistent data storage structures over and over again;
- availability of context-independent queries;
- the possibility of using relational principles in the database architecture;
- ease of designing and using a database.

However, when using the EAV / CR data model, it is necessary to weigh up its shortcomings and design the database in such a way that the disadvantages would not interfere the work.

Figure 1. Generalized structural scheme of the functioning of the AIS of risk assessment and its impact on the economic activity of agro-enterprises



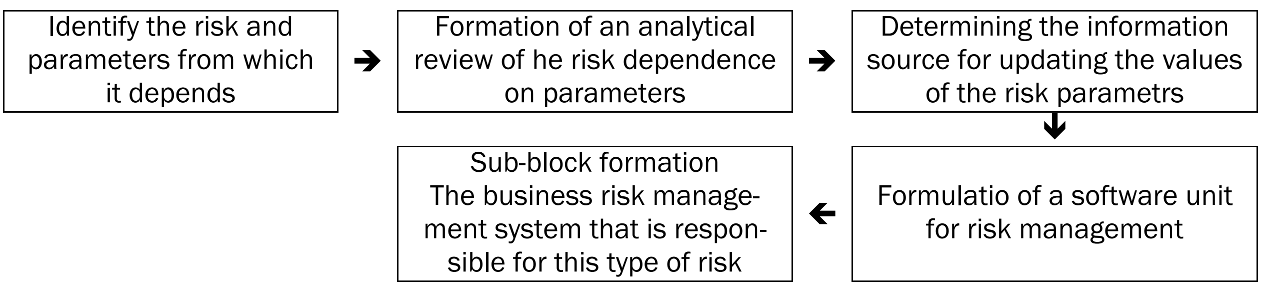
The disadvantages of the EAV / CR data model include:

- transactions in a database other than the classic "create, read, update, delete", i.e. CRUD (English abbreviation for create, read, update, delete) are extremely complex procedures;
- this causes the following disadvantage: the need to create own subtasks for conducting non-typical transactions;
- when relational principles of database design are used, this, in turn, causes a decrease in the efficiency of the work;
- which, in turn, raises the need to optimize the storage of information.

The indicated shortcomings are taken into account, and within the built AIS they do not interfere the work. In order to monitor information about possible risks, it is necessary to develop an algorithm for actions concerning the collection of information and its initial processing. Some of the risks can be tracked automatically. For example, data on exchange rates, fuel costs, etc. are regularly updated in the information network. For each project the risks are identified, information about them should be collected and updated manually. The use of the combination of automatic and manual modes can greatly simplify the processing of information (Soltania, Seyedabrishami, Mamdoohi and Kordehdeh, 2016; Jian and Rehman, 2016; Vozna, Shevtchuk, Nycolaychuk and Vozna, 2017; Lwayo and Obi, 2012). At the same time, manual mode provides "author's supervision" of the formation of suggested for the user options for a set of risks inherent in a particular agricultural enterprise.

Information bases should be made autonomous for each of the risks, as well as the access to them. It simplifies the processing of each of the risks, reduces the processing time, simplifies the control and the operator's actions, and the accumulation, processing and preservation of information for each type of risk. Technologically, the work on risk analysis has two interconnected components. The first component is the process of obtaining data on the parameters on which the risk depends, their processing and obtaining conclusions about the impact of risk on the economic activities of agribusiness. The second component is the process of analysis, processing of information about the new risk and its inclusion into the AIS (see Figure 2).

Figure 2. Procedural algorithm for risk analysis and its inclusion into the AIS



The sequence of operations of the procedural algorithm of risk analysis and its inclusion into the AIS is shown in Fig. It should be noted that the design work of the AIS formation, that is, the programming part of the work, can not be performed separately from the work on the formation of a mathematical algorithm for analyzing the impact of risks on the activity of an agricultural enterprise.

Work on these components must be done simultaneously, or, in extreme cases, in stages, starting with the second component. However, monitoring of risks, identifying new risks, identifying new risk parameters and changing the analytical dependencies of risks on their parameters must be carried out on a regular basis. The use of powerful databases, the software needed to work with dynamic databases in the countryside of Ukraine, is a very problematic issue. Therefore, the use of modern technology of cloud computing, that is, distributed information processing, is a obligatory step. This is assumed in the AIS designing.

They use the cloud platform to place databases and software for their work (Platform-as-a-Service, abbreviation PaaS) operating under the OASIS for CAMP (cloud application management for platforms) that allows you applying unified PaaS management software products. This allows minimizing capital investments into the AIS, simplifying and speeding up the formation and issuance of information requests as much as possible.

Using PaaS solves a whole bunch of problems associated with software upgrades, expanding the required computing facilities associated with, for example, increasing database time. For small agricultural producers, even such an economical version of the AIS may not be available. But the cooperation of local producers can allow the access to such an automated information system. In addition to the above mentioned economic factors, in case of careful and qualified use of databases, the opportunity to receive additional cash inflows from giving the access to databases to the third-party users.

Designing AIS, first of all, the separation of risk management and decision- making systems and risks monitoring system enabled the use of all possibilities of the so-called "infrastructure as a service" (English Infrastructure-as-a-Service, IaaS abbreviation) with all the necessary software applications. As the pilot tests showed, the reducing productivity associated with the use of AIS is unimportant for the Ukrainian user. An important disadvantage of using PaaS, which is currently underway, is the reliability and availability of PaaS. Ukrainian Internet networks in the countryside are not very widespread and are not very reliable. That is, the problem, which is called in the scientific literature, "the problem of the last mile" is very significant in Ukrainian conditions. For example, in case for the services provider leaves the market, who gives the entrepreneur the opportunity to use the cloud platform, the latter may lose the databases.

The cost of the AIS is determined, first of all, by the amount of information to be obtained, analyzed, and saved per unit time. The tasks, AIS is facing, determine the required speed of the removal of information from its source and the speed of information processing.

CONCLUSIONS

As demonstrated by the experience of adaptation of information systems designed for analysis, assessment of risks and of their impact on the economic activity of agricultural enterprises that effectively operate in developed countries, their wide practical exploitation in Ukraine is impossible.

In Ukraine there is no proper infrastructure for such systems and the associated costs are too high for the majority of entrepreneurs working in the Ukrainian agrarian sector. Therefore, the goal to develop such an information system that would meet the requirements of practitioners of Ukrainian agricultural production was set up.

The main requirements to this information system were autonomy, the possibility of effective work in the absence of a part of the data on the factors which influence risks, stable work in the absence of data for a significant past period, economical use of computer resources, affordable price. These requirements have been met. The AIS for analysis and risks assessment in agriculture has been created. The improved scheme of designing the AIS for analysis and risks assessment in the field of agriculture is suggested. The system is currently ready for pilot testing.

The creation of AIS required the development of its own, original mathematical apparatus for risk analysis and its mathematical processing. The mathematical model is constructed using elements of vector algebra, differential analysis, theory of optimal control, probability theory and other fields of mathematics.

Simplification of the representation of a multidimensional attractor through its projections onto Cartesian coordinate planes and the subsequent description of the attractor projections via the system of equations – polynomials of the seventh degree, followed by the use in computations of not all databases, but only the resulting equations, has allowed significantly reducing the amount of computer resources required and, thus, reducing the cost of the AIS.

The decrease in the cost of the AIS was made thanking to the division during the designing of the section into separate systems of risk management and risk monitoring.

The requirement to monitor the risks parameters, due to a significant degree of uncertainty of these parameters, which results not only in the dynamic change of the actual parameters of risk, but even, in the dynamic change in the set of risks.

That is why all possible risks should be passed through the monitoring procedure. To do this, a separate software unit with an autonomous security system should be used. This, in turn, requires the transfer of a significant part of the resources and applications to the cloud platform.

Such a transfer of resources and applications to the cloud platform allows taking advantage of all the features and benefits of cloud technologies, including the so-called "infrastructure as a service" – IaaS, PaaS, and others. In turn, this helped to reduce the use of the automatic information system, to simplify the work of rural entrepreneurs with it.

The application of the EAV / CR data model allowed, as pilot testing of the information system showed, providing data flexibility, efficient data updating in real-time, a significant unification of the database structure, the ability of using consistent data storage structures, and the context-independent querying tool; the possibility of using relational principles in the database architecture and, in general, the ease of designing and using the database.

When forming the package of risks inherent in the activities of a particular agribusiness, a combination of automatic and manual modes was used. This, on the one hand, made it possible to simplify the task significantly, on the other hand, the manual mode ensures the direct formation of a package of risks by the largest of the experts - the owner or the manager of the agricultural enterprise.

In order to ensure the reliability, the databases for the factors of influence on each type of risk are formed autonomous from each other. This allows preventing failures when querying, provides the reliability of databases from damage of information.

The specified model is specially designed to reduce the cost of information system resources. Significant decrease in the volume of computations per unit of time allowed to significantly simplify and cheapen the hardware part of the AIS.

This, in turn, made the use of AIS an affordable budget option of the information support for small and medium-sized farms in Ukraine.

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