MATHEMATICAL METHODS, MODELS AND INFORMATION TECHNOLOGIES IN ECONOMICS

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THE USE OF FUZZY LOGIC FOR RISK ASSESSMENT IN THE CONSTRUCTION PROJECTS

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Introduction. Procurement production is an important link of machine-building enterprises. Blanks contain (cast, welded, forged, stamped), which are consumed in mechanical engineering and metal working, 42% of castings. Reduction in the cost and quality of manufactured products in machine-building industries is largely determined by the efficiency of procurement production. Therefore, the pricing of procurement products is largely due to the technical and economic characteristics of production and key features of products.

Basic material and results. The main tasks for the development of procurement production include:

- acceleration of labor productivity growth based on creation and implementation of new high-performance equipment, machine system, complex mechanization and automation of production processes and control system;
- improvement of quality, reliability, accuracy and quality of cast surface with their optimal approximation to dimensions of finished parts;
- reduction of mechanical processing capacity, reduction of billets and parts weight by 15-20% by introducing progressive alloys and technological processes;
- further improvement of structure of procurement production to increase the specific gravity of castings from high-quality cast iron and alloys with improved physical and mechanical properties;
- deepening in specialization and concentration of procurement production.

However, it should be noted that after the collapse of the Soviet Union, not a single developed procurement production was created in Azerbaijan. All existing plants and workshops work using old methods, which negatively affect the development of machine-building production.

Therefore, considering the needs of the engineering industries, it is necessary to design the construction of procurement production.

Currently, the strategy for the development of mechanical engineering provides for the realization of various procurement industries, including production of steel, cast iron and non-ferrous castings by various methods, as well as the production of forgings, stamping blanks, metal structures and model production.

When implementing projects of such plan, the most important point is to minimize the negative impact of the created objects on the environment.

When developing projects, any decisions are made under conditions of uncertainty. Uncertainty of expected results leads to the risk that the targets can only be partially or not achieved. Therefore, it is very important to consider the change in factors and conditions that may have a negative impact on the project.

In development projects of procurement production for mechanical engineering, it is especially important to assess the risks associated with environmental safety:

- pollution of the environment during production activities;
- emergency risks with environmental consequences;
- risks of deterioration of population and personnel health;
- risks of deterioration of social and cultural well-being of people.

Selection and justification of risk assessment methods for the procurement construction project. All risk factors can be divided into two groups: certain and uncertain.

Certain factors include variables, values of which are known with some required accuracy. Uncertain factor includes variables, in the real process the researcher is not fully aware of their values. The possibility raised by uncertainty that the chosen solution is not achieved, is called risk [1].

Qualitative and quantitative methods are used to assess the risk. Functionality and reliability of the method selection depends on the completeness of the available information a priori.

Depending on the degree of certainty, there are three varieties of methods: used under conditions of certainty; used under conditions of partial uncertainty and used under conditions of total uncertainty [2, 4, 6-8].

Under certainty, calculation and analytical methods are used. They are used to calculate risk indicators mainly according to accounting data. Under partial uncertainty, risk is considered as a probable category, so probable and statistic risk assessment methods are useful in these cases. These include the statistic method, simulation modeling, sensitivity analysis.

The statistic method is used if there is a sufficient statistical base for claims of this type. This method enables to evaluate the frequency of this type of risk, the probability of a risk situation, and determine the value of possible losses. Statistic methods of risk assessment give a high degree of reliability only with a sufficiently large amount of statistical information.

When using the simulation method, many possible combinations of project factors are generated, taking into account their probable distribution. The simulation method provides an accurate and clear assessment of the project risks. It allows taking into account the maximum possible number of environmental factors. The disadvantages of this method are:

- difficulty in determining the type of probable distribution for the parameter under study;
- uncorrelated parameters, which greatly complicate the model and does not always help to assess the dependence between parameters;
- model research is possible only when computer technology is used;
- during development of real models, the involvement of specialists or external scientific consultants may be needed.

When using the sensitivity analysis method, risk is considered as sensitivity degree for resulting indicators of project implementation to changes in operating conditions. The analysis begins by setting the base value of the resulting measure with fixed parameter values that can affect the project assessment result. Then one of the factors is changed, the rest remain unchanged, and the percentage change is calculated.

The tree-structured method is used in situations where decisions made at each point of time are strongly dependent on previous decisions and in turn determine scenarios for further development of events. A limitation in using this method is that the project should have a foreseeable or reasonable number of development options.

Under conditions of complete uncertainty, expert methods of risk assessment can be used, as well as methods based on the use of the apparatus of fuzzy set theory. Expert method is the processing of expert

assessments for each type of risk and the determination of an integral level of risk. In order to obtain more objective assessment, experts who perform examination should have a full range of information about assessed project. After determining probabilities, all indicators are brought to an integral value. The most commonly used approach is to rank risks by priority and determine weights according to the significance of these risks.

The positive aspects of the method are the simplicity of calculations and the lack of a need for accurate information. Fuzzy logic conclusion for risk assessment includes the following main stages: risk identification, filling the rule base, transformation of input variables, transformation to fuzzy form, fuzzy logic conclusion and obtaining of quantitative value of risk value [10].

For modeling the risks of procurement and construction projects, fuzzy models should be presented in the form of fuzzy networks, the elements and set of elements which implement various components of fuzzy models and the stages of fuzzy inference. The fuzzy production model (NPM) can be presented as follows [11]:

$$(i) : Q; P; A \Rightarrow B: S ; F; N. \quad (1)$$

where

Q – application area of fuzzy product;
P – activation conditions of fuzzy product kernel;
A – kernel conditions (antecedent);
B – kernel conclusion;
S – method for determining quantitative value of truth degree of kernel conclusion;
F – fuzzy product certainty;
N – post-condition of product rule.

Fuzzy cause-and-effect relation between antecedent and consequent is given in the form of fuzzy products: if *x* has A, **then** *y* has B, where

x – antecedent definition area;
A – fuzzy set, defined to *x*;
$\mu A(x) \in [0, 1]$ - fuzzy membership function A;
Y – consequent definition area;
B – fuzzy set, defined to *y* ;
$\mu_в(x) \in [0, 1]$ - fuzzy membership function B.

If fuzzy membership function A - μA (x), then for fuzzy set B, membership function is determined by the composition rule:

$$\mu A(x) = \sup \{ T (\mu A(x), \mu_в(x,y))\} \quad (2)$$

where

sup – determination of upper bound of set of elements;
T - operation T-norm.

When modeling the project risk, classical fuzzy implication by the scientist of Azerbaijani origin L. Zade is used as the rule for calculating fuzzy implication:

$$\mu R(x,y)=\max\{\min[\mu_в(x,y\ \mu_в(y)],[1-\mu_в(x)]\} \quad (3)$$

The main methods of fuzzy inference in NPM are direct and reverse inference. Direct inference is based on the fuzzy modus ponens inference rule. When constructing fuzzy production model of risk assessment of ISP it is necessary to form full space of prerequisites for $X = \{xi\}$, $i = \overline{1,n}$ - the factors which are risk sources and full space of inferences $Y = \{yj\}$, $j = \overline{1,m}$ - risk indicators of various areas of ISP.

Disadvantages of the method are the presence of some subjectivity in expert's assessments and difficulties in finding high-skilled specialists (engineers). When using fuzzy inference, rule base can be quite volumetric.

Use of fuzzy logic for risk assessment of procurement production construction. There is no universal method that enables to give an accurate risk assessment. When assessing environmental risks, the use of probable and statistic methods may be limited due to the absence of statistic data or difficulties in selecting the type of distribution of the value.

The use of fuzzy sets allows operating with qualitative variables, considering hidden laws and non-linear dependencies between data.

Let's consider the main steps of fuzzy inference. Let’s take an environmental risk assessment as an example. Contamination threat factors to environmental pollution during production activities were identified: soil contamination, air pollution; water pollution.

For environmental pollution risk, the rule base could be as follows:

«IF<air pollution = very low>&<soil contamination = very low>&<water contamination =very low>THEN<risk = very low>»;

«IF<air pollution = very low>&<soil contamination = low>&<water pollution = low>THEN<risk = very low>»;

«IF<air pollution = very high>&<soil contamination = high>&<water pollution = high>THEN<risk = very high>».

Risk factors "soil contamination" "air pollution," "water pollution" are input variables, and "risk" is output variable. In transformation to fuzzy form, numeric value of an input parameter is transformed to fuzzy form, that is, there is membership function for this parameter. For example, for air pollution, rated 20 on 100-point scale.

At aggregation and activation stages, truth degree of each inferences for each of rules of fuzzy inference systems is determined, and then the obtained fuzzy subsets of each output variable are combined into one fuzzy subset. In the quantitative value calculation step, the resulting output variables are converted to quantitative values by one of the quantitative value calculation methods. Most often, the center of gravity method is used for this [9].

The calculation of quantitative value by this way, environmental risk assessment in development of procurement production is one of the most important points for the development of the project. For environmental and human risks, the most appropriate method is fuzzy logic apparatus, which allows getting values under conditions of uncertainty or in the presence of weekly structured information.

Conclusion. Thus, the evaluation of the construction of a plant on procurement production and environmental risks in development projects for procurement production is one of the most important points in the development of the project. For environmental and human hazards, the most appropriate method is fuzzy logic apparatus, which allows getting values under conditions of uncertainty or in the presence of weekly structured information.

In addition, the developed fuzzy production model and decision support system allows procurement and construction projects to plan actions on reduction of project risk by analyzing situations according to if-then rule. Assessment of various impacts on the design process and the implementation of construction facilities allow purposefully reducing risks at various stages of the project cycle. The obtained risk values based on the fuzzy logic mechanism allow considering both the quality of input information and the reliability of experts’ information. The mechanism is highly capable of adapting it to existing risk management models, including modifying it in view of various implementation conditions of ISP.

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Аліев Е. А., кандидат економічних наук, заступник завідувача науково-дослідної лабораторії наноматеріалів і нанотехнологій. **Габібов І. А.,** доктор технічних наук, професор. Азербайджанський державний університет нафти і промисловості. **Веліев В. К.,** кандидат хімічних наук. **Гасанова Т. Б.**, докторант. Азербайджанський архітектурно-будівельний університет. **Застосування нечіткої логіки для аналізу ризиків інвестиційних проектів.** Відомо, що трудомісткість заготівельних робіт становить майже половину від загального обсягу трудомісткості виробництва продукції машинобудування і чинить серйозний вплив на формування собівартості виробів. Отже, правильний вибір методу їх отримання й визначення геометричних параметрів заготовок на початкових стадіях проектування є важливими етапом процесу зниження собівартості деталей і підвищення економічної ефективності виробництва. Розглянуто проблему оцінювання ризиків під час проектування заготівельного виробництва. Наведено класифікацію методів оцінювання ризиків, засновану на повноті інформації, викладено суть методів імітаційного моделювання, статистичного методу, методу аналізу чутливості, експертного методу й підходу, заснованого на застосуванні нечіткої логіки. Розроблена нечітка продукційна модель і система підтримки прийняття рішень дозволяють інвестиційно-будівельним проектам виконувати планування дій щодо зниження ризику проектів шляхом аналізу ситуацій на передпроектному етапі виробництва.

Ключові слова: невизначеність, ризик, ризикоутворюючі фактори, оцінювання ризиків, методи оцінювання ризиків, нечітка логіка, нечіткий логічний висновок.

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E. A. Aliyev, PhD (Economics), Deputy Head of Scientific-Research Laboratory «Nano Materials and Nano Technology» of Azerbaijan State Oil and Industry University. **I. A. Habibov**, D. Sc. (Technical Sciences), Professor, Azerbaijan State Oil and Industry University. **V. K. Veliyev**, PhD (Chemistry). **T. B. Hasanova**, Doctoral student, Azerbaijan Architecture and Construction University. **The Use of Fuzzy Logic for Risk Assessment in the Construction Projects.** It is known that the labor intensity of procurement works is almost half of the total labor intensity of the production of mechanical engineering products and has a serious impact on the formation of the cost of the product. Therefore, the correct choice of the method of their production and the determination of the geometric parameters of the work pieces in the initial stages of design are important steps aimed at reducing the cost of parts and increasing the economic efficiency of production. The article deals with the problem of risk assessment in the design of procurement production. The classification of risk assessment methods based on the completeness of information is given, the essence of the methods of simulation modeling, statistical method, sensitivity analysis method, expert method and approach based on the use of fuzzy logic is presented. The developed fuzzy production model and decision support system allows investment and construction projects to plan actions to reduce the risk of projects by analyzing situations at the pre-project stage of production.

Key words: uncertainty, risk, risk-generating factors, risk assessment, risk assessment methods, fuzzy logic, fuzzy logic conclusion.