ATLANTIS PRESS
Advances in Computer Science Research (ACSR), volume 85
Third Workshop on Computer Modelling in Decision Making (CMDM 2018)

Approach for Economic Risks Modeling and Anti-risk Decision Making in a Transport Company

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***Abstract*—The article discusses economic risks as a form of uncertainty actualization that characterizes the management decisions quality. An approach to modeling and managing the company's risks which is based on a step-by-step process of identifying the most significant risks and their factors on the basis of simulation modeling and developing management decisions to minimize the economic loss and to minimize the frequency of risk events when it is impossible to completely prevent risks is proposed. This approach was applied in the transport company and demonstrated an economic effect of its implementation.**

***Index Terms*—economic risk, risk modeling, risk management, prediction of economic efficiency of anti-risk decisions, decision making**

I. Introduction

In the practice of companies' production and economic activities until recently the tradition of risk reducing to the problems of financial management prevailed, and methods of financial risk management were associated with methods of economic activity insurance. Such one-sided view on the risk analysis problems was not adequate to existing realities. In the mid-90s of the XX century research investigations began to appear in which the problems of economic risk management were considered in a broader context [1]–[6]. In these works the management of economic risk is correlated with the company multifunctionality and is linked to the interests and expectations diversity of various economic agents. In recent years there has been a transition to a new paradigm providing for a comprehensive review of the risk situation in all divisions and in all spheres of companies' activities [7], [8].

When determining the economic risk it is advisable to use the targeted approach and under the risk to understand the measure of deviation from the purpose of the companies' economic activity and the scale of the potential financial loss caused by this deviation. In this definition risks are identified as the actualization in the future of uncertain and unpredictable results of decisions in the companies' activities in terms of achieving the targeted goals. Risk as an economic category characterizes the quality of decisions in terms of achieving the targeted goals.

Nowadays the risk assessment of economic activity is carried out on the basis of a number of methods, the choice of which is determined by the risk nature and its factors. Statistical methods that use empirical material, expert and heuristic methods, based on the experience and intuition of experts of the relevant subject area, as well as methods of simulation are widely used. The choice of a specific method for risk assessment is determined by the quality of available information, the complexity of the processes being studied, the personality characteristics of the decision-maker (its limited rationality, risk aversion, degree of activity in terms of distortion of the decisions prescribed to him).

The changing mechanisms of interaction of economic agents and systems, the type of communication between them, the composition of system factors and changes in the conditions for the business processes can be quickly displayed and introduced into a computer model. The ideology of analyzing complex but well-adapted computer models replaces with time simple and universal mathematical models. Therefore, the modern research imperative should be based on the development and use of complex behavioral models of economic systems for solving specific problems under specific conditions [9], [10].

The article suggests an approach to modeling and risk management of a company based on a step-by-step process of identifying the most significant risks and their factors and developing management decisions to minimize the economic loss from the risks and to minimize the frequency of risk events when it is impossible to completely prevent them. The conceptual scheme of economic risk management system is presented in Fig. 1.

The work will examine in detail the units of factor analysis and risk assessment and development of anti-risk decisions; also, evaluation of the economic effectiveness of the proposed analysis scheme will be carried out.

II. Economic Risk as a Form of Uncertainty Actualization: Concept, Research Methods

The risk phenomenon in modeling and management of social, economic and production systems is often associated with the uncertainty. Attempts have long been made to divide concepts of "risk" and "uncertainty". Thus, F. Knight [11] distinguished between two types of uncertainty. The first type is a measurable uncertainty, to which a certain probability value can be attributed, so he called such uncertainty "risk". The second type of uncertainty is true uncertainty, it is impossible to estimate its probability. Beginning with Knight in the management literature, the decision-making problems are divided into tasks in terms of risk, decision-making problems under uncertainty. In the management context, uncertainty is a synonym for inaccuracy, insufficiency, incompleteness of information about the object. Also, in the theory of technical

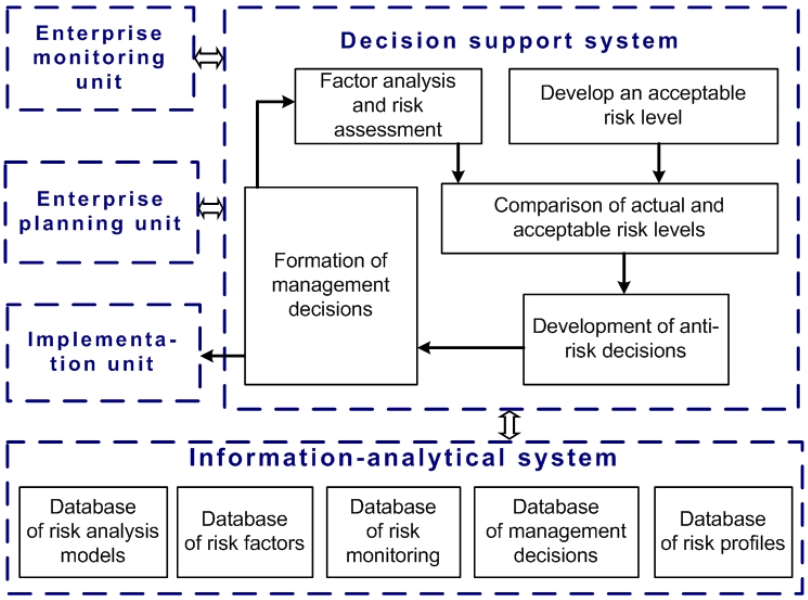

Figure 1. Conceptual scheme of the company's economic risk management system

system control, the category "risk" is not used, and shows that in the absence of a decision maker it is sufficient to use the term of "uncertainty".

The analysis of the insolvency of Knight's statements shows the following. Since all objects, subjects and processes are in a state of irreversible changes, no circumstances can be reproduced with a high degree of accuracy. Secondly, experimental studies [12], [13] have shown that the same individual behaves differently in similar situations. The attribution of human behavior in a given situation is unpredictable, both on the part of other individuals, and on the part of him. Therefore, uncertainty can be neither measurable (which Knight calls risk), nor true. It can only be an uncertainty, since a person is not given a priori any complete list of all possible outcomes of his actions, nor their objective (statistical) probabilities of actualization. The individual can assume the occurrence of certain consequences and attribute to them his subjective probabilities of probability, reflecting the measure of his personal confidence in his predictions.

From the point of view of management, the difference between uncertainty and risk is that risk, as a displaying of the event probability from the set of possible events can be measured or calculated. The risk objectively exists and is connected with the probabilistic nature of many processes, the multivariate nature of material, social, information relations, into which the subjects of socio-economic systems belong. Uncertainty as an economic category reflects the impossibility of accurately taking into account and calculating the changes that arise in the system under the influence of complex cause-effect relationships, social, political, economic, demographic and other reasons. Uncertainty can not be measured and it can not be controlled due to limited scientific knowledge of the processes and laws of economic development. At the same time, the display of uncertainty in economic situations leads to deviations in indicators, to the loss of accuracy of calculations and forecasts, and therefore should be taken into account.

The theory of decision-making distinguishes three types of uncertainty: the uncertainty of the environment external to the system under consideration (uncertainty of nature), the uncertainty of goals, the uncertainty of the actions of other participants in economic interactions, for example, competitors and consumers [14]. In these arguments, the notion of "risk" does not appear anywhere, since uncertainty is a property of reality, objective or subjective. This property exists in itself, without being associated with any activity. In contrast, the concept of "risk" appears when it is required to characterize some activity. It is in the context of action and activity that it becomes necessary to introduce a risk category in order to characterize this activity in conditions of uncertainty and to assess the effectiveness, quality of this activity from the position of the goals set and the achievement of these goals.

The economic-mathematical dictionary [15] concretizes the uncertainty in the system as a situation when information about possible system states and the external environment is completely or partially missing. At the same time true uncertainty is allocated, that is, the multivariance of development, the impossibility of an unambiguous choice of an effective decisions, and information uncertainty arising from incompleteness, inaccuracy of information about the object under study. In this case, it is important to understand what type of information can be obtained to overcome uncertainty in decision-making problems. It seems reasonable to use a sequence of data-information-knowledge, reflecting the degree of comprehension and depth of processing of information [12], [16], [17]. K. Arrow noted that the role of economic information is to reduce uncertainty and prevent losses [18].

In this paper, the division of uncertainty according to the target criterion is adopted, in which uncertainty is a characteristic of objective reality or its subjective representation, and risk is a characteristic of the same reality, but in the context of purposeful activity of the subject. It should also be noted that the classical decision-making theory deals with formalized rules of analysis and choice of solutions, and the theory of risk management shifts the emphasis towards the study of weakly structured phenomena, the development of methods for assessing sufficiency and replenishing the information for decision-making, generating solutions and identifying possible threats, as well as forecasting the results of the application of selected decisions. Thus, the theory of economic laws management [12] pays more attention to the analysis and comparison of information on the economic situation at the time of the preparation of the decision and at the time of decision implementing, as well as the development of prediction methods for the application results of management decisions.

For the formalized description of uncertainty the following mathematical models are used, differing from others by the level of information accessibility of the decision making person. These models are: stochastic, linguistic (fuzzy) and gaming (non-stochastic). In stochastic models uncertainty is described by the probability distribution on a given set, in linguistic models by the membership function, in gaming models it is possible to specify an unstructured set of values of elementary events that can be realized. A more complete set of models for describing uncertainties is given in Table I.

The basis of the classification has two characteristics – information reliability (certainty, risk, uncertainty) and a time factor (statics, dynamics). The methods of decision-making are most well developed for the problems of "statics-certainty". Algorithms of linear programming are especially widespread. To solve nonlinear programming problems, linear approximation is used to apply linear programming algorithms. Stochastic programming allows us to additionally take into account probabilistic factors. The problems of solving static problems for indefinite initial information are considered in game theory, the theory of statistical solutions, methods of multicriteria optimization, and the theory of fuzzy sets. Such methods as "dynamics-certainty" are mainly designed to solve technical and economic problems. Stochastic dynamic programming and control of complex processes relate to dynamic programming and optimal control. Queuing methods are designed for the analysis of service systems of randomly occurring requirements. Such methods as "dynamics-certainty" and "dynamics-risk" differ from "statics-certainty" methods. However, there are many more technological requirements. A correct formulation of some problems requires a sufficiently high level of mathematical preparation. In the problems of socio-economic processes prediction, statistical and econometric methods as well as simulation methods are the most common tools [19]–[22].

III. Simulation Model for Total Financial Loss Estimation

The paper deals with the activities of a transport company, and the risk description is based on the computer simulation method (system-dynamic modeling method). The goals of the model development are analysis and modeling of various risk situations, isolated and joint influence of risk factors on the efficiency of economic activity. The model for simulation of the economic activities under risks and forming the financial results in the form of flows of costs, income, profit and total financial loss is shown in Fig. 2.

The model consists of dynamic variables, or "stores" (denoted by □), auxiliary variables (○) and constants (◇), connected by cause-effect relations. The simulation model allows the change of the following parameters: the rate of profit tax; number of months of equipment per year; number of accidents per year; duration of accident elimination; financial loss from one accident; number of scheduled repairs per year; duration of one repair; costs of labor and materials for one repair; depreciation of equipment; cost of petroleum products. The model takes into account three factors of economic risk: the competitor price, the growth of fuel and the number of accidents per year. The growth of fuel and the competitor

Table I
Mathematical methods for risks description and decision-making models

Type of time dynamic	Certainty	Risk	Uncertainty		
			Several persons	Non-acquaintance	Multiple criteria
Statics	Linear programming	Stochastic programming	Game theory	Statistical Solutions	Multicriteria optimization
	Nonlinear programming				Utility theory
	Parametric programming				Group solutions
	Discrete, including integer programming	Antagonistic games		Games with nature	Games with nature
	Geometric programming			Theory of fuzzy sets	
Dynamics	Calculus of variations	Stochastic dynamic programming	Theory positional games	Theory of learning	Multicriteria optimization in function spaces

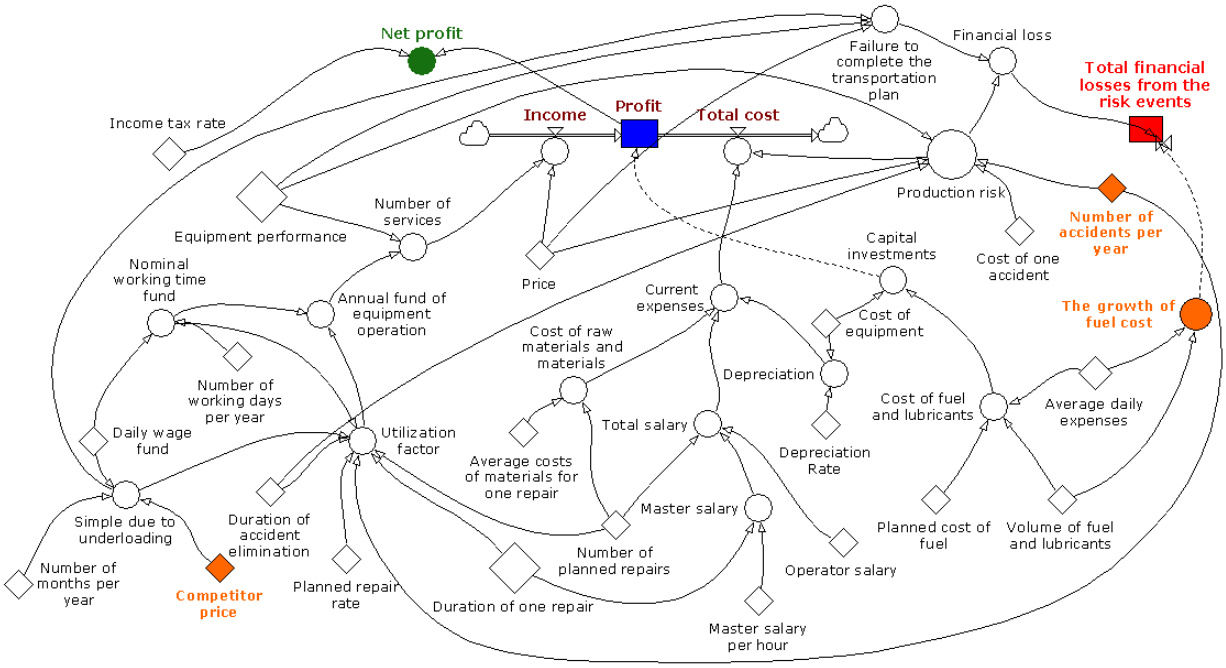

Figure 2. System-dynamic model for the total financial loss

price are characterized by high values of possible financial loss. Emergency situations contribute to the occurrence of unplanned costs which reduce the companies' profitability. There were simulated more than seventy different situations. For each risk, two development scenarios were considered: the best and the worst. All possible combinations of the best and the worst values of risk factors were investigated. Then random combinations of varied parameters were modeled. The following scenarios were investigated: 1) the increase in the competitor price from 4% to 15% from the initial price; 2) increase in the cost of petroleum products from 5% to 15%; 3) an increase in the number of accidents per year from 5% to 15% from the current level; 4) the cooperation impact of factors – the first and second risk factors; the second and third; the first and third; the first, second and third. Selected results of simulation experiments are presented in Table II.

Analysis of the simulation results showed a strong influence of the first and second risk factors on the financial losses, Table III. Interfactor influence does not exceed the permissible limits, that is, multicollinearity is not observed.

The simplest multiple regression risk factors on the total level of financial loss is as follows: the competitor price (r_1), the growth of fuel cost (r_2), the number of accidents per year (r_3), allowing rapid analysis and forecasting of cumulative financial loss for investigated risk factors and has the form:

$$\underset{\text{st. error}}{\text{losses}} = \underset{1021.1}{2268.4} + \underset{11.9}{31.3} \cdot r_1 + \underset{101.6}{637.5} \cdot r_2 + \underset{2154.6}{7858.6} \cdot r_3;$$
$$R^2 = 0.76;\ F = 26.2;\ DW = 2.2,$$

The developed system-dynamic model of financial losses from the possible risk events taking into account the influence of the identified risk factors (the number of accidents per year, changes in the cost of petroleum products and changes in the prices of competitors for the services provided) allows to model various risk situations, to assess the extent of the isolated and joint effect of risk- factors on the financial losses and carry out a forecast of the company's performance indicators (revenue, profit etc.).

IV. Management Decisions for Risks Minimization

Analysis of the most significant risks and their factors has shown a strong impact on the companies' economic and financial efficiency. Statistical information of the analyzed company about revealed risks such as each risk frequency, average cost of a single risk event, and estimates the total financial losses due to the onset of each of the three risk types is presented in Table IV.

The annual financial losses were more than 3% of total revenue, which is quite costly for the company. This necessitates the development of anti-risk decisions and appropriate management solutions for their implementation. Management decisions for the company under study are presented in Table V. Implementation of these solutions allows minimizing the financial losses of the motor transportation company, and thus improving its efficiency. The proposed package of solutions can be used by any other company involved in the transport business.

Calculations of economic feasibility of introduction of the mentioned decisions aimed at minimization of financial loss from negative risk events have shown that the savings from these decisions will amount to 55,318 rubles, which will significantly increase the company's net profit.

Table II
THE RESULTS OF THE SIMULATION EXPERIMENTS (SCENARIO 4)

Experiment number	The competitor price, rub.	Growth of fuel cost,%	Number of accidents per year, rub.	Net profit, ths. rub.	The financial loss from the risk events, ths. rub.
1	20	5	166	2 574 386	511 994
2	20	6	167	2 574 372	511 996
3	20	7	168	2 574 156	511 997
4	20	8	169	2 574 253	512 000
5	20	9	170	2 574 257	512 002
6	20	10	171	2 574 350	512 009
7	20	11	172	2 574 314	512 006
8	20	12	173	2 574 272	512 005
9	20	13	174	2 574 270	512 019
10	20	14	175	2 574 252	512 026
11	20	15	176	2 574 236	512 019
12	25	5	166	2 574 261	512 019
13	26	6	167	2 574 258	512 022
14	27	7	168	2 574 255	512 025
15	28	8	169	2 574 252	512 030
16	29	9	170	2 574 269	512 025
17	30	10	171	2 574 246	512 034
18	31	11	172	2 574 222	512 089
19	32	12	173	2 574 215	512 090
20	33	13	174	2 574 211	512 039
21	34	14	175	2 574 198	512 146
22	35	15	176	2 574 156	512 163

Table III
CORRELATION MATRIX OF RISK FACTORS AND FINANCIAL LOSSES

Variable	r_1	r_2	r_3	losses
r_1	1.000	0.100	0.354	0.004
r_2	0.100	1.000	0.069	0.854
r_3	0.354	0.069	1.000	0.147
losses	0.004	0.854	0.147	1.000

Table IV
THE FINANCIAL LOSS BY TYPE OF RISK

Risk	Frequency of occurrence, number / year	The average cost of one risk event, rub.	The cost of financial losses per year, rub.
Number of accidents	161	93 167	15 000 000
Growth of fuel cost	10	40 000	400 000
Competitor price	3	16 000 000	49 000 000
Total			64 400 000

Table V
MAP OF ANTI-RISK DECISIONS

Risk type	Anti-risk decision	Costs, rub.	Period of fulfillment	Responsible person
Number of accidents	Maintenance frequency	5 760 000	Every month	Technical department
	Timely replacement of tires	26 000	November 1 in the winter season	Technical department
	Training, driver certification	30 000	2 times a year	Human Resources Department
Growth of fuel cost	Conversion to modular refueling of diesel fuel	200 000	During a year	Technical department
Competitor price	Drivers care	132 000	Daily	Medical officer
	Implementation of the pilot project “Turnstile”	2 000 000	During a year	Technical department
	Developing the mobile application	732 000	During a year	Technical department
Total		8 682 000		

V. Results and Conclusions

The necessity of using not only economic and statistical methods of risk assessment, but also heuristic and simulation methods for the adequate description of the economic processes is grounded. This allows taking into account in risks assessing and predicting the following properties and features of economic processes and systems: 1) uncertainty, stochasticity, incompleteness and unclear initial information about economic system and its external environment; 2) non-stationary nature of economic system development; 3) high dynamism of socio-economic processes; 4) subjective nature of economic decisions.

A system-dynamic model for financial loss from the possible risk events takes into account the influence of the main risk factors (the number of accidents per year, the change in the cost of petroleum products, the change in the prices of competitors for the services provided), which allows modeling various risk situations, the isolated and joint influence of risk factors on the financial loss and profit of the company.

A set of decisions for managing some significant risks has been formed, which differs from the existing ones by the complexity of their use, which provides a systemic (synergetic) effect of their implementation. The application results of proposed theoretical provisions, methods and models using actual data about transport company activity of the Republic of Bashkortostan are of great practical significance.

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