УДК 368:519.86

Lapishko M. L.
Ph. D. in Economics, Professor,
Professor of the Finance, Account and Analysis Department
«Lviv Polytechnic» National University, Ukraine;
e-mail: lapishko@i.ua; ORCID ID: 0000-0002-6690-3080
Danylkiv K. P.
Ph. D. in Economics, Assistant,
Assistant of the Finance, Account and Analysis Department
«Lviv Polytechnic» National University, Ukraine;
e-mail: krisdanko@ukr.net; ORCID ID: 0000-0003-1283-6844
Dobosh N. M.
Ph. D. in Economics, Associate professor
Associate professor of the Finance, Account and Analysis Department
«Lviv Polytechnic» National University, Ukraine;
e-mail: nazar_dobosh@ukr.net; ORCID ID: 0000-0001-6600-2111

IMMATIOUS-AUTOMATIC SIMULATION OF PROCESSES IN INSURANCE ACTIVITIES

Abstract. On the basis of automated-simulation method of modelling it is possible to represent prognostication of size formed insurance and systems of accruals and money streams of insurer during realization of processes of insurance, reinsurance and investment activity of insurer.

By means of this method it is possible to investigate dependence of forming of insurance and reserve funds of insurer on the volume of receivabless of insurance bonuses and payments of amounts covered and insurance compensations with the aim of analysis and control after the financial state of insurance company and determination of profitability of insurance operations.

Automated modeling tool allows at any time to predict the size of the existing insurance fund, which serves as the main source for fulfilling the financial obligations of the insurer to the policyholder, while taking into account the probabilistic characteristics of the insurance processes.

Namely, in our opinion, the automated-simulation method of modeling allowed to solve the problem of forecasting the cash flows of the insurer and, accordingly, ensuring its financial stability in the long run. This method provides an opportunity to predict the size of the formed insurance and reserve funds, to solve the problem of establishing the optimal amount of the insurer's own allowance, to choose a strategy of investment activity.

Keywords: insurance, immatious-automatic simulation, forecasting of insurer cash flows, financial instability of the insurer, economic processes.

JEL Classification: C15, C60, G22, G32

Formulas: 14; fig.: 0; tabl.: 2; bibl.: 9.

Лапішко М. Л.
к.е.н., професор кафедри фінансів, обліку і аналізу,
Національний університет «Львівська політехніка»,Україна;
e-mail: lapishko@i.ua; ORCID ID: 0000-0002-6690-3080
Данилків Х. П.
к.е.н., асистент кафедри фінансів, обліку і аналізу,
Національний університет «Львівська політехніка»,Україна;
e-mail: krisdanko@ukr.net; ORCID ID: 0000-0003-1283-6844
Добош Н. М.
к.е.н., доцент кафедри фінансів, обліку і аналізу,
Національний університет «Львівська політехніка»,Україна;
e-mail: nazar_dobosh@ukr.net; ORCID ID: 0000-0001-6600-2111

ІМІТАЦІЙНО-АВТОМАТНЕ МОДЕЛЮВАННЯ ПРОЦЕСІВ У СТРАХОВІЙ ДІЯЛЬНОСТІ

Анотація. Стаття присвячена дослідженню ефективності застосування економіко-математичних методів моделювання процесів страхової діяльності. Оцінено наявні методики аналізу фінансової стійкості страхових організацій і запропоновано напрями їхнього вдосконалення шляхом використання імітаційно-автоматного моделювання та інтеграції у систему аналітичного забезпечення управління фінансовою стійкістю страховика. Визначено основні фактори, що впливають на рентабельність діяльності страхових компаній, та проведено розрахунок відповідного інтегрального показника.

Ключові слова: страхування, імітаційно-автоматне моделювання, прогнозування грошових потоків страховика, фінансова стійкість страховика, економічні процеси.

Формул: 14; рис.: 0; табл.: 2; бібл.: 9.

Лапишко М. Л.
к.э.н., профессор кафедры финансов, учета и анализа,
Национальный университет «Львовская политехника», Украина;
e-mail: lapishko@i.ua; ORCID ID: 0000-0002-6690-3080
Данылкив К. П.
к.э.н., ассистент кафедры финансов, учета и анализа,
Национальный университет «Львовская политехника», Украина;
e-mail: krisdanko@ukr.net; ORCID ID: 0000-0003-1283-6844
Добош Н. М.
к.э.н., доцент кафедры финансов, учета и анализа,
Национальный университет «Львовская политехника», Украина;
e-mail: nazar_dobosh@ukr.net; ORCID ID: 0000-0001-6600-2111

ИМИТАЦИОННО-АВТОМАТНОЕ МОДЕЛИРОВАНИЕ ПРОЦЕССОВ В СТРАХОВОЙ ДЕЯТЕЛЬНОСТИ

Аннотация. Статья посвящена исследованию применения основных экономико-математических методов в моделировании процессов страховой деятельности. Определены тенденции развития и выяснены особенности финансовой деятельности страховщиков на страховом рынке Украины. Оценены имеющиеся методики анализа финансовой стойкости страховых организаций и предложены направления их совершенствования и интеграции в систему аналитического обеспечения управления финансовой стойкостью страховщика. Определены основные факторы, которые влияют на рентабельность деятельности страховых компаний, и проведен расчет соответствующего интегрального показателя.

Ключевые слова: страхование, имитационно-автоматное моделирование, прогнозирование денежных потоков страховщика, финансовая стойкость, экономические процессы.

Формул: 14; рис.: 0; табл.: 2; библ.: 9.

Introduction. The reliability of conclusions of any scientific research depends to a large extent on the use of known mathematical methods and models in the process of its implementation. However, not all commonly used economic and mathematical methods are capable of forecasting and carrying out adequate analysis based on today's market conditions. It is important to choose among them the most adequate, which would take into account all the peculiarities of the type of the activity. The intensive development of the Ukrainian insurance market requires financial forecasting and optimization of insurance and reinsurance processes, which is impossible without the use of economic-mathematical modeling methods. These methods are widely used for optimizing the economic processes, and when solving an insurance specific problem, it is important to find a method that would most closely relate to the situation as well as respond to its effectiveness.

When solving the tasks of forecasting insurance processes it is necessary to take into account their dynamics over sufficient period of time, therefore, utilizing dynamic economic-mathematical methods. It is essential to note that insurance processes inherit only their specific features. All these requirements correspond to an automated-simulation method of modeling, one of the devices of fuzzy logic. It's important to note the universality of application, flexibility, ease of conversion of the characteristics under study, simplicity of the mechanism of framework and the interaction of automated-simulation modeling in comparison with other methods.

Analysis of research and problem statement. Concerns with questions on evaluation, provision and forecasting of the main financial indicators of the insurance market and their individual parts are handled by many scientists. The research of the index of financial stability, one of the most important indicators for an insurance company, is carried out by leading domestic and foreign scientists: I. Alekseev, V. Bazylevych, V. Baranova, N. Vnukova, O. Vovchak, O. Gamankova, O. Zaruba, N. Kostina, V. Malko, M. Mni, S. Naumenkov, L. Orlaniuk-Malitskaya, S. Osadets, V. Plisa, A. Rabiya, T. Rotova, N. Tkachenko, O. Tumanova, K. Turbina, V. Furman, V. Shakhov. Applied aspects of the utilization of economical and mathematical methods of modeling in banking, investment, insurance activities are described in the writings of Ukrainian scientists: V. Vitlinsky, M. Sevavko, M. Prituly and foreign authors - P. Fischburn, A. Nedosekina. Imitation-automatic simulation has found its embodiment in the scientific works of prominent scientists: A.A. Bakayev, N.I. Kostina, N.V. Yarovitsky.

In spite of the considerable scientific advances made on the use of economic- mathematical methods of modeling for financial forecasting and optimization of insurance and reinsurance processes, it must still be noted that the issue of taking into account the dynamics of insurance processes over a sufficient period of time in forecasting insurance processes is due to the lack of attention made by the scientists, which therefore requires a deeper and more detailed study of this issue while utilizing the automated-simulation modeling method.

The purpose of the article is the scientific and methodological substantiation of the framework and use of automated-simulation modeling for optimization of processes within the insurance industry.

The main task is to test the automated-simulation modeling to determine the integrated index of financial stability of an insurance company.

Research results. The practice of insurance business in Ukraine shows that insurance companies, throughout the course of their operations, use a modern apparatus of theory of random mathematical statistics and econometrics processes, which serves as the basis of fundamental means of management. However, in most approaches to the simulation of economic processes in insurance, there is no proper link between theory and practice, since solving insurance tasks is realized without sufficient deepening into the economic essence of simulated phenomena.

For all participants in the insurance market of Ukraine (insurers, the insurer itself, supervisors and insurance regulators, rating agencies and other economic entities) the most important is the ability of an insurance company to timely and fully implement its obligations. This is the key to its financial sustainability and trustworthiness. The main components of ensuring the financial stability of the insurance company include: sufficient equity capital, balanced tariff policy, insurance portfolio balanced by volume and risk, and effective placement of insurance reserves. Importance of concerns of economic-mathematical modeling of insurance processes is present in theoretical, applied, and institutional and regulatory aspects.

In the theoretical aspect, the importance is evideneced in that the calculation of insurance indices involves the quantitative assessment of the random characteristics of insurance risks, which requires a special approach based on the provisions of the theory of probability and mathematical statistics.

In the applied aspect, importance of problems of economic-mathematical modeling is due to the objective need for identification, analysis, measurement and management of the insurance process, which will allow to make informed and effective decisions to management in the process of the insurance company's activities.

In the institutional and regulatory aspect, importance is evidenced in the tasks of regulating and supervising state agencies of the activity of insurance companies in order to maintain the stability of the financial system as a whole and protect the rights of policyholders.

It is necessary to review the conceptual modeling foundations of financial and socioeconomic systems , to introduce mathematical tools in the practice of financial-economic analysis and forecasting, which would enable to take into account all available information about the research object (in particular, expert knowledge), as well as to carry out effective debugging models based on real statistics. It must take into account Ukrainian realities of an organization and conduct of business and be based on modern world trends of economic science, one of which being the theory of fuzzy logic, soft computing and approximate calculations [1, p. 15].

One of the methods of fuzzy logic, which can be applied to determine the financial stability of an insurance company, is automatic-simulation modeling. On the basis of the automatic-simulation method of modeling, one can depict the forecasting of the value of the insurer's current insurance as well as reserve the funds and cash flows in the processes of insurance, reinsurance and investment activities of the insurer.

The method allows to investigate the dependence of the formation of insurance and reserve funds of the insurer on the volume of revenues from insurance premiums and payments of insurance amounts and insurance indemnities and to analyze and control the financial status of the insurance company, determine the profitability of insurance operations.

The automated-simulation model is considered to be given if all its automations and connections between automated systems are determined or absent. Since financial stability of an insurance company can be qualified as: «excellent stability»; «reliable stability»; «good stability»; «normal stability»; «insufficient stability», then a simplified model of the insurance process can be represented in the form of five automatic machines, interconnected with each other. Under a probabilistic automation it is desirable to understand a defined object having an internal state capable of receiving an input signal and delivering an output signal. The subject automation is a discrete, initial probabilistic Mura's automation with determined outputs. This means that a change in state of the machine and the issuance of output signals are only changed at integer time points, the initial state of the automation is strictly fixed, the probability factor affects the formation of the internal state of the automation, the value of the output signal depends on the value of the input only through the internal state. Combination of automations within the system consists in the identity of output signals of some automations and with the input signals of others [2, p. 115].

One of the main factors affecting the financial condition of an insurer is the reinsurance of risks and investment activity. Automated-simulation modeling solves such an important task, such as setting an optimal amount of own allowance and choosing a strategy in the insurer's investment policy.

Automated modeling tool allows to predict the size of an existing insurance fund at any time, which serves as the main source for fulfilling the financial obligations of the insurer to the policyholder, while taking into account the probabilistic characteristics of the insurance processes. The prognosis of the reinsurance process and the investment activity of the insurer will determine the optimal amount of the insurer's own funding, which is of great importance for determining the financial reliability of the insurer, as well as the company's strategy for the adoption, appraisal and management of investment risks [3, p. 87].

The apparatus of fuzzy logic makes it possible to solve practically any economic problem. After all, many of these tasks operate with uncertainty, which in general cannot be uncovered unambiguously and clearly, and therefore they cannot be solved by classic economic-mathematical methods and thus the only remaining - the use of the above apparatus.

For example, the «brand rating» indicator, as a qualitative indicator, may be «high», «average», «high», «very high,» etc. These are the so-called values of the term set of the linguistic variable that corresponds to this indicator. The connection between the quantitative values of this indicator and its qualitative linguistic description is given by the functions belonging to its fuzzy set. So, if an enterprise can be either profitable or non-profitable, then the brand rating may be not only high, medium or some other, but half higher and half average, one quarter high and three quarters very high, etc.

That is, if for a clear set its dependent function $\mu(x)$ can take only two values, zero or one, then for the fuzzy,an arbitrary value from the segment [0, 1]. This function may be discrete or continuous. It can not be identified with probability, because the unknown distribution function, there is no repeatability of the experiments [4, p. 111].

In the considered theory, the fuzzy set is defined as the set of pairs in the form of (1):

$$A=\{(x, \mu_A(x)), x \in X\}, \tag{1}$$

where, X – universal set (base scale);

$\mu_A(x)$ – the multiple membership function A of universal set X, which determines the subjective confidence level of the expert in that the given specific value of the base scale corresponds to the fuzzy set [5, p. 37].

Since we will use continuous trapezoidal type functions (fuzzy numbers), we introduce the definition of such a number. Trapezoidal form of the fuzzy number is called the four-digit number

$$\beta=(a_1, a_2, a_3, a_4), \tag{2}$$

where, a_1, a_2, a_3, a_4 as defined in Fig. 1, that is, a_1 and a_4- abscissa of the lower base, and a_2 and a_3- abscissa of the upper base of the trapezium, which defines μ in the region with zero dependency of the carrier X in the corresponding fuzzy subset [6, p. 111].

Let's consider now the meaningful statement of the problem and the algorithm of the fuzzy assessment of the financial stability of the insurance company. Let the enterprise be characterized by a set of N indicators $X_1, X_2, ..., X_N$, which are built on the basis of accounting and expert assessments and have value for the period under investigation, respectively $x_1, x_2, ..., x_N$. It is assumed that the system of indicators $\{X\}$ is sufficient for the reliability of the analysis.

The complete set of states of A an insurance company is divided into five fuzzy subsets, which in general overlap:

A_1 - Fuzzy subset of states of «insufficient stability»;

A_2 - Fuzzy subset of states of «normal stability»;

A_3 - Fuzzy subset of states of «good stability»;

A_4 - Fuzzy subset of states of «reliable stability»;

A_5 - Fuzzy subset of states of «excellent stability».

That is, the term-set of the linguistic variable «Financial stability of the insurance company» consists of five components. Each of the A_1, A_2, A_3, A_4, A_5 sets corresponds to its dependent functions $\mu_1(V), \mu_2(V), \mu_3(V), \mu_4(V), \mu_5(V)$, where V is a comprehensive indicator of the level of financial stability of the insurance company. Moreover, the higher the V, the better the financial stability of the insurance company. We will assume that the integral index of stability V can take values from zero to one, and each of these membership functions is given by the trapezoidal number of the form (2):

$$\begin{aligned} \mu_1(V)&=\beta_1=(0,0;\, 0,0;\, 0,15;\, 0,25); \\ \mu_2(V)&=\beta_2=(0,15;\, 0,25;\, 0,35;\, 0,45); \\ \mu_3(V)&=\beta_3=(0,35;\, 0,45;\, 0,55;\, 0,65); \\ \mu_4(V)&=\beta_4=(0,55;\, 0,65;\, 0,75;\, 0,85); \\ \mu_5(V)&=\beta_5=(0,75;\, 0,85;\, 1,0;\, 1,0). \end{aligned} \tag{3}$$

The complex indicator functionally or algorithmically connected with a set of primary indicators:

$$V=\Psi(X_1, ..., X_N), \tag{4}$$

but the species Ψ is unknown and must be found.

The analytical form of formula (4) will depend on which of the primary indicators are stimulants, that is, an increase in the value of which leads to an increase of V, and which are the dissimulators, that is, the increase in magnitude leads to a decrease of V. We introduce for each of these parameters $\delta_i \left(i=\overline{1,N}\right)$, which characterizes whether this indicator is a stimulator or a dissimulator. It is calculated by the formula:

$$\delta_i = \begin{cases} 1, \mathit{if}\ X_i\ \mathit{is\ stimulator}, \\ -1, \mathit{if}\ X_i\ \mathit{is\ unstimulator}. \end{cases} \tag{5}$$

In order to solve our problem, it is necessary to determine the primary indicators that will be used by us to assess the financial stability of insurance companies and their dependent functions. Let $D(X_i)$ - the area defined by index X_i, the infinite set of points of the axis of real numbers. The linguistic variable «The level of the index X_i« will be determined identically for all indicators using five fuzzy subsets of the set $D(X_i)$: $B_j \left(j=\overline{1,5}\right)$ - the fuzzy subset «very low $(j=1)$, low $(j=2)$, average $(j=3)$, high $(j=4)$ and very high $(j=5)$ level X_i«. To describe the subset of $\{B\}$ it is necessary to form the corresponding membership functions $\lambda_j(x_i)\left(j=\overline{1,5}\right)$.

Based on expert surveys in the course of our research to determine the level of financial stability of an insurance company, we selected 7 primary indicators of $(N=7)$: the level of awareness of the brand of the company (X_1), its solvency (X_2), the liquidity of (X_3), the financial results of (X_4), the sufficiency of equity (X_5), reinsurance (X_6) and the level of financial the potential of (X_7). All of them are stimulants, therefore, $\delta_i = 1\left(i=\overline{1,7}\right)$.

If necessary, one can take into account the priority of these indicators. That is, to identify the level of financial stability of the insurance company for each i-th indicator for each of the k-th level of company's stability, it is possible to put in line the assessment of the p_{ki} significance of this initial indicator. The system of these assessments is appropriate to choose a normalized one so that it meets the following conditions:

$$\sum_{i=1}^{N} p_{ik} = 1\left(k=\overline{1,5}\right). \tag{6}$$

The values of the priority coefficients p_{ki} can be determined with the help of experts. If the primary indicators are ordered in descending order of significance for analysis:

$$X_1 \text{ f } X_2 \text{ f } ... \text{ f } X_N, \tag{7}$$

then to evaluate this significance you can use the Fishbern's scale [9]:

$$p_i = \frac{2\cdot(N-i+1)}{N\cdot(N+1)}, i=\overline{1,N}. \tag{8}$$

In the absence of advantages, the indicators are equal and equal to each other, the coefficients of priority can be calculated by the formula:

$$p_i = 1/N. \tag{9}$$

To determine the coefficients of priority in subsequent calculations, we use formula (9).

The next step of the algorithm is to construct for each of its $X_i \left(i=\overline{1,N}\right)$ attributes its $\lambda_{ij} \left(i=\overline{1,7};\ j=\overline{1,5}\right)$ dependent function. In this case, beforehand for each of them it is necessary to describe the corresponding subset of this parameter $\{B\}$ (to construct the corresponding trapezoidal numbers).

Using expert evaluation, we propose to each of the primary parameters to match the trapezoidal numbers of values of the linguistic variable of this parameter (Table 1).

Table 1

Classification of primary parameters

Indicator	Trapezoidal numbers $\{\beta\}$ for values of the linguistic variable «Parameter value»				
	«Very low»	**«low»**	**«average»**	**«high»**	**«Very high»**
X_1	(0; 0; 0,17; 0,23)	(0,17; 0,23; 0,37; 0,42)	(0,37; 0,42; 0,48; 0,53)	(0,48; 0,53; 0,67; 0,73)	(0,67; 0,73; 1; 1)
X_2	(0; 0; 0,12; 0,17)	(0,12; 0,17; 0,23; 0,28)	(0,23; 0,28; 0,52; 0,58)	(0,52; 0,58; 0,72; 0,78)	(0,72; 0,78; 1; 1)
X_3	(0; 0; 0,22; 0,27)	(0,22; 0,27; 0,38; 0,43)	(0,38; 0,43; 0,57; 0,63)	(0,57; 0,63; 0,77; 0,83)	(0,77; 0,83; 1; 1)
X_4	(0; 0; 0,08; 0,13)	(0,08; 0,13; 0,27; 0,33)	(0,27; 0,33; 0,47; 0,53)	(0,47; 0,53; 0,77; 0,83)	(0,77; 0,83; 1; 1)
X_5	(0; 0; 0,09; 0,15)	(0,09; 0,15; 0,30; 0,35)	(0,30; 0,35; 0,42; 0,47)	(0,42; 0,47; 0,63; 0,69)	(0,63; 0,69; 1; 1)
X_6	(0; 0; 0,08; 0,13)	(0,08; 0,13; 0,18; 0,23)	(0,18; 0,23; 0,37; 0,43)	(0,37; 0,43; 0,57; 0,63)	(0,57; 0,63; 1; 1)
X_7	(0; 0; 28; 33)	(28; 33; 48; 53)	(48; 53; 78; 83)	(78; 83; 108; 113)	(108; 113; ∞; ∞)

Source: calculated by the authors.

Based on the known values of each of the considered primary parameters for the investigated insurance company for each of these parameters and each value of its linguistic variable, we find the value of the membership function $\{\lambda\}$.. Next we turn from the values of the linguistic variable to the set of values $\{\lambda\}$ (Table 2).

Table 2

Transition from trapezoidal numbers to membership function

Indicator	Value of the membership function for the value of the linguistic variable «Parameter Value»				
	«Very low»	**«low»**	**«average»**	**«high»**	**«Very high»**
X_1	λ_{11}	λ_{12}	λ_{13}	λ_{14}	λ_{15}
…	…	…	…	…	…
X_7	λ_{71}	λ_{72}	λ_{73}	λ_{74}	λ_{75}

Source: calculated by the authors.

Let's consider the framework of dependent functions for each of the primary parameters $X_i \left(i = \overline{1, N}\right)$.

The first of these indicators is the level of awareness of the brand of an insurance company X_1. The scope of this indicator is $D(X_1) = [0, 1]$. Let's denote its value through K_1. Method of classification of level X_1, is made by the decision maker (CEO).

The boundary value of the intervals in the second column of this table is given by the abscissa of trapezoidal fuzzy numbers $\beta_i = (a_{1i}, a_{2i}, a_{3i}, a_{4i})$ $\left(i = \overline{1, 5}\right)$. On the sides of the adjacent trapezoid (these sides necessarily intersect), both λ are calculated, which correspond to the interval of values in which the value of K_1 falls.

A method for classifying the level of indicators X_i $(i = 1,...,7)$, performed by CEO.

The area of definition of all these indicators is the same as X_1, except for the last, for which $D(X_7) = (0, \infty)$. In this area, it is taken into account that the value of the indicator X_i $(i = 1,...,7)$ is equal to K_i $(i = 1,...,7)$.

After creating for each indicator X_i $\left(i=\overline{1, N}\right)$ dependent functions λ_{ij} $\left(i=\overline{1, 7};\ j=\overline{1, 5}\right)$, we pass to the calculation of the fuzzy number V and the corresponding exact number Y. At the same time, it is necessary to calculate auxiliary coefficients Y_k $\left(k=\overline{1, 5}\right)$ first by the formulas:

$$Y_k=\frac{\sum_{k=1}^{7} p_{ik}\lambda_{ik}}{\sum_{k=1}^{7} p_{ik}}\leq 1,\ \left(k=\overline{1, 5}\right). \tag{10}$$

It is taken into account that all the indicators that we take are stimulants, and p_{ik} are priority coefficients, determined by one of the considered methods, for example, by the formula (8).

The best way to build V is to coordinate it with the selected system of numbers $\{\beta\}$. This involves finding V in a fuzzy form [7]:

$$V=\left(v_1, v_2, v_3, v_4, v_5\right)=\sum_{k=1}^{5} Y_k\otimes\beta_k, \tag{11}$$

where the sign «$\otimes$» expresses the operation of multiplying a real number and a fuzzy number. Note that the linear combination of trapezoidal fuzzy numbers is also a trapezoidal number. Therefore, the operation of adding such numbers can be filed by a set of operations of the standard component addition of real numbers.

The final step of our algorithm is the transition from the fuzzy number V to the actual type Y, which is suitable for use of CEO, that is, the implementation of the operation of de-fuzzing this fuzzy number.

The affiliation of the trapezoid number V to one of the fuzzy subsets $\{A\}$ of state of the insurance company can be determined using the cross-sectional formulas and the union of fuzzy sets. The degree of affiliation of an insurance company to one of the classes A_k is determined by the formula:

$$Identity..level=\frac{area\left(V\cap A_k\right)}{area\left(V\cup A_k\right)}, \tag{12}$$

where the area is defined as the corresponding area, limited by trapezoidal curves of dependent functions.

To recognize the state of the financial stability of an insurance company, we use a rule that is based on (3).

We will use to identify the state of the insurance company by an approximate method that is more convenient in the calculations. It consists in the definition of functions $\mu_k(Y)$ $\left(k=\overline{1, 5}\right)$ by the type of numbers β (3) and taking into account the auxiliary parameters.

$$y_k=\frac{a_2^k+a_3^k}{2},\ \left(k=\overline{1, 5}\right). \tag{13}$$

The formula (2) is used here.

If the value obtained in the analysis is $\mu_k\left(Y\right)>0,\ k=1, ..., 5,$ then we calculate that the state of the insurance company is described by the linguistic value of subset A_k with the level of compliance $\mu_k\left(Y\right)$. In other cases, the dependency of Y has no other subset of A_k. Although here it should be noted that with such a choice of system $\{\mu\}$ the affiliation is possible no more than two overlapping subsets [8, p. 192].

Taking into account (3), (11) and (13) we obtain:

$$Y=\sum_{k=1}^{5} y_k\cdot Y_k=0,075\cdot Y_1+0,3\cdot Y_2+0,5\cdot Y_3+0,7\cdot Y_4+0,925\cdot Y_5. \tag{14}$$

This integral indicator reflects the profitability of an insurance company with a high probability accuracy of its impact on all deterministic components. [9, p. 22].

This complex analysis of the insurer's economic components, using the described economic-mathematical model, has shown that profitability of insurance companies affects the distribution of income between different types of insurance, the main impact being the share of income from voluntary property insurance and «other activities»; the overall effectiveness of the insurer is significantly affected by structural links by the type of insurance and their profitability.

At the present stage, insurers use a variety of shadow schemes, concealment of income, manipulation of cash flows, discredited by the insurance institution itself, and requires the creation of a state regulation mechanism adapted to market changes and the basis of which should be the modern regulatory framework [10, p. 207].

Conclusions. In our opinion, the automated-simulation method of modeling allowed to solve the problem of forecasting the cash flows of the insurer and, accordingly, ensuring its financial sustainability in the long run. This method provides an opportunity to predict the size of a formed insurance and reserve funds, to solve the problem of establishing the optimal amount of the insurer's own funding, and to choose a strategy of investment activity.

Further studies should be conducted in the direction of forecasting and assessing the financial stability and solvency of an insurance organization both in the long-term and in the short-term. Also, in our opinion, it would be important and expedient to resolve the following concerns:

- develop a model for managing the risk of loss of financial stability of the insurer;
- to investigate the role of reinsurance and co-insurance as factors of influence on the level of financial stability of insurance organizations;
- to formulate and substantiate practical recommendations regarding optimization of the capital structure of the insurance organization;
- to develop proposals for diversifying the structure of capital sources of insurance organizations in Ukraine in order to ensure their financial stability;
- identify and establish the optimal structure of insurance portfolio for companies in terms of collected insurance payments by type of insurance;
- to substantiate the necessity of the fastest adoption of a set of legislative and institutional measures to prevent the crisis of the domestic insurance system as a result of the threat of loss of nationality.

To solve some of these tasks successfully a automated-simulation modeling method can be used. The results of the work should be used to optimize the mechanism for the formation and maintenance of financial stability of insurance organizations in the Ukrainian economy.

Література

1. Леонова О. В. Моделирование процессов убытков страховщика с помощью вероятностных распределений на примере страховой компании РОСГОССТРАХ / О. В. Леонова, П. Г. Сорокина // Baikal Research Journal (г. Иркутск). – 2017. – Т. 8, № 4. – С. 17–27.
2. Недосекин А. О. Нечетко-множественный анализ риска фондовых инвестиций / А. О. Недосекин. – Санкт-Петербург, 2002. – 180 с.
3. Borch K. Mathematical Models in Insurance / K. Borch // Astin Bulletin: The Journal of the IAA. – Cambridge, 1974. – № 3, Vol. 7. – P. 192–202.
4. Сявавко М. Математичне моделювання за умов невизначеності / М. Сявавко, О. Рибицька. – Львів : НВФ Українські технології, 2000. – 320 с.
5. Вітлінський В. Зміна парадигми в сучасній теорії економіко-математичного моделювання / В. Вітлінський, А. Матвійчук // Економіка України. – 2007. – № 11. – С. 35–43.
6. Добош Н. М. Алгоритм розпізнавання рівня фінансової стійкості страховика / Н. М. Добош // Формування ринкової економіки в Україні : наук. зб. – Львів : Львівський національний університет імені Івана Франка, 2010. – Вип. 22. – С. 107–113.
7. Фишберн П. Теория полезности для принятия решений / П. Фишберн. – М.: Наука, 1978. – 352 с.
8. Недосекин А. О. Анализ риска банкротства предприятия с применением нечетких множеств / А. О. Недосекин, О. Б. Максимов // Вопросы анализа риска. – 1999. – № 2–3. – С. 17–29.
9. Frejd P. Mathematical Modelling as a Professional Task / Peter Frejd, Christer Bergsten // Educational Studies in Mathematics. – Springer Netherlands. – 2016. – № 1, Vol. 91. – P. 11–35.
10. Козьменко О. Статистична модель оцінки ризиків в роботі страхової компанії / О. Козьменко, В. Олійник // Інвестиційний менеджмент та фінансові інновації. – 2015. – № 2. – Вип. 12. – С.189–194.

Стаття надійшла до редакції 05.09.2017

References

1. Leonova O. V., Sorokina P. G. (2017). Modelirovanie processov ybitkov strakhovshchika s pomoshchju verojatnosnykh raspredelenij na primere strkhovol kompanii ROSGOSSTRAKH [Design of processes of losses of insurer by means of probabilistic distributions on the example of insurance company РОСГОССТРАХ]. *Baikal Research Journal,* 8, № 4, 17–27 [in Russia].
2. Nedosekin A. O. (2002). *Nechetko-mnozhestvennyj analiz riska fondovyx investicij [Fuzzy Set Analysis of a stock investment risks]*. St. Petersburg, 180 [in Russia].
3. Borch K. (1974). Mathematical Models in Insurance. Astin Bulletin: The Journal of the IAA, № 3, Vol. 7, 192–202.
4. Syavalko M., Rybitskaya O. (2000). *Matematychne modelyuvannya za umov nevyznachenosti [Mathematical modeling under uncertainty]*. Lviv: NPF Ukraintehnologii, 320 [in Ukrainian].
5. Vitlinsky V., Matviichuk A. (2007). Zmina paradygmy v suchasnij teoriyi ekonomiko-matematychnogo modelyuvannya [Changing the paradigm in the modern theory of economic-mathematical modeling]. *Ekonomika Ukrayiny*, 11, 35–43 [in Ukrainian].
6. Dobosh N. M. (2010). Algorytm rozpiznavannya rivnya finansovoyi stijkosti straxovyka [The algorithm for recognizing the level of financial stability of the insurer]. *Formuvannya rynkovoyi ekonomiky v Ukrayini*, 22, 107–113 [in Ukrainian].
7. Fishburn P. (1978). *Teoriya poleznosti dlya prinyatiya reshenyj [Theory of utility for decision-making]*. M.: Nauka, 352 [in Russia].
8. Nedosekin A. O. (1999). Analyz ryska bankrotstva predpryyatyya s prymenenyem nechetkyx mnozhestv [Analysis of the risk of bankruptcy with the use of fuzzy sets]. *Vaprosy analiza riska*, 2–3, 17–29 [in Russia].
9. Frejd P., Bergsten C. (2016). Mathematical Modelling as a Professional Task. Educational Studies in Mathematics, № 1, Vol. 91, 11–35.
10. Kozmenko O. (2015). Statistical model of risk assessment of insurance company's functioning [Statistical model of risk assessment in the work of the insurance company]. *Investment Management and Financial Innovations*, № 2, Vol. 12, 189–194 [in Ukrainian].

Received 05.09.2017