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Statistical model of risk assessment of insurance company's functioning

Abstract

The article studies the basic problems of studying the risks of insurance companies' functioning. It distinguishes the main types of risks of losses that occur during the functioning of insurers. Considering the fact that in practical activity of insurance companies not all types of risks are realized it is offered to use the algorithm of constructing a model for risk assessment of insurance companies' operations. The model is based on the essential requirements and defining features of statistical models, including: risk assessment on the basis of probability theory.

Keywords: risk, risk of losses, statistical models of risk assessment, probability, mathematical expectations.

JEL Classification: G22, G32.

Introduction

Problem statement. The period of active market transformations in the economies of different countries, the worsening of crisis phenomena in the international financial system had a significant impact on the activity of insurance companies marked by the need to address fundamentally new challenges related to the prevention, identification and elimination of a significant increase in the concentration of risks in the insurance business. In this regard, it is necessary to carry out a thorough research of the issues related to the risks of insurance companies' operations.

Analysis of the latest research and publications.

Theoretical and methodological aspects of assessing the risks of insurance companies are reflected in the numerous works of scholars, in particular: O. Zhabynets explores the problems of classification of risks of insurance companies under conditions of European integration [7]. O. Kozmenko, V. Royenko study the risks of insurance companies in the process of investment activities [4]. O. Kozmenko and O. Kuzmenko study the fundamental formalization of the term "risk" through reinsurance operations [5]. Researcher R. Sobol explores the risks of insurance companies in the context of impact of methods of risk management on the financial condition of insurers [6]. Investigation of management of insurance risks is presented in the works of P. Bondarenko [2]. A. Boyko, V. Royenko, O. Kozhukhovska consider the assessment of risks from the point of view of insurance companies' participation in scheme operations [1, 3].

Earlier unsolved parts of the problem. The analysis of the scientific research shows the lack of a common approach to determining the risks of insurance companies. Thus, it is increasingly important to carry out the modeling of risks of

insurance companies in Ukraine because of the lack of an appropriate, adequate and objective methodology for assessing such risks.

The goal of the article is to develop a model for assessing the risks of insurance companies' functioning.

Presentation of the main material. Today, the risks of insurance companies' functioning are considered through the prism of losses caused by inadequate and erroneous internal processes or certain uncontrollable external events. The risks of insurance companies are characterized by a certain probability of occurrence in different combinations.

Figure 1 shows the necessity of building a statistical model of risk management of insurance companies' functioning by using the probability approach. Therefore, the model should take into account all the peculiarities of risks of insurance companies' functioning while meeting certain general requirements.

The key requirements to the building of statistical model of risk management for insurance company's functioning with the use of probability approach are:

- ◆ the model should include and describe the main risk management process characteristics for insurance company's functioning, avoiding significantly simplifying them;
- ◆ the obtained results should be similar to the actual results, for it cannot be very common to the real situation;
- ◆ the model is applicable in the making of managerial decisions;
- ◆ the model should include both quantitative and qualitative parameters of risk assessment;
- ◆ the model should be predictable and easily analyzed, letting to identify the most dangerous risk factors.

In addition to the outlined ones, the basic requirement to the model is its adequacy to the real process.

Figure 2 shows the defining features of building the model of risk assessment.

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The goal of the survey is to receive answers to the questions regarding the presence of certain risks during the analyzed time period.

The relevance of this approach is caused by the fact that risk incidents have a qualitative nature. It is possible to quantitatively describe them only through singular and zero values.

Therefore, in order to receive the relevant information for the model of risk assessment of insurance companies' functioning it is necessary to survey respondents with an expert method. It is proposed to gather the opinions of all representatives of insurance companies in Ukraine both in the context of risk incidents and the quantitative description of possible losses.

Another important feature in the assessment of risks is the assessment of risks in the functioning of insurance companies in the context of classical

approaches based on the theory of probability. Traditionally, risk has a mathematically expressed probability of losses and can be calculated with a sufficiently high degree of reliability. Therefore, the probability is calculated on the basis of statistical data for a certain period of functioning of a particular insurance company for each risk factor.

Let us consider in detail the structure of the proposed statistical model for assessing the risks in the functioning of insurance companies.

To enter input data we will build two tables, the first of which contains K_i – the absolute number of realizations of a certain risk factor for each insurance company, and the second contains S_i – possible losses of insurance companies in certain currencies for each risk factor in general.

The model for assessing risks in the functioning of insurance companies is shown in Figure 3.

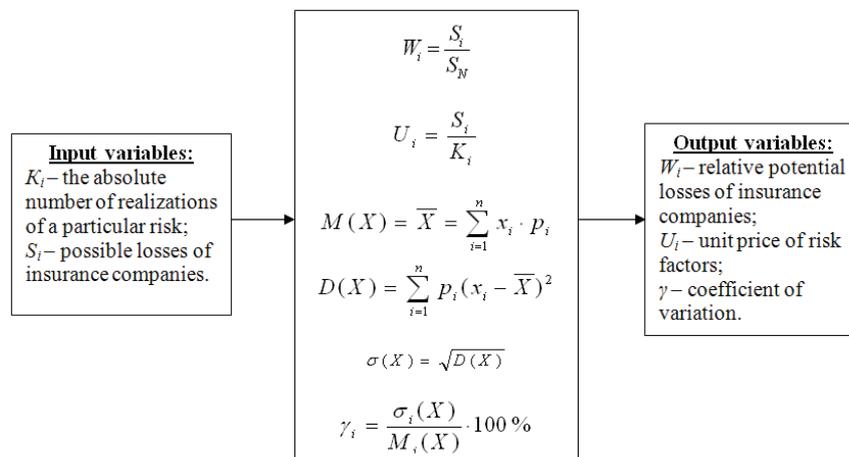


Fig. 3. Description of the statistical model for assessing the risks of insurance companies' functioning

As the basis of input data for assessing the risks of insurance companies' functioning we can consider the following:

- ◆ the absolute number of realizations of a particular risk K_i ;
- ◆ possible losses of insurance companies in certain currencies for each risk factor S_i .

Mathematical correlation for the model assessing the risks of insurance companies' functioning can be presented as:

- ◆ mathematical expectations $M(X) = \bar{X} = \sum_{i=1}^n x_i \cdot p_i$ of monetary losses of insurance companies;
- ◆ variance $D(X) = \sum_{i=1}^n p_i (x_i - M(X))^2$ that characterizes the dispersion of the random variable $x_i (i = \overline{1, n})$ relative to mathematical expectation $M(X)$;

- ◆ standard deviation $\sigma(X) = \sqrt{D(X)}$, which also characterizes the dispersion of the random variable relative to mathematical expectation.

Output parameters of the model for assessing the risks of insurance companies' functioning include:

- ◆ relative potential losses of insurance company W_i ;
- ◆ unit price of risk factor U_i ;
- ◆ coefficient of variation.

A random event $A_i (i = \overline{1, n})$ is considered the occurrence of factor i for the risks of insurance company's functioning (n – a total number of risk factors in insurance company's functioning). The probability of random events $A_i (i = \overline{1, n})$ is denoted as $p_i (i = \overline{1, n})$. We assume that some risk factors are always realized. This means that the events $A_i (i = \overline{1, n})$ form a complete group, that is $\sum_{i=1}^n p_i = 1$. The

possible monetary losses of the insurance company from the occurrence of an event $A_i(i = \overline{1, n})$ is denoted through $x_i(i = \overline{1, n})$. Based on these data we can set up a series for the distribution of random variables $x_i(i = \overline{1, n})$.

For a start, we assume that all risk factors in the functioning of insurance companies are equal. In the future, to take into account different importance of various factors it is possible to introduce the so-called weight coefficients.

It is possible to distinguish the following methods for assessing the risks of insurance company's functioning:

1. Probability $p_i(i = \overline{1, n})$ of occurrence of random event $A_i(i = \overline{1, n})$, that is the probability that one or another risk factor of the insurance company's functioning is realized.

2. Mathematical expectations

$M(X) = \overline{X} = \sum_{i=1}^n x_i \cdot p_i$, of monetary losses of insurance company.

3. Variance $D(X) = \sum_{i=1}^n p_i(x_i - M(X))^2$ that characterizes the dispersion of the random variable $x_i(i = \overline{1, n})$ relative to mathematical expectation $M(X)$.

4. Standard deviation $\sigma(X) = \sqrt{D(X)}$, which also characterizes the dispersion of the random variable relative to mathematical expectation. If the variance is measured in square units relative to the random variable x_i , then the standard deviation is measured in the same units as x_i .

Let us consider this model.

At the first stage it is necessary to enter the data for K_i and S_i .

$K_i(i = \overline{1, n})$ is a number of detected encroachments on the insurance company relating to the risk factor i , $N = \sum_{i=1}^n K_i$ is a total number of encroachments relating to all risk factors of the insurance company's functioning. Then, accordingly, the statistical probability (for a certain period of time) of the occurrence of risk factor i will be $P_i = \frac{K_i}{N}$.

Possible losses of the insurance company in certain currency units are denoted as $S_i(i = \overline{1, n})$ for each risk factor. General potential losses of the insurance

company relating to the risks of its functioning will be $S_N = \sum_{i=1}^n S_i$.

At the second stage, based on the values of statistical probability we calculate quantitative risk assessment of insurance companies' functioning:

- ◆ risk of the presence of the corresponding factor, which is exactly the probability p_i ;
- ◆ risk of potential losses of the insurance company expressed in absolute units S_i , or corresponding relative units $W_i = \frac{S_i}{S_N}$;
- ◆ unit price of risk factor $U_i = \frac{S_i}{K_i}$.

Let us assume that the total probability of the occurrence of different risks (information risk, risk of legislation violation, errors in the structure and functioning of internal business processes, risk of personnel qualifications and mistakes, risk of competition) equal p_s , and the possible total losses have the value V_s . This probability p_s consist of the sum of probabilities of each risk, that is

$p_s = \sum_{i=1}^N p_i$. In this particular case we use equation 1:

$$p_s = p_1 + p_2 + p_3 + p_4 \tag{1}$$

$p_i = \frac{K_i}{K_s} \cdot p_s$ ($i = \overline{1, 4}$), where

$$K_s = K_1 + K_2 + K_3 + K_4.$$

Then we use equation 2:

$$\begin{aligned} p_s &= p_1 + p_2 + p_3 + p_4 = \frac{K_1}{K_s} \cdot p_s + \\ &+ \frac{K_2}{K_s} \cdot p_s + \frac{K_3}{K_s} \cdot p_s + \frac{K_4}{K_s} \cdot p_s = \\ &= \frac{K_1 + K_2 + K_3 + K_4}{K_s} \cdot p_s = \\ &= \frac{K_s}{K_s} \cdot p_s = p_s. \end{aligned} \tag{2}$$

Thus, we need to determine the probability p_s by means of statistical research.

There may be several ways:

1. Let us suppose that Π_s is the profit of insurance company (or working capital) for a certain period, and V_s is the real or potential loss of profits (or reduced working capital) during the same period. Then the statistical probability can be defined as $p_s = \frac{V_s}{\Pi_s}$.

2. If N_s is the total number of transactions for all risk factors for a certain period, and N_r is the number of transactions which contained threats for the property of insurance companies, then $p_s = \frac{N_r}{N_s}$.

3. If p_{ti} is a statistical probability of profit losses on day i of observations

($0 \leq p_{ti} \leq 1$), and N_t is the number of observation days, then $p_s = \frac{\sum_{i=1}^{N_t} p_{ti}}{N_t}$.

4. Other approaches to determining the statistical probability p_s .

Let us assume that A_i is an event that is realized as risk factor i .

Then the following events can be realized (equation 3). All possible combinations of options relating to the occurrence or non-occurrence of events A_i were considered (for example, $B_2 = A_1 \cdot A_2 \cdot A_3 \cdot \overline{A_4}$). As the next step we calculate the probability B_i of each event ($q_i = 1 - p_i$ ($i = 1, 4$)), for example $h_2 = p(B_2) = p(A_1 \cdot A_2 \cdot A_3 \cdot \overline{A_4}) = p_1 \cdot p_2 \cdot p_3 \cdot q_4$.

The possible losses from the occurrence of event B_i will be x_i , which in this case will have the following values:

$$\begin{aligned} x_1 &= S_1 + S_2 + S_3 + S_4, & x_2 &= S_1 + S_2 + S_3, \\ x_3 &= S_1 + S_2 + S_4, & x_4 &= S_1 + S_2, \\ x_5 &= S_1 + S_3 + S_4, & x_6 &= S_1 + S_3, \\ x_7 &= S_1 + S_4, & x_8 &= S_1, \\ x_9 &= S_2 + S_3 + S_4, & x_{10} &= S_2 + S_3, \\ x_{11} &= S_2 + S_4, & x_{12} &= S_2, \\ x_{13} &= S_3 + S_4, & x_{14} &= S_3, \\ x_{15} &= S_4, & x_{16} &= 0. \end{aligned} \tag{3}$$

These events will form a complete group.

In this model, the following quantitative assessments of risks of insurance companies' functioning can be considered:

- ◆ risk of the presence of the corresponding factor, which is the probability $h_i = p(B_i)$;
- ◆ risk of potential losses of the insurance company in case of realization of the event B_i expressed in values x_i or in corresponding relative units

$$W_i = \frac{x_i}{x_s};$$

- ◆ unit price of risk factor $U_i = \frac{x_i}{S(B_i)}$.

In this case $x_s = \sum_{i=1}^{16} x_i$, $S(B_i)$ denotes possible losses of the insurance company from the occurrence of event B_i . For these distribution series we use equation 4:

$$\begin{aligned} K(B_1) &= K_1 + K_2 + K_3 + K_4, & K(B_2) &= K_1 + K_2 + K_3, \\ K(B_3) &= K_1 + K_2 + K_4, & K(B_4) &= K_1 + K_2, \\ K(B_5) &= K_1 + K_3 + K_4, & K(B_6) &= K_1 + K_3, \\ K(B_7) &= K_1 + K_4, & K(B_8) &= K_1, \\ K(B_9) &= K_2 + K_3 + K_4, & K(B_{10}) &= K_2 + K_3, \\ K(B_{11}) &= K_2 + K_4, & K(B_{12}) &= K_2, \\ K(B_{13}) &= K_3 + K_4, & K(B_{14}) &= K_3, \\ K(B_{15}) &= K_4, & K(B_{16}) &= 0. \end{aligned} \tag{4}$$

We calculate mathematical expectation of losses knowing the values h_i and x_i . This can be used to adjust and assess the approaches to quantitative evaluation of risks of insurance companies' operations.

As a result, we have mathematical expectation for each group of insurance companies (equation 5):

$$M_i(X) = \sum_{i=1}^n h_i \cdot x_i. \tag{5}$$

As in the classical probability theory the calculation of mathematical expectation makes it possible to assess, which losses from risks the insurance company will bear in relative units. In other words, these are the losses relative to the total amount of losses.

In addition, in making managerial decisions it is important not only to assess the risks quantitatively, but also to take into account the fluctuations of indicators, that is, to determine the extent of variability of the results obtained from the model's use.

Classically, the variance and standard deviation are used for this purpose.

In practice, in the calculation of the variance a simplified equation is used:

$$D(X) = M(X^2) - M^2(X).$$

The variance for each group of insurance companies is calculated with equation 6:

$$D_i(X) = M_i(X^2) - M_i^2(X) \tag{6}$$

Accordingly, standard deviation is calculated with equation 7:

$$\sigma_i(X) = \sqrt{D_i(X)}. \tag{7}$$

Variance and standard deviation of random variables demonstrate the variability of random

values relative to mathematical expectations $M_1(X)$, $M_2(X)$, $M_3(X)$ and $M_4(X)$ for the groups of insurance companies under consideration.

To determine the level of risks in the functioning of insurance companies a variation coefficient is used (equation 8):

$$\gamma_i = \frac{\sigma_i(X)}{M_i(X)} \cdot 100 \% . \quad (8)$$

Calculation of the variation coefficient makes it possible to analyze and approve the scale of risks in the functioning of insurance companies:

- ◆ from 0% to 10% – minimal risk;
- ◆ from 10% to 25% – low risk;
- ◆ from 25% to 50% – acceptable risk;
- ◆ from 50% to 75% – critical risk;
- ◆ from 75% to 100% – catastrophic risk.

According to this well informed managerial decisions should be made relating to risk management of insurance companies' functioning.

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Conclusions

We believe that this model meets all the stated requirements and organically describes risk assessment of insurance companies' functioning.

The whole model is based on the fact that insurance companies function in uncertain conditions. Before making managerial decisions the departments of risk management of insurance companies should conduct a preliminary analysis of different types of risks by using the probability approach. This approach makes it possible to identify the most significant risk factors and to take measures aimed at minimizing the occurrence of negative consequences for companies.

An additional advantage of this model is that the model takes into consideration the company's real activities where each risk factor may be unrealized or realized in different combinations with different levels of probability, which for one company might have negative consequences while giving advantages for another.