IBIMA Publishing
Journal of Eastern Europe Research in Business and Economics
http://ibimapublishing.com/articles/JEERBE/2022/765785/
Vol. 2022 (2022), Article ID 765785, 16 pages, ISSN: 2169-0367
DOI: 10.5171/2022.765785

Research Article

New Methods in Assessing the Risks and Solvency of Insurance Companies

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Received date:7 May 2021; Accepted date:12 July 2021; Published date: 23 February 2022

Academic Editor: Liudmyla Chvertko

Abstract

Determining the solvency of insurance companies on the basis of comprehensive consideration of different risk groups is becoming especially relevant in modern financial activity, which requires thorough research of these aspects of the problem. This article contains the types and structuring of the main risks of insurance activity and it also presents their relationships. Methods. The article is based on general scientific methods of cognition especially on such as analysis and synthesis, induction and deduction, system-structural method, quantitative and qualitative comparison, grouping, method of logical generalization. Results. There is a proposed method of assessing the solvency of national insurance companies which is based on the acquired foreign approaches, considering various risk groups such as insurance, market, credit and operational risks. In order to take into account all the main risks faced by a particular insurer, the estimating technique is subject to significant transformation. A feature of the new system should be a change in approaches to assessing solvency basing on individual risks inherent in a particular insurance company. Conclusion. Practical calculations prove that the new approach proposed by the authors to determine the regulatory solvency, which is based on a set of risks, including insurance, market, credit and operational risks, requires increased requirements for the actual capital of the insurance company. The main advantage of this approach towards assessing the solvency of the company is an analytical assessment of various risks, which allows improving insurance risk management, control risk positioning in the financial market, effectively managing economic activity and ensuring overall financial stability.

Keywords: insurance companies, solvency, risk.

Cite this Article as: Nataliia TKACHENKO, Yuliia KOVALENKO and Liudmyla BOHRINOVTSEVA (2022)," New Methods in Assessing the Risks and Solvency of Insurance Companies", Journal of Eastern Europe Research in Business and Economics Vol. 2022 (2022), Article ID 765785, DOI: 10.5171/2022.765785

Introduction

The importance of providing the solvency of insurers has become particularly important as a result of the global financial crisis of 2007–2008. For example, in the United States, the American International Group (AIG) faced with financial uncertainty, which led to the development of the Own Risk and Solvency Assessment (ORSA), is a tool for decision-making and strategic analysis. Its aim is providing continuous and forward-looking assessment of the general indicators of solvency connected with a particular insurance company's risk.

In countries of the EU, the Solvency II Regime (Directive 2009/138/EC) was introduced in 2009 – as amended by Directive 2014/51 / EU (Omnibus II), replacing the 14 existing directives, commonly known as Solvency I. This was due to the fact that the simplified Solvency I model did not provide an accurate assessment of the risks faced by each insurance company. It also did not provide the optimal distribution of capital, the effectiveness of which was confirmed by the minimization of risks and profitability for shareholders. Solvency II, like the Basel Framework for Banks, now aims to correct disadvantages of financial and insurance activities in order to minimize risks for both the financial institution and its shareholders and customers. In this way, the asymmetry of information is overcome, endogenous and exogenous shocks and imbalances in the financial markets are reduced.

Approaches to determining the solvency of insurance companies, similar to the latest European ones, will be implemented in the practice of insurance in other countries, including Ukraine. That is why determining the solvency of these financial institutions on the basis of comprehensive consideration of different risk groups is becoming especially relevant and it is necessary to focus on this aspect of the problem.

Actual scientific research and analysis

In the scientific community, there are also many developments of Ukrainian and foreign economists, which relate to methods of assessing the solvency of insurance companies, as well as the riskiness of their activity. As for the essence of the risk itself, it was thoroughly studied by Korvat (2008), Yepifanov, Vasilieva, Kozmenko et al. (2012), Kostrichenko, Krasovska and Krasovsky (2017) and others. In the context of insurance, Shirinyan (2014) defines risk as the probability of any event with objective nature, and its occurrence will lead to losses or profits, and Sokirinska, Zhuravlyova and Abernikhina (2016) specify that this is not only a costly expression of the probability of any event that leads to loss or loss of profits comparing with plans, forecasts, projects, programs, but also the possibility of deviation from the purpose for which the decision was made. On the other hand, Govorushko, Stetsiuk and Tolstenko (2012) pay attention to the fact that any risk arises from the uncertainty and conflict that exist regardless of its consideration and realized by people who have taken this decision.

According to Zhabinets (2013), the specificity of the insurance company is that it is exposed to risks that are inherent in both the business entity and the financial institution. Similarly, Oleshko (2016) believes that in addition to the entity's own risks, the insurance company assumes additional risks of other legal entities or individuals due to the specifics of its activity. Different approaches can be seen in the classification of insurance risks. Most researchers focus on financial, investment, portfolio, and catastrophic risk. At the same time, Sorokivska, Zhuravlyova and Abernikhina (2009) propose to structure the financial risks of insurance companies by type of their activity.

In our opinion, the risks of insurance companies are most fully studied in the works of Mak (2008) and Sandström (2006), where they have been quantified, and this fact significantly increases the practical significance of this classification and allows assessing solvency.

It is well-known that solvency is a comprehensive indicator of financial activity of an insurance company, as compliance with the requirements for ensuring a proper level of solvency provides financial stability. However, the practice of insurance activity in Ukraine proves that the assessment of the solvency of insurance companies is not fully up-date, namely: 1) ignoring assessment of assets and liabilities of market disturbances, it means that adequate definition of regulatory capital will be possible only if there is a stable general economic situation; 2) dependence of the size of the regulatory solvency margin on clearly defined coefficients, which cannot be an adequate measure of insurance risk – bonus and payment in risk insurance; 3) inability to take into account market and credit risks when calculating the solvency margin; 4) ignoring the diversification of risk and the relationship between insurance assets and liabilities; 5) lack of approaches to assessing the creditworthiness of the reinsurer; 6) determining the solvency margin on the analysis of retrospective data, rather than on the basis of long-term planning; 7) insufficient attention of the management of insurance companies and insurance supervisory authorities to specific risks.

Therefore, in our work we will focus on adapting the achievements of foreign practice to reality of insurance activity in Ukraine, as well as developing new approaches to assessing the solvency of insurance companies taking into account the impact of insurance, market, credit and operational risk.

The main part

At first, we consider the standard approach. We assume that the value of the insurer's liabilities has a distribution density. The optimal estimate of the amount of liabilities can be determined by the formula:

$$\mu = M(X) = \int_{-\infty}^{\infty} x \cdot p(x)\, dx, \qquad (1)$$

where $M(\cdot)$ – symbol of mathematical hope. At this level the size of technical reserves is set.

The main reason for introducing a risk bonus to the level of technical provisions is to take into account the parameters of the uncertainty model in time frames exceeding 1 year. This risk bonus is the regulatory solvency margin (SCR). In general, the size of technical provisions and the value of SCR determine the level of capital that will guarantee the solvency of the insurer (*SCL*) (Figure 1).

Direct $x = \mathrm{SCL}$ divides the area under the graph of the function $p(x)$ into two parts. To the right α of the line there is the area that characterizes the level of significance and determines the probability of sufficient capital reserves to cover insurance liabilities for payments. The area γ to the left of the line characterizes reliability $\gamma = 1 - \alpha$. The decision to choose a reliability level of 0.99 or 0.995 is the prerogative of actuaries. The characteristic function of a random variable X can be written as such number (2):

$$\varphi(t) = \exp\left(\kappa_1 t + \kappa_2 \frac{t^2}{2!} + \kappa_3 \frac{t^3}{3!} + \kappa_4 \frac{t^4}{4!} + \ldots\right) = \exp\left(\mu t + \sigma^2 \frac{t^2}{2!} + \kappa_3 \frac{t^3}{3!} + \kappa_4 \frac{t^4}{4!} + \ldots\right), \qquad (2)$$

where $\kappa_1 = \mu$, $\kappa_2 = \sigma^2$, κ_3, κ_4, ... – cumulants of random variable X.

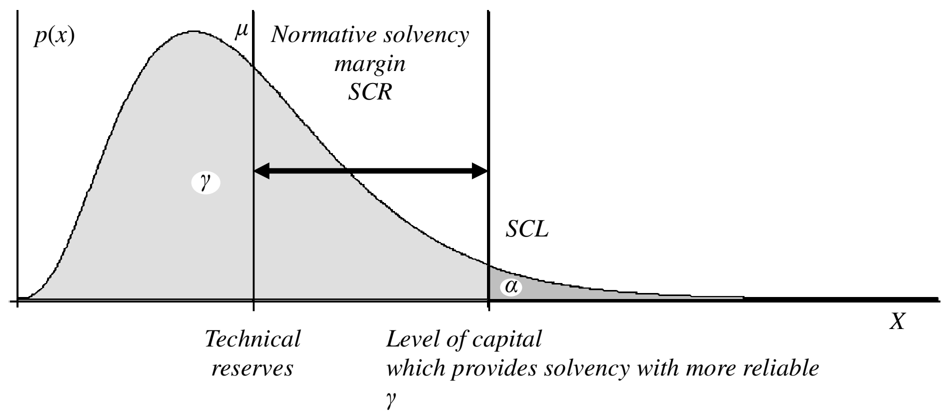

Fig. 1: The function of the density distribution of liability value of the insurance company, which reflects the uncertainty of solvency limits

The first two cumulants have special names: $\mu = \kappa_1$ called mathematical expectation, and $\sigma^2 = \kappa_2$ – dispersion value X and denote accordingly $\mathrm{var}(X)$ or $D(X)$. According to the definition:

$$\sigma^2 = D(X) = \int_{-\infty}^{\infty} (x - M(X))^2 \cdot p(x)\,dx = \int_{-\infty}^{\infty} x^2 \cdot p(x)\,dx - \mu^2, \qquad (3)$$

and the value itself $\sigma = \sqrt{D(X)}$ is called standard deviation of a random variable X.

We will cut the specified number on the first two terms and we will receive such function (4):

$$\varphi(t) = \exp\left(\mu t + \sigma \frac{t^2}{2!}\right). \qquad (4)$$

This function is characterized by a normal distribution of a random variable, and its distribution density has the following form (5):

$$\phi(x) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right). \qquad (5)$$

This approach is called the normal approximation of a random variable X, which greatly simplifies further calculations, because a normally distributed random variable is characterized by its mathematical expectation μ and standard deviation σ with a slight loss of accuracy of calculations (Figure 2). In addition, μ and σ can be a subject to easy statistical evaluation by building a model for a particular insurance company.

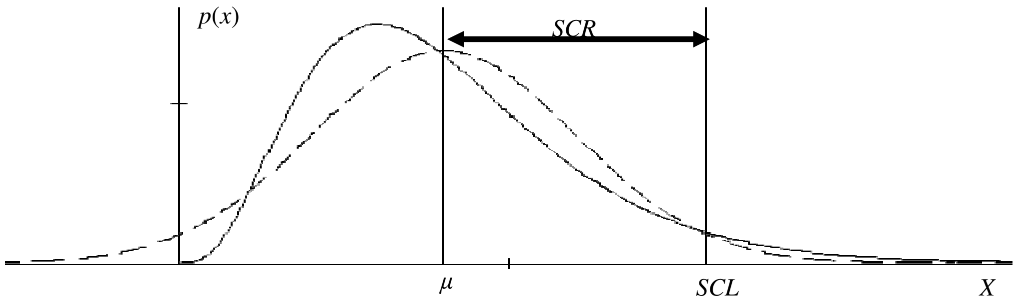

Fig. 2: Normal approximation of the density distribution of liabilities size

Taking into account the normal approximation of the value X the risk bonus SCR can be calculated quite simply (6):

$$C = k_{\gamma} \cdot \sigma, \tag{6}$$

where k_{γ} – the Student critical point distribution according to a given reliability γ and unilateral critical area (for example, $k_{0,99} = 2{,}33$, $k_{0,995} = 2{,}58$).

In practice, insurance activities are influenced by many random factors which are usually different one from another by their complex hierarchical structure. Then the capital reserves for each risk component in the model are determined by the total needs or capital reserves.

We will consider the procedure for determining total capital reserves for pooling risks at one level of the hierarchy.

In this situation, the total liabilities of the insurance company X are presented as the sum of random variables:

$$X = X_1 + X_2 + \ldots + X_n, \tag{7}$$

where μ_1, μ_2, ..., μ_n – mathematical expectations, and σ_1, σ_2, ..., σ_n – standard deviations.

From the theory of probabilities in this case, the optimal estimate of the amount of liabilities $\mu = M(X)$, therefore, the number of technical provisions will be calculated by formula 8:

$$\mu = \sum_{i=1}^{n} \mu_i\ . \tag{8}$$

The variance σ^2 of the value X will be calculated by formula 9:

$$\sigma^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} \rho_{ij}\sigma_i\sigma_j = \sum_{i=1}^{n} \sigma_i^2 + \sum_{i \neq j}^{n}\sum^{n} \rho_{ij}\sigma_i\sigma_j\ , \tag{9}$$

where $\rho_{ij} = \mathrm{corr}(X_i, X_j)$ – correlation coefficient of values X_i and X_j.

According to the definition, the correlation coefficient is calculated by formula 10:

$$\rho_{ij} = \frac{r_{ij}}{\sigma_i \sigma_j}, \quad (10)$$

where covariance $r_{ij} = \mathbf{cov}(X_i, X_j)$ is calculated by formula 11:

$$r_{ij} = M((X_i - \mu_i)(X_j - \mu_j)) = M(X_i X_j) - \mu_i \mu_j = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x_i x_j p(x_i, x_j)\, dx_i\, dx_j - \mu_i \mu_j. \quad (11)$$

The correlation coefficient will become within from –1 to 1. And if $|\rho_{ij}| = 1$, namely values X_i and X_j are connected by the functional linear dependence of the species $X_j = \alpha X_i + \beta$. If values X_i and X_j are independent, then $\rho_{ij} = 0$.

Whereas $\rho_{ij} = \rho_{ji}$, then the correlation matrix (12) is symmetric.

$$\mathrm{Corr}(X_1, X_2, ..., X_n) = \begin{pmatrix} 1 & \rho_{12} & \cdots & \rho_{1n} \\ \rho_{21} & 1 & \cdots & \rho_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \rho_{n1} & \rho_{n2} & \cdots & 1 \end{pmatrix}. \quad (12)$$

Taking into account this fact, formula (9) will take the form:

$$\sigma^2 = \sigma_1^2 + \sigma_2^2 + \ldots + \sigma_n^2 + 2\rho_{12}\sigma_1\sigma_2 + 2\rho_{13}\sigma_1\sigma_3 + \ldots + 2\rho_{1n}\sigma_1\sigma_n + \\ + 2\rho_{23}\sigma_2\sigma_3 + \ldots + 2\rho_{2n}\sigma_2\sigma_n + \ldots + 2\rho_{n-1,n}\sigma_{n-1}\sigma_n. \quad (13)$$

Taking into account the correlation (6) and formula (13), we can derive a formula showing the total level of risk bonus SCR:

$$C = k_\gamma \cdot \sigma = k_\gamma \sqrt{\sigma_1^2 + \sigma_2^2 + \ldots + \sigma_n^2 + 2\rho_{12}\sigma_1\sigma_2 + \ldots + 2\rho_{n-1,n}\sigma_{n-1}\sigma_n} = \\ = \sqrt{C_1^2 + C_2^2 + \ldots + C_n^2 + 2\rho_{12}C_1C_2 + \ldots + 2\rho_{n-1,n}C_{n-1}C_n}, \quad (14)$$

where $C_1, C_2, ..., C_n$ are separate components of the risk bonus.

As it is difficult to accurately estimate the correlation coefficient, further we will use a simplified approach to the calculation of expression (14). In the case when the level of correlation between the values X_i and X_j is high, we assume that $\rho_{ij} = 1$, and if it is low, then $\rho_{ij} = 0$.

In the case when all values are weakly correlated, then formula (14) takes the form:

$$C = \sqrt{C_1^2 + C_2^2 + \ldots + C_n^2}, \quad (15)$$

and in the case when it is strongly correlated, then formula (14) takes the form:

$$C = \sqrt{(C_1 + C_2 + \ldots + C_n)^2} = C_1 + C_2 + \ldots + C_n. \quad (16)$$

Research Methodology

Taking into account the study of general approaches, we will describe the structure of the main risks of insurance activity and introduce the following notation:

1. Insurance risk – C_{IR} : 1.1. Warranty risk – C_{ur} ; 1.2. Biometric risk – C_{br} ; 1.3. Correlation risk price/ costs – C_{er} .
2. Market risk (risk of mismatch of assets and liabilities) – C_{MR} .
3. Credit risk – C_{CR} : 3.1. Credit default risk – C_{dcr} ; 3.2. Concentration risk – C_{cor} ; 3.3. Reinsurance risk – C_{rr} .
4. Operational risk – C_{OR} .

We are considering connections between risks and as a result we are going to get approaches to assessing overall risk.

Based on the proposed simplified approach, which determines the correlation between risks, for top-level risks we obtain a correlation matrix (Table 1).

Table 1: Correlation matrix of upper-level risks

Correlation matrix	C_{IR}	C_{MR}	C_{CR}	C_{OR}
C_{IR}	1	1	1	1
C_{MR}	1	1	1	1
C_{CR}	1	1	1	1
C_{OR}	1	1	1	1

Then by formula 14 the total capital reserve is determined as follows:

$$C_{TOT} = C_{IR} + C_{MR} + C_{CR} + C_{OR}. \tag{17}$$

For insurance risk C_{IR} second-level dependencies are described by a matrix (Table 2).

Table 2: Correlation matrix of second level risks

Correlation matrix	C_{ur}	C_{br}	C_{er}
C_{ur}	1	1	1
C_{br}	1	1	0
C_{er}	1	0	1

According to this:

$$C_{IR} = \sqrt{C_{ur}^2 + C_{br}^2 + C_{er}^2 + 2C_{ur}C_{br} + 2C_{ur}C_{er}} = \sqrt{(C_{ur} + C_{br} + C_{er})^2 - 2C_{br}C_{er}} \tag{18}$$

In the scientific literature, this formula is sometimes written as follows:

$$C_{IR} = C_{ur} + \sqrt{C_{br}^2 + C_{er}^2}. \tag{19}$$

We have such a matrix for credit risk (Table 3):

Table 3: Correlation matrix of second level risks

Correlation matrix	C_{dcr}	C_{cor}	C_{rr}
C_{dcr}	1	0	0
C_{cor}	0	1	0
C_{rr}	0	0	1

So that:

$$C_{CR} = \sqrt{C_{dcr}^2 + C_{cor}^2 + C_{rr}^2}\ . \tag{20}$$

Substituting (19) and (20) into equation (17) in a result we are going to obtain:

$$C_{TOT} = \sqrt{C_{ur}^2 + C_{br}^2 + C_{er}^2 + 2C_{ur}C_{br} + 2C_{ur}C_{er}} + C_{MR} + \sqrt{C_{dcr}^2 + C_{cor}^2 + C_{rr}^2} + C_O \tag{21}$$

Now we are going to consider the method of assessing the relevant risks based on real statistics.

At first, the method of statistical evaluation of various parameters of random variables is determined. In this case X is a random variable, and a vector $(x_1, x_2, \ldots, x_n)$ – isa sample of this volume n. Above the symbol we will mark a dash of statistical estimation of parameters of random variable X .

Then the mathematical expectation (the first initial moment) has an optimal estimate as the average sample:

$$\overline{M}(X) = \frac{1}{n}\sum_{i=1}^{n} x_i\ . \tag{22}$$

For the second initial moment:

$$\overline{M}(X^2) = \frac{1}{n}\sum_{i=1}^{n} x_i^2\ . \tag{23}$$

For dispersion:

$$\overline{D}(X) = \overline{M}\left((X - \overline{M}(X))^2\right) = \overline{M}(X^2) - \overline{M}^2(X) = \frac{1}{n}\sum_{i-1}^{n} x_i^2 - \left(\frac{1}{n}\sum_{i-1}^{n} x_i\right)^2 . \tag{24}$$

For standard deviation:

$$\overline{\sigma}(X) = \sqrt{\overline{D}(X)} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2 - \left(\frac{1}{n}\sum_{i=1}^{n} x_i\right)^2}\ . \tag{25}$$

If a pair of random variables is investigated (X,Y), then by sampling $((x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n))$ it is necessary to consider the assessment of the second compatible moment:

$$\overline{M}(XY) = \frac{1}{n}\sum_{i=1}^{n} x_i y_i \tag{26}$$

covariance:

$$\overline{r}(X,Y) = \overline{M}(XY) - \overline{M}(X)\overline{M}(X) = \frac{1}{n}\sum_{i=1}^{n} x_i y_i - \frac{1}{n}\sum_{i=1}^{n} x_i \frac{1}{n}\sum_{i=1}^{n} y_i \tag{27}$$

and correlation coefficient:

$$\overline{\rho}(X,Y) = \frac{\overline{r}(X,Y)}{\overline{\sigma}(X)\overline{\sigma}(Y)} = \frac{\frac{1}{n}\sum_{i=1}^{n} x_i y_i - \frac{1}{n}\sum_{i=1}^{n} x_i \frac{1}{n}\sum_{i=1}^{n} y_i}{\sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2 - \left(\frac{1}{n}\sum_{i=1}^{n} x_i\right)^2}\sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2 - \left(\frac{1}{n}\sum_{i=1}^{n} y_i\right)^2}} \tag{28}$$

There are approaches to the calculation of the main risks in insurance activity.

By definition, the guarantee risk is calculated as follows:

$$C_{ur} = k_{\gamma}\sigma_{ur}\,, \tag{29}$$

and

$$\sigma_{ur} = \sigma(P - X)\,, \tag{30}$$

where P – the amount of net bonus received by the insurance company for a year; X – the amount of net payments made by this company for a year.

The official website of the Internet magazine "On Insurance" contains data on the annual income of insurance bonus of some insurers for a certain period, the amount of premiums transferred to reinsurers and the amount of payments of companies for a certain period.

Basing on the calculation of the difference between the amount of bonus and the share of bonus to reinsurers, we determine the amount of net bonus P_i, $i = 1,2,\ldots,n$ (we assume that observations are equal to $n = 7$). Having at your disposal the amount of payments X_i, $i = 1,2,\ldots,n$, we are going to calculate the amount of the difference:

$$Y_i = P_i - X_i\,,\; i = 1,2,\ldots,n\,.$$

After that we can calculate the estimate $\overline{\sigma}_{ur1} = \overline{\sigma}(Y)$.

According to the conclusions of Sandström (2006), we can estimate σ_{ur} using the formula:

$$\sigma_{ur} = \left(\sum_{l=1}^{L}((1+b_{url})\beta_{stl} + D(LR_l))M^2(X_l) + \sum_{l \neq j}^{L}\sum^{L} r(LR_l, LR_j)M(X_l)M(X_j)\right)^{\frac{1}{2}}$$

(31)

In this case $M(X_l)$ – the mathematical expectation of different amounts of payments by type of insurance number l, $LR_l = X_l / P_l$ – level of payments at l-th type of insurance, $D(LR_l)$ – dispersion of the level of payments, $r(LR_l, LR_j)$ – covariance of payment levels by type of insurance number l and j, b_{url} – forecast business scale coefficient (taking into account the inflation coefficient), β_{stl} – structural coefficient.

We should note that according to this approach it is enough for insurance company to calculate the $\overline{M}(X_i)$, all other parameters are determined at the EU level.

Instead, the distribution of data by type of insurance from publicly available sources is unknown; in other words, the calculation of the second term of formula (31) is impossible. Instead of the value $M(X_l)$ we use the value X_n – the amount of payments for the last observation period ($n = 7$ for our study), other parameters will be selected from the statistical reporting of companies. As a result, we obtain the following estimate:

$$\overline{\sigma}_{ur2} = \left((1+b_{ur})\beta_{st} + D(LR)\right)^{1/2} X_n. \tag{32}$$

The third approach is based on the use of statistical estimates for the parameter β_{st} and $D(LR)$.

Instead of β_{st} we use the estimate:

$$\overline{\beta}_{st} = \frac{\overline{M}(X^2)}{X_n \cdot \overline{M}(X)} \beta_m, \tag{33}$$

where $\beta_m = 0{,}175$, and instead of $D(LR)$ – value $\overline{D}(LR)$, where $LR_i = \frac{X_i}{P_i}$, $i = 1,2,\ldots,n$. Then

$$\overline{\sigma}_{ur3} = \left((1+b_{ur})\overline{\beta}_{st} + \overline{D}(LR)\right)^{1/2} X_n. \tag{34}$$

We have selected the following parameter values in the abovementioned formulas:

$$b_{ur} = 0{,}08, \quad \beta_{st} = 0{,}015, \quad D(LR) = 0{,}11, \quad k_\gamma = 2{,}58.$$

Therefore, the values of risks obtained by these three methods $\overline{C}_{ur1}$, $\overline{C}_{ur2}$ i $\overline{C}_{ur3}$ are mutually consistent and can be used to determine the warranty risk.

However, when processing large data sets, the simplest estimate is:

$$\overline{C}_{ur2} = k_\gamma \overline{\sigma}_{ur2} = k_\gamma \sqrt{(1+b_{ur})\beta_{st} + D(LR)}\, X_n. \tag{35}$$

Results of Research

Assessment of biometric risk. According to the formula given by Sandström (2006), biometric risk is calculated by the formula:

$$C_{br} = k_\gamma \sigma_{br} = k_\gamma \left(\sum_{l=1}^{L} {}_M\sigma_{VOL\,l} + 0.5 \sum_{l=1}^{L} {}_M b_l \sigma_{VOL\,l} + \sum_{l=1}^{L} {}_S\sigma_{VOL\,l} + 0.5 \sum_{l=1}^{L} {}_S b_l \sigma \right. \quad (36)$$

For companies dealing with risky types of insurance, the first two terms in gaps, corresponding to deaths, do not play any role. And only health insurance differs in the impact of this risk. So this formula for non-life companies is simplified in the following way:

$$C_{br} = k_\gamma \sigma_{br} = \left(1 + \frac{1}{2} b_{br}\right) \sigma_{VOL} ,$$

where parameter b_{br} the steepness of the incidence trend is set at the level $b_{br} = 0{,}015$.

The value σ_{VOL} is calculated by the formula:

$$\sigma_{VOL} = \sqrt{\frac{(C_R - E)E}{n}} , \quad (37)$$

where C_R – the amount of venture capital; E – actual payments; n – the number of concluded insurance contracts.

Calculations according to this formula can be made only on the internal statistics of the insurance company.

However, for non-health insurance companies, this risk is insignificant and can be excluded from the calculations.

Assessment of correlation price/cost risk

To assess it, you can use the formula in almost unchanged form:

$$C_{er} = k_\gamma \sigma_{er} = k_\gamma \left(\sum_{l=0}^{L} c_l^2 (1 + p_l)^2 E^2 (X_l) \right)^{\frac{1}{2}} \quad (38)$$

where p_l – factors of load on bonus; c_l – price correlation.

In the work of Sandström (2006), it is indicated that $p_l = 0{,}1$ for all types of insurance, and c_l acquires a value in the range from 0.09 to 0.22.

Whereas we are using publicly available data and costs are not divided into types of insurance, we will establish that $p = 0{,}1$; $c = 0{,}155$; $k_\gamma = 2{,}58$ and calculate the risk by a simplified formula (39):

$$\overline{C}_{er} = k_\gamma \overline{\sigma}_{er} = k_\gamma c (1 + p) X_n . \quad (39)$$

Assessment of market risk

The capital required to cover market risk is calculated as follows:

$$C_{MR} = k_{\gamma}\sigma_{MR} =$$

$$= k_{\gamma}\left(\sum_{k-1}^{8} A_{01}^{2}(d_k)\sigma^2(d_k) + \sum_{j-2}^{c} A_{0j}^{2}\sigma^2(j) + \sum_{j\neq l}^{c}\sum^{c} A_{0j}A_{0l}\rho(j,l)\sigma(j)\sigma(l)\right)^{\frac{1}{2}} \quad (40)$$

The standard deviation $\sigma(d_k)$, $\sigma(j)$ and correlation coefficients $\rho(j,l)$ are calculated at the level of the European Union.

The first appendix of this formula describes the risk that arises from the mismatch between the amount of assets and the amount of liabilities. It is worth noting that only the part of the assets that covers the relevant liabilities is taken into account for its calculation.

The maturity of the bonds is divided into 8 intervals:

d_1 [0 - 1] year (average term: md_1=0,5);
d_2 [1 – 2] years (average term: md_2=1,5);
d_3 [2 – 5] years (average term: md_3=3,5);
d_4 [5 – 8] years (average term: md_4=6,5);
d_5 [8 – 12] years (average term: md_5=10,0);
d_6 [12 – 16] years (середній термін: md_6=14,0);
d_7 [16 – 24] years (average term: md_7=20,0);
d_8 [24 –] years (average term: md_8=28).

According to the specified time intervals, there is a distribution of bonds: $B_0(d_s)$, $s = 1,2,\ldots,8$.

The interval d_4 also includes shares $S_0(d_4)$, and interval d_5 includes property $P_0(d_5)$.

Liabilities are also divided into eight parts $V_0(d_s)$, $s = 1,2,\ldots,8$ according to the terms d_s.

Then calculate the discrepancies:

$$A_{01}(d_s) = md_s\big(B_0(d_s) - V_0(d_s)\big),\ s = 1,2,3,6,7,8;$$
$$A_{01}(d_4) = md_4\big(B_0(d_4) + S_0(d_4) - V_0(d_4)\big),\ s = 4;$$
$$A_{01}(d_5) = md_5\big(B_0(d_5) + P_0(d_5) - V_0(d_5)\big),\ s = 5.$$

The second appendix of the formula displays the variable characteristics of the value of assets, and the third takes into account the correlation between them.

In this case A_{0j} – the current value of the asset j-th type. It is believed that the first type of assets includes bonds. And such as the bonds in these terms, appendixes are not taken into account, the numbering begins from the second one.

According to this A_{02} – shares, A_{03} – property, so that, for these assets are accepted $\sigma(2) = 0{,}17$ and $\sigma(3) = 0{,}13$.

According to analytical data, it is impossible to divide liabilities by terms, so only the second number can be calculated:

$$\overline{C}_{MR} = k_{\gamma}\overline{\sigma}_{MR} = k_{\gamma}\sqrt{\sum_{j=2}^{c} A_{0j}^{2}\sigma^2(j)}\,. \quad (41)$$

Assessment of the concentration risk

This risk is associated with the risk of investment losses (concentration of assets), catastrophic events (concentration of liabilities), etc.

The amount of capital required to cover this risk can be calculated by the formula:

$$C_{cor} = k_{\gamma}\left(A^{*2}\left(\max(a_i^*)\bar{a}^* - \bar{a}^{*2}\right) + \left(M_X \bar{X}^* - \bar{X}^{*2}\right)\right)^{\frac{1}{2}} \quad (42)$$

The first appendix of this formula contains the risk of concentration of assets, and the second one contains the risk of concentration of liabilities.

According to this, A^* is the total amount of assets that cover the relevant liabilities. Let us represent this value by the sum of investments A_i^*, $i = 1,2,\ldots,n$, so that, we have the following:

$$A^* = \sum_{i=1}^{n} A_i^* .$$

Denote $a_i^* = \frac{A_i^*}{A^*}$, $i = 1,2,\ldots,n$ the relative size of individual investments. Then $\max(a_i^*)$ is the maximum of relative size of the investment $\bar{a}^*$ is the average value of these values.

The value X^* means the total amount of liabilities divided into categories X_i^*, $i = 1,2,\ldots,m$, that can be caused by various catastrophic events. Then:

$$X^* = \sum_{i=1}^{m} X_i^* .$$

We denote $\bar{X}^*$ as the average value of the values X_i^*, and M_X as the maximum amount of net payments.

If you use publicly available data, then there is no way to calculate the capital needed to cover the risk of concentration.

Assessment of reinsurance risk. Each reinsurer operating in the European Union is identified by a score ω_i, corresponding to its rating. This score varies from 0 to 1.

The amount of capital to cover the risk of reinsurance is calculated by the formula:

$$C_{rr} = k_{\gamma}\sigma_{rr} = k_{\gamma}\left(\sum_{i=1}^{r}(1-\omega_i)\sigma_i^2 + \sum_{i=1}^{r}(1-\omega_i)P_{i,rr}^2\right)^{\frac{1}{2}}, \quad (43)$$

where σ_i is standard deviation of the number of receivables from the i-th reinsurer; $P_{i,rr}$ is the amount of bonus transferred to this reinsurer.

Basing on the data of national credit ratings for reinsurers, it is possible to assess the reinsurance risk by the formula (44):

$$\overline{C}_{rr} = k_\gamma \overline{\sigma}_{rr} = k_\gamma \sqrt{1-\omega} \cdot P_{rr}, \quad (44)$$

where $1-\omega = 0{,}2382$; P_{rr} is the amount of bonus transferred to reinsurers.

Assessment of credit default risk

For this type of risk, we propose to use an approach that is standardized for the banking sector, where the required capital is:

$$C_{dcr} = \left(0.08 \sum_{j,c} r_{jc} A_{jc}\right)^{\frac{1}{2}} = \left(\sum_{j} \omega_{jc} A_{jc}\right)^{\frac{1}{2}} \quad (45)$$

where r_{jc} is the risk weight coefficient; A_{jc} is the amount of venture capital of j-th group.

However, these calculations cannot be performed on the basis of publicly available data.

Assessment of operational risk

The capital required to cover operational risk is calculated by the formula:

$$C_{OR} = \sum_{i=1}^{L} \overline{B}_{i,3} \beta_i, \quad (46)$$

where $\overline{B}_{i,3}$ – this is the average size of gross bonus for the last three years by i-th type of business;

β_i is the coefficient set at the level of the European Union which is 0.01.

At this stage, the coefficient β for all types of insurance is the same, so the calculation can be performed according to a simplified formula:

$$\overline{C}_{OR} = \overline{B}_3 \beta, \quad (47)$$

where $\overline{B}_3$ is the average size of gross insurance bonus for the last three years.

Therefore, the risk of credit default and operational risk are assessed by banking activity algorithms.

Overall assessment of the regulatory solvency margin (SCR)

Taking into consideration that C_{br}, C_{dcr} i C_{cor} can not be calculated on public data, so we do $\overline{C}_{br} = 0$, $\overline{C}_{dcr} = 0$ and $\overline{C}_{cor} = 0$.

In this case, formula (21) acquires some simplifications and has the form:

$$\overline{C}_{TOT} = \sqrt{\overline{C}_{ur}^2 + \overline{C}_{er}^2 + 2\overline{C}_{ur}\overline{C}_{er}} + \overline{C}_{MR} + \sqrt{\overline{C}_{rr}^2} + \overline{C}_{OR} = \\ = \overline{C}_{ur} + \overline{C}_{er} + \overline{C}_{MR} + \overline{C}_{rr} + \overline{C}_{OR}.$$

Here we substitute the results presented in (35) - (47) and obtain the following general factor model:

$$\overline{C}_{TOT} = k_{\gamma}\left(\left(\sqrt{(1+b_{ur})\beta_{st} + D(LR)} + c(1+p)\right)X_n + \sqrt{\sum_{j=2}^{c} A_{0j}^2\sigma^2(j)} + \sqrt{1-\omega}\cdot P_{rr}\right) + \\ +\overline{B}_3\beta.$$

Taking into consideration the current values of the coefficients $k_{\gamma} = 2{,}58$; $b_{ur} = 0{,}08$; $\beta_{st} = 0{,}015$; $D(LR) = 0{,}11$; $p = 0{,}1$; $c = 0{,}155$; $\sigma(fixed\_assets) = 0{,}13$; $\sigma(long-term\ investments) = 0{,}17$; $\sigma(current\_investments) = 0{,}007$; $\sigma(others) = 0{,}3$; $1-\omega = 0{,}2382$; $\beta = 0{,}01$, the general factor model can be written as follows:

$$\overline{C}_{TOT} = 2{,}58\cdot\left(0{,}52575\cdot X_n + \sqrt{0{,}0169\cdot P_n^2 + 0{,}0289\cdot S_n^2 + 0{,}000049\cdot I_n^2 + 0{,}09\cdot A_n^2} + \\ + 0{,}488057\cdot P_{rr}\right) + 0{,}01\cdot\overline{B}3.$$

where X_n is the amount of insurance payments for the last year; P_n – fixed assets; S_n – long-term investments; I_n – short-term investments; A_n – others; P_{rr} – the amount of bonus transferred to reinsurers; $\overline{B}_3$ – the average size of gross bonus for the last 3 years.

Conclusions

This article proves that there are many scientific developments related to approaches to determining the solvency of insurance companies. However, the issue of developing a new system for assessing the solvency of insurance companies, taking into account their inherent individual risks, is given insufficient attention, which requires further comprehensive study of their specifics.

Practical calculations prove that the new approach proposed by the authors to determine the regulatory solvency, which is based on a set of risks, including insurance, market, credit and operational risks, requires increased requirements for the actual capital of the insurance company. The main advantage of this approach towards assessing the solvency of the company is an analytical assessment of various risks, which allows improving insurance risk management, controlling risk positioning in the financial market, effectively managing economic activity and ensuring overall financial stability. In the future, the authors intend to study the process of risk management in insurance activity in details, as well as to propose measures to minimize these risks.

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