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Stress-Testing Technologies of Financial Stability of Financial Corporations: Aspect of Insurance Companies

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Abstract

The purpose of the article is to perform stress-testing technologies of the financial stability of an insurance company based on the constructed mathematical model of the insurance company's activity, which would meet the established requirements (adequate reproduction of the main parameters of the insurance company's functioning; taking into account the stochastic nature of insurance processes; flexible management of model parameters describing company's behaviour; the ability to influence the intensity of flows; suitability for algorithmization and construction of computational simulation model. The relevance of this study is due to the need to address the problem of changes and complications, the growing variety of strategies and products implemented by insurance companies. There is a need for innovative methods to assess and monitor the vulnerability of these institutions to various types of risks. One of these methods, which is gaining widespread recognition both among regulators and financial corporations, is stress testing. It has been established that stress testing as a risk management tool is used both to assess the insurance company's readiness for a crisis situation, and to develop a plan of adequate measures to counteract and eliminate its negative impact. The development and application of the proposed mathematical and simulation model of stress testing of the financial stability of the insurance company allows to solve issues of ensuring sufficiency of capital level, control of financial stability and solvency, reliability of efficiency of activities, taking into account the probabilistic nature of insurance activities, various typical insurance risks and time horizons.

Keywords: Insurance Company, Risk, Financial Stability, Stress Testing, Technologies, Insurance Rates, Reinsurance.

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Introduction

According to the UN definition, the society development is sustainable, that is, it can be maintained for a long period of time, if it allows to meet the needs of current generations without compromising the opportunities inherited by future generations to meet their needs [Report of the World Commission on Environment and Development "Our common future»]. In this context, under the conditions of reforming the global financial architecture, the key issue is the sustainable institutional development of the financial sector, in particular the subset of insurance companies, as its system-wide property (Kovalenko, 2011). The main question of this sustainability can be formulated as follows: Is the consolidated institutional structure of insurance companies able to convey the results of financial activity to the end user of insurance services?

In the context of globalization, there is a "constant approximation of the concepts of "sustainable development" and "global management". As a result, the diversity of the interrelations between the flow of financial and industrial capital, the integration of financial corporations, in particular insurance companies, with the socio-economic environment is concentrated in the stability of these corporations as a basic characteristic of their development.

Experts of the Financial Stability Board, which includes finance ministers and central bank managers of the world's leading countries, see the main causes of current imbalances in errors within the risk management system of financial corporations; imperfect valuation of structured financial products and information about them, as well as investors' underestimation of the risks of these instruments and excessive reliance on rating agencies; overestimation of the importance of risk transfer to the balance sheets of financial corporations, through which such reduction measures had the opposite effect; unreasonable confidence of financial corporations in their ability to provide liquidity in wholesale markets and the refinancing mechanism of Central Banks [Financial Stability Board]. The financial sectors of those countries where insurance companies carry out: 1) active system risk management (using information from rating agencies, stress testing, investors) proved to be stable; 2) adequate valuation of financial assets (purchase and sale of small blocks of securities with determining their price, and then conducting large-scale transactions); 3) professional liquidity management (availability of complete and reliable information from the main company about the needs and liquidity of all divisions.

It is well known that financial stability is a complex indicator of the implementation of the insurance company financial performance, since meeting the requirements of solvency appropriate level provides financial stability through introduction of stress testing. However, insurance practice in Ukraine proves that stress testing of insurance companies' financial stability does not fully meet the requirements of the time.

Literature Review

The problem of financial stability lies in the spotlight of Western economic theory, in particular Keynesianism, Neoclassicism and Monetarism, and is mainly limited to price or market stability, as well as abilities for countercyclical stability of financial markets and systems. Financial science defines financial stability as mainly centered around specific economic entities (non-financial sector corporations and banking institutions) or around the entire financial system, as, for example, its dynamic state, in which the impact of any shocks on a system (or on its individual elements) does not prevent it from ensuring an effective redistributing of financial resources throughout the economy, the functioning of the payment system, as well as absorption (depreciation) of shocks. Besides, financial stability is understood as the equally-weighted functioning of the financial system or financial market for the formation and use of financial resources, where the stability of the former is a special case of general financial stability.

Research on stability of the insurance companies has not become widespread, but context of financial globalization and impact of crisis phenomena on economic relations, as well as processes of

Maintaining their stability are becoming particularly important, since they serve as indicator of strategic development not only for the insurance sector, but also for other sectors related to it. The founder of the systems theory L. Bertalanffy (1969) proved that open systems operate under condition of dynamic equilibrium, which can cause system complexity with a simultaneous decrease in its chaotic nature (an entropy decrease). It is apriori considered that insurance companies with a high degree of self-organization and self-regulation, where risks are leveled, are theoretically capable to balance and maintain sustainable development.

The scientific community also has many developments of Ukrainian and foreign economists concerning methods for assessing the financial stability and solvency of insurance companies, as well as the riskiness of their activities. The risk concept was thoroughly studied by Korvat (2008), Yepifanov, Vasilieva and Kozmenko et al. (2012), Kostrichenko, Krasovska and Krasovsky (2017) and others. Regarding insurance, Sokirinska, Zhuravlyova and Abernikhina (2016) clarify that not only a costly expression of the event probability leads to losses or shortfalls in profits compared to plans (Kaganovska, 2021-2022), forecasts, projects, programs, but also the possibility of deviation from the goal for which the relevant decision was made (Vasilyeva, 2013). Exposition to risks inherent in both the economic entity and a financial institution shapes the specific nature of an insurance company (Zhabinets, 2013). Oleshko (2016) also believes that, the insurance company assumes additional risks of other legal entities or individuals due to the specifics of its activities in addition to the entity's own risks (Belhadi, 2023). Biener and Eling (2013) proposed separate risk assessment models (Malyarets, 2017). Their study focuses on operational risk (depend on operating losses), disaster risk (to ensure which is necessary to increase the equity level, and consequently increase the cost of insurance premiums; constantly improve the solvency requirements), systemic risk and its evaluation. Yu Lei (2011) proposed a simulation model for risk management under uncertainity and minimization of risk costs.

Analysis of the financial stability of insurance companies using stress testing and financial ratios is considered in studies of Oliynyk and Bondarenko (2014), Sich and Pavlosyuk (2018), Bila (2018). Requirements for assessing the financial stability and solvency of insurance companies, the difference between current Solvency standards and the European Solvency II requirements are studied in the works of Orlova (2013) and Yukhimenko (2017). Pooser and Browne (2018) investigate the impact of insurance companies' financial performance on customer satisfaction and conclude that customer satisfaction leads to cost reduction and higher profitability (Gutorova, 2022; Hrabovskyi, 2020). The use of applied economic and mathematical methods of fuzzy logic and data mining (neural networks) allow to assess the financial stability of the insurance broker, provide an opportunity to analyze the competitiveness of the insurance product, insurance activities, management and marketing simultaneously. The use of variety of mathematical tools has become widespread in insurance practice (Blahun, 2020; Kuznetsov, 2019). Thus, in relation to the research problem of stress resistance and financial stability of the insurance company, the developing of Berlin (2006) is noteworthy, where a simulation model propose to determine the level of required financial stability of the insurance company, taking into account changing operating conditions.

Development and application of mathematical and simulation model for analytical reporting and stress testing of the insurance company financial stability is an urgent task that can allow to deal the issues of capital sufficient level provision, financial stability and solvency, reliability and efficiency of insurance activities, taking into account its probabilistic nature, various insurance risks and time horizons

Methodology

Based on the data of the insurance company's analytical reports for three quarters, the mathematical and simulation models can be built. To simplify further analysis, we will group the types of insurance by groups:

Group №1 – compulsory insurance (compulsory civil liability insurance of vehicle owners, compulsory insurance of subjects for transportation of dangerous goods, compulsory traffic accident insurance, etc.).

Group №2 – property insurance (property insurance of legal entities against fire and other risks, property insurance of individuals, property insurance of construction and assembly works, cargo and baggage insurance, etc.).

Group №3 – personal insurance (accident insurance, health insurance in case of illness, continuous health insurance, etc.).

Group №4 – liability insurance (professional liability insurance, water transport owners' liability insurance, third party liability insurance for product quality, lthird party liability insurance due to environmental pollution, etc.).

It is necessary to consider the problem of building a mathematical model of the insurance company's activities with the following requirements:

1. Adequate reproduction of the main parameters of the insurance company, in particular, the intensity of the flow of insurance payments and insurance indemnity payments, etc.

2. Taking into account the stochastic nature of insurance processes.

3. Flexible management of model parameters describing company behavior, including tariff policy, profit distribution, dividend payment, reinsurance process, etc.

4. Ability to influence the intensity of flows.

5. Suitability for algorithmization and construction of computational simulation model.

This model allows to analyze: 1) the impact of management decisions on changes in the company's behavior as results of financial activities over time; 2) the company's resistance in certain parameters to changes in the external environment (increase in frequency of the insurance events or decrease in the flow of customers). This model is built, algorithmized and implemented in the Mathcad 13 environment as a simulation model. The «simulation" term means, that the model takes into account the influence of random factors based on random number generators. Let’s consider in detail the main blocks of the program and their mathematical support.

The first block of the program is responsible for modeling the customer flow. Statistical estimates of the average number of customers arriving on that day and the corresponding standard deviation are calculated for each day of the week for all insurance groups. The functions and graphs in Figure 1 approximate seasonal fluctuations in customer flow throughout the year. On the graph, they are normalized so that the integral of any period of time is equal to the number of customers in the corresponding period. The combination of the above functions with the average values for the days of the week gives the average value for each current day. The given curves are normalized to one by the average value, then we take the product of the curve value for the current day and the average value of the number of customers. In view of the corresponding standard deviations, we have the main numerical characteristics of the random variable – the number of customers for the current day. Then type of distribution of the specified random variable is selected depending on the day of the week and the insurance group, which best approximates its empirical distribution (estimation of the distribution based on statistical data). This is the general principle of building a customer flow model.

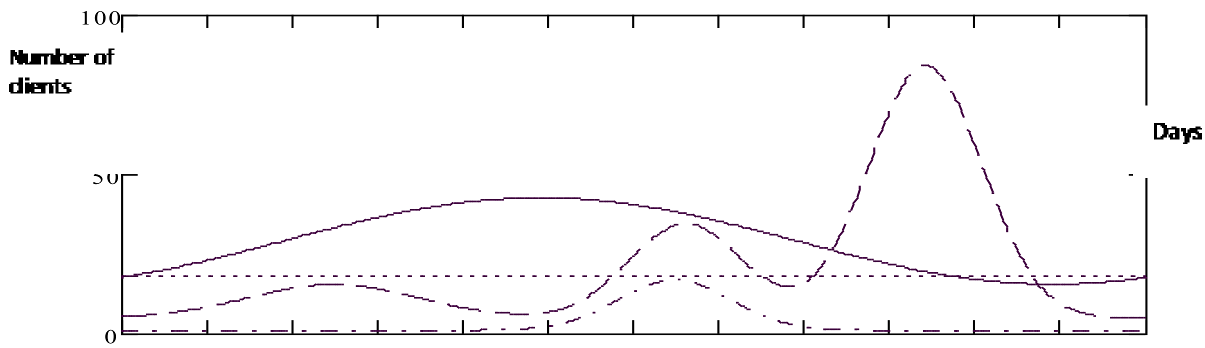

Figure 1. Approximation of seasonal fluctuations in number of customers (during the year) received in one day: —— group #1, - - - - group #2, – – – group #3, – · – · – group #4

The model provides coefficients that increase or decrease the flow of customers both for each individual insurance group and for all groups proportionately.

The next important task of the built model is to recreate the impact of changes in insurance rates (prices for insurance services) on the flow of customers.

$$\mathrm{K}(k) = \begin{cases} \kappa(0{,}84) - 3(\exp(1{,}5(k - 0{,}84)) - 1), \ k < 0{,}84; \\ \kappa(k), \ 0{,}84 \le k \le 1{,}13; \\ \kappa(1{,}13) \cdot \exp(10(1{,}13 - k)), \ k > 1{,}13; \end{cases} \tag{1}$$

where

$$\kappa(k) = c \cdot \mathrm{sign}(1-k) \cdot |1-k|^{1,5} + 1 \qquad \mathrm{sign}(x) = \begin{cases} -1, \ x < 0; \\ 0, x = 0; \\ 1, \ x > 0; \end{cases} \tag{2}$$

A constant $c = 7{,}9$ for compulsory insurance and $c = 6{,}2$ for voluntary use. Customers entering into compulsory insurance contracts are more sensitive to changes in the insurance price compared to customers entering into voluntary insurance contracts (continuous and dotted curve respectively).

Indicating the coefficient k, in the model applied to insurance rates, by formula (1) we obtain the coefficient K. Through multiplying the tariff value by the corresponding number of contracts, we can estimate how the amount of insurance payments (premiums) reacts to changes in the tariff. Finally, taking into account that the increase in the number of contracts also leads to an increase in the amount of insurance payments, we determine the relative income from insurance transactions by formula $\frac{(k-z)\mathrm{K}(k)}{(1-z)\mathrm{K}(1)}$, where z – is the payout level is 30 %.

The revenue function has two maxima. One of them corresponds to a price increase by 1-2% relative to the average market, and the other is a significant price reduction. The position of the second maximum is less explored in the scientific literature, as it depends on many specific factors, including the level of coverage of the insurance field, competitive environment, etc. It should also be noted that the second maximum is observed only when the payout level is less than 50%. If the payout rate exceeds 50%, the reduction in tariffs dramatically reduces the company's revenues.

The second block of the program is responsible for modeling insurance conditions.

First of all, a random value corresponding to the insurance amount is drawn. The distribution of this random variable is based on detailed statistical analysis and has a complex discrete-continuous character. For example, the first group of insurance has the following function of the distribution density of the insured amount:

$$f_s(x) = \frac{690}{9001}\cdot\delta(x-8500)+\frac{1280}{9001}\cdot\delta(x-41000)+\frac{6951}{9001}\cdot\delta(x-76500)+$$
$$+\frac{80}{9001}\left(0{,}1677\cdot f_u(x{,}0{,}1200000)+0{,}8323\cdot f_{|n|}(x{,}70000{,}55000)\right),$$

Where $f_u(x,a,b)$ the density is evenly distributed over the gap $[a,b]$ of a random variable, and $f_{|n|}(x,m,\sigma)$ – distribution density of the modulus of a normal random variable with a mathematical expectation m and standard medium-quadratic deviation σ, $\delta(x)$ – Dirac delta function.

After determining the insured amoun s a random value corresponding to the insurance rate t is drawn. The distribution density of this random variable functionally depends on the amount insured: $f_t(x,s)$.

Insurance payment (premium) is defined as the product of the amount insured and the insurance rate: $p = s\cdot\frac{t}{100}$.

The amount transferred for reinsurance s_p, according to statistical analysis, is determined as follows: 10% of the insurance payment, if the latter exceeds b = 40 000 UAH in the 4th group of insurance, i.e.; $s_p = 0{,}1\cdot p$; in all other cases $s_p = 0$.

The same principle determines the amount of commission's fees $s_k = s_p$ for the 2nd, 3rd and 4th insurance groups. For the 1st group $s_k = 0{,}05\cdot p$, that is, 5% of the insurance payment, if the insurance amount is UAH, in other cases it is equal to 0. After that, you can calculate the income of the insurance company from the concluded contract: $s_n = p - s_p - s_k$.

It is possible to select other reinsurance parameters for each insurance group separately. In this case, a quota reinsurance may be selected. Then the reinsurer receives from the insurance payment:

$$s_p = \begin{cases} 0, & s < b, \\ c_p\cdot p, & s \ge b, \end{cases} \tag{3}$$

Where b – the threshold of the insured amount is set, and c_p – reinsurer's share.

Another option is reinsurance of the excess amount

$$s_p = \begin{cases} 0, & s < b, \\ \left(1 - \dfrac{b}{s}\right) \cdot p, & s \geq b, \end{cases} \tag{4}$$

Where b – threshold of the insured amount under the reinsurance contract.

In each case, the commission amount is calculated from the reinsurer's share in the insurance payment amount: $s_k = c_k \cdot s_p$, where $c_k \cdot 100$ – set commission percentage.

Liability under each insurance contract is distributed between the insurer and the reinsurer in proportion to the share of each of them in the insurance payment.

In default, the program reproduces reinsurance rules in accordance with statistical data (quota reinsurance for the 4th group of insurance at $b = 40000$ UAH, $c_p = 0,1$, $c_k = 1$).

The same block of the program is responsible for maintaining a database, that records all the above parameters, as well as the date of conclusion of the contract, its number, insurance group, etc.

Modeling the process of occurrence of the insured events is the task for the next block of the program. The procedure returns a percentage v of the insured amount s, which the insurance company must pay to the customer for this insured event. If on a current day the insured event did not occur, then we have $v = 0$.

The distribution of a random variable v, usually depends on the amount insured and is built on a basis of beta distributio. For example, for the first insurance group the distribution density function looks like this:

$$f_v(x,s) = \begin{cases} 9,343 \cdot 10^{-5} \cdot f_\beta\left(\dfrac{x - 0,88}{30}, 1,7\right) + (1 - 9,343 \cdot 10^{-5}) \cdot \delta(x), & s = 76500, \\ 9,582 \cdot 10^{-6} \cdot f_\beta\left(\dfrac{x - 0,88}{30}, 1,7\right) + (1 - 9,582 \cdot 10^{-6}) \cdot \delta(x), & s \neq 76500, \end{cases} \tag{5}$$

Where $f_\beta(x, \tau_1, \tau_2)$ – beta distribution density function with parameters τ_1 and τ_2.

This block of the program is responsible for maintaining a database of insurance events.

Investment revenue model is presented as a recurrent formula:

$$w_i = w_{i-1} + q_n\left(0, \frac{0,05}{1 + |5 - w_{i-1}|^{0,5}}\right), \tag{6}$$

Where w_i equal to the percentage value for the current day, w_{i-1} – the previous day, $q_n(m,\sigma)$ – – the implementation of a normally distributed random variable with a mathematical expectation m and standard deviation σ.

The main program combines all the blocks discussed above, coordinates their operation and manages processes according to user-defined parameters. It contains a large cycle, each course of which corresponds to one day of operation of the insurance company.

Also, in the main program, the company's profit is calculated and distributed in accordance with the parameters set by the user in the following areas: payment of dividends; replenishment of equity; replenishment of insurance reserves; new investments. This redistribution occurs at the end of each quarter (an average 91 days later).

This software unit provides accumulation, calculation and coverage in a convenient form of the results of the company's financial activity based on the results of the computational experiment. The user can choose the desired time period for which the program summarizes results.

Results

To verify the adequacy of the built model, we will conduct a series of computational experiments and compare the results to statistical data.

For this reason, we will make calculations for the period 364 + 272 = 636 days and summarize the results for the last 272 days. This approach is due to the fact that the first year of model operation reproduces the transition process that occurs at the beginning of the new company's activity. Therefore, it is the first 272 days of model operation in the second year that correspond to the statistics that are available to us. To improve the accuracy, we wil repeat the experiment 5 times.

Based on the results of the experiment, it is established that the main indicators obtained from the model lie within the statistical errors of the relevant parameters of the real company. Thus, the built mathematical model of the insurance company functioning process and its software implementation adequately reproduce the main characteristics of the insurance company (IC) chosen for modeling. The model allows to analyze the impact of changes in external factors on the company financial stability: the flow of customer’s intensity and frequency of insured event occurrence, as well as the impact of internal management decisions: the method of profit distribution; rate policy; reinsurance contract terms.

Thus, the created mathematical and software environment is a convenient and powerful tool for studying the financial stability of the IC. The method of building the model is universal and can be used in the study of other companies.

The developed simulation model will be used to study the impact of changes in these factors on the results of the financial activity of the IC.

The research methodology is as follows. We make calculations for 2 years, using the company's standard operating conditions determined from statistical data. Then, based on the data of the 2nd year, we can estimate the stationary mode parameters for company operation in standard conditions.

Then we change the parameters and continue the calculation for another 2 years. Hence, the results of the 4th year of modeling describe the stationary mode of operation with changed parameters.

First, we will perform calculations under standard conditions for all 4 years of observation and analyze the results obtained in order to compare them. (Table 1).

Table 1. Financial indicators of the insurance company operation model under standard conditions, UAH

Period / Parameters	1st year	2nd year		3rd year	4th year
	Amount of liability at the end of the period				
Insurance company	1388223181.6	1445877777.2		1445455624.3	1412275558.5
Reinsurers	39893665.0	40192652.4		39226915.0	36651687.0
Total	1428116846.6	1486070429.6		1484682539.3	1448927245.5
	Amount of insurance premiums received for the period				
Insurance company	7226588.5	7293596.1		7283819.6	7401932.0
Reinsurers	17102.3	18682.9		17687.2	15737.4
Commission fees	67468.5	71797.6		73565.9	69991.1
Total	7311159.4	7384076.5		7375072.8	7487660.5
	Amount of payments made for the period				
Insurance company	1173049.0	2030607.96		1907721.1	2377512.0
Reinsurers	0	3482.6		0	2048.0
Total	1173049.0	2034090.6		1907721.1	2379560.1
Contracts concluded	25356	25740		26074	26076
Payments made	248	545		539	546
	Increase of financial resources				
Insurance income	6053539.5	5262988.1		5376098.5	5024420.0
Investment income	610568.3	838931.2		1149870.9	1440702.6
Total	6664107.9	6101919.3		6525969.5	6465122.6
	Distribution of revenues				
Δ equity	2273007.9	4443349.1		4922842.6	4912365.6
Including investment resources	1818406.3	3554679.3		3938274.1	3929892.5
Dividends paid	126278.2	246852.7		273491.3	272909.2
Δ insurance reserves	3180833.5	317678.1		237062.7	169558.0
Business expenses	1083988.3	1094039.4		1092572.9	1110289.8
Total	6664107.9	6101919.3		6525969.5	6465122.6

Note that during the calculations, we set the following model parameters: 1) initial equity – $1{,}003 \cdot 10^{7}$ UAH; 2) including investment resources – $8{,}024 \cdot 10^{6}$ UAH; 3) interest per annum on investments – 7%; 4) initial insurance reserves – 4253791,02 UAH; 5) business expense – 15%; 6) profit distribution: a) replenishment of equity – 90%; b) including investment resources – 72%; c) payment of dividends – 5%; d) replenishment of insurance reserves – 5%. These parameters remain unchanged in all computational experiments.

The data in Table 1 allows: first, see the level of random fluctuations of any particular indicator in the company's performance; secondly, analyze the dynamics of changes in indicators. As an example, regarding the growth of the company's financial resources, we have a significant increase in the first year of operation, a significant decrease in this indicator in the following year, and stabilization of values in the 3rd and 4th subsequent years.

This is due to the fact that the amount of revenues from insurance activities under the experimental conditions is approximately the same throughout all years. However, the number of contracts serviced, and, therefore, the amount of liability of the company (3), increases gradually from 0. Therefore, the amount of payments made in the first year of operation is significantly lower compared to the following subsequent years.

In the second year, the volume of payments increases significantly (almost twice), and the accumulated capital gains (investments) are not sufficient enough to completely depreciate the corresponding losses. In this regard, the company's growth rate in the 2nd year of operation is the lowest. In the following years, the situation stabilizes and, moreover, due to a significant increase in investment capital, there is an increase in the dynamics of the company's financial growth. In numerical terms we have about 5·106 UAH asset growth per year with an upward trend.

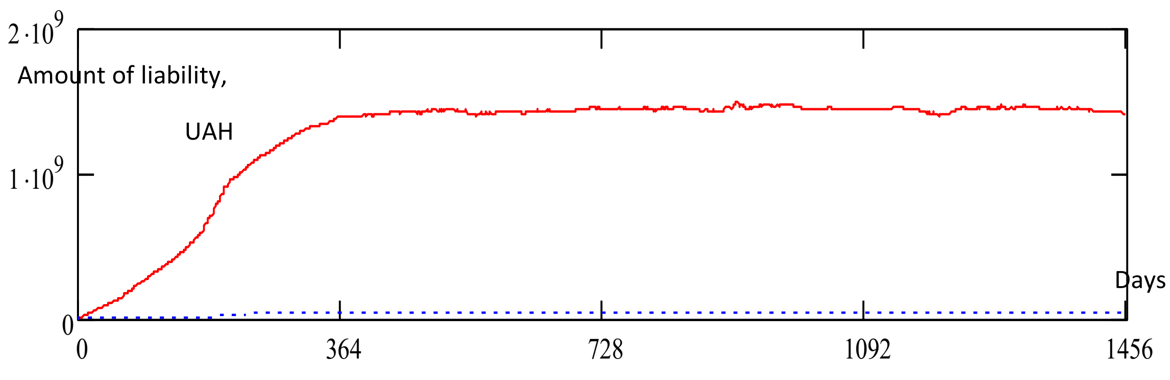

Figure 2. Amount of liability of IC and reinsurers

Graphical analysis of specific data as flow of customers (Figure 3), receipt of insurance premiums, flow of insurance payments, etc., in direct terms is quite complex. This fact is explained by significant dependance of these values on random factors (therefore changing rapidly over time).

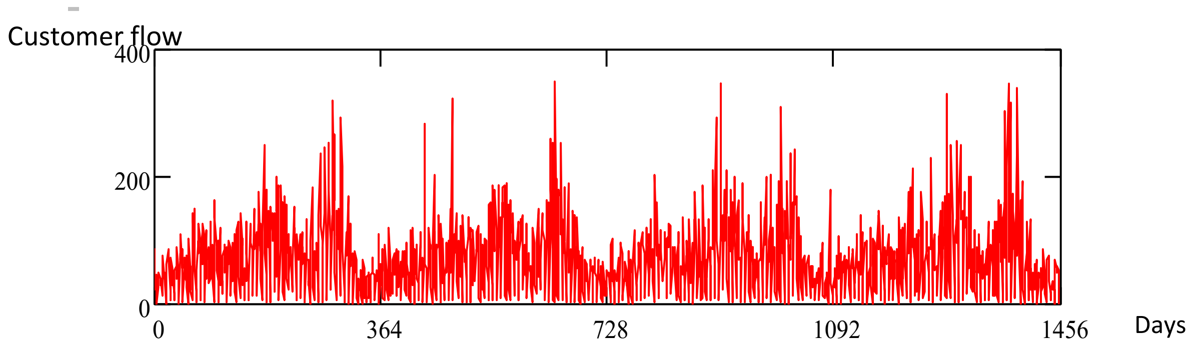

Figure 3. Number of insurance contracts concluded per day

These fast-changing processes will be henceforth graphicaly represented in cumulative (accumulated) data. If y_i , $i = 1,2,..,n$, vector of daily indicators, then vector of cumulative data $\tilde{y}_i$ will be obtained by the formula:

$$\tilde{y}_i = \sum_{j=1}^{i} y_j, \ \ i = 1,2,..,n$$

This expression is actually a discrete integration formula. If necessary, the reverse transition from cumulative to current data can be carried out using the discrete differentiation formula:

$$y_1 = \tilde{y}_1, \ \ y_i = \tilde{y}_i - \tilde{y}_{i-1}, \ \ i = 2,3,\ldots,n \ .$$

Figure 4 shows cumulative data on three main indicators of the company's performance: the receipt of insurance premiums, the amount of insurance payments, the company's income (insurance premiums - insurance payments + income from investment activities).

As Figure 4 shows, the advantage of this data display is that there are no fast graphic jumps, it allows to place several graphs in the same coordinate system and conduct comparative analysis. In addition, the integration process is known to eliminate the effect of random parameter fluctuations to a certain extent, and therefore make it easy to identify general development trends.

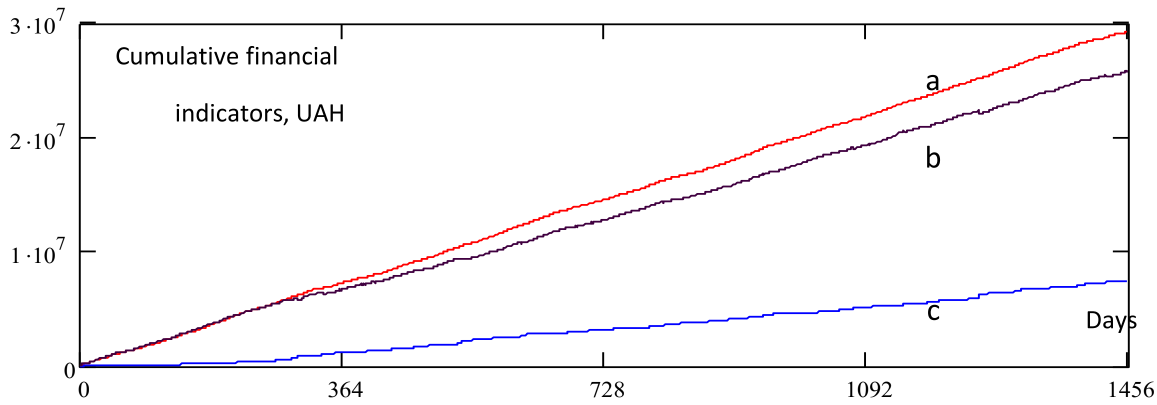

Figure 4. Cumulative data on insurance premiums (a), insurance payments (b) and company income (c)

Figure 5 demonstrate that in the first year of operation the amount of insurance payments (curve B) is not significant, the company's investment capital has not yet accumulated, so the curve of insurance premiums A and revenues of company B almost coincide. In the following years, payments increase significantly, so the revenue curve deviates downwards from the curve A. At the same time, investment revenues are increasing, which to a certain extent compensates for losses. In this regard, the curve B differs significantly from the simple difference of curves A and B.

Analysis of the data in Table 2 shows that absolutely critical for the company is the first year after the fall of customers flow, since the volume of revenues of this year is significantly reduced, and the amount of liability remains unchanged for a long time due to contracts concluded in the previous period. A year later, the situation stabilizes, but the company's growth rate decreases. Significant losses of the company's clientele (about 50% or more) lead to financial losses in the initial period and almost stagnation of the company in the future.

Now let us analyze the impact of changes in the flow of customers on the company's financial stability. Table 2 shows the main financial indicators of the company for the 4th year of operation, provided that at the beginning of the 3rd year there is a certain coefficient for the average number of insurance contracts. All other parameters of the model remain unchanged. For comparison, the first column of the table contains data obtained under standard conditions. Figure 6 illustrates progress changes in key financial indicators over the 3rd and 4th year.

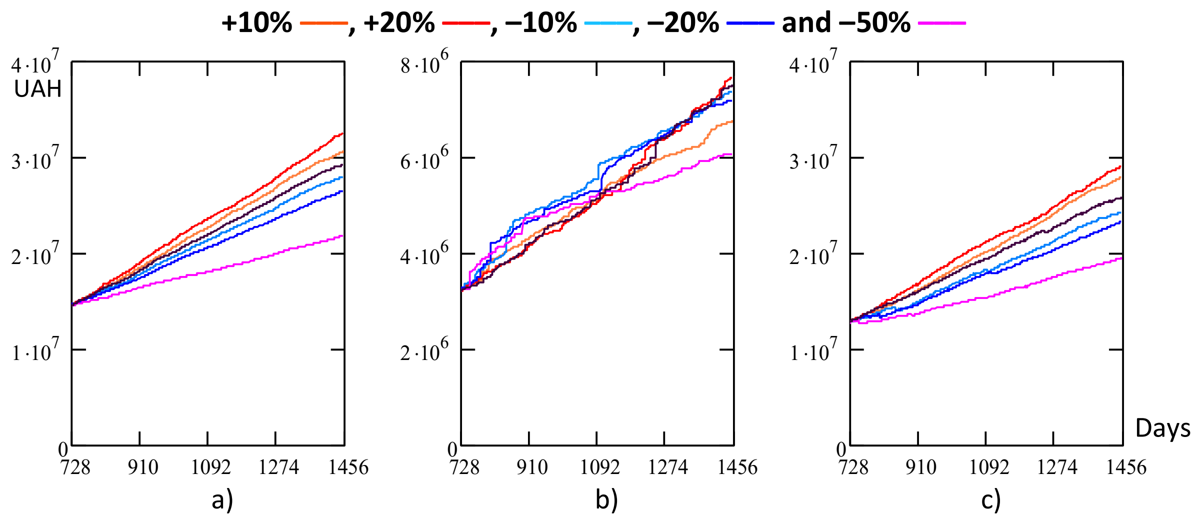

Figure 5. Amount of insurance premiums (a), insurance payments (b) and income (c) under standard conditions and when changing the flow of customers by

Table 2. Impact of changes in customer flow intensity on key financial indicators

Conditions / Parameters	Standart conditions	+10%	–10%	–20%
Amount of liability at the end of the period, UAH				
Insurance company	1412275558.5	1668927544.2	1366741297.8	1178142970.8
Reinsurers	36651687.0	56109839.4	39055305.0	30374820.0
Total	1448927245.5	1725037383.7	1405796602.8	1208517790.8
The amount of insurance premiums received for the period, UAH				
Insurance company	7401932.0	8036140.1	6712970.4	598494325
Reinsurers	15737.4	22526.2	18336.7	13062.6
Commission fees	69991.1	80127.5	70916.8	59024.5
Total	7487660.5	8138793.7	6802223.9	6057030.40
The amount of payments made for the period, UAH				
Insurance company	2377512.0	1653212.5	1829524.7	1885130.1
Reinsurers	2048.0	910.6	0	10226.1
Total	2379560.1	1654123.1	1829524.7	1895356.2
Contracts concluded, units.	26076	28449	24575	20987
Payments made, units.	546	568	531	459
Increase in financial resources, UAH				
Insurance income	5024420.0	6382927.6	4883445.7	4099813.2
Investment income	1440702.6	1467869.1	1184255.2	1403580.0
Total	6465122.6	7850796.7	6067701.0	5503393.2
Distribution of revenues, UAH				
Δ equity	4912365.6	6151388.6	4701173.7	4207559.1
including investment resources	3929892.4	4921110.9	3760939.0	3366047.3
Dividends paid	272909.2	341743.8	261176.3	233753.3
Δ insurance reserves	169558.0	152243.3	98405.4	164339.3
Business expenses	1110289.8	1205421.0	1006945.6	897741.5
Total	6465122.6	7850796.7	6067701.0	5503393.2

It can be concluded that adding every 10% to the customer flow gives about 0.6·106 ÷ 1.2·106 UAH addition to the company's financial growth. Conversely, the loss of 10% of the customer flow leads to a decrease in the company's financial growth by 0.3·106 ÷ 0.5·106 UAH. Consequently, the intensity of the flow of insurance contracts is an extremely important factor that critically affects all the main financial indicators of the company. Therefore, maintaining at least a stable level (and preferably increasing) of this flow is one of the main tasks of the company's management.

Another extremely important external factor affecting the financial stability of the company is the probability of an insured event occurring. This factor directly affects the intensity of the company's insurance payments, so a significant increase, as seen in Figure 6 and Table 3, can lead to bankruptcy. On the contrary, reducing the probability of insured events occurrence leads to the increase in the company's revenues. Therefore, it is appropriate to pay attention to implementation of preventive measures to reduce the number of insured events (e.g., immunization of customers in health insurance, etc.).

In Figure 6 (c) the cumulative revenue curve of the company, which corresponds to a 200% increase in the flow of insured events, is decreasing. In fact, this means that the company suffers losses during the period of time under study, and if the situation remains unchanged in the future, it will inevitably go bankrupt.

Note that the reaction of the model to a change in the parameter "probability of an insured event" is not as clear as in the case of a change in the intensity of customer flow. This is due to the fact that the occurrence of an insured event is much rarer issue, than the conclusion of an insurance contract.

According to calculations, a 3-fold increase (+200%) in the intensity of the occurrence of insurance events does not lead to the company's bunkrupcy. This fact indicates an extremely high level of financial stability. Only 4-fold increase of this parameter is critical to the company's existence. This is explained among other things by the low level of payments under standard operating conditions of the company (according to statistics, 23.77%).

Factors influencing the financial stability of the company, discussed above (the intensity of the customer flow, the intensity of the insurance event occurrence flow) depend mainly on the external situation in the insurance market. Next, we consider the impact of the company's internal parameters on its financial results: rates policy, reinsurance conditions.

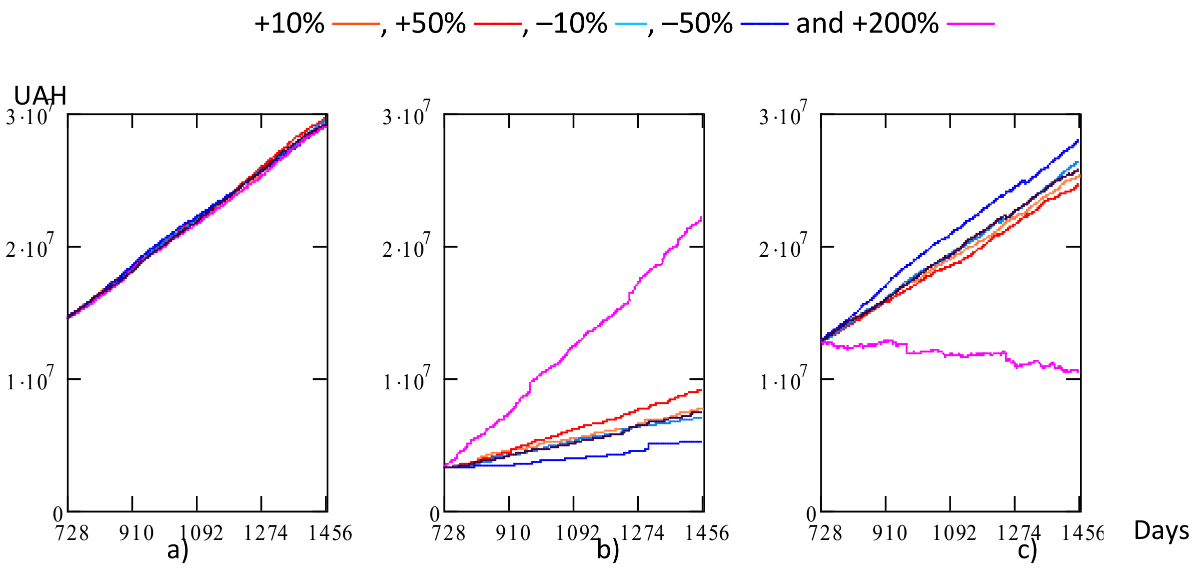

Figure 6. The amount of insurance premiums (a), insurance payments (b) and revenue (c) under standard conditions, and if the possibility of the insured case changes

Table 3. Impact of changes in the probability of an insured event on the main financial indicators

Conditions / Parameters	Standart conditions	–50%	+50%	+200%
Amount of liability at the end of the period, UAH				
Insurance company	1412275558.5	1362303629.6	1508125776.1	1469389499.0
Reinsurers	36651687.0	36729143.5	44339695.0	43608552.9
Total	1448927245.4	1399032773.1	1552465471.1	1512998051.9
Amount of insurance premiums received for the period, UAH				
Insurance company	7401932.0	6923471.8	7712345.3	7395033.3
Reinsurers	15737.4	15767.1	19927.6	18676.5
Commission fees	69991.1	67835.3	75779.4	73137.3
Total	7487660.5	7007074.2	7808052.3	7486847.2
Amount of payments made for the period, UAH				
Insurance company	2377512.0	1320947.6	2988066.5	9801923.2
Reinsurers	2048.0	10196.5	1052.3	130737.2
Total	2379560.1	1331144.2	2989118.7	9932660.5
Contracts concluded, units.	26076	24354	26892	25537
Payments made, units	546	252	802	2179
Increase in financial resources, UAH				
Insurance income	5024420.0	5602524.1	4724278.9	-2406889.9
Investment income	1440702.6	1551424.1	1475593.35	1077163.5
Total	6465122.6	7153948.5	6199872.2	-1329726.4
Distribution of income including investment resources				
Δ equity	4912365.6	5704970.6	4489679.9	0
including investment resources	3929892.4	4563976.5	3591743.9	0
Dividends paid	272909.2	316942.8	249426.7	0
Δ insurance reserves	169558.0	93514.1	303913.8	-2438981.4
Business expenses	1110289.8	1038520.8	1156851.8	1109255.0
Total	6465122.55	7153948.2	6199872.23	-1329726.4

As already noted, the change in the company's rates policy has a complex impact on a number of features of the company's activities. First of all, the change in the rates affects the intensity of the customer flow and only then (indirectly) on the receipt of insurance premiums, the amount of insurance payments and the total amount of the company's income.

Previously there has been a hypothesis that low level of payments gives the company additional opportunities to increase revenues.

The literature considers the peak point of income, which corresponds to an increased level of rates by 1÷3% compared to the average market. If the level of payments is low (<50%), we hypothetically have an additional maximum with a 10÷20% reduction in the rates. It can be seen from the simulation data shown in Table 4 and Figure 7, this hypothesis is confirmed by calculations.

Table 4. Impact of changes in the rates leve l on key financial indicators

Conditions / Parameters	Standart conditions	–20%	+20%	+2%
Amount of liability at the end of the period, UAH				
Insurance company	1412275558.5	2356729588.3	457530378.9	1443647591.6
Reinsurers	36651687.0	65938824.2	14263433.6	41520010.0
Total	1448927245.4	2422668412.5	471793812.5	1485167601.6
The amount of insurance premiums received for the period, UAH				
Insurance company	7401932.0	9346385.7	2897616.4	7449468.1
Reinsurers	15737.4	24637.7	8463.5	19305.7
Commission fees	69991.1	96401.1	27310.5	73317.6
Total	7487660.5	9467424.5	2933390.4	7542091.4
The amount of payments made for the period, UAH				
Insurance company	2377512.0	3269700.4	937245.2	1771325.2
Reinsurers	2048.0	14745.1	13146.4	2548.5
Total	2379560.1	3284445.4	950391.6	1773873.7
Contracts concluded, units.	26076	40664	8247	24964
Payments made, units	546	880	157	511
Increase in financial resources, UAHн				
Insurance income	5024420.0	6076685.3	1960371.2	5678142.9
Investment income	1440702.6	1471765.5	1273515.8	1496640.7
Total	6465122.5	7548450.9	3233887.0	7174783.6
Distribution of revenues, UAH				
Δ equity	4912365.6	5618428.1	2501164.9	5555845.2
including investment resources	3929892.4	4494742.5	2000931.9	4444676.2
Dividends paid	272909.2	312134.9	138953.6	308658.1
Δ insurance reserves	169558.0	215930.0	159126.0	192860.1
Business expenses	1110289.8	1401957.9	434642.5	1117420.2
Total	6465122.55	7548450.9	3233887.0	7174783.6

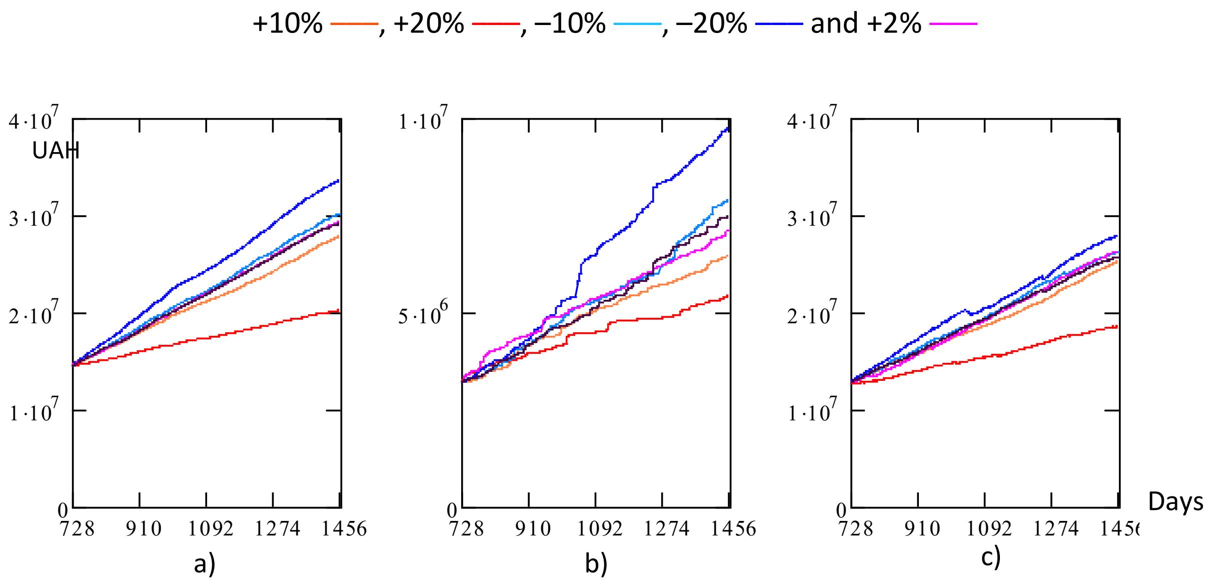

Figure 7. The amount of insurance premiums (a), insurance payments (b) and income (c) under standard conditions, and if the probability of the insured case changes to

The mechanism for generating revenue growth when reducing tariffs is as follows: reducing rates leads to a significant increase in the flow of customers and (although the average amount of the insurance premium decreases) as a result, the amount of insurance premiums received increases. It should be noted that with an extremely large reduction in rates, the losses from the reducing insurance premiums along with increase in the amount of insurance payments (more customers = > more payments) outweigh the positive effect of increasing the number of customers and the company's revenues decreases.

An increase in rates has a positive effect on the company's financial growth, if it lies within 1÷3%. The same increase in the company's revenue can be achieved by reducing rates by 8-12%. However, the mechanism of growth is completely different. A small increase in rates leads to minor losses in customer flow of customers, so by increasing the average size of insurance premiums, we get an increase of revenues. In addition, reducing the flow of customers leads to a decrease in the amount of insurance payments.

It is important to note that a significant increase in rates (>10%) l eads to tangible financial losses. In this context, an increase in the average size of the insurance premium can not compensate for the loss of the company's clientele.

Thus, optimization of the company's rates policy is a difficult task. Miscalculations in solving this problem have significantly negative consequences for the company's finances. Therefore, a computational experiment based on the simulation model of the company's activity can be a convenient tool for solving this problem and forecasting the results of the rates policy change.

The next question that requires quite complex mathematical calculations is the choice of the optimal parameters of the reinsurance contract. Based on our previous research, it is reasonable to conclude that the reinsurance mechanism (provided that all parameters are optimally selected) can be successfully used to regulate the level of payments of the insurance company. This is confirmed by both theoretical calculations and simulation results

Conclusion

Research shows that the selected company is able to maintain its stability for quite a long time with a decrease in the flow of customers almost 2-3 times or with an increase in the flow of insurance claims up to 3 times. So, we have confirmation of the high level of financial stability of the IC. With the help of simulation modelling, we have shown that on the current level of payments, the company can achieve an increase in revenues both by increasing rates by 1-2% and by reducing themby 10-15%. The choice of optimal reinsurance parameters allows to reduce the level of payments with minimal loss of income.

Thus, stress testing, as a risk management tool, is used both to assess the readiness of an insurance company for a crisis situation, and develop an adequate plan of measures to counteract and eliminate its negative impact. Stress testing proves to be essential for insurers, who plan to rapidly develop their business and increase capitalization. The results of stress testing allow to define the stability degree of the insurance company, but estimated potential losses cannot be considered as an accurate forecast of the vulnerability level for the insurer in a crisis situation, which makes stress testing an important, but not the ultimate tool to analyze the financial stability of the company. However, stress testing is becoming increasingly relevant for domestic insurers due to the volatility of financial markets.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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References

Battiston, S., Martinez-Jaramillo S. (2018). Financial networks and stress testing: Challenges and new research avenues for systemic risk analysis and financial stability implications, *Journal of Financial Stability*, 35, 6–16.

Biener, C. & Eling, M. (2013). Recent Research Developments Affecting Nonlife Insurance-The CAS Risk Premium Project 2012 Update, *Risk Management and Insurance Review*, 16 (2), 219–231.

Belhadi, A., Abdellah, N., & Nezai, A. (2023). The Effect of Big Data on the Development of the Insurance Industry. *Business Ethics and Leadership, 7*(1), 1-11. https://doi.org/10.21272/bel.7(1).1-11.2023

Berlin, M. (2006). Modeling the level of financial stability required by an insurance company, taking into account the dynamics of its operating conditions, Models of management in a market economy, 9, 326–337.

Bertalanffy L. von. (1969) General System Theory. New York: George Braziller, 1969, 172 p.

Bila, D. (2018). Regulation of the activity of insurance companies in the European Union, Business Inform, 4, 33–39.

Blahun, I.S., Blahun, I.I., Blahun, S.I. (2020). Assessing the stability of the banking system based on fuzzy logic methods. *Banks and Bank Systemsthis*, 15(3), 171–183.

Gutorova, N., Pashkov, V., & Kaganovska, T. (2021). Ensuring the Citizens' Rights and Freedoms in Case of Covid-19 Vaccinatio in the Public Health System. Wiadomosci Lekarskie (Warsaw, Poland : 1960), 74(11 cz 2), 2863-2869. doi: 10.36740/wlek202111201

Hrabovskyi, Y., Babenko, V., Al'boschiy, O., Gerasimenko, V. (2020). Development of a Technology for Automation of Work with Sources of Information on the Internet. *WSEAS Transactions on Business and Economics,* 17(25), 231-240. https://doi.org/10.37394/23207.2020.17.25

Farmer, J.D., Kleinnijenhuis, A.M., Schuermann, T. & Wetzer, T. (2022). Handbook of financial stress testing, Cambridge University Press, 726 p.

Financial Stability Board. URL: http://www.financialstabilityboard.org (Accessed 25.07of .2022).

Ivashchenko, A., Kovalenko, Yu., Hubanov, O., Hubanova, T., Lutsenko, I. & Fialkovska, A. (2021) Digital tools in cross-cultural analysis of sme financial state support in the conditions of pandemic crisis, *Journal of Information Technology Management*, 13, 142–162.

Kaganovska, T., Muzyka, A., Hulyk, A., Tymchenko, H., Javadov, H., & Grabovskaya, O. (2022). Introduction of information technologies as the newest concept of optimization of civil proceedings. *Journal of Information Technology Management,* 14(3), 1-25. doi: 10.22059/jitm.2022.87260

Kaganovska, T., Nazarenko, O., Cherniak, O., Onegina, V., Ulyanchenko, Y., Bondarenko, S. (2023). Adaptive Case Management in the International Practice of Civil Proceedings. *Review of Economics and Finance,* 2023, 21(1), 202-211, https://doi.org/10.55365/1923.x2023.21.19

Klepikova, O. A., Polishchuk, S. O., Saramkov, O. A. & Nechay, D. V. (2019). Analysis of the main indicators of the financial stability of the insurance company using simulation modeling, Bulletin of VN Karazin Kharkiv National University series "Economic", (96), 80-94. URL: https://doi.org/10.26565/2311-2379-2019-96-09 (Accessed 25.07.2022).

Korvat, O. V. (2008) Risks of the Insurer's Activity, Kharkiv, 20.

Kovalenko, Yu. (2014). Research toolkit for transformations in financial activities, *Actual Problems of Economics,* 154 (4), 51–58.

Kovalenko, Yu. (2015). Financial sector development and economic factors of its support in Ukraine, *Economic Annals-XXI,* 5–6, 77–81

Kostrichenko, V. M., Krasovska, Yu. V. & Krasovsky, V. R. (2017). Economic risk and methods of its measurement: a summary of lectures. URL: http://in1.com.ua/book/12607/9927 (Accessed 25.07.2022).

Kuznetsov, A., Shekhanin, K., Kolhatin, A., Kovalchuk, D., Babenko, V., Perevozova, I. (2019). Performance of Hash Algorithms on GPUs for Use in Blockchain. 2019 IEEE International Conference on Advanced Trends in Information Theory, ATIT 2019 – Proceedings Kyiv, Ukraine, 166-170. https://doi.org/10.1109/atit49449.2019.9030442

Malyarets, L., Draskovic, M., Babenko, V., Kochuyeva, Z., Dorokhov, O. (2017). Theory and practice of controlling at enterprises in international business. *Economic Annals-XXI,* 165, (5-6), 90-96. https://doi.org/10.21003/ea.V165-19

Oleshko, N. V. (2016) Managing the capital adequacy of insurance companies, Kyiv, 23.

Oliynyk, V., Bondarenko, E. (2014). The concept of financial stability of the insurance company and the elements of influence on it. *Collection of scientific works*, 39, 149–157.

Ong, L. L., Jobst, A. A. (2020) Stress Testing. Principles, Concepts, and Frameworks. Washington, DC: International Monetary Fund, publisher, 526 p.

Orlova, O. (2013). Evolution of approaches to assessing the solvency of insurance companies: foreign experience and domestic practice, Effective economy, 10. URL: http://www.economy.nayka.com.ua/?op=1&z=5780 (Accessed 25.07.2022).

Pakhnenko, O., Semenog, A. & Milyutina, M. (2017). Insurance market of Ukraine and the EU: comparative analysis, Economy and society. *Mukachevo State University*, 12, 612–617. URL: http://www.economyandsociety.in.ua/journal/12_ukr/101.pdf (Accessed 25.07.2022).

Pooser, D. M., & Browne, M. J. (2018). The Effects of Customer Satisfaction on Company Profitability: Evidence From the Property and Casualty Insurance Industry, *Risk Management and Insurance Review,* 21(2), 289–308.

Report of the World Commission on Environment and Development "Our common future". General Assembly Resolution 42/187 of United Nations. URL: http://www.un-documents.net/wced-ocf.htm (Accessed 25.07.2022).

Sich, O. & Pavlosyuk, H. (2018). Estimation of financial stability of an insurance company, Effective economy, 11. URL: http://www.economy.nayka.com.ua/?op=1&z=6704 (Accessed 25.07.2022).

Sokirinska, I. G., Zhuravlyova, T. O. & Abernikhina, I. G. (2016) Insurance Management, Dnipropetrovsk, 293.

Tkachenko, N. Current state of solvency assessment of insurance companies. URL: http://fkd.org.ua/article/viewFile/29635/26521 (Accessed 25.07.2022).

Yepifanov, A. O., Vasilieva, T. A., Kozmenko, S. M. et al. (2012) Management of bank risks, Ukrainian Academy of Banking of the National Bank of Ukraine, Sumy, 283.

Yukhimenko, V. (2017). Insurance market of Ukraine in the context of Solvency II implementation requirements, *International economic relations and world economy*, (12, part 2), 190–193.

Yu, L. (2011). Minimizing the cost of risk with simulation optimization techniqu, *Risk Management and Insurance Review*, 14, 1, 121–144.

Vasilyeva, T. A., Leonov, S. V., & Lunyakov, O. V. (2013). Analysis of internal and external imbalances in the financial sector of ukraine's economy. *Actual Problems of Economics*, 150(12), 176-184. Retrieved from https://www.scopus.com/record/display.uri?eid=2-s2.0-84922478082&origin=resultslist

Zhabinets, O. Y. (2013). Problem of classification of risks of insurance companies: scientific approaches and legislative initiatives in the conditions of European integration, Scientific Bulletin of Lviv State University of Internal Affairs (economic series)*,* 2, 38–46.

Zhuravka, O. & Vasylchuk, A. (2017). Analysis of the current state of the Ukrainian insurance market, Effective economy, 3. URL: http://www.economy.nayka.com.ua/?op=1&z=5493 (Accessed 25.07.2022).

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