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SETTING-UP OF INSURERS' RETENTION UNDER THE CIRCUMSTANCES OF RISING REINSURANCE PRICES

SCIENTIFIC PAPER

Abstract

Reinsurance provides protection to the Insurer against large and catastrophe claims and mitigates fluctuations in the aggregate amount of claims, thus contributing to the reduction in insolvency risk. However, a transfer of part of liability under the insurance contract to the reinsurer comes at a price, which reduces the Insurer's profitability. The current increase in reinsurance prices, which was caused by a constellation of natural, macroeconomic and political shocks, is one of the largest ever. Under such circumstances, stating the adequate self-retention is of crucial significance for the Insurer's performance. The paper presents a possible approach to definig the level of self-retention based on the revenue and risks. The approach is based on stochastic simulations of the probability distribution of the aggregate amount of claims at the level of the insurance portfolio and the effects of different reinsurance programs on such distribution, in order to select the program that achieves the maximum ratio between the revenue and risk. Such a reinsurance program corresponds to a level of self-retention that is optimal for a given insurer.

Keywords: *reinsurance, self-retention, capital at risk, return on capital at risk*

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I. Introduction

Reinsurance represents the most important method of risk management by means of which the Insurer (assignor) transfers to the Reinsurer (assignee) parts of the insured risk which exceed the Insurer's retention. By transferring parts of the risk to the reinsurer the realization of which may be in a manifold excess of their financial capacities, the Insurers manage their solvency and profitability in the most efficient way. The primary purpose of reinsurance is to protect the Insurer against large and catastrophe claims, as well as against portfolio losses that significantly exceed the expectations. All these undesired situations can, in the absence of reinsurance protection, lead to the failure of the Insurer, who is solely responsible for indemnifying the Insured. Reinsurance increases the homogeneity of portfolio and reduces the volatility of technical result, which is particularly important for small insurers. The importance of reinsurance is precisely reflected in the protection of the Insurer's financial strength, which increases the Insurer's capacity to absorb large potential losses. Owing to their experience and expertise, reinsurers provide useful assistance in the field of formulation and pricing of new and complex insurance services, as well as with regard of new business entries or new geographical areas. By ceding part of the liability to the Reinsurer, the Insurer is able to assume risks that exceed their capacity. Risks arising from natural disasters would, but for the reinsurance coverage that allows their diversification on a global scale, be uninsurable. Reinsurance represents the fastest and most widespread way of risk atomization and distribution of incurred damages, preventing the Insurer from ending up in a situation of compromising their liquidity, that is, paying more than they can handle.

The benefits of reinsurance coverage for insurers, although undoubted, come at a price. The reinsurance premium directly reduces the profitability of the Insurer. The subject-matter of this paper is the setting-up of self-retention of insurers under the circumstances of rising reinsurance prices. When reinsurance prices rise, the effective use of this significant risk management tool becomes increasingly important for insurers. By keeping too large a part of the risk under their own coverage, the Insurers expose themselves to the risk of being unable to settle their obligations towards the Insured. By assigning too much of the risk under the insurance contract to the Reinsurer, on the other hand, the Insurers expose themsleves to high reinsurance costs. Therefore, the statement of self-retention involves balancing the competing demands of both the Insurer's solvency and profitability. The paper aims to present a possible approach to determining the level of self-retention that reaches the optimal relation between the risk and revenue for the insurer.

II. Current Trends in Global Reinsurance Market

The key challenges for global reinsurance market include increasingly frequent natural disasters, high inflation, the crisis caused by the covid 19 pandemics and the conflict between Russia and Ukraine. Under the influence of these factors, reinsurers around the world have sustained losses that reduce their risk-carrying capacity, which, combined with the growing demand for reinsurance, inevitably leads to an increase in reinsurance prices. The available capital in the global reinsurance market in 2022 was 15.7% lower compared to 2021, which represents the largest decline in reinsurer capital since 2008.[4] Starting from January 2023, the reinsurance prices at the global level have recorded a significant increase, after several years of relatively low levels. Thus, the global reinsurance market entered the so-called *hard* phase, which implied that the reinsurance coverage was more expensive and less available.

Reinsurance broker *Guy Carpenter* estimates that, as of January 2023, relative to January 2022, the reinsurance prices at the global level rised on average by 27.5%,[5] while, according to the estimates of *Howden* broker, the rise amounted to as much as 37% , which is the highest recorded annual growth rate of reinsurance prices since 1992.[6] In North America, property reinsurance prices have increased in the range of 40% to 60%, as from 1 January 2023. The price increase of European reinsurers was somewhat lower, ranging from 25% to 35%.[7] Price growth has been recorded in all lines of business, although at an uneven pace. Particularly large losses recorded in aircraft (re)insurance since the beginning of the conflict in Ukraine, led to a price increase in this reinsurance sector by as much as 200%.[8]

The price index on the global reinsurance market experienced a significant decline starting in 2014, so prices on this market were relatively low during almost the entire previous decade. It is noticeable that since 2017, the annual amounts of insured damages from catastrophe events at the global level were significantly higher, relative to the previous years (Figure 1). In 2017 alone, property damages from natural disasters totaled $147 billion. By comparison, in 1994, these claims ammounted to approximately $20 billion, while reinsurance prices in 2017 were

[4] Howden, *The Great Realignment*, 2023, *https://www.howdengroup.com/sites/g/files/mwfley566/files/2023-01/the-great-realignment-report-2023.pdf* , accessed on: 20.10. 2023, p. 10.

[5] Luke Gallin, "Global property cat rates-on-line up 27.5% at Jan 1 renewals: Guy Carpenter", Reinsurance News, 2023, *https://www.reinsurancene.ws/global-property-cat-rates-on-line -up-27-5-at-jan-1-renewals-guy-carpenter/* , accessed on: 21.10.2023

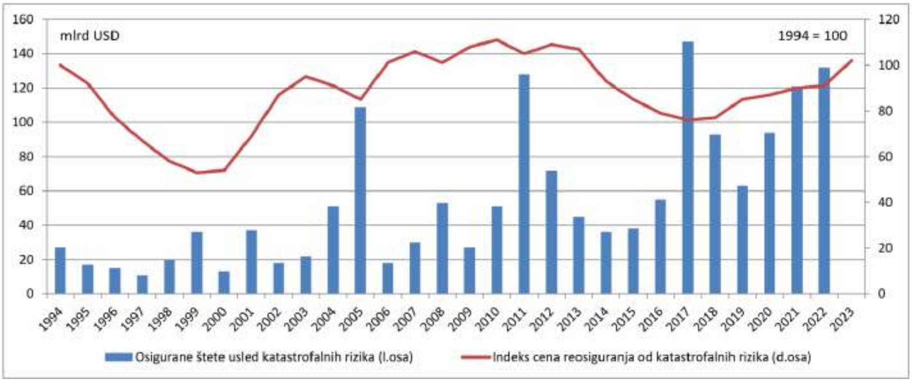
[6] Howden, *The Great Realignment*, p. 3.

[7] Guy Carpenter, "Reinsurance Renewal Insights", January 2023, *https://www.guycarp.com/content/dam/guycarp-rebrand/pdf/Insights/2022/2023 Jan Renewal Briefing v5.pdf* , accessed 10/25/2023, p. 3.

[8] The Financial Times, "Reinsurance costs rise up to 200% as Ukraine war and extreme weather bite", 2023, *https://www.ft.com/content/f5f9d450-c539-47a7-bc5c-44a8db57e74e,* accessed on: 20.10. 2023.

by 24% lower relative to 1994 (price index 2017 = 76, price index 1994 = 100). [9]The annual growth rate of insured losses due to natural disasters during the past three decades ranged from 5 to 7%.[10] Given climate change, urbanization, and the accelerated growth of economic values in areas prone to natural disasters, the trend of insured claims exceeding $100 billion per year can be expected to continue.

Figure 1. Insured Catastrophe Losses and Catastrophe Reinsurance Price Index (1994–2023)



Source: Prepared from M. Panda, "The State of the Reinsurance Property Catastrophe market", Swiss Re

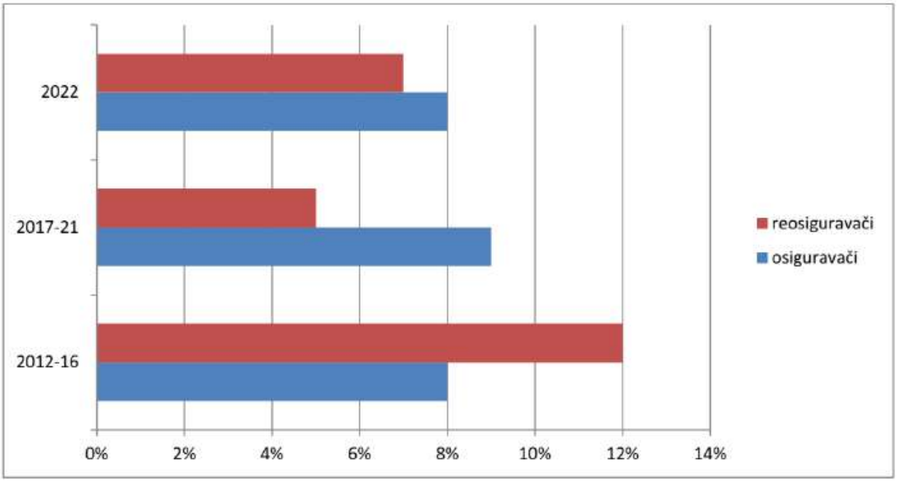
From 2017 to 2022, the (re)insurance sector paid out USD 650 billion (at the 2022 prices) to cover property losses arising from catastrophe weather events.[11] However, premiums did not follow the incresed number of claims, which led to a drop in the profits of (re)insurers and impaired the adequacy of their capital. Consequentially, there was a decline in *return on equity* (ROE), as follows: in the period 2012-2016, the average return on capital in the reinsurance sector equalled 12%, so that in the period 2017-2021 it was reduced to only 5%. However, in 2022, a slight recovery was achieved, so this indicator equalled 7% at the level of global reinsurance market. While return on equity has traditionally been higher in the reinsurance sector than in the insurance sector, the situation has changed since 2017, when on average, the insurers recorded a higher ROE than the reinsurers (Figure 2).

[9] Mohit Pande, "The State of the Reinsurance Property Catastrophe market", Swiss Re, 2023, *https://www.swissre.com/risk-knowledge/mitigating-climate-risk/state-of-reinsurance-property-cat-market .html,* accessed on: 10/22/2023.

[10] Swiss Re Institute, "Natural catastrophes and inflation in 2022: a perfect storm", *Sigma*, No. 1/2023, *https://www.swissre.com/institute/research/sigma-research.html,* accessed on: 26.11.2023, p. 5.

[11] Ibid, p. 21.

Figure 2. Return on Equity (ROE) of Insurers and Reinsurers (2012–2022)



Source: Prepared from Swiss Re Institute, "Natural catastrophes and inflation in 2022: a perfect storm", Sigma, No. 1/2023, p. 21.

Taking into account the data presented, it can be concluded that after several years of poor performance, burdened by losses due to natural disasters, the global reinsurance market is regaining the trend of sustainable development and adequate pricing of actual risks. In September 2023, the rating agency *S&P* published their rating assessment for the global reinsurance sector. The sector was rated as "stable", which represented an improvement relative to the previous negative rating. The agency had had a negative rating of the sector since May 2020, after the covid-19 pandemics began, but the rating was then revised due to structural sectoral changes that occurred during the year 2023. The changes relate to price increase and tightening the reinsurance terms and conditions, as well as an increase in income from reinsurers' investments owing to a slight increase in interest rates.[12] According to the *S&P* agency, the combined ratio of the 20 major global reinsurers amounted to 96% in 2022. The favorable trend continued in the first half of 2023, when the reinsurers recorded a combined ratios ranging from 80 to 90%.[13]

In September 2023, the rating agency *Fitch Ratings* also upgraded the rating of the global reinsurance sector from "neutral" to "upgraded". This improvement reflected the expectations that the financial performance of the sector would be

[12] S&P Global Ratings, *Global Reinsurance Stabilizes As Green Shoots Emerge in Underwriting*, 2023, *https://www.spglobal.com/ratings/en/research/articles/230905-global-reinsurance-stabilizes-as-green-shoots-emerge- in-underwriting-12838027* , accessed 10/30/2023.

[13] Ibid.

better in 2024 as a result of increased reinsurance prices, increased investment returns of reinsurers and high demand for reinsurance. It is forecasted that the rising of the reinsurance prices at the global level will continue in 2024, although to a lesser degree than in 2023, and that in 2025, the price growth would stop.[14]

III. Stating the Self-Retention

Starting from the available data on the history of actual claims, it is possible to predict the total (aggregate) amount of claims in the future, as a basis for stating the insurance premium. In practice, there are deviations of the predicted form the actual losses, which are of a random nature. Fluctuations in the aggregate amount of claims lead to instability of the insurer's business results. Reinsurance makes it possible to reduce the risk of unfavorable deviations from predicted damages to an acceptable level.

However, the question arises as to what effect reinsurance really has on the insurer's business result. On the one hand, this result is positive, because reinsurance protects the Insurer against the large and catastrophe claims and mitigates fluctuations in the aggregate amount of claims that compromise the Insurer's solvency. However, on the other hand, reinsurance coverage comes at a price. The amount of reinsurance premium, which negatively affects the result of the Insurer's business, can be large. In the long term, the reinsurance premium usually exceeds the part of the indemnity paid by the reinsurer.[15] The average price of reinsurance against catastrophe risks which the insurers pay is much higher than the actuarial cost of the risks.[16] Therefore, the net effects of reinsurance on the Insurer's performance are not necessarily positive. It has been shown that the degree of reinsurance utilization, measured by the ratio between reinsurance benefits and the premium transferred to reinsurance, negatively affects the rate of return on the insurer's own capital.[17] The empirical research confirms that reinsurance significantly reduces the volatility of claims and, at the same time, significantly increases the cost of providing insurance services.[18] Depending on the actual realization of claims, the result of the Insurer's business in a specific year can improve but also deteriorate, on account of the reinsurance coverage. Therefore, it is very important to adequately set self-retention,

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[14] Fitch Ratings, *Global Reinsurance Outlook 2024,* 2023, *https://www.fitchratings.com/research/insurance/global-reinsurance-outlook-2024-07-09-2023,* accessed on: 10/30/2023.

[15] Anthony Bradshaw, Martin Bride, Andrew English, David Hindley, George Maher, *Reinsurance and Retentions – A London Market Actuaries Group Paper,* Volume 1, Casualty Actuarial Society, Arlington, 1991, p. 19.

[16] Kenneth A. Froot, "The market for catastrophe risk: A clinical examination", *Journal of Financial Economics,* 60, 2001, p. 540.

[17] Yu Lei, "Reinsurance and Insurers' Risk-Return Profile", *Journal of Insurance Issues*, 42(1), 2019, p. 37–65.

[18] David J. Cummins, Georges Dionne, Robert Gagné, Abdelhakim Nouira, "The costs and benefits of reinsurance", *The Geneva Papers on Risk and Insurance - Issues and Practice,* 46, 2021, p. 195.

as the maximum amount of liability the Insurer can take on without sompromising his liquidity.[19]

Depending on the type of insurance and reinsurance contract, the self-retention is expressed in absolute amount or percentage. The regulation in some countries requires that self-retention corresponds to a certain percentage of the insurer's capital. In practice, there are also rules according to which the amount of self-retention is defined as a percentage of the total insurance premium, profit or assets of the Insurer. An important direction in the actuarial literature refers to the development of mathematical models for setting up the Insurers' self-retention. The interest of actuarial science in solving this problem has not waned since the first contribution made by *De Finetti* in 1940, marking as optimal the level of self-retention at which the variance of the Insurer's profit is the smallest. [20]The mathematical models developed so far are mainly based on the theory of utility [21]or the theory of failure [22]and more or less strict assumptions that make their practical application difficult. However, the amount of self-retention in most cases is determined by factors such as the management's tendency to take risks, the Insurer's financial capacity, but also the current market enviromnent, that is the cost of reinsurance. Further below, the paper presents a possible approach to determining the optimal self-retention of the Insurer based on the risk and return.[23]

IV. Approach to Setting-Up Self-Retention Based on Risk and Return

The result of the Insurer's business, as a random variable, can be represented as follows:

$R = P - S - C$, (1)

where:

R - the result of Insurer's operations (not taking into account the net return on investments),

[19] Jelena Kočović, Tatjana Rakonjac-Antić, Marija Koprivica, Predrag Šulejić, *Insurance in theory and practice,* Faculty of Economics, University of Belgrade, 2021, p. 340.

[20] Bruno De Finetti, *Il problema dei pieni,* Istituto italiano degli attuari, 1940.

[21] For example, Phelim P. Boyle, Jennifer Mao, "Optimal risk retention under partial insurance", *Insurance: Mathematics and Economics,* 1(1), 1982, pp. 19–26; Nan Zhang, Zhuo Jin, Linyi Qian, Rongming Wang, "Optimal quota-share reinsurance based on the mutual benefit of insurer and reinsurer", *Journal of Computational and Applied Mathematics,* 342, 2018, pp. 337–351.

[22] For example, Erwin Straub, *Non life insurance mathematics,* Springer-Verlag Berling Heidelberg, 1988; David CM Dickson, Howard R. Waters, "Reinsurance and ruin", Insurance: Mathematics and Economics, 19(1), 1996, pp. 61–80.

[23] Victor N. Salin, Aleksandr A. Pilipchuk, "Statistical approach to the determination of the optimal level of equity retention for a fearsome company", *Finance: theory and practice,* 2, 2007, p. 34–43.

P – total premium,
S - total (aggregate) amount of claims,
C – operating expenses.

The stochastic nature of business results stems from the stochastic nature of claims, since the total premiums and operating expenses for the following year are easier to predict. Capital at Risk (CaR) should cover unfavorable deviations of actual from the expected business results (Figure 3). In case of:

α - acceptable probability of failure,

H_α - the quantile of the distribution of business results at the level of trust α,

$E(R)$ – expected value of business results.

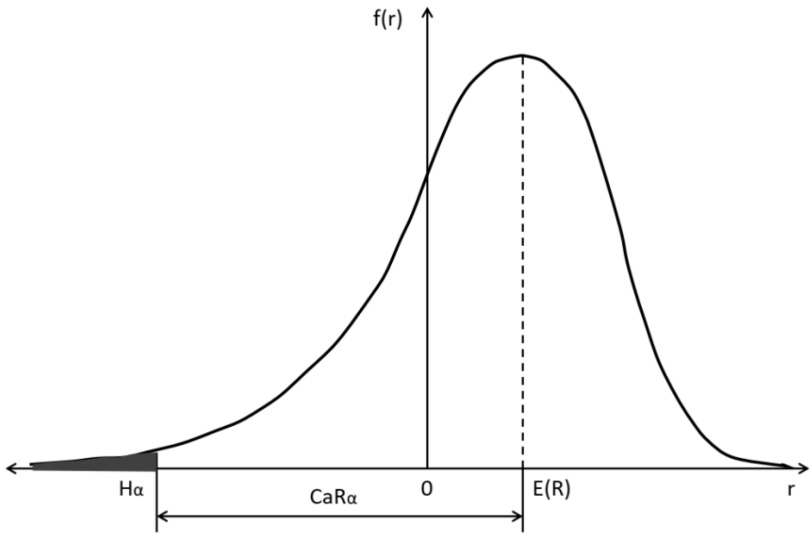
the following shall apply:

$$\Pr(R \leq H_\alpha) = \alpha, \tag{2}$$

and the capital at risk may be represented as:

$$CaR_\alpha = E(R) - H_\alpha. \tag{3}$$

Figure 3. Density function of business results



Source: Adapted from V. N. Salin, A. A. Pilipchuk, p. 36.

In order to adequately manage the risks that may compromise the Insurer's solvency, it is necessary to identify factors that can affect the probability distribution of the annual business result, and thus the size of the capital at risk. Expected growth in premiums with the same level of risk means higher profits with the same level of capital at risk. Lowering operating expenses increases operating results and reduces capital requirements. Also, changing the portfolio structure can change the probability distribution of business results. However, these are all factors that the Insurer cannot significantly influence in the short term. An instrument by which the Insurer can affect the probability distribution of business results is reinsurance.

The concept of capital at risk combines two important quantities: risk and return. Namely, the quantile of the probability distribution of business results reflects the risk of failure of the company at the chosen confidence level. The expected value of the probability distribution of business results corresponds to the expected profit. The relationship between these quantities is reflected by the return on capital at risk *(* RoCaR):

$$RoCaR = \frac{E(R)}{CaR}. \quad (4)$$

Return on capital at risk ($RoCaR$) can be used as a criterion for comparing different reinsurance programs. In the general case, at the same level of risk, the reinsurance program with the higher expected result of the Insurer's business is better. At the same expected profit, the reinsurance program with lower capital at risk is better. Consequentially, it is necessary to choose the reinsurance program where the return on capital at risk ($RoCaR$) is the highest, because this leads to a maximum ratio between the return and risk.

Stochastic modeling can be used to determine in practice which reinsurance program achieves the highest return on capital at risk ($RoCaR$). The model for determining the self-retention consists of three modules: a claims module, a module that includes reinsurance and a resulting module.[24]

1. Claims Module

Within the claims module, a complex probability distribution of the aggregate amount of claims S is done by combining the distributions of the number (frequency) and amount (intensity) of claims. The basis for describing the distribution of damage probabilities is the available data on realized claims. For these purposes, an analytical method is most often used, which implies adopting the appropriate theoretical model of distribution and which, to the best possible extent, is adapted to the given set of data.[25]

[24] V. N. Salin, A. A. Pilipchuk, p. 37.

[25] Krzysztof Burnecki, Adam Misiorek, Rafał Weron, "Loss Distributions", *Statistical Tools for Finance and Insurance* (editors Pavel Čížek, Rafał Weron, Wolfgang Härdle), Springer-Verlag, Berlin, 2005, p. 289.

The starting point for modeling the aggregate amount of claims is the choice of the appropriate theoretical distribution of the number of cliams N, as a discrete, non-negative random variable. In practical applications, the Poisson distribution, which has only one parameter (λ) is always the premium choice.[26] As the expected number of claims per insurance policy, the parameter λ can be estimated based on the average frequency of claims. [27]It is known that the expected value and variance of a random variable having a Poisson distribution with parameter λ equal λ. Therefore, the Poisson distribution is not adequate in a situation where the variance of a given variable exceeds its expected value, and where a negative binomial distribution may be applied instead.

For the purposes of modeling the variable amount (intensity) of claims X, absolutely continuous probability distributions are used. Although the set of possible values of a given variable is reasonably limited, the usual domain of definition of the used distributions is $(0,+\infty]$. Data on the amounts of claims in non-life insurance are most often described by distributions such as gamma, exponential, log-normal, Weibull, Pareto, Burr and log-gamma distributions.

Based on the separately modeled number of claims N and the amount of individual claims $X_i, i=1,2,...$, a complex distribution of the aggregate amount of all claims S at the level of the insurance portfolio during one year is performed using the simulation method:

$$S=\sum_{i=1}^{N} X_i.. \quad (5)$$

If, for example, the Poisson distribution is chosen for the distribution of the number of claims, the distribution of the total amount of claims is a complex Poisson distribution. Similarly, for the negative binomial distribution of the number of claims, the distribution of the total amount of claims is a complex negative binomial distribution. The algorithm that simulates the distribution of the aggregate amount of claims S includes the following steps:

1) From the selected random variable distribution N, using a random number generator, the number of claims n_1 is extracted and the same number of values $x_1, x_2, ..., x_{n_1}$ from the random variable distribution of the amount of individual claims.
2) The sum $s_1 = x_1 + x_2 + ... + x_{n_1}$ represents the first random realization of the total amount of claims S.

[26] Rob Kaas, Marc Goovaerts, Jan Dhaene, Michel Denuit, *Modern Actuarial Risk Theory Using R,* Springer, 2008, p. 45.

[27] Marija Jovović, *Risk measurement when determining the solvency of non-life insurers,* doctoral dissertation, Faculty of Economics, Belgrade, 2015, p. 165.

Steps 1)-2) are repeated n times in order to create a "pseudo" random sample of data $s_1, s_2, ..., s_n$, on the basis of which an empirical distribution function is derived that approximates the unknown distribution function of the variable S.[28]

2. Module That Includes Reinsurance

In the following module, it is necessary to incorporate the effects of the various reinsurance programs that are being considered into the distribution of the aggregate amount of claims using the simulation method. The inputs for such module are the parameters of the reinsurance contract: the type of contract, how much of the risk is carried forward to reinsurance, the number of layers of protection and their scope, reinsurance premium, etc. Through a random number of simulations, the aggregate amount of claims at the level of the Insurer's portfolio is classified in the protection levels for each of the reinsurance programs.

In general case, the effect of reinsurance is reflected in the reduction of the dispersion of the aggregate amount of claims. At the same time, different types of reinsurance affect the distribution of the aggregate amount of claims in different ways.[29] Pro rata reinsurance reduces the expected value of the distribution of the aggregate amount of claims pro rata the the percentage by which part of the liability under the insurance contract is carried forward into the reinsurer's coverage. In the case of non-proportional reinsurance, the reinsurer compensates (in an unlimited or a limited manner) the cliams in excess of the Insurer's defined self-retention through the insurer's defined self-retention, by individual cases (reinsurance of excess claims) or on an annual basis (reinsurance of excess annual cliams). The effect of non-proportional reinsurance on the distribution of claims is reflected in its cut-off at the level of a defined threshold (self-retention). Thus, proportional reinsurance reduces the insurer's risk linearly, while non-proportional reinsurance coverage shortens, or even eliminates, the tail of the cedent's claims distribution, thereby reducing exposure to catastrophe claims.[30]

By combining the simulated aggregate amount of claims that includes the effects of one reinsurance program with the premium and costs of the Insurer's business according to form (1), we obtain one realization of the results of the Insurer's business R with a given reinsurance program. By conducting a random number of simulations, we obtained the probability distribution of the results of the Insurer's business that would be achieved with each of the observed reinsurance programs individually.

28 M. Jovović, p. 291.

29 Jorge W. Euphasio, João VF Carvalho, "Reinsurance and Solvency Capital: Mitigating Insurance Companies' Ruin Probability", *Revista de Administração Contemporânea,* 26(1), 2022.

30 M. Jovović, p. 69.

3. Resulting Module

In the resulting module, for each of the derived distributions of the Insurer's business results with different reinsurance programs, the expected value of the business results $E(R)$ and the capital at risk CaR_α are calculated (as the difference between the expected result and the quantile of the distribution of results at the selected confidence level α). By comparing those two quantities according to form (4), the return on capital at risk $RoCaR$ is calculated. Thereafter, it is determined which of the considered reinsurance programs achieves the maximum value of $RoCaR$ This reinsurance program corresponds to a level of self-retention that is adequate for a given insurance company, taking into account the return and the risk.

V. Conclusion

Due to increasingly frequent and devastating natural catastrophes, inflationary growth and the crisis caused by the covid-19 pandemics, as well as the conflict between Russia and Ukraine, reinsurers around the world are facing losses that reduce their risk-taking capacity. Following the decline of reinsurers' capital and the simultaneous growth of the demand for their services, reinsurance prices at the global level are recording a record growth. Increasingly expensive reinsurance coverage requires the statement of an adequate self-retention, which will preserve the insurer's solvency, but not at the cost of compromising their profitability. The paper presents a possible approach to stating the level of self-retention based on returns and risks. The approach is based on stochastic simulations of the probability distribution of the aggregate amount of claims at the level of the insurance portfolio and the effects of different reinsurance programs on such distribution, in order to select the program that achieves the maximum ratio between return and risk. Such a reinsurance program corresponds to a level of self-retention that is optimal for a given insurer.

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