FACTA UNIVERSITATIS
Series: **Economics and Organization** Vol. 21, Nº 3, 2024, pp. 185 - 201
https://doi.org/10.22190/FUEO230819013M

Original Scientific Paper

RISK FACTORS FOR THE OCCURRENCE OF CLAIMS AND THE ADEQUACY OF NON-LIFE INSURANCE PREMIUMS

UDC 368.91

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Abstract. *In order to maintain business stability and ensure the fulfillment of assumed obligations, insurers strive to establish adequate systems for identifying and measuring risks. Identifying the sources of risk factors for premium inadequacy and finding solutions to mitigate these risks is of crucial importance for the ability of insurance companies to cover claims and ensure business continuity. Therefore, the aim of this paper is to demonstrate how the occurrence of claims affects premium adequacy and to contribute to the elimination or mitigation of the risk of premium insufficiency*.

Key words: *claims (damages), premium, risk, reserves, premium instability*

JEL Classification: G22, G32

1. INTRODUCTION

The business activity of insurance companies is based on insurance statistics. Therefore, it is stated that insurance statistics is the foundation for determining the amount of obligations an insurance company has toward the policyholder (Sibindi, 2015). Given the vast amount of statistical data and the differences in their quality, there are numerous topics that can be discussed using such data. Considering the aforementioned claim, all statistical data can be classified into reporting data and risk statistics data.

The task of insurance reporting statistics is to collect insurance data, systematize it, process it, and produce statistical reports in a legally prescribed format and within specific time periods. Since this type of statistics uses financial data, there is the assertion that statistical and accounting financial reports have different objectives and will never be

Received August 19, 2023 / Revised September 26, 2024 / Revised October 29, 2024 / Accepted October 30, 2024
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fully harmonized. This was the reason why, in June 2003, IFAC initiated a meeting of relevant international organizations to discuss (Parry, 2011, p. 8):

- the differences in information reported by IPSAS, the IMF, and the Statistics Manual and
- the necessity of identifying processes that would eliminate or reduce all forms of discrepancies appearing in the mentioned reports.

In the Republic of Serbia, the Insurance Law from 2004 contributed to the improvement of reporting statistics. Namely, it replaced the previously lax legal regulation with strict supervision by the National Bank of Serbia, which enabled orderly and systematic reporting.

The goal of risk statistics is to provide the insurer with the necessary information so as to more accurately predict potential risks they undertake and to more precisely determine the amounts of money needed in the form of premiums for different types of insurance. In other words, the analysis of past statistical data aims not only to provide descriptions and explanations of specific phenomena but also to enable forecasting the magnitude and dynamics of occurrences in the future. It offers clear and detailed information about the actual exposure of the insurance company to a particular risk, as well as about the claims themselves (Parkinson, Noble, 2005). Additionally, this type of statistics involves the application of statistical analyses and tests to monitor the correctness of the company's operations, as well as the use of various simulation methods in cases where there is no database available for actuarial analysis.

Considering the aforementioned claim about the numerous topics that can be discussed using insurance statistics, the primary objective of this paper is to determine the interdependence between the risk of claim occurrence and the adequacy of non-life insurance premiums. Specifically, an inadequately low premium leads to insufficient technical reserves and jeopardizes the continuity of fulfilling obligations by insurance companies. On the other hand, an excessively high premium makes the insurance company uncompetitive, leads to potential policy holders abandoning the purchase of insurance services, and results in loss of business (Doganjić, 2015, pp. 85-98). Therefore, maintaining the risk of premium adequacy within acceptable limits is a guarantee of ensuring the continuity of fulfilling the insurance company's obligations. Accordingly, the research in this paper tested the following hypotheses:

H_1: An important element for the accurate calculation of insurance premiums is the expected value of future claims.

H_2: Considering that the primary function of insurance is to compensate the policyholder for claims, it is essential that the insurance company always has the necessary funds to meet its obligations towards the policyholder. This also means that the premium level must be adequately determined.

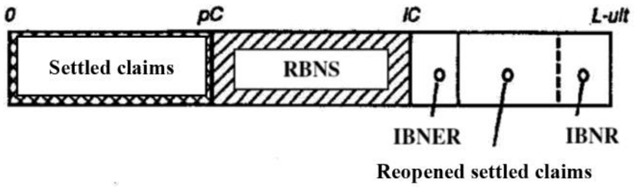
H_3: It is possible to determine the individual impact of the risk of a damaging event and the risk of forming technical reserves on the level of insurance premiums.

In determining the interdependence between claims and premiums, both quantitative and qualitative indicators were used, and relevant literature was consulted.

The structure of the paper consists of five sections. Following the introductory considerations, the second part provides an overview of theoretical discussions and existing research on the interdependence between the risk of claim occurrence and the adequacy of premiums. The third part focuses on the methodology for calculating premiums, which includes the basic insurance risks. Given that the paper, apart from theoretical, also includes a practical section related to the insurance industry for auto liability risks, the fourth part presents a practical example, using data from the National Bank of Serbia, to perform the necessary calculations that support the proposed hypotheses. The final part, as the fifth section, summarizes the research findings.

2. Interindependece of Claims and Premiums

The expected value of future claims is a significant element for the adequate calculation of insurance premiums. However, in many cases, the incurred claims cannot be accepted as an estimate of the final amount of losses from claims. The reasons are numerous. For example, there is the possibility of reopening already settled claims (see Figure 1), or insufficient funds have been reserved for reported and unreported claims (see Figure 2).



IBNER - Incurred But Not Enough Reported
IBNR – Incurred But Not Reported

Fig. 1 Structure of incurred claims
Source: Pavlović B., 2010, p. 239-260

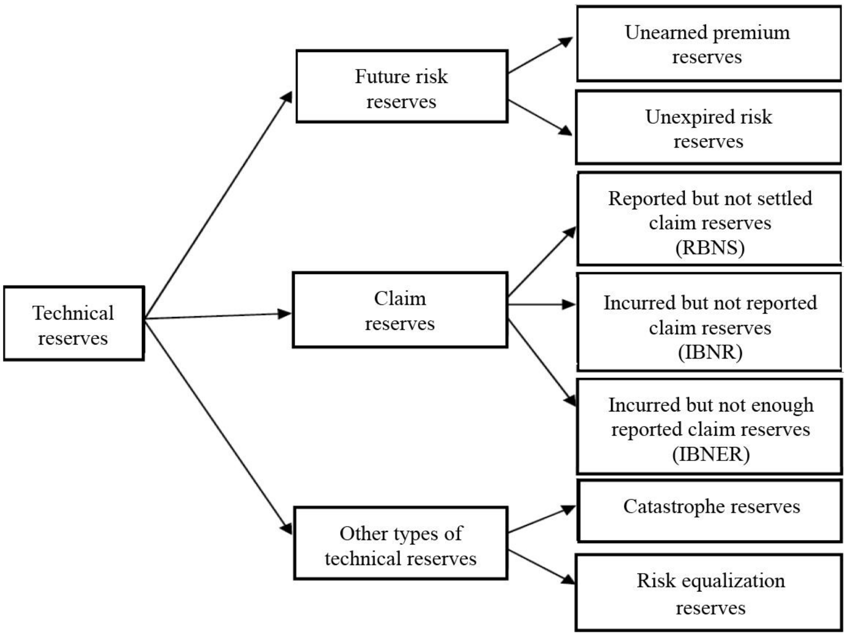


Fig. 2 Technical reserves for non-life insurance

Additionally, different risk communities have varying conditions, and therefore, the data on claims alone are often insufficient and not relevant. By examining Figure 3, it can be observed that the function of paid claims (pC) and incurred claims (iC) gradually converge and eventually merge at point L-ult, which represents the final amount of claims. This problem is particularly pronounced in types of insurance characterized by a long period between the incurrence of the claim and its settlement. The logical conclusion is that accurately estimating the final amounts of claims is complex and that sometimes available statistical data are insufficient and inadequate for determining the portion of the premium intended for claims payments.

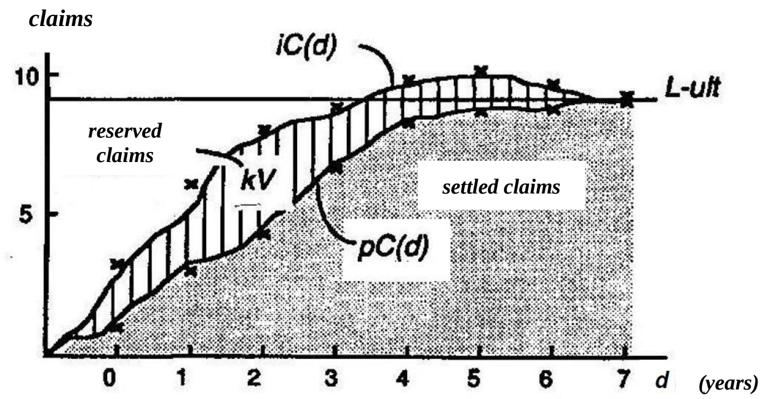


Fig. 3 Ratio of reserved to settled claims
Source: Pavlović, 2010, p. 239-260

In recent decades, there has been a noticeable trend of increasing economic losses resulting from catastrophic events. Their characteristics are high amounts of claims and low frequency. As such, these events negatively affect the accuracy of insurance premium forecasting. Namely, they distort the loss distribution approximated by exact data from the risk group where the catastrophic event occurred. Therefore, stochastic methods and probability theory are used for assessing the insurance premiums for catastrophic risks. One category of these models includes Nat Cat probabilistic models, which comprise the following modules: event generator, claim intensity assessment, exposure database, physical claim assessment, and assessment of claims covered by insurance (Doganjić J., 2018). Claims about catastrophic risks clearly demonstrate that one of the prerequisites for creating a quality premium system for a specific type of insurance is defining the key risk factors that influence the frequency and severity of claims. In this sense, to assess the risk of claim occurrence, it is necessary to understand distrributions of the probability of claim occurrence. The most commonly used loss distributions are the Weibull, exponential, log-normal, Burr, and Pareto distributions (Table 1). However, determining the probability distribution is difficult, which has serious implications for the reliability of premium estimates. For example, Heckman and Meyers developed an algorithm for calculating cumulative probability and pure premium based on collective risk theory, using data on the distribution of the size and frequency of claims (Heckman, Meyers, 1984, p. 22-61). Boland proposed using predictive methods to demonstrate that the collected premiums may be sufficient to cover the losses (Bortoluzzo, 2011). According to Dropkin and Bickerstaff, the log-normal distribution should be used for assessing the interdependence of premium and certain types of homogeneous loss data (Dropkin, 1964, p. 68; Bickerstaff, 1972, p. 68).

Table 1 Some forms of continuous probability distributions for the occurrence of claims"

Distribution	Distribution function	Density function	Conditions
1. Weibull	$F(x) = 1 - \theta^{-(\frac{x}{\theta})^{\tau}}$	$f(x) = \frac{\tau(\frac{x}{\theta})^{\tau}\theta(\frac{x}{\theta})^{\tau}}{x}$	x≥0, θ >0. τ >0
2.Exponential	$F(x) = 1 - \theta^{-\frac{x}{\theta}}$	$f(x) = \frac{1}{\theta}\theta^{-\frac{x}{\theta}}$	x≥0, θ >0.
3. Log-normal	$F(x) = \Phi(\frac{lnx - \mu}{\sigma})$	$f(x) = \frac{1}{x\sigma\sqrt{2\pi}}\exp(-\frac{1}{2}\left(\frac{lnx - \mu}{\sigma}\right)^{2})$	x>0, σ >0, $\mu \in R$
4. Burr	$F(x) = 1 - (\frac{1}{1 + \left(\frac{x}{\theta}\right)^{\gamma}})^{\alpha}$	$f(x) = \frac{\alpha\gamma(\frac{x}{\theta})^{\gamma}}{x\left[1 + (\frac{x}{\theta})^{\gamma}\right]^{\alpha+1}}$	x>0, γ>0, α>0
5. Paret	$F(x) = 1 - (\frac{\theta}{x + \theta})^{\alpha}$	$f(x)\frac{\alpha\theta^{u}}{(x + \theta)^{\alpha+1}}$	x>0. θ>0, α>0

Source: Klugman, Panje, Willmot, 2004, pp. 627-643

Pentikainen argues that using normal distribution can yield acceptable results regarding the interdependence of premiums and claims only if the volume of risky business is sufficiently large and the distribution of individual claims is not heterogeneous (Pentikainen, 1977, p. 281). In his paper, Seal utilized estimates based on gamma distribution and concluded that it provides the best estimate for the interdependence of claims and premium levels (Seal, 1977). Sundt (Sundt, B., 1982, p. 89) published a paper on the asymptotic behavior of complex loss distributions and proved that if the distribution of the number of losses is negative binomial, then the aggregate loss distribution in the tails can be approximated by gamma distribution. Gendron and Crepeau found that reasonable and accurate data can be obtained using estimates based on gamma distribution if the claim size follows an inverse Gaussian distribution and the frequency follows a Poisson distribution (Gendron, Crepeau, 1989, p. 251). Venter proposed transformed gamma and transformed beta distributions for estimating aggregate loss distributions (Venter, 1983). Papush, Patrik, and Podgaits concluded that gamma distribution allows for better fitting of individual distribution data compared to normal or log-normal distributions (Papush, Patrik, Podgaits, 2001). Considering these studies, a logical conclusion is that gamma distribution represents a reasonable choice for estimating aggregate loss distribution when specific data for frequency and specific data for claim size are unavailable. On the other hand, practice has shown that statistical tests (Kolmogorov-Smirnov, Jarque-Bera, Anderson-Darling tests) are also used for this purpose, which opens up real possibilities for stochastic methods in premium determination to be increasingly utilized in the future.

The interdependence of claims and premiums can also be viewed from the perspective of cyclical movements in premiums, particularly in non-life insurance. Specifically, the property insurance market is characterized by fluctuations between periods of a "hard" market, when strict insurability standards and high premiums prevail, and a "soft" market, where liberal insurability standards and low premiums dominate (Rejda, 2005, pp. 67). This ultimately reflects on the level of claim coverage. Transitions from one insurance market to another occur through four phases or steps (Trufin, Albrecher, Denuit, 2009, pp. 386).

- In the recession phase, insurers strive to improve their sales and consequently begin to lower the premium levels, becoming more lenient regarding the risks they accept for coverage. This leads to greater losses from insurance operations.
- The crisis phase is characterized by insurers' efforts to regain profits by increasing premiums and implementing stricter conditions for accepting risks into coverage. This is achieved by offering coverage only for the "safest" risks.
- Considering that the sequence of "hard" and "soft" markets is documented by premium levels, profitability, and insurance capacity (Manikowski, 2012, 1309-8055), in the recovery phase, profitability does not rise above the limits reached during the crisis phase.
- During the fourth phase, profitability gradually decreases, and the insurance industry returns to a period of low profitability.

Fig. 3 Insurance cycle
Source: Mihelja Žaja, Jakovčević, Anđelinović, 2014. p. 99.

The duration of one insurance cycle, historically observed, is limited to periods of five to seven years (Venezian 1985; Cummins, Outreville 1987; Grace, Hotchkiss 1995; Lamm-Tennant, Weiss 1997). However, in different countries and for different insurance lines, the cycle length varies. For example, Meier found that if a larger number of explanatory variables are included in the regression model for calculating cycle length, the insurance cycle in the U.S. is 10 years, and in some countries, it can reach up to 18 years (Manikowski, 2012; Boyer, Jacquier, Norden, 2012, pp. 995-1015). Regarding the Serbian insurance market, data on cyclical movements are almost nonexistent. Despite this, many authors believe there is no possibility of adequately using past information to determine premiums for insurance products that will be sold "tomorrow" and the level of claims that may arise in the distant future. Furthermore, the above reasoning also explains why cyclical movements in the property insurance industry will continue to occur in the future (Njegomir, 2006, pp. 47-61).

The causes that lead to the occurrence of cycles in non-life insurance are numerous. The most significant include: delayed availability of information and premium adjustments, dependence on the capital market, adjustments in reserve levels, the state of profitability and cash flows, forecasting errors, insurer moral hazard, risky debt, interest rate fluctuations, and capacity limitations in underwriting (Dionne, 2000, pp. 4; Skurnik, 2003, pp. 378-381).

3. PREMIUM AS A FUNCTION OF FUNDAMENTAL RISKS

By accepting risks of claims into insurance, an insurance company forms a grouping of risks and disperses them, which implies that, given a sufficient number of insured homogeneous risks, losses will occur according to the anticipated scenario. However, the temporal mismatch between premium agreement and claim payment, as well as the uncertainty of the frequency and intensity of claims, results in the absence of a unique methodology for determining premiums. According to Denuit, the concept of pricing insurance can be seen as a procedure that involves determining a fair premium that is adequate for the individual risk profile of the policyholder. Starting from this idea, some authors view the process of determining insurance pricing as a method for establishing the price that policyholders pay to the insurance company in exchange for risk transfer. In recent empirical studies, there are claims that the price of insurance is an effective mechanism against asymmetric information only if the insurance portfolio is divided into sub-portfolios, as the risks are independent variables, and each risk class has its own premium depending on the severity of the risk (Chiappori, Salanié 2000; Dionne, Gouriéroux, Vanasse, 2001.).

The contracting of equal premiums for all policyholders of a certain type of insurance implies that the adequacy of the premium to cover the insurer's expected losses depends on the participation of policyholders from individual homogeneous risk groups, which ultimately causes premium instability and negative risk selection. Therefore, insurers must pay attention to defining risk factors and create tariffs according to the assessed risks. The "fair" risk-premium, or the premium that would correspond to the risk for each individual homogeneous risk group, can be represented by an equation:

$$Pi=E(Xi) \tag{1}$$

where: Pi is the "fair" risk-premium for each homogeneous risk group; $E(Xi)$ is the expected amount of losses for each homogeneous risk group; and i represents the homogeneous risk group where $i = 1, 2,..., m$.

However, the general requirement is that the premium be assessed based on all expected future costs related to the transfer of risk of claims to the insurance company. In this sense, the insurer should calculate the following indicators: loss ratio, expense ratio, combined ratio, and operational ratio using data from the income statement for the reporting period.

The loss ratio represents the relationship between the claims that have occurred and the earned premiums. This calculation indicates whether the premiums cover the risk taken under the insurance contract. The expense ratio is the ratio of expenses to earned premiums, where expenses include commissions, administrative costs, and other costs associated with the implementation of the insurance. This ratio is used to assess how well the expenses are covered by the premiums. The combined ratio, which is the sum of the loss ratio and the expense ratio, provides a rough estimate of the profitability of the insurance business. The operating ratio is the combined ratio adjusted for investment returns. This ratio allows for an assessment of the business after accounting for allocated investment income.

Some methods for calculating the adequacy of premiums or their constitutive parts use data on trend assessment. Therefore, insurers should publish not only historical data on earned premiums but also data on technical reserves by types of insurance. One of the methods that incorporates a trend component is the Hodrick–Prescott filter[1] (Mihelja Ž.M. 2013). In this sense, the risk of a harmful event can be calculated as the ratio of the difference between the frequency of loss occurrence and loss trend.

$$risk\ of\ a\ harmful\ event\ occurring = \frac{loss\ frequency - trend}{trend} \tag{2}$$

The risk of reserve formation refers to the risk that the total amount of technical reserves has been poorly estimated and, as such, will not be sufficient to cover claims. This risk can be quantified using data on technical reserves for non-life insurance and data on mathematical reserves for life insurance.

$$reserve\ formation\ risk = \frac{technical\ reserves - trend}{trend} \tag{3}$$

According to the previous statements, the risk of premium determination can be calculated as the difference between the combined ratio and the trend component, using Formula 3. The risk of premium determination is present at the moment of issuing the policy, i.e., before the insured event occurs. It implies that the costs and claims that will arise will be greater than the received premium.

$$risk\ of\ premium\ determination = \frac{combined\ ratio - trend}{trend} \tag{4}$$

Greater values of the calculated indicators imply a higher risk of premium determination, risk of reserve formation, and risk of a harmful event occurring.

4. Specificity of the Interdependence between Claims and Premiums in Liability Car Insurance

Modern society makes great efforts to keep compensation for claims from traffic accidents under control. Therefore, it is the obligation of the state to bring the risks associated with traffic flow into socially acceptable limits. In this sense, by mandating

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[1] *The Hodrick-Prescott filter is a smoothing method used in economics to obtain an estimate of the long-term trend component of a time series. Specifically, to estimate the HP filter, it is necessary to select a smoothing parameter value of 100 when using annual data, 1600 for quarterly data, and 14400 for monthly data.*

compulsory liability car insurance (AO), states prescribe the conditions under which this insurance is implemented. Thus, in some countries, there is a dominant premium system that all insurance companies must comply with. However, their experiences show that the model of administrative supervision over compulsory liability car insurance is not sustainable in the long term due to inefficiencies. Some reasons for these inefficiencies include price as a component of social policy, excessive administration, a narrowed space for competition among insurers, etc. The experiences of countries that have introduced free tariff formation for compulsory liability car insurance show that allowing insurers to freely determine premiums, by itself, without adequate risk management, sufficient premiums and reserves for compensation for claims, and without permanent oversight by relevant institutions, does not lead to improvements in the compulsory liability car insurance system or better protection for both policyholders and insurers.

By applying statistical functions in Excel to the annual data from the National Bank of Serbia regarding the operations of insurance companies, it was determined that the share of premiums from liability car insurance in the Republic of Serbia accounted for an average of 32.50% of total insurance from 2005 to 2022, with a share of 40.43% in non-life insurance—making it the largest individual share. Additionally, 96.99% of the risks from liability car insurance were retained by insurance companies within their own reserves. The correlation between premiums and the value of claims during the same period was extremely high at 0.9095, between premiums and the value of technical reserves at 0.9646, between technical reserves and the value of settled claims at 0.9197, and between the total number of claims and the number of policies at 0.8723. The centralized system of organizing liability car insurance, combined with the significant relative share of this insurance in the overall non-life insurance portfolio, raises the question of the adequacy of premium assessment per liability car insurance policy and its implications for the overall non-life insurance market in the Republic of Serbia. According to the previously mentioned data, the average premium during the period from 2005 to 2022 was 10,098 dinars, while the average claim was 137,035 dinars. For one claim to be settled, it was necessary for 28 policyholders to have no claims at all.[2]

Based on the logic of further research, the following quarterly time series have been defined: gross premiums for liability car insurance, the risk of a harmful event occurring (r_dog), the risk of obtaining insurance (r_prib), the risk of forming technical reserves (r_rez), and organizational risk (r_org). To enable the use of data from these time series in analyses, the data have been transformed in two ways.

- The time series data for the gross premiums of liability car insurance were transformed using the logarithmic function (LN), as these are the only nominal data. Given that this series was used to calculate the insurance cycle duration, it was determined using the equation defined by Meier and Outreville (Meier and Outreville, 2006, pp. 164). The duration of the liability car insurance cycle in the Republic of Serbia was 6.28 years (Table 2), which indicates that changes in liability car insurance prices ultimately affect the availability of insurance coverage. In some years, it is harder to obtain coverage, while in others, it is easier.

$$Period(II) = 2\pi / \cos^{-1}(a_1 / 2\sqrt{-a_2}) \quad (5)$$

[2] Average premium=premium value/number of policies; average claim=value of settled claims/number of settled claims; to liquidate one claim=total number of policies/total number of liquidated claims

- Other data (r_dog, r_prib, r_rez, and r_org) were transformed using the Hodrick-Prescott filter to eliminate short-term fluctuations that could be attributed to the cyclicality of insurance.

Table 2 Calculation of the length of the cycle of liability car insurance in the Republic of Serbia

	Coeffi-cients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	0.02657	0.02071	1.28315	0.20535	(0.01502)	0.06816	(0.01502)	0.06816
a1	0.52761	0.13231	(3.98755)	0.00022	(0.79337)	(0.26185)	(0.79337)	(0.26185)
a2	(0.31522)	0.13019	(2.42121)	0.01914	(0.57672)	(0.05372)	(0.57672)	(0.05372)

Source: Author's calculation based on the NBS data for the period 2005-2022

$$X_t = a_0 + a_1 X_{t-1} + a_2 X_{t-2} + w_t \quad (6)$$

where X_t – the premium in period t; w_t – is the random error.

Condition for the presence of the cycle

$$a_1 > 0, a_2 < 0 \text{ and } a_1^2 + 4a_2 < 0 \quad (7)$$

$$0.52761 > 0; \; -0.31555 < 0; \; 0.278372+4 \times (-1.26088) = -0.98251 < 0$$

Length of the cycle of liability car insurance

$$\text{Period (II)} = 2\pi / \cos^{-1}(a_1/2\sqrt{-a_2}) = (2x3.14) \text{ x } (1: \cos (0.52761 \text{ x } \sqrt{0.31522})) =$$

$$6.28 \text{ x } [1/\cos (0.2962237672)] = 6.28 \text{ x } (1/0.9999866352) = 6.28 \text{ years}$$

The condition for answering the question of whether the premium reflects the individual influence of the risk of occurrence of a harmful event, the risk of forming technical reserves, and organizational risk, involves applying a multiple linear regression model. However, determining the overall interdependence of all the mentioned variables requires the application of a vector autoregression (VAR) model. The first step in applying these models is to determine the stationarity of each time series individually. Stationarity was tested using the ADF test, and the results are presented in Table 3.

Table 3 ADF test results

	ADF test		
Variable	Constant	Constant and trend	Without deterministic components
ln_prem	-1.116	-2.284	1.230
r_dog	-5.601*	-5.568*	-5.658*
r_rez	-5.608*	-5.564*	-5.667*
r_prib	-3.621*	-3.598*	-3.663*
r_org	-7.583*	-7.526*	-7.654*
	ADF test		
First difference	Constant	Constant and trend	Without deterministic components
dln_prem	-13.467*	-13.351*	-12.247*

Stationarity of the time series at a significance level of 5%
Source: Author's calculation based on the NBS data for the period 2005-2022

The next step is to determine the information criterion of the model. According to the data in Table 4: AIC suggests a lag length of k=3; HQIC suggests a lag length of k=2;

and SBIC suggests a lag length of k=1. Due to the presence of significant autocorrelation at lag k=3, a lag length of k=2 was chosen.

Table 4 Information criterion of the model

Selection-order criteria
Sample: 2005q2—2022q4 Number of obs =71

lag	LL	Df	p	FPE	AIC	HQIC	SBIC
0	264.890	25		2.6e-11	-101.918	-101.194	100.024
1	358.533	25	0.000	1.8e-12	-128.837	-124.494	11.7473*
2	401.135	25	0.000	9.1e-13*	-135.739	-12.7778*	114.906
3	427.927	25	0.001	9.1e-13	-13.6442*	-124.862	106.139
4	448-445	25	0.023	1.3e-12	-134.684	-119.486	949-113

Source: Author's calculation based on the NBS data for the period 2005-2022

After establishing the stationarity of the time series (r_dog, r_rez, r_prib, r_org), the first-order differentiation of the time series dln_prem was performed, followed by lagging of 2 steps (forming the variable dln_prem_L2). A multiple linear regression analysis was then conducted where the dependent variable was dln_prem_L2, and the predictors were r_dog, r_rez, r_prib, and r_org. The results of the analysis are presented in Table 5. According to the data in Table 5, the explanatory power of the model is 60%, meaning that 60% of the variability in the dependent variable can be explained by the variability of the predictors. The value of F is less than 0.05, indicating that the model is statistically significant. For the model to be representative, it is also necessary to test the presence of autocorrelation and heteroscedasticity.

Table 5 A multiple linear regression analysis results

Source	SS	df	MS	Number of obs	= 72
Model	.95491092	4	.23872773	F(4, 68)	= 20.14
Residual	.56906055	68	.01185543	Prob>F	= 0.0000
Total	1.5239714	72	.02930714	R-squared	= 0.6266
				Adj R-squared	= 0.5955
				Root MSE	= .10888

dln_prem_l2	Coef.	Std.Err	t	P>T	95% Conf. interval	
r_dog	.286486	.149501	1.91	0.062	-0.0144049	.5873786
r_rez	.797637	.310462	2.57	0.013	0.1734105	1.421.863
r_prib	_.617736	.222718	-2.77	0.008	-1.065.541	-.1699307
r_org	1.445207	.414528	3.49	0.001	0.6117418	2.278673
_cons	.015561	.014966	1.04	0.304	-0.0145304	.0456523

Source: Author's calculation based on the NBS data for the period 2005-2022

The simplest way to test autocorrelation is to apply the Durbin-Watson test. The value of the Durbin-Watson coefficient in the regression model used is 2.45, indicating the presence of a slightly negative correlation. For further testing, it was necessary to generate the residuals of the regression model and perform their autoregression. The results of the model are provided in Table 6.

Table 6 Results of the AR(I) residuals from the regression model

Source	SS	df	MS	Number of obs	= 72
Model	.03603943	1	.03603943	F(1, 70)	= 14671
Residual	.05298998	70	.01059799	Prob> F	= 0.0711
Total	.56593915	71	.02930714	R-squared	= 0.0637
				Adj R-squared	= 0.0450
				Root MSE	= .10295

Residuals	Coef.	Std. Err.	T	P>t	[95% Conf. Interval]	
L1	-.2559271	.1387839	-1.84	0.071	-.5346828	.0228286
_cons	-.0017332	.0142807	-0.12	0.904	-.0304168	.0269505

Source: Author's calculation based on the NBS data for the period 2005-2022

The AR(I) model of the residuals has a low explanatory power of 4.5%, and an F-value of 0.07 indicates that it is not statistically significant. If we disregard the previous finding, it is clear that there is a negative correlation, as the L1 predictor (the time series with a lag of 1) has a negative sign. Therefore, it is necessary to determine whether there is a significant correlation using the Breusch-Godfrey test. The linear regression equation is

$$Y_t = \beta_1 + \beta_2 X_{t,2} + \beta_3 X_{t,3} + \mu_t \tag{8}$$

and the random errors that follow the autoregressive pattern of (ρ) order are displayed as follows

$$\mu_t = \rho_1 \mu_{t-1} + \rho_2 \mu_{t-2} + \ldots + \rho_\rho \mu_{t-\rho} + \varepsilon_t \tag{9}$$

Based on the previous statements, we can say that it is possible to fit the regression model using the least squares method and obtain a set of residuals based on which the following pattern is obtained

$$\hat{U}_t = \gamma_1 \hat{U}_{t-1} + \ldots + \gamma_\rho \hat{U}_{t-\rho} + \beta_1 X_{1t} + \beta_k X_{kt} + \varepsilon_t \tag{10}$$

which represents the regression model of the residuals and the original structural predictors of the initial regression. Based on the new linear regression, the null hypothesis is defined, which

$$Ho: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_\rho = 0 \tag{11}$$

is tested using a statistical test of the form:

$$N \text{ x } R^{2\sim} \text{ x } \chi_\rho^2 \tag{12}$$

where N – is the number of samples; $\chi p2$ - Lagrange multiplier in the form of a χ^2 test with p degrees of freedom; p – number of lags in the autoregressive model

The results of the additional second-order autoregressive model are presented in Table 7.

The coefficients of the L1 and L2 predictors, as first and second-order lags of the residuals, are not equal to zero. The number of observations in the model is 72, the R^2 parameter value is 0.1187, and the value of the degrees of freedom is 2 (given that an AR(II) has been performed). Based on these parameters, statistical testing was conducted, and it was determined that the value of χ^2 with two degrees of freedom at the 1% level is 9.526. The critical value from the tables is 9.21, thus the null hypothesis of no significant autocorrelation cannot be rejected.

Table 7 Results of the additional second-order autoregressive model

Source	SS	df	MS	Number of obs	= 72	
Model	.06718308	6	.03603943	F(6,65)	= 0.99	
Residual	.49875107	65	.01059799	Prob>F	= 0.4452	
Total	.56593415	71	.02930714	R-squared	= 0.1187	
				Adj R-squared	= -0.0015	
				Root MSE	= .10647	
Residuals	Coef.	Std. Err	T	P>t	[95% Conf. Interval]	
L_1	-.3209578	.1526229	-2.10	0.041	-.628549	-.0133666
L_2	-.2548464	.1662183	-1.53	0.132	-.589837	.0801445
r_dog	.0250078	.1472337	0.17	0.866	-.2717220	.3217378
r_rez	.0415289	.3167504	0.13	0.896	-.5968396	.6798974
r_prib	-.0536149	.2333387	-0.23	0.819	-.5238782	.4166483
r_org	-.0510799	.4232729	-0.12	0.904	-.9041304	.8019706
_cons	-.0030572	.0149337	-0.20	0.839	-.0331541	.0270397

Source: Author's calculation based on the NBS data for the period 2005-2022

Heteroscedasticity of the regression model is determined using the Breusch-Pagan and White's tests. The results of the tests are presented in Table 8. Both tests indicate that at a significance level of 1%, the null hypothesis of homoscedasticity of the regression model cannot be rejected.

Table 8 Heteroscedasticity tests results

Test name	White	BP
Value	Chi2(14)14.59	F(4.68)2.49
ρ	0.4069	0.0555

Source: Author's calculation based on the NBS data for the period 2005-2022

Based on the data from the initial regression model, as well as the evidence of meeting the conditions, the following equation can be formed

$$\text{Dln\_prem\_l2} = 0.78 \times \text{r\_rez} - 0.618 \times \text{r\_prib} + 1.445 \times \text{r\_org} + \mu t \quad (13)$$

Based on this equation, it can be concluded that the premium for liability car insurance is significantly influenced by the risk of reserves, the risk of acquisition, and the organizational risk. This influence is quantified by the specified coefficients with a lag effect of two quarters, or half a year.

Examining the coefficients reveals an inconsistency. The coefficient for the acquisition risk (r_prib) has a negative sign, which contradicts the fundamental logic and principles of insurance. Specifically, an increase in acquisition risk, defined as the ratio of settled claims to collected premiums, implies either a relative increase in the amount of settled claims or a relative decrease in the amount of collected premiums. This inconsistency may also arise from how the dependent variable—the liability car insurance premium—is presented, or from a significant correlation between the predictor r_prib and other statistically significant predictors in the regression model. The first explanation stems from the fact that the dependent variable is denominated in euros and retains its absolute form of representation. On the other hand, the predictors, while denominated in euros, are displayed in a relative form across different categories of insurance. Thus, the euro denomination serves as a scalar, statistically having no effect on the structural change of the data.

To examine the impact of the denomination of the dependent variable's value, another regression analysis was conducted under the same assumptions, with the dependent variable being the liability car insurance premium expressed in the national currency (ln_premdin). The time series was made stationary (stationary at a significance level of 5%), and the test value is -11.621, with a lag of 2 periods determined (HQIC = -13.1261). The regression model was tested for autocorrelation (DW = 2.39, Breuch-Godfrey = 0.0898) and heteroskedasticity (Breuch-Pagan = 0.1136, White = 0.2861). The results of the regression are presented in Table 9.

The coefficient of the predictor r_prib in the new regression analysis has a negative sign, thus rejecting the assumption that its value in the original regression model was a result of the denomination of the gross liability car insurance premium.

Table 9 Results of the modified regression model

Source	SS	df	MS	Number of obs	= 72
Model	.77636151	4	.19409038	F (6,66)	= 15.71
Residual	.59312158	68	.01133525	Prob>F	= 0.0000
Total	1.3694831	72	.02633621	R-squared	= 0.5669
				Adj R-squared	= 0.5308
				Root MSE	= .11116

Dln_premdi~	Coef.	Std.Err	t	P>t	[95% Conf. Interval]	
r_dog	.2797783	.1527811	1.83	0.073	-.0274088	.5869653
r_rez	.8634167	.3169579	2.72	0.009	.2261301	1500703
r_prib	-.6084916	.2273781	-2.68	0.01	-1065666	-.1513117
r_org	1.14802	.4232013	2.71	0.009	.2971152	1.998922
_cons	.0217402	.0152792	1.42	0.161	-.0089807	.0524612

Source: Author's calculation based on the NBS data for the period 2005-2022

To test the second assumption, a correlation matrix is used, the results of which are presented in Table 10.

Table 10 Correlation matrix

mat. correl.	dln~ml2	r_dog	r_rez	r_prib	r_org
dln~ml2	1				
r_dog	0.4775	1			
r_rez	0.6409	0.4896	1		
r_prib	0.4781	0.7853	0.7962	1	
r_org	0.7483	0.6571	0.7896	0.7381	1

Source: Author's calculation based on the NBS data for the period 2005-2022

Based on the data from the previous table, it can be determined that there is a strong positive correlation between the predictors r_prib and r_org. Given the high value of the t-test (3.49) and the coefficient value of the predictor r_org, the strong positive correlation between the predictors r_prib and r_org may be the cause of the negative sign of the coefficient r_prib. Undoubtedly, an increase in the share of settled claims in the total number of claims (which represents the predictor r_org) results in an increase in the share of the amount of settled claims in the collected premium (which represents the predictor r_prib); however, the removal of one of these two predictors would lead to obscured results of the model itself. All-time series used for these calculations consist of quarterly data, while the bonus/malus system, which has a significant impact on the volume of the premium, is calculated annually. This means that any claim that occurs under the policy only affects the value of that policy after one year. On the other hand, the information criterion suggests a lag of two periods, but further lags would cause significant issues with autocorrelation and heteroskedasticity.

5. Conclusion

In the insurance industry, fluctuations in the relationships between supply and demand, premium rates, and profitability are logical. It is also reasonable for this industry to face limiting regulations, as well as political, economic, and other pressures from users of insurance coverage.

The quality of risk management in premium adequacy is crucial for the successful operation of insurance activities and the preservation of the solvency of insurance companies. Therefore, in modern business conditions, it is necessary to pay greater attention to effective methods for mitigating and overcoming risks that affect premium adequacy. Testing the applicability of methods for premium calculation, ensuring quality statistical data, improving disaster risk modelling, timely responses to external changes, and strengthening communication between key departments in insurance companies are prerequisites for calculating the real insurance premium and thus ensuring business continuity.

All the mentioned factors, as well as those not mentioned, influence the cyclicality that prevents insurers from accurately projecting their revenues and expenses, leading to increased capital costs and the potential to quickly transform a profitable year into an unprofitable one. Insurers have access to strategies that can be implemented to manage cycles more effectively, enabling better outcomes in certain phases of the cycle.

The significance of adequate calculation of Technical Reserves (TR) in non-life insurance has resulted in numerous studies at the European Union level. The inherent uncertainty regarding both the occurrence and the severity of claims in non-life insurance strongly reflects on the projection of the amount of technical reserves as a part of the insurance premium.

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FAKTORI RIZIKA NASTANKA ŠTETA I ADEKVATNOST PREMIJE NEŽIVOTNIH OSIGURANJA

Da bi očuvali stabilnost poslovanja i obezbedili izvršenje preuzetih obaveza, osiguravači nastoje da obezbede adekvatne sisteme za identifikovanje i merenja rizika. Identifikovanje izvora faktora rizika neadekvatnosti premije i iznalaženje rešenja za ublažavanje rizika je od krucijalne važnosti za mogućnost osiguravajućih kompanija da pokriju štete i obezbede kontinuitet poslovanja. Zato je i cilj ovog rada da kroz prikaz uticaja nastanka šteta utiču na adekvatnost premije i i doprinese eliminisanju ili ublažavanju rizika nedovoljnosti premije.

Ključne reči: *štete, premija, rizik, rezerve, premijska nestabilnost*