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MODELING THE PERSONAL VOLUNTARY INSURANCE MARKET

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This paper presents a comprehensive econometric study covering the period from 2014 to 2023 to identify key patterns, construct adequate predictive models, and generate a well-founded forecast for the personal voluntary insurance market in the Russian Federation for 2024. The models constructed for the personal voluntary insurance market demonstrate high quality and statistical significance, providing valuable insights for insurance companies in financial planning, reserve formation, risk management, and product strategy development, as well as for regulators and financial market analysts.

Keywords: modeling; forecasting; insurance payouts; insurance premiums; statistics.

Introduction

In times of economic uncertainty and rising social risks, personal voluntary insurance (PVI) has become an important tool to ensure financial security for individuals. This has led to an increase in the role of PVI in the financial protection system for the population. The Russian PVI market is characterized by significant dynamism and sensitivity to macroeconomic factors, which requires the development of appropriate analysis and forecasting methods [1].

Over the past decade, the PVI market in Russia has seen significant changes. Economic sanctions, the COVID-19 pandemic, legislative changes, and the transformation of consumer preferences have all influenced its development. Therefore, reliable predictive modeling, which can adequately describe the dynamics of key insurance indicators – insurance premiums and payouts – has become a crucial task.

The main challenges in analyzing time series of insurance indicators are their non-stationarity, the presence of trend and seasonal components, and potential heteroscedasticity [2]. Traditional regression analysis methods are often ineffective for working with such data. Therefore, the use of specialized time series analysis methods, in particular ARIMA models and their seasonal modifications (SARIMA), seems to be the most promising area [3, 4, 5].

1. Time Series Research

Data from the Federal State Statistics Service (Rosstat) [6] were used for mathematical modeling to forecast the personal voluntary insurance market. The analysis was based on quarterly data on insurance premiums and payouts for personal voluntary insurance

from the first quarter of 2014 to the fourth quarter of 2023. The choice of quarterly data frequency was justified by the need to identify seasonal patterns; ensure a sufficient sample size for statistical modeling; and minimize the impact of random fluctuations typical of monthly data.

Figures 1 and 2 show the dynamics of insurance premiums and insurance payouts for 2014–2023.

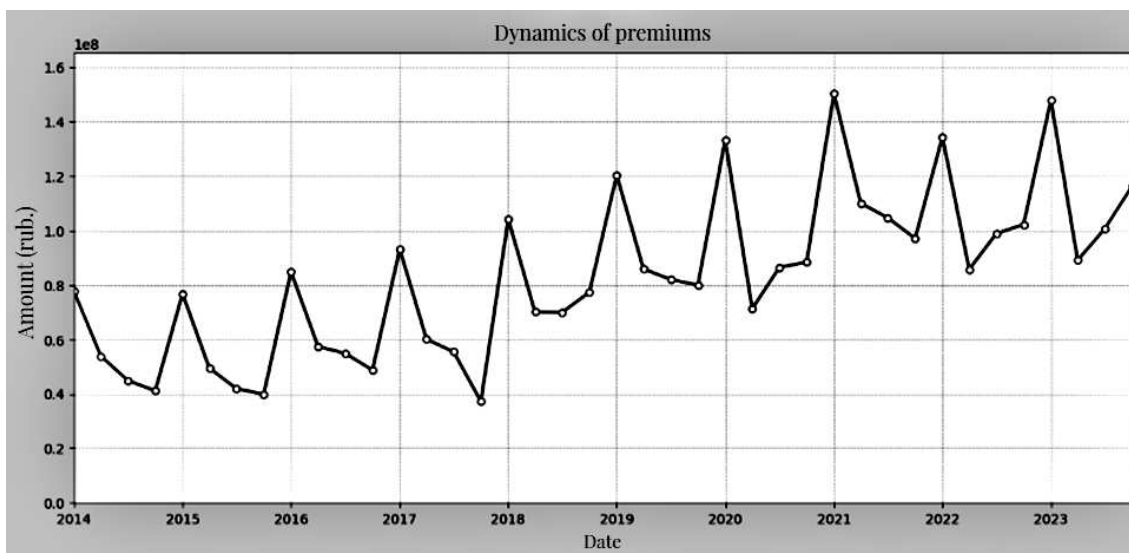


Fig. 1. Dynamics of insurance premiums

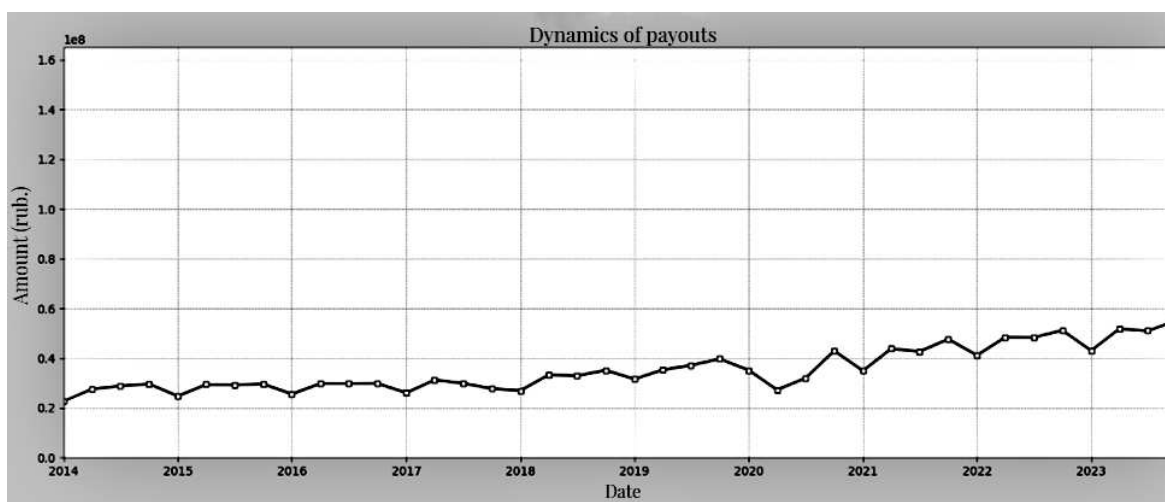


Fig. 2. Dynamics of insurance payouts

The graph of the dynamics of insurance premiums clearly shows steady growth from 2014 to 2019; seasonal peaks in the first and fourth quarters of each year; a noticeable decline in 2020 due to the impact of the COVID-19 pandemic; as well as recovery and further growth in 2021–2023. The maximum premium value was recorded in the fourth quarter of 2023, and the minimum in the first quarter of 2014.

The dynamics of insurance payouts are characterized by a smoother growth compared to premiums; a less pronounced seasonal component; a relatively stable ratio of payouts

to premiums (loss ratio). Peak values in 2022–2023 may be associated with the realization of accumulated insurance claims.

Statistical data analysis revealed the following:

1. The premium distribution is characterized by a slight right-hand skewness (0.432) and a plateau-like shape (negative kurtosis).
2. The payout distribution has a more pronounced right-hand skewness (0.721) and is also plateau-like.
3. The mean premium value is significantly higher than the median, indicating the influence of extremely high values.
4. High standard deviations indicate significant variability in both indicators.

The data were tested for the normality of distribution using the Shapiro–Wilk test. The results are presented in Table 1.

Table 1

Shapiro–Wilk test results

Indicator	W statistic	<i>p</i> -value
Premiums	0.960	0.200
Payouts	0.912	0.003

Thus, the hypothesis of a normal distribution is not rejected for insurance premiums, but rejected for insurance payouts. Due to the deviation of the payout distribution from normality, a Box–Cox transformation was applied (Figure 3). The optimal value of the λ parameter was determined using the maximum likelihood method and was -0.98 .

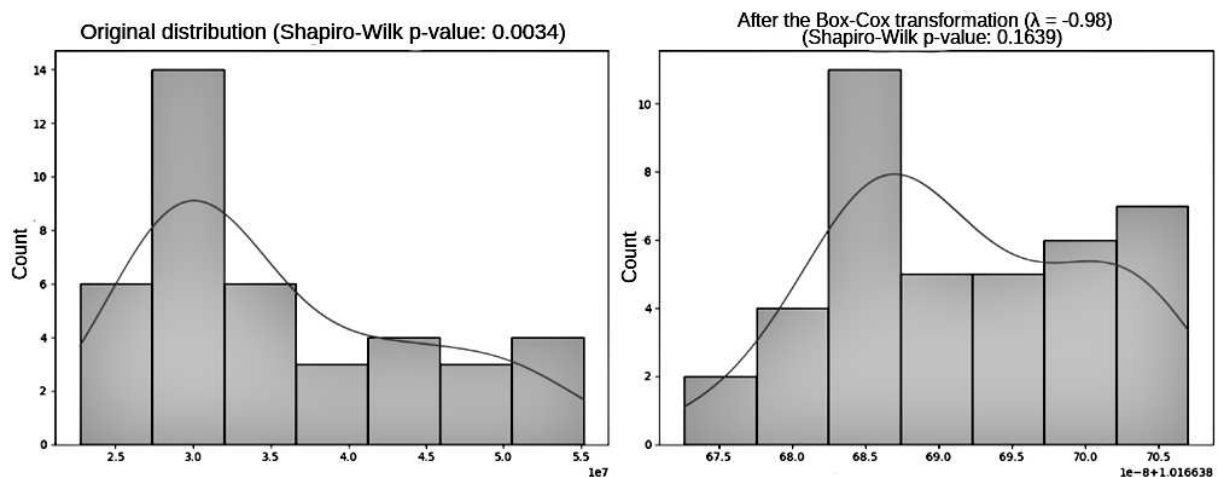


Fig. 3. Distribution of payouts before and after the Box–Cox transformation

After the transformation, the payout distribution began to correspond to the normal law (Shapiro–Wilk test: $W = 0.975$, p -value = 0.160), with improved distribution parameters.

To test the stationarity of the time series, we applied the augmented Dickey–Fuller test, which showed that the original series was not stationary. Two differentiations were required to achieve stationarity for the premium series, while a single differentiation after the Box–Cox transformation was sufficient for the payout series.

2. Modeling the Personal Voluntary Insurance Market

In order to identify the parameters of the SARIMA models, we constructed autocorrelation and partial autocorrelation graphs for the stationary series (Figures 4 and 5).

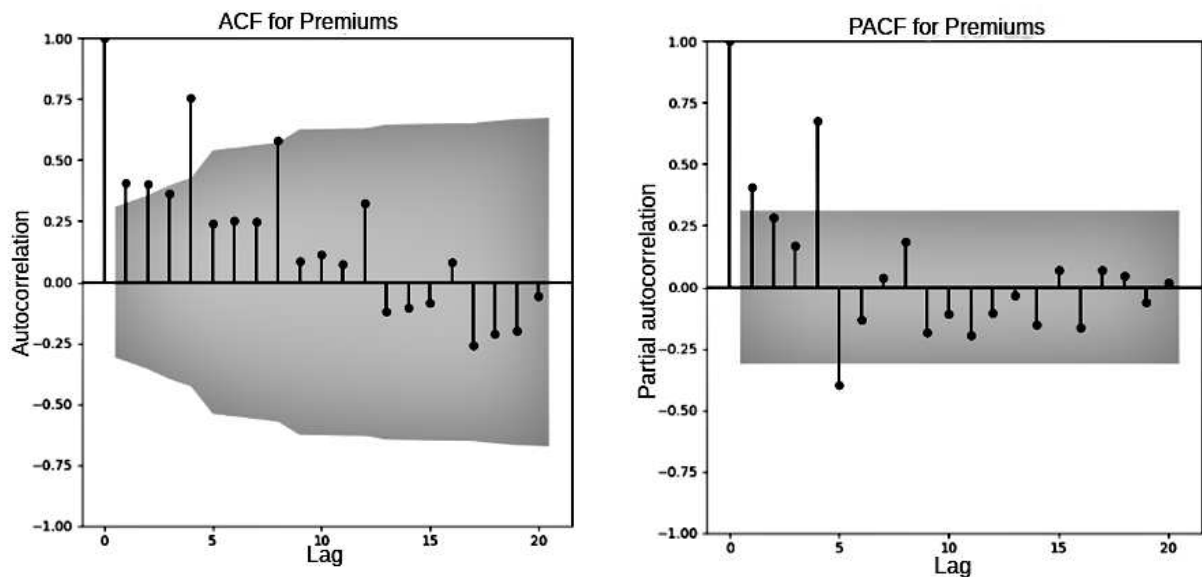


Fig. 4. ACF and PACF for the premium series

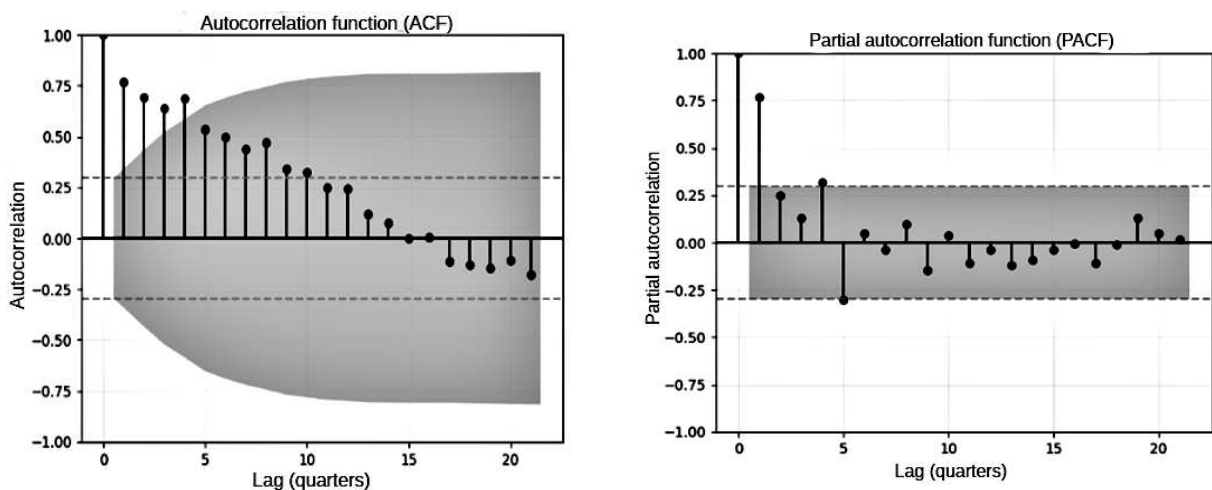


Fig. 5. ACF and PACF for the payout series

The analysis of the graphs revealed the presence of significant seasonal autocorrelations with a period of four quarters, the mixed nature of the processes (the presence of both

AR and MA components), and the need to account for seasonality in predictive models. Based on the ACF and PACF analysis, the SARIMA(1,2,1)(1,0,1) model was chosen for the premium series. The insurance premium model equation is:

$$y_t = 0.4346y_{t-1} - 0.3370y_{t-4} + 0.1465y_{t-5} + \epsilon_t - 1.0000\epsilon_{t-1} - 0.3743\epsilon_{t-4} + 0.3743\epsilon_{t-5}.$$

The Box-Cox transformation was applied to the payout series, and the SARIMA(1,1,1)(1,0,1) model was then constructed.

The insurance payout model equation is:

$$y_t = 0.2446y_{t-1} - 0.000024y_{t-4} + 0.000006y_{t-5} + \epsilon_t - 0.7181\epsilon_{t-1} - 0.7324\epsilon_{t-4} + 0.5257\epsilon_{t-5} + 12.6879.$$

Both models demonstrate high coefficients of determination and statistically significant parameters, indicating their good quality.

Figure 6 presents the results of forecasting insurance premiums for the next period (2024).

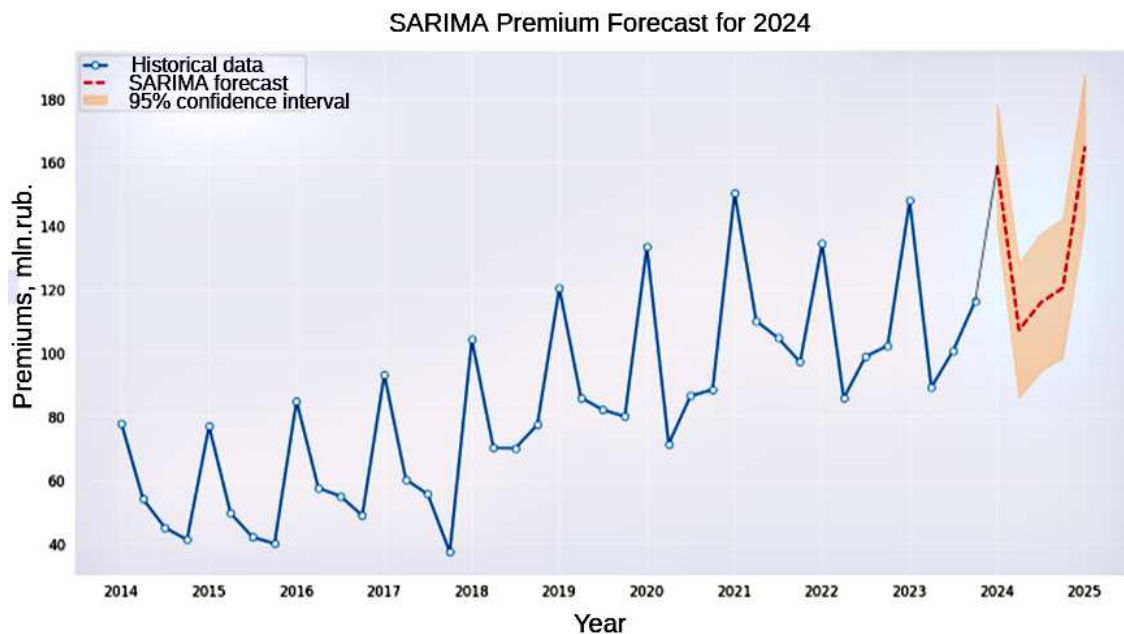


Fig. 6. Actual and forecasted values of insurance premiums

The average annual value is projected to be 15.2% higher than the average for the studied period.

Figure 7 presents the forecast for insurance payouts for the next period (2024).

The average annual value is projected to be 51.8% higher than the average value for the studied period.

Premium and payout dynamics are characterized by different types of models, reflecting differences in the factors influencing these indicators. The relatively more stable payout dynamics allow for more accurate forecasts compared to premiums.

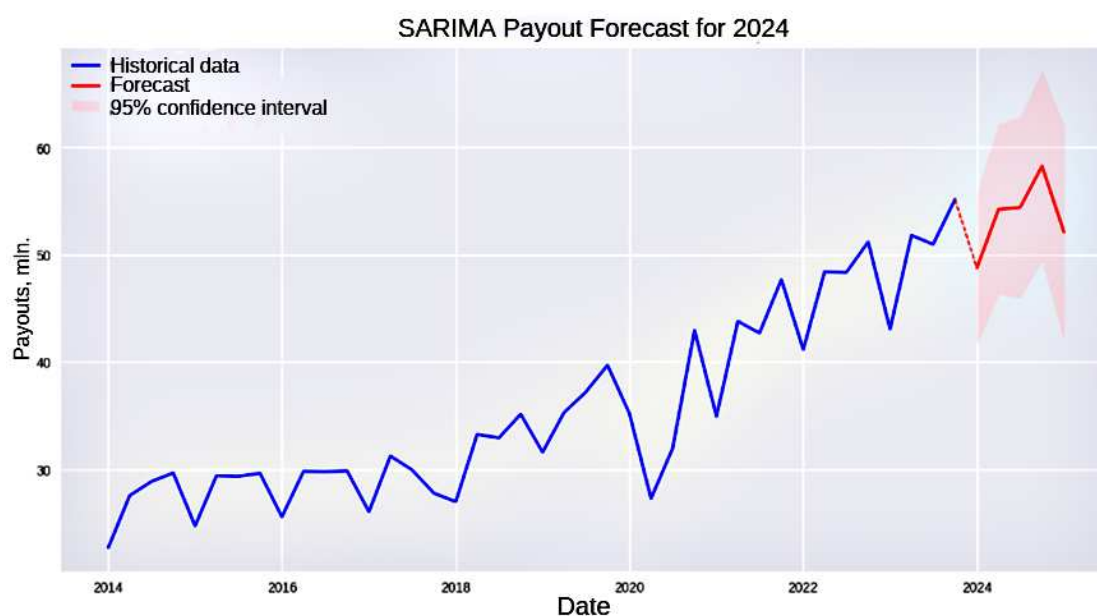


Fig. 7. Actual and forecasted insurance payout values

Conclusion

We developed a methodology for analyzing insurance indicators, including a comprehensive verification of the statistical properties of time series and the identification of predictive model parameters. We identified statistical patterns in the dynamics of insurance premiums and payouts: the presence of an upward trend, pronounced seasonality with a fourth-quarter period, and differences in distribution patterns. We constructed and verified SARIMA predictive models for insurance premiums and payouts, demonstrating high accuracy using historical data. We developed a forecast for 2024, predicting an average quarterly increase in insurance premiums of 15.2% compared to the historical average, and an increase in insurance payouts of 51.8%. We verified the forecast using actual data for the first quarter of 2024, demonstrating a high accuracy of the payout forecast (-1.2%) and the need to consider additional factors to improve the precision of the premium forecast.

The obtained results can be used by insurance companies to optimize pricing policies and reserve management; by regulators to monitor the insurance market behavior; by investors to assess the investment attractiveness of the sector; and by analysts to work out insurance development strategies.

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МОДЕЛИРОВАНИЕ РЫНКА ЛИЧНОГО ДОБРОВОЛЬНОГО СТРАХОВАНИЯ

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Для выявления ключевых закономерностей, построения адекватных прогнозных моделей и формирования обоснованного прогноза рынка личного добровольного страхования в Российской Федерации на 2024 год проведено комплексное эконометрическое исследование динамики за период с 2014 по 2023 год. Построены модели рынка личного добровольного страхования, которые продемонстрировали высокое качество и статистическую значимость. Результаты прогнозирования имеют практическую значимость для страховых компаний в области финансового планирования, формирования резервов, управления рисками и разработки продуктовой стратегии, а также для регуляторов и аналитиков финансового рынка.

Ключевые слова: моделирование; прогнозирование; страховые выплаты; страховые премии; статистика.

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