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Synergistic Effects In The Dynamics Of Socio-Economic Systems And Processes

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This article is devoted to describing the research methodology for a complex socio-economic process in modeling time series of personal and social insurance using fractal analysis methods. The authors demonstrate the adaptation of the well-known fractal analysis methods, with the help they reveal and give quantitative estimates and qualitative properties of time series. These are such fundamental pre-predictive characteristics of socio-economic time series as long-term memory, depth, qualitative characteristics of the process as persistent (anti-persistent, trend-stable, or reverse), noise color. A complete system of models and methods of fractal analysis of time series has been adapted and proposed to reveal the fundamental pre-forecast characteristics of socio-economic time series, allowing the most effective methods for predicting the dynamics of these processes.

Keywords: insurance company; Hurst index; pre-predictive analysis; R/S-analysis; time series noise color.

INTRODUCTION

Insurance activity (insurance services) is a different sector of the economy that can be defined as strategic. A major investment decision, including private investment, up to lending to individuals, is not complete without insurance support. In Russian reality, the study of the insurance sector's financial capabilities is relevant and requires a special approach (Bogoviz et al. 2018; Latysheva et al.2018).

There are many social, political, criminal, scientific, and practical problems in Russia's insurance development. Many can be successfully solved if there is an appropriate concept in forecasting problems and making informed management decisions in the insurance business.

In the presented work, the study's relevance is determined, since in a market economy, taking into account the specifics of the Russian mentality, insurance companies' activities should clearly show the future opportunities of insurance activities, its relevance, and development paths. The need to forecast the financial stability of insurance companies is fairly emphasized.

For the further development of the economy, it is necessary to use modern forecasting methods. The economic and mathematical forecasting methods are based on a condition that assumes the independence of observations that make up a time series. However, a very significant part of the time series, reflecting the evolution of real socio-economic processes, have the property of persistence (Krichevsky, 2005; Yangishieva, 2005; Perepelitsa et al. 2007). It means that the condition of independence of observations is not met, due to which classical models and forecasting methods often turn out to be inadequate.

The study's relevance is because the need to

consider the properties of the nonlinearity of dynamic socio-economic systems and processes in the construction of mathematical models becomes more and more acute (Kumratova et al., 2019).

As an object of research, a time series was chosen, reflecting the dynamics of the main indicator of insurance companies' economic activity. In essence, the paper proposes a toolkit for studying time series for the stability of their evolution. This toolkit is of both theoretical and practical value in predicting an evolving economic system's financial performance.

The article examines the values of the time series's aggregated data for the accounting of contracts for all insurance types of the STERKH company. The main indicator of the activity of the insurance company is the number of insured clients. The authors investigated both the time series (VR) themselves and the aggregated VR: the general series, separately the VR of insured men and women. Note that the study of averaged (typical) values for predictive conclusions is not effective. Forecast information is determined, first of all, by the sequence of data, which allows you to identify the possibility of the next value in time.

MATERIALS AND METHODS

In the presented study, the authors proposed using the revealed advantages of fractal analysis (Peters, 2000) for the considered evolutionary processes and identifying pre-predictive properties to increase further forecast reliability (Kumratova et al., 2015; Kumratova et al., 2014).

Comparative analysis of the initial time series are obtained characteristics, and predictability properties and its other formations (increment and aggregation) are of interest for further research.

The initial time series of the number of insured persons is denoted by u_i^k where *k=1* is aggregated weekly data, *k=2* - increments of aggregated weekly data, $i = 1, 2, \dots, n$ (calendar period for the period from 03.11.2015-15.12.2019). Similarly to the BP data on the number of insured men and women, we denote v_i^k and w_i^k respectively.

Due to the peculiarities of the Hurst normalized range method's algorithm, it is impossible to calculate the Hurst exponent and plot the R/S-trajectory for the original time series's increments due to the presence of consecutive zero values in the time series.

To preserve the dynamics of the initial weekly time series increments' behavior, the authors carried out a data normalization procedure.

Let's present the data normalization algorithm:

1-Find the minimum value in the original BP of the increments;

2-Calculate its absolute value;

3-Add the latter to each element of the original BP increments;

4-To avoid zero elements of the series, we add to each value of the obtained BP $\Delta > 0$ in our case $\Delta = 1$.

Thus, the dynamics of the studied normalized series of increments correspond to the base series's dynamics. The normalized series elements' positive values allow us to calculate the Hurst exponent and apply the R/S-analysis algorithm to the series.

Figure 1 shows the classification of the Hurst exponent's values (according to the color of the noise).

A detailed description of the Hurst normalized range method's operation algorithm is presented in the sources [1, 2, 4].

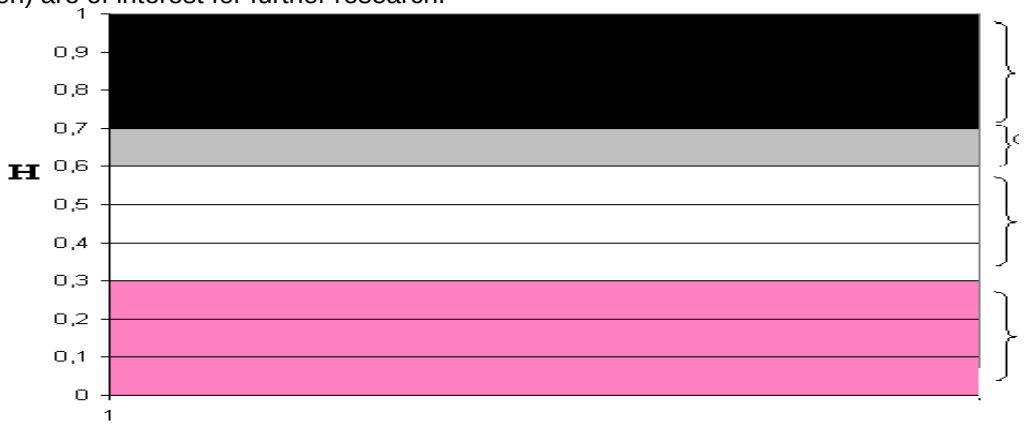
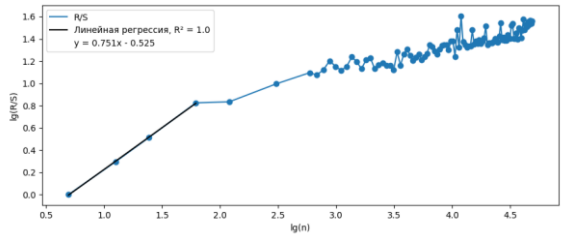
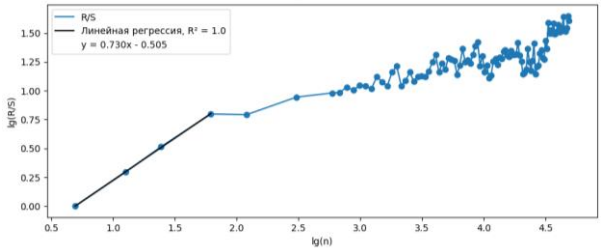


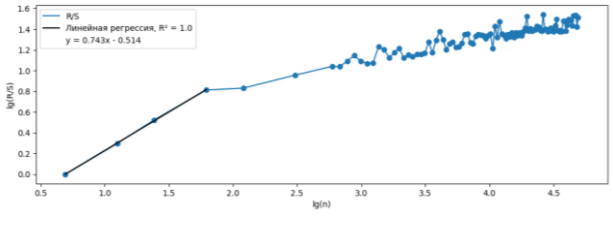
Figure 1: Classification of Hurst exponent values (noise color)



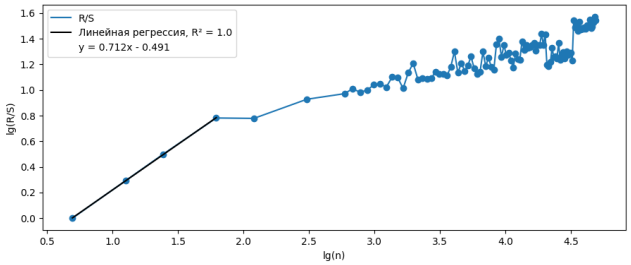
a) R / S-trajectory of the aggregated weekly baseline BP



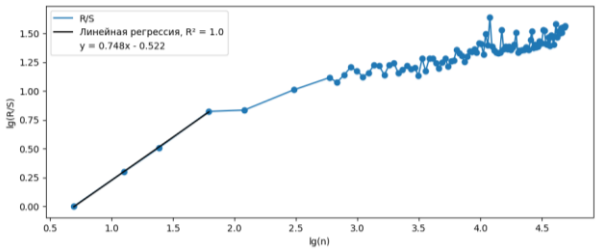
b) R / S-trajectory of increments of normalized aggregated weekly initial BP



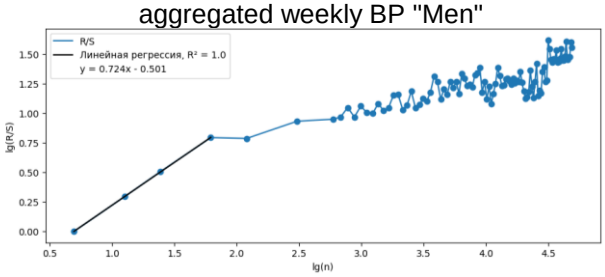
c) R / S-trajectory of the aggregated weekly VR "Men"



d) R / S-trajectory of increments of the normalized aggregated weekly BP "Men"



e) R/S-trajectory of the aggregated weekly VR "Women"



f) R/S-trajectory of increments of the normalized aggregated weekly BP "Women"

Figure 2: R/S-trajectories of the surveyed time series of data of the insurance company

$$Q = \frac{m_0 - m_s}{m_s} \quad (2),$$

where Equation is considered as a part of the sentence. Please make sure that all symbols are explained.

RESULTS AND DISCUSSION

Figure 2 shows the results of calculations and a graphical representation of the author's development "Methods of nonlinear dynamics" (Kumratova and Sivkov, 2020), which implements the algorithm of the Hirst normalized range method.

depth of 5 weeks.

- for all-time series, the value of the Hurst exponent belongs to the zone of "black" noise, which characterizes them as persistent and trend-stable BP;

- the regression equations are of the same type for all investigated VRs. This conclusion

Analysis of the calculated data in Table 1 allows us to draw the following conclusions:

- for each of the studied time series, the fifth point of breakdown from the R / S-trajectory is fixed. On average, the duration of 5 weeks characterizes a month, which confirms the presence of a memory series with an identified allows us to analyze the coefficient a, which ranges from 0.712 to 0.75.

Using the sequential R / S analysis algorithm's mechanism allows observing the synergistic effect in the study of complex socio-economic processes in the context of the triad results: the initial time series, a number of its increments, and aggregated data. The obtained pre-forecast results and the conclusions drawn will make it possible to adapt, develop and use adequate forecast models for predicting the dynamics of the process under study (Popova et al. 2019).

Table 1 : Summary table according to the Hirst normalized span method

	Aggregated weekly BP			Normalized values of BP increments		
	BP "Basic"	BP "Men"	BP "Women"	Increases in the main BP	Increases in the BP "Men"	Increases in the BP "Women"
Hurst exponent value	0.75	0.74	0.748	0.73	0.71	0.72
Regression equation	Y=0.75x-0.5	Y=0.74x-0.51	Y=0.748x-0.52	Y=0.73x-0.505	Y=0.712x-0.49	Y=0.724x-0.5
R/S stall point	5	5	5	5	5	5

CONCLUSION

The novelty of the authors' results in the course of the study is ensured by the simultaneous use of both classical methods and modern methods of nonlinear dynamics. Comparison of these approaches makes it possible to delineate the circle of those economic, financial, actuarial, marketing, agricultural, and production problems in which synergetic methods prevail over classical ones. Giving idempotent and more valid results and highlighting the range of processes for which the classical paradigm remains quite accurate. At the same time, it is more familiar, simple, and understandable.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

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AUTHOR CONTRIBUTIONS

EP conceived of the presented idea. AK developed the theory and performed the computations. ET verified the analytical methods. NT encouraged AM to investigate and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript. All authors read and approved the final version.

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