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# Trends and Forecasts Analysis of Insurance Industry in Russia

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Time series; Predictive models; Life insurance; Quasi-cycles length; Memory depth; Insurance business.

## Abstract

The best solution is the complex use of analysis and forecast for making management decisions in the insurance business. The basis of any insurance activity is the presence, first of all, of a client interested in purchasing an insurance product. Therefore, the number of insured clients is the primary indicator of the effectiveness of the insurance company. Preparing data for analysis and then using this data as input data for predictive models is a separate preparatory stage of the study. In work, had prepared the basic time series (TS): TS data of men and women daily insured, separate daily TS by gender, and aggregated weekly TS, as well as their increments. Using the research theory of time series shows that a specific ordering of data in time makes it possible to determine or predict the subsequent value of these TS.

**Disciplinary**: Computer technologies, Information Systems.



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## 1 Introduction

It is necessary to use an insurance risk assessment system that is effectively functioning in world practice. The valid policy of insurance organizations should become the basis for conducting insurance operations and the financial stability of numerous Russian insurers. Good risk management presupposes their application based on reliable forecasting. According to the law of the Russian Federation of 27.11.1992 N 4015-1 (revised from 02.07.2021), "On the organization of insurance business in the Russian Federation" [1], insurance is a relationship to protect the interests of individuals and legal entities, the Russian Federation, constituent entities of the Russian Federation and municipalities upon the occurrence of certain insured events at the expense of monetary funds formed by insurers from paid insurance premiums (insurance premiums), as well as at the cost of other insurers funds.

Based on the results and analysis of the Russian insurance market for 2020 [2], the Central Bank of Russia published statistical indicators of insurance companies for 2020 on March 5, 2021. According to the data for last year, the volume of premiums signed increased by 3.9%, while the volume of payments made increased by 7.8%.

The insurance market today for an entrepreneur is a market for new opportunities. Living conditions are caused by many risks such as complex diseases, industrial accidents, car accidents, plane crashes. Dozens of insurance companies have entered the market with different insurance programs for both life and accident. There are several life insurance programs when a person can insure himself or a relative and receive the insurance amount urgently, having a death certificate in hand, and within a day. Thus, if earlier the older generation collected the so-called "coffins" and kept them under the pillow, now it is the offered insurance instruments that help financially support relatives in difficult times and ensure the safety of funds from the encroachments of fraudsters.

Government decisions support the development of the national insurance market. It is legally determined that the insurance company itself must always have an insurer, in case of an unforeseen event, who can assume the obligations of this company to its customers. The insurance market is based on statistical data and an integrated system for assessing insurance risks. Changing conditions require reassessment and definition of risk management strategies [10] using modern tools and forecasting methods.

This work proposes to use a comprehensive analysis and forecast for making management decisions [6, 11] in the insurance business. The basis of any insurance activity is the presence, first of all, of a client interested in purchasing an insurance product. Therefore, the number of insured clients is the primary indicator of the effectiveness of the insurance company. Preparing data for analysis and then using this data as input data for predictive models is a separate preparatory stage of the study.

So, the authors have prepared the basic time series (TS): TS data of men and women daily insured, separate daily TS by gender, aggregated weekly TS, and their increments [3]. Using the theory of time series research, the authors clearly show that a specific ordering of data in time allows one to determine or predict the subsequent value of this TS.

## 2 Materials and Methods

The graphical presentation of daily data in a complex circular histogram clearly shows that women are the most responsible for health and life insurance. In 2016, the number of insured people was 3122 people / 77.6% of women and 899 people / 22.4 men. This trend corresponds to subsequent years with an increase in the share of insured men in 2017 = 25.9%, 2018 = 28.7%, 2019 = 29.1%.

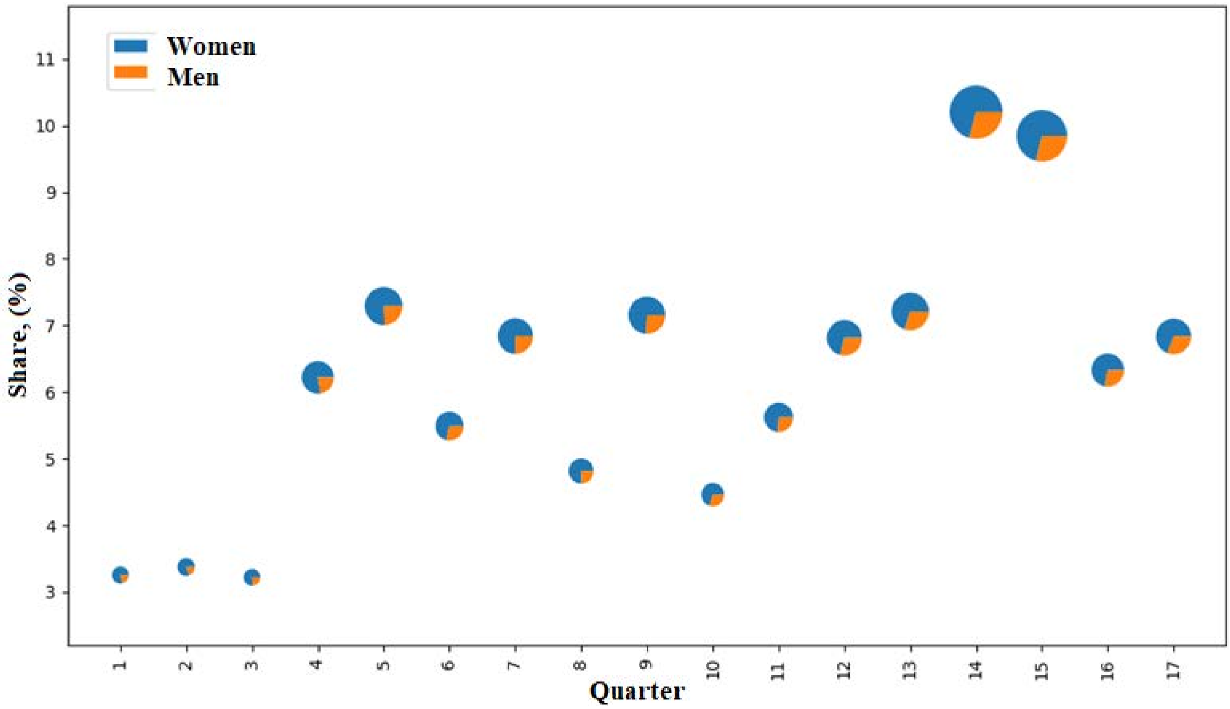



**Figure 1:** Comprehensive presentation of dynamics and share distribution of insured men and women quarterly in the period from 2016 to 2019.

The graphical data in Figure 1 confirms that women are more active in matters of life insurance. In each quarter from the 4th quarter of 2015 to the 4th quarter of 2019 inclusive, the share of women who have concluded life insurance contracts ~ 80% (Δ1-2%), respectively, men ~ 20% (Δ1-2%). The tendency of the share composition by gender has been constant for four years. Therefore, the dynamics of the development of the insurance company in terms of the number of concluded contracts, as can be seen in Figure 1, is positive: the growth in 2017 was 21%, over four years 65%.

For clarity and perception of tabular data, the authors suggest using infographics in color. The color of the table cell is based on the value that is the largest in the data matrix. In our case, it is the value of 854 of the contract in March 2019. The graphical presentation in the cells of the bottom summary row allows the analyst to see trends for the entire year, including highlighted minimum values (red dots) and maximum values (green dots).

**Table 1:** Dynamics of changes in the monthly number of insured persons from 2016 to 2019.

| Month | Years | | | | Changes from 2019 to 2018 | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | % | Pieces |
| January | 173 | 336 | 213 | 517 | 142,72 | 304 |
| February | 316 | 306 | 310 | 669 | 115,81 | 359 |
| March | 186 | 456 | 369 | 854 | 131,44 | 485 |
| April | 121 | 489 | 396 | 711 | 79,55 | 315 |
| May | 223 | 436 | 377 | 704 | 86,74 | 327 |
| June | 300 | 443 | 351 | 554 | 57,83 | 203 |
| July | 470 | 346 | 487 | 388 | -20,33 | -99 |
| August | 379 | 243 | 401 | 293 | -26,93 | -108 |
| September | 395 | 374 | 475 | 585 | 23,16 | 110 |
| October | 440 | 488 | 455 | 497 | 9,23 | 42 |
| November | 484 | 465 | 561 | 442 | -21,21 | -119 |
| December | 534 | 478 | 426 | 428 | 0,47 | 2 |

The most significant increase in the number of contracts concluded in 2019 compared to 2018 occurred in the first half of the year, which corrected the dips from July to December and gave a positive trend of + 38% in 2019, relative to the total value of 2018.

Comparative analysis of the obtained characteristics and predictability properties of time series and its other formations (increment and aggregation) is of interest for further research. Therefore, the authors studied the aggregated weekly data: all insured clients, for insured men, for insured women, as well as the time series of their increments (calendar period for the period from 03.11.2015-15.12.2019).

Table 2 shows the values of risk indicators for each separately investigated TS.

**Table 2**: Indicators obtained on the basis of nonlinear dynamics methods by the number of concluded personal insurance contracts for aggregated weekly time series and their increments

| Nonlinear dynamics methods | Indicators | Time series name | | | | | |
|---|---|---|---|---|---|---|---|
| | | TS "Basic" | Main TS increments | TS "Men" | TS increments "Men" | TS "Women" | TS increments "Women" |
| Phase Analysis | The length of the quasi-cycles with the highest frequency, (week) | 5, 6 | 5, 6 | 5, 6 | 4, 5, 6 | 5, 6 | 5, 6 |
| | Frequency of the length of quasi-cycles, (week) | 19, 14 | 25, 12 | 14, 16 | 9, 13, 17 | 26, 10 | 27, 9 |
| Linear cellular automaton | Forecast (people) | 85 | 168 | 31 | 49 | 44 | 90 |
| | Memory depth, (week) | 8 | 9 | 8 | 8 | 7 | 9 |
| | Forecast error (%) | 30.3 | 22.4 | 31.6 | 20.5 | 32.8 | 22.4 |
| | MAE* (%) | 23.2 | 26.7 | 6.5 | 8.16 | 18.6 | 19.27 |

*Mean absolute error

Analysis of the calculated indicators in Table 2 allows us to draw the following conclusions:

- the lengths of the quasi-cycles with the highest frequency are 5 and 6 (weeks), respectively, which on average will make it possible to make a mid-term forecast for 1.5 months of the calendar period;

- one of the pre-predictive characteristics is the highest frequency of the length of quasi-cycles, which characterizes the "const" property of the process under study. TS "Women" and several increments have the highest value of this indicator, which means the presence of frequently encountered five and 6-week quasi-cycles. In this context, we can talk about the presence of the property of trend stability of the process under study;

- for the investigated initial time series, the value of the memory depth varies from 7 to 9. The latter means that the investigated processes have the property of trend stability [4];

- the results obtained based on a linear cellular automaton (column "Forecast error") for the aggregated weekly time series of increments in the number of concluded personal insurance contracts are much better (lower) than for the initial TS. The forecast error for aggregated weekly time series of increments does not exceed 22.4% and is an order of magnitude lower than the initial data. Note that for natural processes, the testing of the Linear cellular automaton algorithm shows a forecast error of no more than 25% [5].

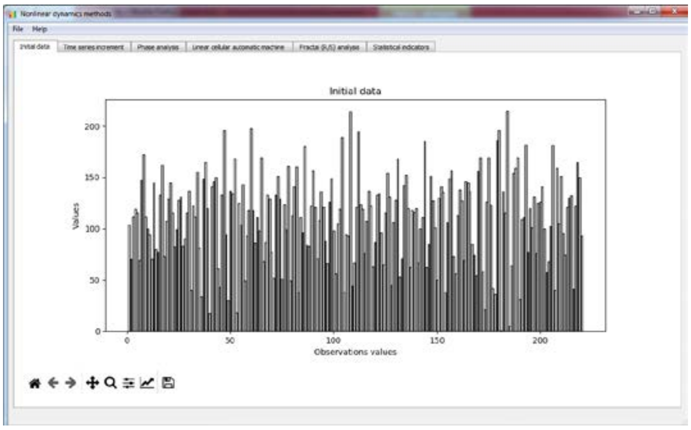
- the average absolute error MAE for the initial aggregated weekly TS varies in the range (6.5; 23.2). Therefore, the predictive model had compiled sufficiently high accuracy for the TS "Men" since the smallest MAE value was obtained.

A detailed description of the algorithm for the operation of phase analysis and a linear cellular automaton is presented in [4, 5, 6, 7].

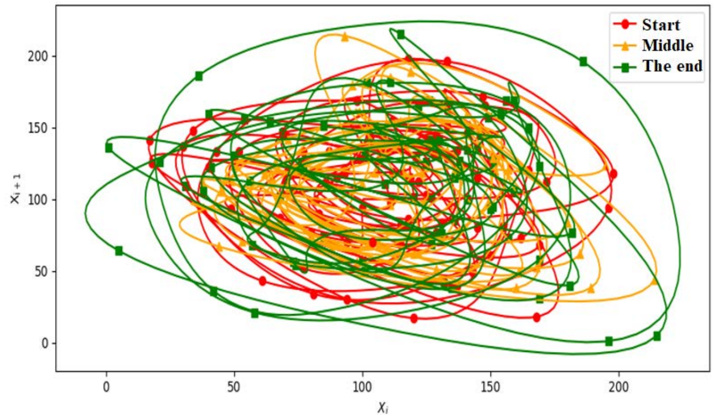
## 3 Results and Discussion

Figures 2 and 3 show the author's development "Methods of nonlinear dynamics" [8], which contains the above algorithms for methods of nonlinear dynamics. For example, the results of a study on increments of aggregated weekly data on insured women.

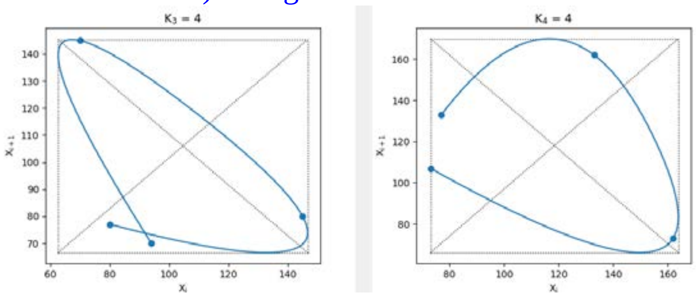
For visualization convenience, the points of the phase portrait are divided into three equal sub-periods and colored: the first sub-period of the time series is red, the second is yellow, and the third is red (see Figure 2b). The highest values are inherent in the third sub-period, which generally means an increase in the number of concluded personal insurance contracts for women. Figure 2c shows typical examples of the found quasi-cycles of the series under study, indicating their lengths. The histogram of frequency lengths is in Figure 2d. The most common length in the identified quasi-cycles is 5 (weeks), which is pre-predictive information and cycles in the process under study. According to the algorithm of phase analysis, the graphs of the area's movement and trajectory of the dynamics of the centers of the dimensional rectangles of the quasi-cycles had been constructed (Figures 2e, 2f). The dynamics of the movement of the areas of the dimensional rectangles of quasi-cycles are characterized by reversals of decline/rise for all sub-periods of the series. Regarding the trajectory of motion of the centers of the dimensional rectangles of quasi-cycles, the following can be noted: there is no grouping of data for each sub-period, the data are scattered almost evenly, which means the presence of high and low values in all three sub-periods of the time series.



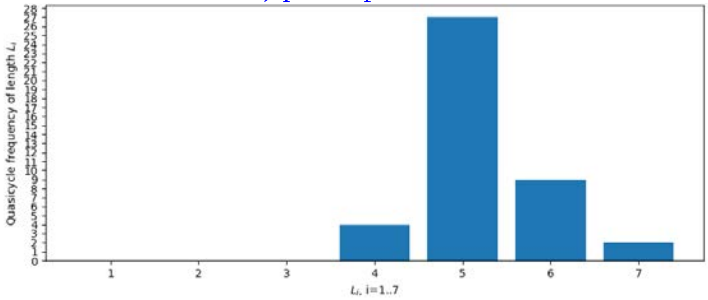

a) histogram of the series



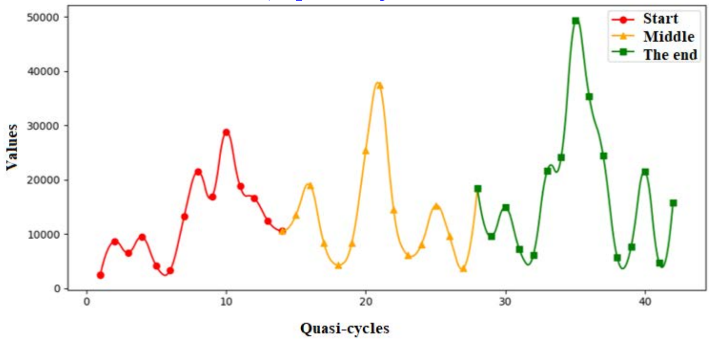

b) phase portrait



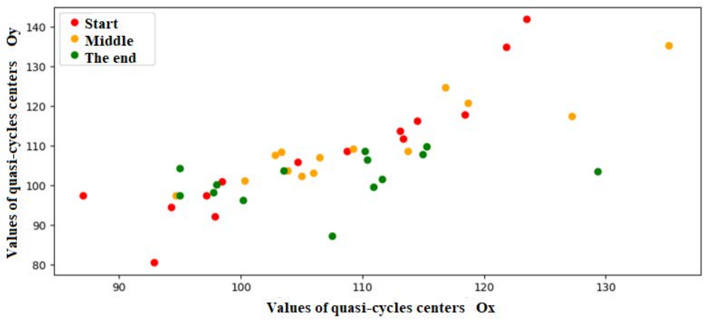

c) quasi-cycles




d) histogram of quasi-cycles lengths frequencies



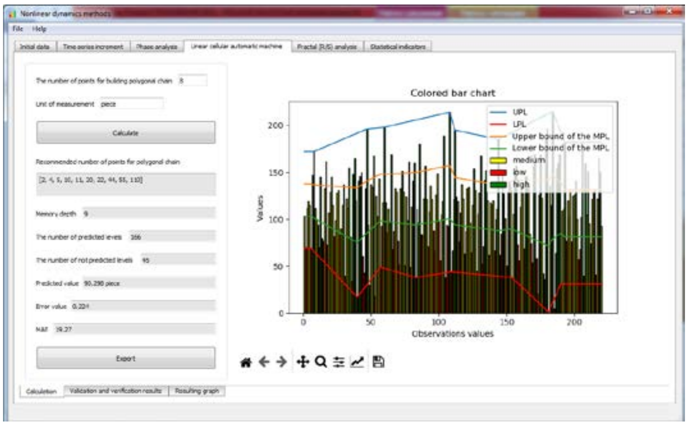

e) dynamics of movement of the areas of dimensional rectangles of quasi-cycles



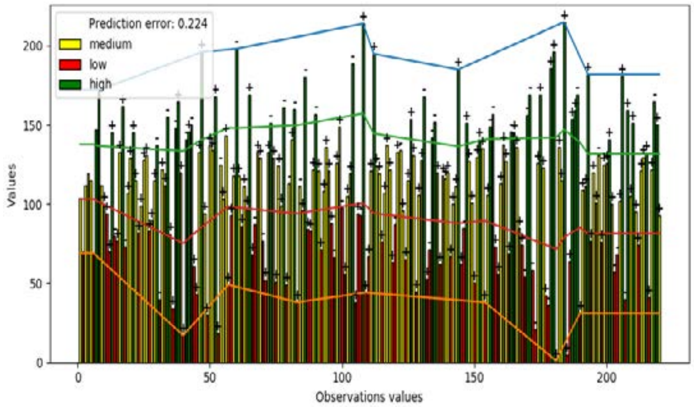

f) the trajectory of movement of the centers of the dimensional rectangles of quasi-cycles

**Figure 2:** The program interface "Methods of nonlinear dynamics" in the study of increments of aggregated weekly data on insured women based on the phase analysis algorithm

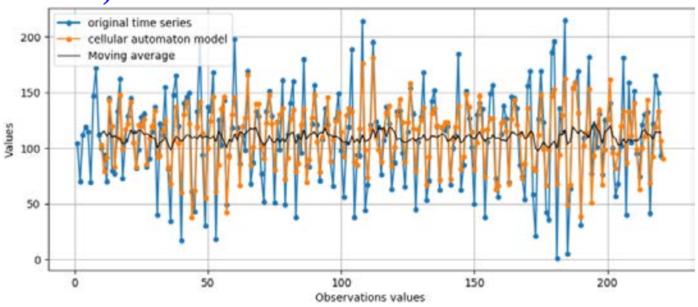
Figure 3 shows the results of building a predictive model based on a linear cellular automaton. A classic three-color coloring was chosen to construct a predictive model: low values of the investigated time series are colored red, medium values are yellow, and high values are green. Figures 3a and 3b show the results of the “Verification” and “Validation” stages of the Linear cellular automaton, respectively. The original series of increments of the aggregated weekly data on insured women are volatile with its inherent sharp recession/rise reversals; the constructed predictive model practically "repeats" the dynamics of the series' behavior. As a result, the constructed moving average significantly averages the values and, in this case, cannot be used to build a forecast model (see Figure 3c). As for Figure 3d, it can be noted that the constructed regression only indicates the direction of the process; in this case, there is an almost stationary process from the point of view of regression analysis. However, this research shows that this is not the case.



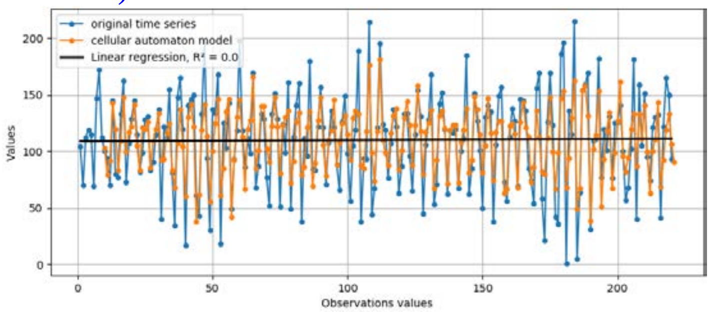

a) Linear cellular automaton verification




b) Linear cellular automaton validation




c) Linear cellular automaton and moving average




d) Linear cellular automaton and regression

**Figure 3:** The program interface "Methods of nonlinear dynamics" in the study of increments of aggregated weekly data on insured women based on the algorithm of a linear cellular automaton

The weekly time series of the increase in the number of insured has high volatility, which confirms the correct choice of methods and tools of nonlinear science for studying the dynamics and constructing forecast values [3, 9]. Using the mechanism of operation of phase analysis algorithms and a linear cellular automaton, the synergistic effect obtained from the study of complex socio-economic processes in terms of the triad results is essential: the initial time series, a number of its increments, and aggregated data.

# 4 Conclusion

The obtained forecasts show the results of the predicted values and the identified specifics, such as nested cyclicality (small ones are nested in longer cycles), with the same approach in the insurance company to the sale of insurance products, without the introduction of new sales technologies. Thus, the complex economic and mathematical forecasting models presented in this study are handy for insurance companies in terms of strategic planning of their activities, analysis, and implementation of new approaches and technologies for selling insurance products. In addition, the proposed author's methods and models are of interest to developers of information and analytical systems to support management decisions.

# 5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

## 6 Acknowledgement

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