Prediction of the Income and Expenditure Risk of Social Medical Insurance Fund Based on ARIMA Model

Runji Jiao [1 a] and Yanru Zhang [1 b *]

[1]Medical School of Henan Polytechnic University, Jiaozuo, Henan, China

[a] e-mail: Jrj1108@163.com

[*] Corresponding author e-mail: zyr@hpu.edu.cn; sqh@hpu.edu.cn

Keywords: Social Medical Insurance Fund; ARIMA Model; Prediction

Abstract: Objective: To predict the growth trend of social medical insurance fund revenue and expense and provide reference for prevention of fund income and expenditure risk. Methods: This paper uses ARIMA model to forecast the income and expenses of social health insurance fund. Results: The revenue and expenditure of showed a continuous upward trend, but in 2024, the income value of the fund will be less than the value of the fund expenditure, which may lead to the risk of overspending. Conclusion: The ARIMA model is a good fit for predict of social medical insurance fund, which has a certain reference significance for fund management.

1. Introduction

Social medical insurance fund refers to the special fund for basic medical insurance of employees raised by medical insurance agencies from units and individuals according to the relevant provisions of the state to protect the basic medical treatment of employees. With the advancement of medical insurance reform, social medical insurance system in China has completed the transition from welfare-based security to socialist market economy. It has initially formed a social healthy insurance system framework with the goal of ensuring basic health needs of the people [1]. However, with the further deepening of the reform, some deep-seated problems are gradually exposed. Especially the problem of medical insurance fund [2]. The so-called revenue and expenditure risk of health insurance fund refers to the possibility that the income of health fund cannot offset expenses. This problem directly leads to the failure of social medical insurance to pay medical expenses effectively, which affects the implementation efficiency of the system and hinders the smooth progress of medical insurance reform.

The operation of health fund should conform to principle of slight balance and reasonable growth, which requires that the health insurance policy should determine the payment standard and limit of medical insurance expense in a certain period according to the amount of medical insurance fund raised in a certain period [3]. Under the background of the increasingly aging problem in China, the proportion of medical insurance expenditure of the aging population has increased significantly. In addition, the growth rate of medical expenses in China is relatively fast. Under the situation of weak financing growth and strong expenditure of medical insurance funds, how to effectively prevent the occurrence of the risk of medical insurance funds income and expenditure and ensure its smooth operation is currently a problem that needs attention [4]. In this study, the ARIMA model of social health insurance fund income and expenditure is established by time series analysis method to predict the operation of the fund and the time and intensity of the occurrence of the income and expenditure risk, and then to formulate the control measures of the income and expenditure risk of the fund.

2. Materials and Methods

2.1 Source of Data

The data of this study were collected from the "2018 China Statistical Yearbook and Health Statistical Yearbook", as well as from the Statistical Bulletin on Human Resources and Social Security Development.

2.2 Research Method

Time series analysis and prediction is a set of methods in the 1960s. ARIMA (Autoregressive Integral Moving Average) model is the most widely used type of time series analysis model [5], and its common formula is:

$$\Phi(B)\nabla^d X_t = \Theta(\mathrm{B})\varepsilon_t \tag{1}$$

The above model is called sum autoregressive moving average model, which is recorded as ARIMA (p, d, q) model, refers to difference; representing the autoregressive coefficient polynomial; represents the moving average coefficient polynomial.

There are the following steps to use ARIMA method to model prediction [6]: (1) handling stability of Time Series. First, drawing the time series graph of the data, observe whether the time series is stable from the graph, or do unit root test to observe whether the statistics are significant. If it is a non-fixed order, the series should logarithmically transformed and differential processed until the time series is stable. (2) Model recognition. According to the autocorrelation coefficient (ACF) and partial autocorrelation coefficient (PACF) of the processed time data, the autocorrelation order p, the moving average order q and the difference order d are preliminarily determined. (3) Evaluation and test of parameters. The estimation of parameters is to use the least square method and other methods to calculate coefficients according to determined model order (P, D, q), and test the coefficients to determine whether the established model has statistical significance. (4) Forecast according to the established model. In this paper, SPSS 22.0 is used to build and predict the model.

3. Result

3.1 Preprocessing of Time Series

Firstly, draw the sequence diagram of social health insurance fund, shown as Fig.3-1. It can be seen that the income and expenditure of the fund have an obvious exponential growth trend and are not stable. After the logarithm conversion and difference processing of the original sequence, convert a stable time order. Sequence diagram after conversion is shown as Fig.3-2. As can be seen from the figure, the processed sequence values fluctuate around 0.

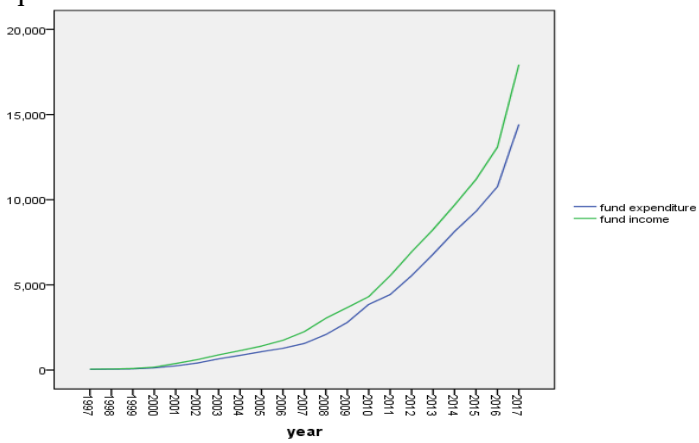

Fig.3-1 Revenue and Expenditure sequence of social health insurance fund in 1997-2017

Fig.3-2 Transformed sequence of social health insurance fund in 1997-2017

And at the same time, from the autocorrelation graph and partial autocorrelation graph of sequence, the auto-coefficient of order decays rapidly to 0 with the increase of the number of delay periods, indicating processed order has short correlation, which can be modeled for fitting and prediction. From the graph of the series (shown in Fig.3-3 and 3-4), we can see that the balance of social health insure fund have certain tailing. It shows that this sequence establishes ARIMA model, combined with the size of standardized BIC value, and finally determines the model of fund income as ARIMA (2,2,1); the model of fund expenditure as ARIMA (1,2,1).

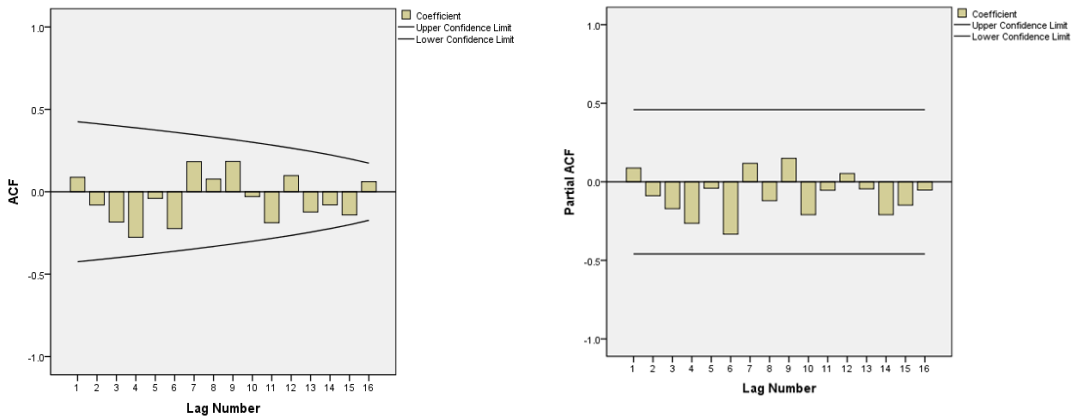

Fig.3-3 Autocorrelation graph and partial autocorrelation graph of fund income

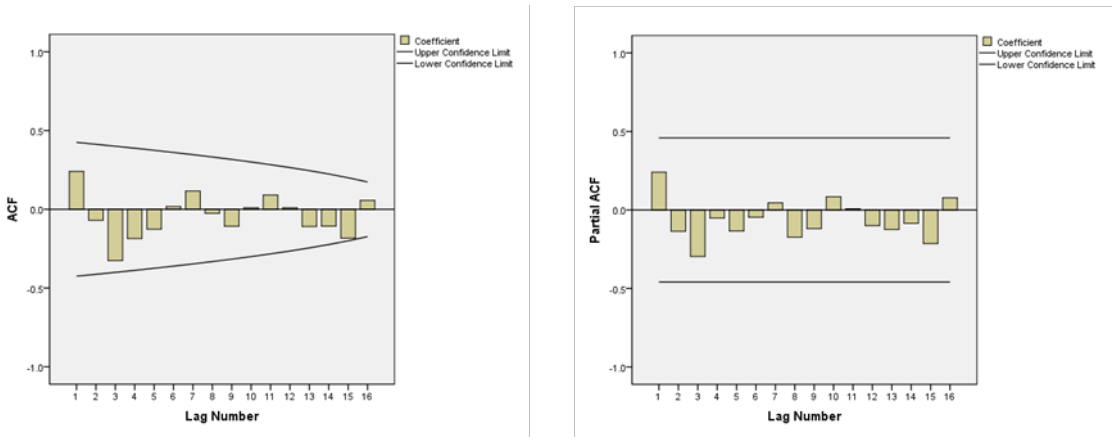

Fig.3-4 Autocorrelation graph and partial autocorrelation graph of fund expenditure

3.2 Model Parameter Evaluation and Examination

From the fund income model, parameters ϕ_1 value is estimated as 0.921, t = 1.498, P = 0.158 > 0.05; the ϕ_2 value is estimated as -0.715, t = -1.306, P = 0.214 > 0.05, indicating that the parameters are statistically significant. The θ value is estimated as 0.994, t = 0.095, P = 0.926 > 0.05. As shown in the following table (Tab.3-1):

Tab.3-1 Estimation table of fund income model parameters

Parameters	Estimate	SE	T	Sig
$\boldsymbol{\phi_1}$	0.921	0.615	1.498	0.158
$\boldsymbol{\phi_2}$	-0.715	0.547	-1.306	0.214
θ	0.994	10.439	0.095	0.926

In terms of the overall fitting effect and significance test of the model, R^2 of the fund income model is 99.7%, the normalized BIC value is 12.329, and the Ljung box (q) statistic value is 6.695, P = 0.996 > 0.05, which shows that the model is well fitted, significant and can be used for prediction.

From fixed results in fund expenditure model, parameters ϕ were estimated as 0.855, t = 0.644, P = 0.530 > 0.05, indicating that the parameters are statistically significant. The θ value is estimated as 0.997, t = 0.051, P = 0.960 > 0.05, indicating that the parameters are statistically significant. As shown in the following table (Tab.3-2):

Tab.3-2 Estimation table of fund expenditure model parameters

Parameters	Estimate	SE	T	Sig
Φ	0.855	1.328	0.644	0.530
θ	0.997	19.659	0.051	0.960

In terms of the overall significance test of the model, R^2 of the fund income model is 99.5%, the normalized BIC value is 12.378, and the Ljung box (q) statistic value is 10.231, P = 0.845 > 0.05, which shows that the model fits well, has significance, and can be used for prediction.

3.3 Model Prediction

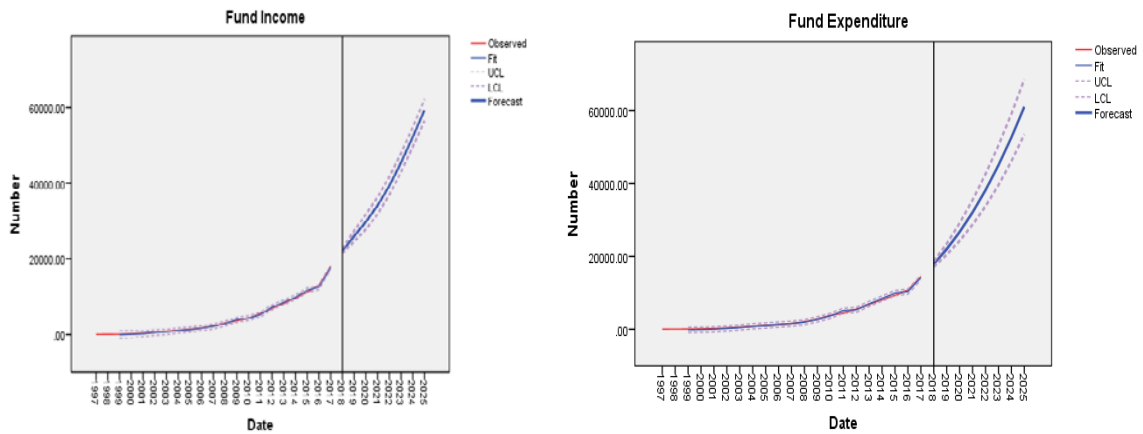

Fig.3-5 1997-2025Fit chart of revenue and expense of social health insurance fund

Using established model to predict the revenue and expense of health insure fund in 2018-2025, and judge whether there will be fund income and expenditure risk in the next few years. as shown in the following figure (Fig.3-5). It can be seen that predictive value is basically consistent with the actual value, indicating that fitting effect is good.

According to the forecast values in the next few years (as shown in the Tab.3-3), the income and expenditure of the fund will continue to rise. However, in 2024, the income of the fund will be smaller than the expenditure of the fund, which may lead to overspending risk.

Tab.3-3 2018-2025 Fund revenue and fund outcome of social health insurance

Year	Fund income	Fund outcome	Annual balance of the fund
2018	22114.08	17918.02	4196.06
2019	25995.50	22005.79	3989.71
2020	29791.25	26721.68	3069.57
2021	34096.99	32102.73	1994.26
2022	39328.39	38186.27	1142.12
2023	45463.63	45009.89	453.74
2024	52206.62	52611.39	-404.77
2025	59321.45	61028.78	-1707.33

4. Discussion and Conclusion

There are many time series data fitting methods, which are widely used in various fields such as economy, health, society, etc. [7]. Before modeling ARIMA model, it is necessary to ensure the stability of the sequence data. The general detection methods include unit root method, autocorrelation function and partial autocorrelation function. Sometimes, the unstable sequence needs logarithmic transformation and difference processing to meet the stability requirements. However, model identification, model parameter estimation and test are a continuous and repeated process [8]. It is necessary to select the model with higher goodness of fit to predict according to the test results of different models. The test of model fitting effect can be judged by fitting index R2 and Ljung box (q) statistics, and can also be judged by the normal BIC value. The smaller the BIC value is, the better model is fitted.

After advance of China's health insure system, from initial labor insure system to current urban resident's insurance system, the overall fund's level has gradually improved, and the anti-risk capability of insure fund has been enhanced. However, with medical cost advancing in China, expenditure pressure of health fund increased. Besides, social health insurance fund is affected by various controllable and uncontrollable factors [9]. The smooth operation of health insure fund is very important. This paper forecasts income and outcome of the fund in next few years by establishing ARIMA model, which provides a scientific reference for effectively preventing risk of health fund. However, this model has some shortcomings, constantly supplement data is necessary to improve the accuracy of prediction [10].

References

[1]. Wang Y, Zhu Y, Shi H, et al. The Effect of the Full Coverage of Essential Medicines Policy on Utilization and Accessibility of Primary Healthcare Service for Rural Seniors: A Time Series Study in Qidong, China [J]. Int J Environ Res Public Health, 2019, 16 (22).

[2]. Dong Liming. Study on the balance of income and expenditure of urban and rural basic medical insurance funds [J]. Modern economy (in Chinese), 2014, (05): 15-19

[3]. Van Den Bogaert S, Ceuterick M, Bracke P. The silver lining of greying: Ageing discourses and positioning of ageing persons in the field of social health insurance[J]. Health (London), 2018.

[4]. Ma Guifeng, Sheng Hongqi, Zhang Ting, et al. Study on the balance of payments and risk assessment of social medical insurance funds [J]. China health economy (in Chinese), 2017, 36 (07): 25-27

[5]. Tian Y, Liu H, Si Y, et al. Association between temperature variability and daily hospital admissions for cause-specific cardiovascular disease in urban China: A national time-series study [J]. PLoS Med, 2019, 16 (1): e1002738.

[6]. Li L, Jiang J, Xiang L, et al. Impact of Critical Illness Insurance on the Burden of High-Cost Rural Residents in Central China: An Interrupted Time Series Study[J]. Int J Environ Res Public Health, 2019, 16 (19).

[7]. Wang Yi, Zhang Zhen, fan Junjie, et al. Application of ARIMA model in prediction of infectious diseases [J]. Chinese Journal of preventive medicine (in Chinese), 2015, 16 (06): 424-428

[8]. Chen W, Wang S, Wang Q, et al. Direct medical costs of hospitalisations for mental disorders in Shanghai, China: a time series study[J]. BMJ Open, 2017, 7 (10): e015652.

[9]. Qiu X, Zhao T, Kong Y, et al. Influence of population aging on balance of medical insurance funds in China[J]. Int J Health Plann Manage, 2019.

[10]. Zhang Yanqi, Tang Guili, Wang Wenchang, et al. ARIMA model and its application in the prediction of tuberculosis [J]. Modern preventive medicine (in Chinese), 2008, (09): 1608-1610 + 1615