PREDICTION OF THE BASIC PENSION OF GOVERNMENT EMPLOYEES BASED ON ARMA MODEL

Yanwei Zhou & XingJing
(College of science, Yanbian university, statistics)

ABSTRACT

To predict the future short-term trend of the basic pension of the employees in China's government institutions, to calculate the replacement rate of the social average salary of the pension, and to use the ARMA model to predict the analysis. The results show that the ARMA model can get more accurate prediction results. Based on the relevant actual data, it is expected that the replacement rate of the average salary of the pension of the organs and institutions in China will gradually decrease year by year with the upper limit of 0.7915 in 2018, and the value will be stable between 0.6 and 0.7.

Keywords: ARMA model; Pension replacement rate; Time series analysis.

0INTRODUCTION

The old-age security system of government and public institutions is one of the important components of China's social security system. With the development of the society, the main malpractice of the "dual-track system" which leads to the unequal distribution of income is becoming more and more prominent and waiting to be solved.

At present, the reform of the basic endowment insurance system of state organs and public institutions has come into normal operation. It is of great significance to predict the future trend of the basic pension of the staff and workers of the state organs and institutions in China.

*Received date: 2020-05-02

1 Introduction of principles and methods

1.1ARMA model

The basic model with the following structure is called the autoregressive moving average model, denoted as ARMA(p,q) model:

$$\begin{cases} x_t = \phi_0 + \phi_1 x_{t-1} + \cdots + \phi_p x_{t-p} + \varepsilon_t \\ -\theta_1 \varepsilon_{t-1} - \cdots - \theta_q \varepsilon_{t-q} \\ \phi_p \neq 0 \end{cases}$$

$$E(\varepsilon_t) = 0, \mathrm{Var}(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t \varepsilon_s) = 0, \ s \neq t$$

$$Ex_s \varepsilon_t = 0, \forall s < t$$

In the formula:

$\Phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \cdots - \phi_p B^p$, which p order polynomial regression coefficient.

$\Xi(B) = 1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q$, namely q order moving average coefficients polynomial.

It can be seen that when q = 0, ARMA(p,q) is reduced to AR(p) model. When p = 0, ARMA(p,q) is reduced to MA(q)

model. Therefore, the two mathematical statistical properties of ARMA(p,q) model are an organic combination of two mathematical statistical properties based on AR(p) and MA(q) models.

1.2Test and evaluation of the predictive effectiveness of ARMA model

In order to further illustrate the data accuracy and prediction effectiveness of ARMA model prediction, the relative percentage error index of RPE was used to evaluate. The smaller the RPE and the closer it is to 0, the better the prediction effect of the model was. The specific formula is as follows:

$$RPE = \frac{|\hat{x}_t - x_t|}{x_t}$$

Type of $\hat{x}_t$ an x_t represent the predicted values and actual values.

2Calculation of basic pension

2.1Data sources

From 1999 to 2017, the actual expenditure of the basic endowment insurance fund for employees of state organs and public institutions, the number of retirees insured at the end of the year and the average annual salary of employees were selected. (data from China labor economy database)

The annual per capita basic pension was used to draw a time sequence chart, showing that the annual per capita basic pension increased year by year with the increase of salary. In order to eliminate the policy impact of wage reform and improve the prediction accuracy of the model, the concept of "replacement rate of social average wage pension" was introduced.

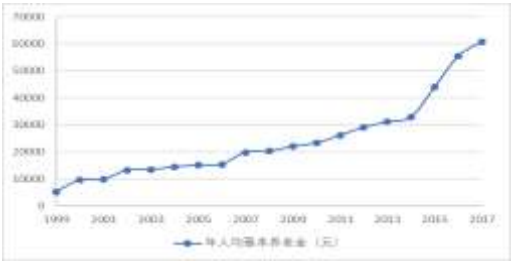


Figure 1Time sequence of annual per capita basic pension

2.2Research content

Table 1 Data of replacement rate of social average salary pension in

year	Pension expenditure (hundred million RMB)	The number of retired insured by the end of the year (ten thousand)	Average salary of employees (RMB)	Pension replacement rate (%)
1999	61.7505	119.9	8319	61.91%
2000	145.443	153.4	9333	101.59%
2001	204.405	209.335	10834	90.13%
2002	340.13	258.6	12373	106.30%
2003	405.9	303.3	13969	95.80%
2004	470.9	327.6	15920	90.29%
2005	545	362.3	18200	82.65%
2006	609.4	396.8	20856	73.64%
2007	811.3	409.7	24721	80.10%
2008	882	435.6	28898	70.07%
2009	1007.84	459	32244	68.10%
2010	1144.99	493.348	36539	63.52%
2011	1339.28	513	41799	62.46%
2012	1553.29	534.75	46769	62.11%
2013	1728.97	556.244	51483	60.38%
2014	1907.4	579.8	56360	58.37%
2015	2671.82	605.469	62029	71.14%
2016	5988.74	1079.51	67569	82.10%
2017	9510.42	1565.29	74318	81.75%

institutions from 1999 to 2017

Social average salary pension replacement rate [1], that is, the actual

[1]Zhu Ying. A study on the influence of delayed Retirement Age on the Pension replacement rate of

expenditure of the current social average pension accounts for the percentage of the average salary of the current social employed personnel. It can truly reflect the difference between the average pension income of the current society and the real average salary of the current society, which can explain the situation more.

In view of this paper, the concept of "replacement rate of social average salary pension" is extrapolated and extended to obtain the index of "replacement rate of social average salary pension of organs and institutions". And by measuring the value of the index, it is used as a time series variable to analyze the actual situation of the study.

3Empirical analysis

3.1 ARMA prediction

SAS software was used to analyze the pension replacement rate sequence from 1999 to 2017, and the modeling steps were as follows.

(1) Stationarity and white noise test

According to the time series chart of pension replacement rate, there is no obvious non-stationary trend in the data. Then, according to ACF diagram and PACF diagram (figure 3), except for the (partial) autocorrelation coefficient of delay order 1, all the other values fall within the range of coefficient of 2 standard deviations, so the data of the sequence can be stable, so d = 0. In order to accurately judge the application value and analysis significance of the data, we need to carry out white noise test on the sequence.

Figure 2 White noise test of pension replacement rate sequence

According to the output test results, the P values of LB statistics under different orders of delay were all significantly greater than 0.05, so the sequence was identified as a non-white noise sequence.

Figure 3Pension replacement rate sequence (partial) autocorrelation function diagram

Enterprise employees-- A case study of H state-owned enterprises [D]. East China normal University, 2016.

(2) Model establishment

In order to better find the relative optimal order determination of ARMA model and avoid identification errors caused by personal inexperience, (partial) autocorrelation graph (figure 3) and BIC criterion were used to show that the autocorrelation coefficient was tailed and partial autocorrelation coefficient was truncated in order 1. ARMA(1,0) is a relatively optimal model.

Figure 4Optimal order of pension substitution rate sequence fitting ARMA model

Minimum Information Criterion

Lags	MA 0	MA 1	MA 2
AR 0	-4.54	-5.0453	-5.20476
AR 1	-5.75802	-5.6473	-5.48418
AR 2	-5.70187	-5.56028	-5.43284

Error series model: AR(4)
Minimum Table Value: BIC(1,0) = -5.75802

(3) Model test

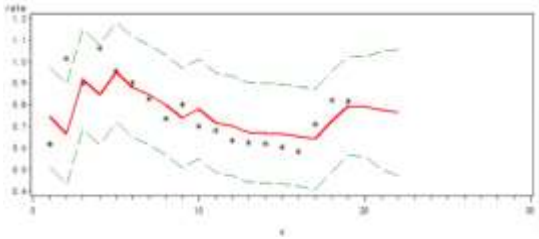
As shown in FIG. 5, the P value of LB statistics for each delay order is significantly greater than 0.05, the residual sequence of the fitting model belongs to the pure random sequence, and it can be considered that the model fitting pension replacement rate data is reasonable and effective. It can be obtained from the output chart of parameter significance test that both parameter tests are significant.

In summary, the test results show that the simulation test results of the sequence: AR(1) model can effectively simulate the data and observe the frequency fluctuations in line with the values of the sequence.

Figure 5 ARMA(1,0) model (parameter) test fitting the pension replacement rate sequence

(4) Model prediction

The step size parameter to set the short-



term forecast value is 4, that is, to predict the short-term trend of the pension replacement rate in the next four years. The predicted values for 2018-2020 are 0.7915, 0.7744, 0.7634 and 0.7563.

Figure 6Effect diagram of ARMA(1,0) model on the series fitting prediction of pension replacement rate

The predicted values in the figure are all within the 95% confidence interval, the fitting effect is good, the error is small, and the model fitting is reasonable and effective.

3.2Results analysis of ARMA model prediction method

Table 2 ARMA model to predict the relative percentage error

Autocorrelation Check of Residuals

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations
6	5.42	5	0.3668	-0.182 0.303 -0.172 -0.021 0.000 -0.167
12	9.27	11	0.5967	0.049 -0.212 -0.051 -0.155 -0.089 -0.093
18	13.41	17	0.7086	0.010 0.014 0.057 0.100 -0.015 -0.013

Conditional Least Squares Estimation

Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|	Lag
MU	0.74321	0.06598	11.26	<.0001	0
AR1,1	0.64638	0.18897	3.42	0.0033	1

ye

2017

Comparing the predicted value of ARMA model with the actual value of 2017, the relative percentage error of ARMA model prediction is 3.12%, which is small, indicating that ARMA model can obtain relatively accurate prediction results, and

verifying the accuracy and effectiveness of the model for prediction.

4Conclusions and prospects

To sum up, the short-term trend of the replacement rate of pensions for government institutions and public institutions has a continuous downward trend, which may be due to the promulgation and adjustment of policies related to the reform of the pension security system or the general increase in the average salary of employees. According to the world bank and the national labor department [2], the replacement rate of the average salary pension for the government institutions will decrease year by year from 0.7915 in 2018, and the future turning point may be between 0.5 and 0.6, and then slowly rise and stabilize between 0.6 and 0.7. Or with 0.7915 as the upper bound, the small value fluctuates between 0.6 and 0.7 and tends to be stable.

In order to eliminate the influence of wage reform, the relative concept of substitution rate was constructed. However, without considering other factors, if a major policy event occurs, the actual value will exceed the range predicted by the model in this paper. If longer-term prediction is needed, the sample size or data dimension should be further expanded, and the prediction model should be improved by combining policy intervention factors in the background.

[2]"A 2018 increase in pension is a good thing, but don't forget that the pension replacement rate is more important."http://www.360doc.com/content/18/0410/13/41100889_744438650.shtml

REFERENCE

[1] Liwan Yang. Path analysis of pension reform in public institutions [D]. Huazhong University of Science and Technology, 2014.

[2] Meng Bin. Study on the influencing factors of pension replacement rate of urban workers in China [D]. Inner Mongolia University of Finance and Economics, 2017

[3] Chaonan Li. Several forecasting methods of GDP in Shandong Province and their comparison [D]. Shandong University, 2018.

[4] Guihai Ruan. A course on the Application of SAS Social Statistics [M]. Peking University Press, 2006.