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Prediction Model of Fire Rescue Alarm Times Based on Time Series Analysis

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Keywords: Time series analysis, Winters additive mathematical model, Prediction model

Abstract: Based on the data of a place from January 1, 2016 to December 31, 2019, this paper analyzes the number of fire rescue alarms in months, establishes a time series model by using SPSS software, and obtains that the type of alarm number prediction model is simple seasonal type through the calculation and analysis of BIC selection principle and fitting statistical stationary R^2. At the same time, ACF and PACF coefficients show that the model has high accuracy and stability. Considering the policy and other influencing factors, the model is well trained, and the winters additive mathematical model is established by using the data given in 2020 to predict the number of police calls in 2021.

1. Introduction

The global economic industry has entered a period of rapid development. With the continuous acceleration of China's industrialization and urbanization, the spatial utilization rate of land and environmental complexity have increased sharply. The causes of fire accidents are sudden, diverse and complex. Therefore, improving fire fighting and rescue capacity, building disaster injury prevention and control system and reasonably establishing fire rescue model according to fire alarm data can effectively improve rescue capacity and strengthen the construction of public health system. Based on the annual data from 2016 to 2019, this paper establishes the prediction model of fire rescue alarm times in monthly units; Take the annual data of 2020 as the validation data set of the prediction model to evaluate the accuracy and stability of the model; The number of fire rescue calls in each month in 2021 is predicted.

2. Model Establishment and Solution

2.1 Establishment and test of simple seasonal prediction model

After formulating the prediction variables, the expert modeler in SPSS software will select those models with statistically significant relationship with the dependent sequence for the contents of ARIMA model, and automatically find the best fitting model of each dependent sequence. When appropriate, the model variables are transformed using difference sum square root or natural logarithm transformation. Therefore, the expert modeler has good stability.

According to the data from 2016 to 2019, the expert modeler is used to establish the time prediction

model of fire rescue alarm times, which is a simple seasonal model.

$$\begin{cases} l_t = \alpha(x_t - s_{t-m}) + (1-\alpha)l_{t-1} \\ s_t = \gamma(x_t - l_{t-1}) + (1-\gamma)s_{t-m} \\ \hat{x}_{t+h} = l_t + s_{t+h-m(k+1)}, k = \left[\frac{h-1}{m}\right] \end{cases}$$

Assuming that the above time series are stationary series, ACF autocorrelation coefficient and PACF partial autocorrelation coefficient are introduced; In order to find the best balance between the complexity of the model and the ability of the model to interpret the data, the BIC principle is introduced:

$$BIC = \ln(T)\,(\text{Number of parameters in the model}) - 2\ln(\text{Maximum likelihood function value of model})$$

The maximum likelihood function value of the model reflects the degree of data fitting of the model. In particular, BIC is the principle of small selection. The average values of fitting statistical stationary R^2 and BIC are 0.801 and 6.92 respectively. Table 1 shows the statistical indicators of model fitting degree, and Figure 1 shows the ACF autocorrelation coefficient and PACF partial autocorrelation coefficient.

Table 1: Model fit result

Fitting statistics	average value	minimum value	Maximum value	Percentile						
				5	10	25	50	75	90	95
Stable R^2	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
R^2	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627	0.627
Normalization BIC	6.920	6.920	6.920	6.920	6.920	6.920	6.920	6.920	6.920	6.920

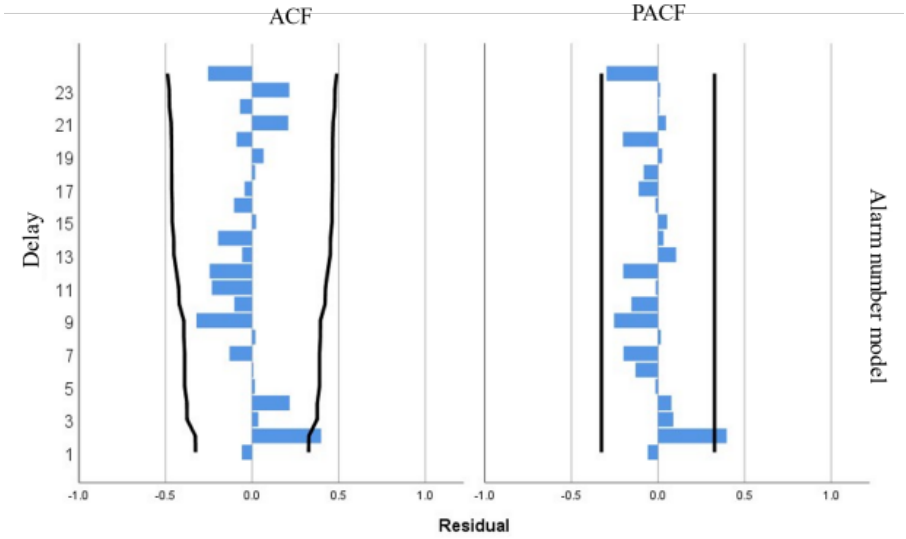

Figure 1: ACF autocorrelation coefficient and PACF partial autocorrelation coefficient

Taking the 2020 data as the validation data set, the accuracy of the prediction model is tested, and the results in Figure 2 are obtained. By observing Figure 2, it is found that the fit between the validation data set and the prediction model is poor. In order to eliminate the impact of other objective

factors on the prediction results of fire alarm numbers and determine the relationship between the results generated by hypothetical factors and the actual situation, the model is established by using the data of 2016-2018, and the data of 2019 is used as the validation data set. The method is the same as above, as shown in Figure 3.

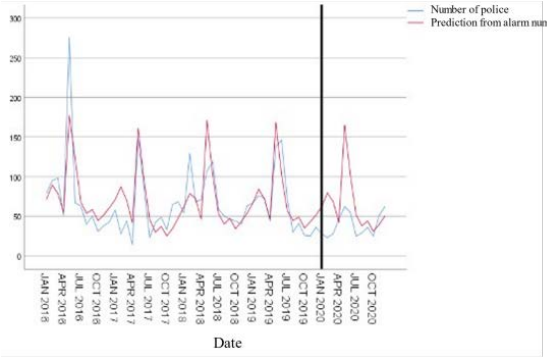

Figure 2: Fitting results

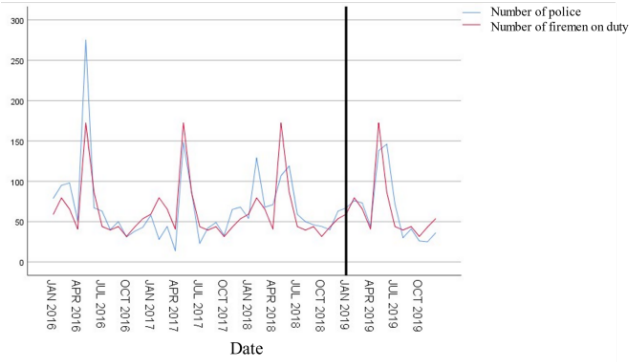

Figure 3: Fitting results

According to the above analysis, it can be concluded that the simple seasonal model itself has certain stability and accuracy. We find that the above method has a good fit for 2016-2019 data. For the low fitting degree in 2020, the following analysis is made: Considering the decision on Amending eight laws such as the construction law of the people's Republic of China at the 10th meeting of the Standing Committee of the 13th National People's Congress on April 23, 2019, the state has issued relevant policies, which will play a positive role in fire safety in 2020.

2.2 Establishment and test of winters additive mathematical model

The simple seasonal model has good fitting in 2016-2019. Therefore, the 2020 model shall be well trained: Based on the simple seasonal model, other impact factors caused by the policy shall be added, and the winters additive mathematical model shall be established by using the expert modeler according to the 2020 data. Similarly, the model fitting results, ACF and PACF are obtained, as shown in Table 2

$$\begin{cases} l_t = \alpha(x_t - s_{t-m}) + (1-\alpha)(l_{t-1} + b_{t-1}) \\ b_t = \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \\ s_t = \gamma(x_t - l_{t-1} - b_{t-1}) + (1-\gamma)s_{t-m} \\ \hat{x}_{t+h} = l_t + s_{t+h-m(k+1)}, k = \left[\frac{h-1}{m}\right] \end{cases}$$

Table 2: Model fit result

Fitting statistics	average value	minimum value	Maximum value	Percentile						
				5	10	25	50	75	90	95
R^2	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999
Normalization BIC	-51.8	-51.8	-51.8	-51.8	-51.8	-51.8	-51.8	-51.8	-51.8	-51.8

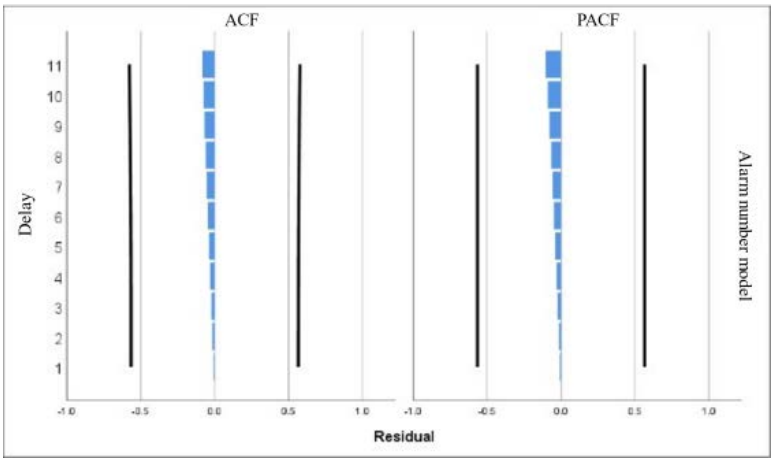

Figure 4: ACF autocorrelation coefficient and PACF partial autocorrelation coefficient

Therefore, more accurate data in 2020 and the predicted number of police calls in each month of 2021 can be obtained by fitting with texability, which are shown in Figure 5 and Figure 6 respectively.

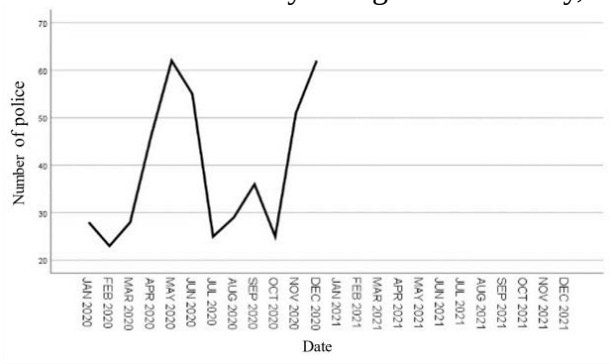

Figure 5: Alarm frequency in 2020

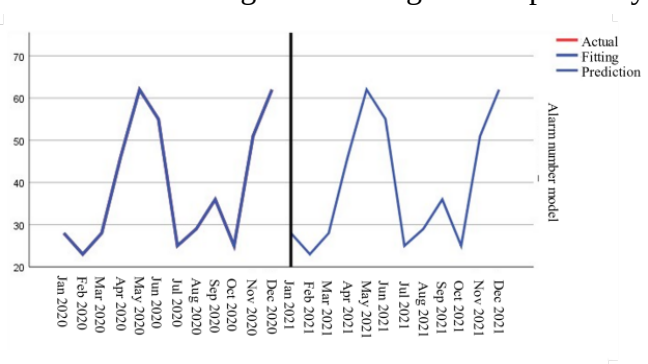

Figure 6: Forecast value of alarm frequency in 2021

2.3 Prediction results

Finally, the predicted alarm times of fire rescue in each month of 2021 are obtained, and the results are as follows

Table 3: Forecast value of fire rescue alarm times in each month of 2021

Month	Predicted value (Times)
2021.01	28
2021.02	23
2021.03	28
2021.04	46
2021.05	62
2021.06	55
2021.07	25
2021.08	29
2021.09	36
2021.10	25
2021.11	51
2021.12	62

3. Model Evaluation

The model in this paper is based on rigorous and comprehensive logical analysis and rich data, including comprehensive consideration of various influencing factors. It has the characteristics of good stability and high accuracy. The model fully considers the influence of practical factors and has great reference value in practical application.

4. Conclusion

Based on the data of a place from January 1, 2016 to December 31, 2019, this paper analyzes the number of fire rescue alarms in months, establishes a time series model by using SPSS software, and obtains that the type of alarm number prediction model is simple seasonal type. Considering the policy and other influencing factors, the model is well trained, and the winters additive mathematical model is established by using the data given in 2020 to predict the number of police calls in 2021.

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