Analysis and Forecast of Total Investment in Environmental Pollution Treatment in China Based on ARIMA Model

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Abstract. In this paper, by selecting the annual data of total investment in environmental pollution control in China from 2002 to 2021 and using R language to process and test the data, an optimal ARIMA (1,2,1) model is established, which is used to make the total investment in environmental pollution control in China for the next five years from 2022 to 2026. The model is used to forecast the total investment in environmental pollution control in China for the next five years 2022–2026. According to the model, the total investment in environmental pollution control in the next five years is predicted to be 1,029.472 billion yuan, 10,132.279 billion yuan, 1,044.827 billion yuan, 1,052.752 billion yuan, and 1,072.366 billion yuan, indicating an overall upward trend from 2022 to 2026, but more slowly. This reflects that China's environmental problems are still serious, and the country should pay more attention to environmental and ecological problems, and finally put forward reasonable proposed measures.

Keywords: Environmental pollution management · time series · ARIMA model

1 Introduction

With the growing prominence of environmental problems, the national and local governments continue to increase their efforts to comprehensively improve the environment, and have introduced a series of policies such as the "Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Vision 2035", which specify the development direction, structural layout and main tasks of the environmental protection industry, providing a broad market space for the environmental pollution treatment industry. Environmental protection is a basic national policy in China, and investment in environmental pollution treatment is an important guarantee for implementing the basic national policy of environmental protection and sustainable development, and the analysis and forecast of total investment in environmental pollution treatment is of great significance to the development of China's environment. This has important theoretical significance and practical guidance.

2021 saw the successful completion of the eight binding indicators in the national economic and social development plan in the field of ecology and environment, a continuous decrease in pollutant emissions, a continuous improvement in ecological and

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environmental quality, and a good start in ecological and environmental protection. The "14th Five-Year Plan" is off to a good start. Investment in environmental pollution control includes investment in the treatment of old industrial pollution sources, investment in environmental protection for the completion of construction projects, and investment in urban environmental infrastructure construction. 2021, the total national investment in environmental pollution control is RMB 949.18 billion, accounting for 0.8% of gross domestic product (GDP) and 1.7% of total social fixed asset investment, a trend of slow growth year by year.

2 Research Status

In recent years, environmental pollution has attracted much attention, and it has been the top priority to solve the environmental problems, and as environmental pollution becomes more and more serious also leads to a series of problems the country needs to control the pollution of the environment, so China's environmental pollution control investment is getting stronger and stronger, and the total amount of investment is also on the rising trend year by year, which is closely related to our life and economy. According to Yue Zhang (2015), China's total investment in environmental pollution management has increased year by year but is not stable, the structure is unreasonable, the investment in the management of industrial pollution sources has lagged far behind the other two segments in terms of percentage and growth rate [1].

Regarding the impact between investment in environmental pollution management and environmental pollution, scholars have used different research methods, mainly from two aspects: one is the study of the relationship between environmental management and environmental quality, and the other is the study of the relationship between environmental management and the efficiency of energy conservation and emission reduction. For the aspect of environmental quality, Wuyi Zhang et al. (2013) concluded that technology is a constraint on the effectiveness of environmental governance The study also concluded that technology is the dominant factor limiting the effectiveness of environmental management, and put forward policy recommendations to appropriately increase the investment in science and technology [2]. Ke Zhang et al. (2016) argue that there is an obvious strategic interaction and regional interaction of environmental protection investment in neighboring provinces in China, i.e., "if you invest more, I will invest less", while pollution emissions show the result of "if you emit more, I will also emit more" [3]. Jun Huang (2018) concludes that technology is the dominant factor limiting the effectiveness of environmental management, and puts forward the policy recommendation that the investment in science and technology should be increased appropriately [4].

RamónLópez (2011) constructed the first general equilibrium model in which fiscal expenditures affect environmental quality, dividing them into productive and non-productive expenditures and arguing that increasing the share of non-productive fiscal expenditures significantly reduces water and air pollution [5]. Halko et al. (2013) argued that increasing the proportion of government fiscal spending in the health and environmental sectors is effective in improving environmental pollution when the level of environmental regulation is constant [6]. Ming Luo et al. (2019) argue that the management of environmental pollution should not be the sole responsibility of one of the subjects, either the government or the enterprises, but the two should work together so that environmental pollution can be effectively managed [7]. According to Yeguang Cui et al. (2019), the current source of funds for investment in environmental pollution control in China is mainly related to environmental taxes and fees as well as the government's financial expenditure [8]. Ye Zhang et al. (2019) scholars obtained the predicted values through scientific methods by studying the air quality of Datong City, accumulating valuable experience and information for the study of environment-related prediction [9]. For the efficiency of energy conservation and emission reduction, Dong Xiaoqing (2021) argued that China should accelerate the layout and promotion of carbon emissions trading, while optimizing financial services to better utilize the positive effects of carbon emissions trading on energy conservation and emission reduction [10]. According to Tingyong Zhong et al. (2022), "key source monitoring" strengthens the central government's efficacy in collecting information on enterprises' emissions while maintaining the local government's environmental enforcement power [11]. Xiang Li et al. (2022) showed that energy efficiency, energy structure, and industrial structure are important ways for carbon emissions trading system to promote energy conservation and emission reduction [12].

3 Research Methodology and Model Construction

3.1 Time-Series Analysis

Time-Series Analysis contains many factors, periods, trends and other issues that need to be discovered. When we deal with a time-series data, we need to integrate every factor of the time-series, and comprehensively analyze and consider the problem in order to ensure the accuracy of the data analysis.

Data processing using time series analysis methods. First, to obtain the dynamic data of the time series, we can obtain the dynamic data by using statistical survey, finding database data, etc. The dynamic data of the time series in this paper is obtained from the query of Chinese database and analyzed. First of all, we judge whether the dynamic data of time series are smooth, if not, we should perform difference operation, select the smooth series after difference for further analysis, and finally choose the appropriate model for prediction. The time series of total investment in environmental pollution control described in this paper is non-smooth, i.e., non-smooth should be differential operation. This paper focuses on the ARIMA model and determines the values of each parameter of the ARIMA model.

3.2 ARIMA Model

(1) Structure of ARIMA model

ARIMA model is called Autoregressive Integrated Moving Average Model, which is a relatively simple analysis method in time series analysis and is widely used in data processing and forecasting analysis nowadays.

The so-called ARIMA model is just a smoothness test and white noise test, according to the judgment of the smoothness test, we generally know that the series is not smooth, the need for differential operations, the number of differential operations by the series is smooth, smooth time series data can be modeled, according to the model to determine the forecast trend. We perform the difference operation on the original data, and the number of differences should not be too many to ensure the accuracy of the experimental results. Then in the selection of ARIMA model according to the AIC criterion. And, the ARIMA model performs better on linear data.

ARIMA(p, d, q) is called the differential autoregressive moving average model, and the structure of the ARIMA(p, d, q) model is as follows:

$$\begin{cases} \Phi(B)\nabla^d x_t = \theta(B)\varepsilon_t \\ E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, s \neq t \\ E(x_s\varepsilon_t) = 0, \forall s < t \end{cases} \tag{1}$$

where $\nabla^d = (1 - B)^d$, $\Phi(B) = 1 - \varnothing_1 B - \ldots \varnothing_p B^p$, this polynomial is the autoregressive coefficient polynomial of the ARMA model, and the ARMA model is smooth and reversible; $\Phi(B) = 1-\varnothing_1 B- \ldots \varnothing_p B^p$, is the moving smoothing coefficient polynomial of the ARIMA model, and the ARIMA model is smooth and reversible.

The determination of the p, d, and q parameters of the ARIMA model, with d being the number of difference operations until the time series dynamic data are smooth, and the determination of p and q relying on the autocorrelation and partial autocorrelation plots after the difference operations, determines the optimal ARIMA model based on the approximate image.

(2) ARIMA modeling

We model the ARIMA model, the first thing is to check the dynamic data of the time series we obtained, for example, the smoothness test and white noise test are required, because only the smooth time series can complete the next step of model selection, so the difference operation is very important, the minimum value model passed the AIC criterion for the residual white noise test, the future forecast. The processing step diagram of ARIMA model modeling is shown in Fig. 1.

(3) Data sources

These data come from the Ministry of Ecology and Environment of China and show in detail the dynamic data of the total investment in environmental pollution control in China from 2002 to 2021. We can broadly see the growth trend of investment and the importance the government attaches to environmental issues.

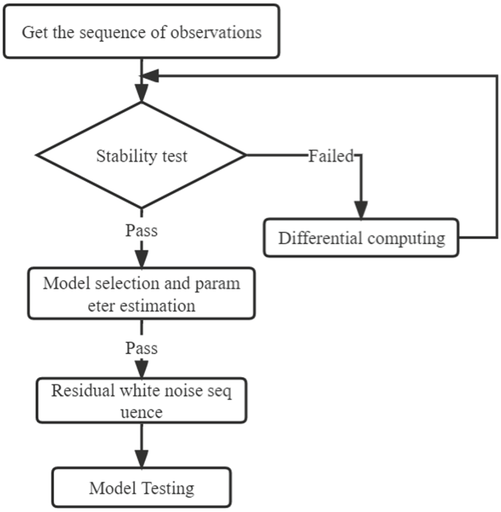

Fig. 1. ARIMA modeling

4 Analysis of Empirical Results

4.1 Test of the Model

(1) Plotting the time series graph

We can see from Fig. 2 that the national environmental pollution is becoming more and more serious, the state pays more attention to environmental problems, and the investment in environmental pollution control has increased greatly, starting from 162.770 billion yuan in 2002 to 2020, China's investment in environmental pollution control has reached a high point. Reached a high point, the general trend is growing year by year, showing a state of oscillating growth, until 2021 reached 949.18 billion yuan.

(2) Autocorrelation

As shown in Fig. 3. More intuitively shows that the autocorrelation graph of the total investment in environmental pollution control falls into the interval only after the 4th order, the data decay to 0 very slowly, and the autocorrelation coefficient is greater than zero for a long time, indicating that the data has a certain autocorrelation, which can be further tested to determine whether the series is smooth, and we need to further processing to turn the data into a smooth series. As shown in the autocorrelation graph, we can see that the first 3 orders of correlation coefficients are outside the range of 2 times the standard deviation, while the other correlation coefficients fluctuate within the range of 2 times the standard deviation.

(3) ADF unit root test. From the ADF test results, the p-value is 0.9534 is much greater than 0.05, then we can know that the time series is not smooth, that is, the series is non-smooth time series, need further processing.

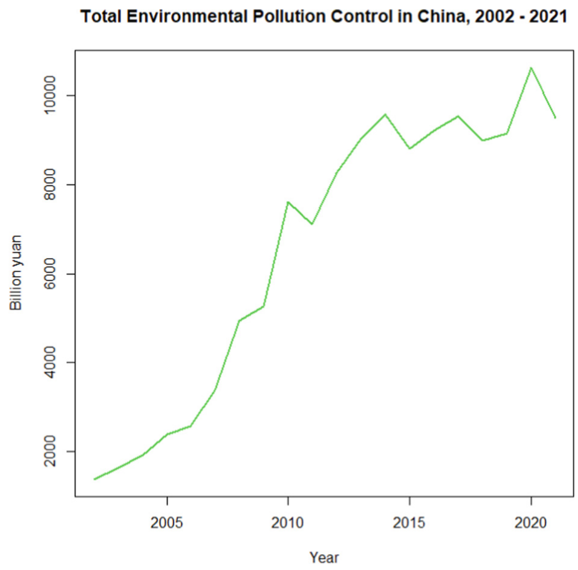

Fig. 2. Time series of total investment in environmental pollution control, 2002–2021

(4) White noise verification. The results of the white noise verification show that the p-value of 1.168e−06 is less than 0.05, indicating that the total investment in environmental pollution control is a non-random series, that is, a non-white noise series, which also indicates that there is a correlation between the data.

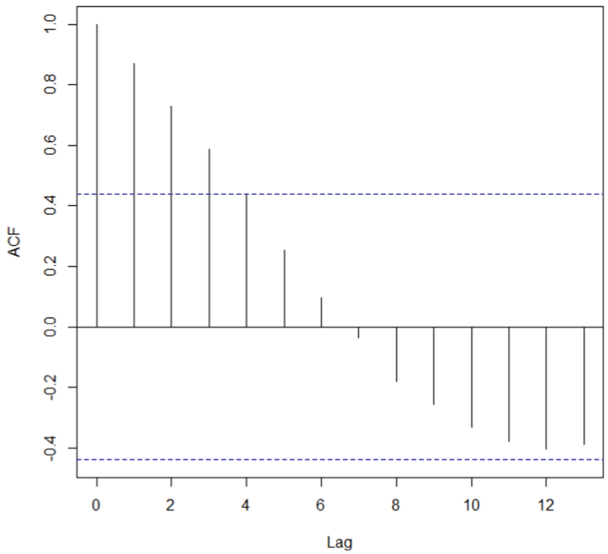

Fig. 3. Autocorrelation of total investment in environmental pollution control

4.2 Model Selection and Parameter Estimation

(1) First-order difference operation

The difference operation is the bridge of data smoothing, through the difference operation, we can get a smooth time series, we start from the first order, in order to carry out the N order difference test, the difference should not be too much, to complete the series smooth, this is to ensure the accuracy of the difference results. First is the 1st order difference, from the ADF test results, the P VALUE is 0.07812, greater than 0.05. We use the ADF test, if the PVALUE is greater than 0.05, it is basically determined that the experimental data in the 1st order difference is not a smooth time series, we need to do further difference operations.

(2) Second-order difference operation

In Fig. 4, the series after the second-order differencing no longer has a long-term growth trend, and the performance is smooth within a certain range, and then the ADF test is used to determine whether it is a smooth time series, so that we do not need to perform the difference test again to ensure the accuracy and scientific nature of the results, and the ADF test results show that the series is a smooth time series. In Fig. 4, the series after the second-order difference no longer has a long-term growth trend, but is smooth within a certain range, and then the ADF test is used to determine whether it is a smooth time series, so that we do not need to carry out the difference test again to ensure the accuracy and scientific nature of the results, and the ADF test results show that the series is a smooth time series. From the ADF test results of the series after the 2nd order difference, we get a VALUE of 0.01, but 0.01 is less than 0.05. The series after the 2nd order difference is the smooth time series we need.

In summary, after the 1st and 2nd order differences the time series reaches smoothness, and the smooth time series after the 2nd order difference is obtained.

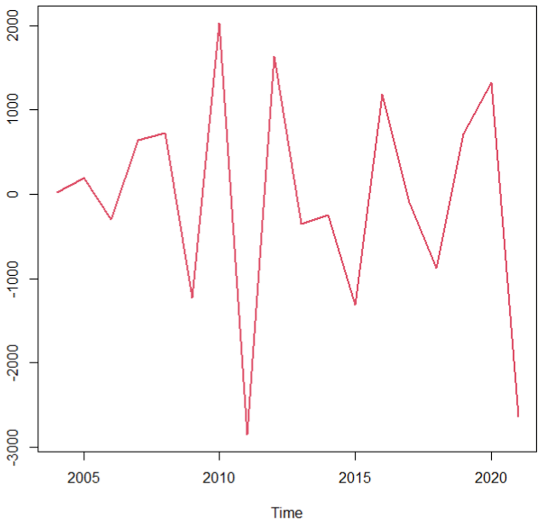

Fig. 4. Second-order difference timing diagram

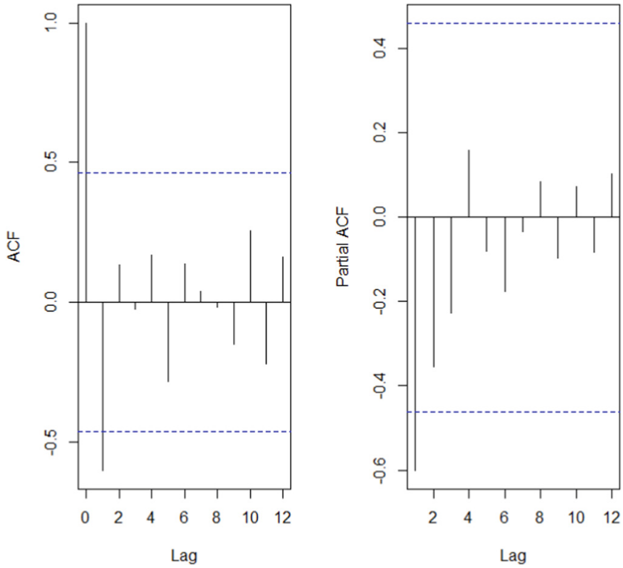

Fig. 5. Autocorrelation and partial autocorrelation plots after second-order differencing

From Fig. 5, I can get these two images with certain trailing by R language autocorrelation and partial autocorrelation plots, as shown in the figure, the autocorrelation and partial autocorrelation plots after 2nd order difference are both up and down in the range of 2 times difference interval, which can be identified as smooth time series.

4.3 Model Prediction

According to the above results, we carry out the ARIMA model determination, by the above processing we get d for 2, by the above autocorrelation graph and partial autocorrelation graph realistic change process we can basically determine the p, q, the general direction. According to the AIC criterion, the optimal ARIMA model is selected, and further predictions are made according to the model.

The AIC of the ARIMA model is derived, as shown in Table 1, and we can clearly see that the minimum AIC is 299.83, which is the ARIMA(1,2,1) model. The ARIMA(1,2,1) model is subjected to a white noise test of the residuals, and the results show that after the white noise test, the p-value of the ARIMA(1,2,1) model is 0.7789 greater than 0.05, which means that the model passes the white noise test, so we choose the ARIMA(1,2,1) model for forecasting.

Using the ARIMA(1,2,1) model obtained above to forecast the future, the forecast results are shown in Table 2. From the table, we clearly derive the forecast value of total investment in environmental pollution control for each year in the last four years, the forecast value from 2022 to 2026 shows a yearly growth trend, from 2020 to 2023 the forecast value increases from 1,029.472 billion yuan to 10723.66 billion yuan.

Table 1. ARIMA model corresponding to AIC values

ARIMA model	AIC
ARIMA(0,2,1)	300.55
ARIMA(1,2,1)	299.83
ARIMA(2,2,1)	300.89

Table 2. Forecast values for 2022–2026

Year	Predicted value	80% confidence interval	95%confidence interval
2022	10294.72	(9249.214,11340.24)	(8695.754,11893.70)
2023	10132.79	(8758.597,11506.99)	(8031.141,12234.45)
2024	10448.27	(8534.832,12361.70)	(7521.922,13374.61)
2025	10527.52	(8110.015,12945.03)	(6830.263,14224.78)
2026	10723.66	(7728.117,13719.19)	(6142.375,15304.94)

(3) Drawing a forecast map

According to the forecast value to draw the forecast time series chart to view the future trend of total investment in environmental pollution control, as shown in Fig. 6. we can see the direction of investment in environmental pollution management in recent years, as well as the importance of the state to environmental issues and investment efforts. The results show that the prediction results are largely on an upward trend, and the predicted trend is slowly rising year by year, and the growth rate is slowing down, which reflects more the government's high attention to environmental management and environmental protection, increasing the investment in environmental pollution and environmental protection, and gaining a deeper understanding of environmental issues.

5 Summary and Recommendations

5.1 Conclusion

This thesis focuses on environmental pollution control, which is closely related to people's life. As the most basic guarantee of environmental pollution control, the control investment plays a pivotal role. This paper first analyzes the current situation of environmental pollution in China since 2002, analyzes the problems in China's investment in environmental pollution control, and makes statistical forecasts of investment in environmental pollution control for the time series data of investment in environmental pollution

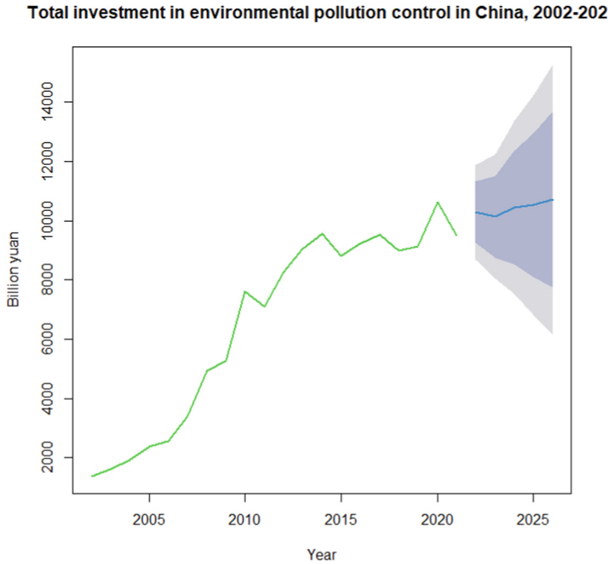

Fig. 6. Forecast of total investment in environmental pollution control in China, 2002–2026

control, aiming to provide reference for decision making in scientific budget. Through the analysis, this paper concludes that.

(1) Statistical forecasting methods can be used to make scientific predictions on the amount of governance investment. The establishment of a time series prediction model, through scientific forecasting, can be used as the basis for budgetary decision-making, while replacing the traditional ratio growth budgetary decision-making approach, not only to improve the budgetary accuracy, more conducive to the relevant state departments to guide the development of the market economy.
(2) The analysis and forecast results are derived from the empirical results. 2002–2015, the investment in environmental pollution control is a stage of sharp rise with extremely fast growth rate, which indicates that China's environmental problems are serious and in urgent need of control investment; 2015–2021, the investment is in a stable state, oscillating around 900 billion yuan with a slowdown in growth rate. Overall, China's environmental governance investment is on an upward trend, and the trend is predicted to rise slowly year by year through the ARIMA model, and the predicted growth is slower, which more reflects that China's environmental problems are still serious, and the country should pay more attention to environmental and ecological issues.

5.2 Suggestions

(1) Strengthen the investment in environmental pollution control, optimize the investment structure of environmental pollution control, and implement the relevant policies of pollution removal and emission reduction. The government should appropriately strengthen the proportion of industrial pollution sources treatment in the

investment of environmental pollution treatment, realize the seriousness and harm of pollution, increase the investment in solid waste.

(2) After the investment in environmental pollution control, a perfect supervision mechanism should be established to ensure that the investment funds are put in place. Strengthen its supervision, resolutely put an end to the behavior of enterprises to sneak out pollutants on their own, and crack down on irregular discharge enterprises, so as to reduce the environmental burden at source. Improve the supervision mechanism for safeguarding the ecological environment to ensure that investment funds for environmental pollution control are put in place to truly solve environmental problems.

(3) Continuously improve the relevant provisions of environmental protection tax and consumption tax. Vigorously promote the treatment of environmental pollution, while increasing the treatment from the level of laws and regulations through the imposition of environmental taxes and other means, so that the ecological environment quality has continued to improve in recent years, and constantly improve the environmental protection tax and consumption tax to provide protection for the ecological environment.

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