Research on Newborns Forecasting in China-based on the Three-Child Policy

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Abstract. The essay uses data from 1921-2021 to forecast the impact of three-child policy on births based on the National Bureau of Statistics of China. By using different methods (Arima, Holt, Change Point, Functional Data Analysis), this paper draws a conclusion that the number of newborns in China is likely to be an upward trend after the publication of three-child policy. To be precise, the result from the Arima model has no reference value, while the results from Holt's method and the change point method indicate that the number of babies born in China will rise. Referring to the change point analysis, it represents a downward trend if there are not any adjustments. However, after combining the data with world birth tendency, the result shows that the number of newborns in China is growing in the next following years. These results represent that the publication of China's three child policy has a positive effect on the figure for new babies born in China.

Keywords: Newborns; three-child policy; ARIMA; change point; functional data analysis.

1. Introduction

The number of newborns has become a key issue of national and social concern nowadays. In the 1980S, the Chinese government published a policy named: "family planning", which effectively curbed the rapid birth of the population in China at that time. In 40 years, the number of births in China had fallen more than 400 million, which alleviating the pressure on environmental resources caused by excessive population growth and prompted the development on social and economy [1].

However, China's birth rate has been low for a long time, below 1.3% sicne1991 [2]. The resulting problems cannot be underestimated. For example: labor shortage, aging of population and insufficient incentives for innovation and competition. In order to solve the above problems, Chinese government published the two-child policy to encourage births in 2015 [3]. At that time, many demographers in China had used Leslie method, analytical estimating method, GM (1.1) method and time prediction model to get a conclusion that the number of newborns in the next following years will increase [4-7]. Unfortunately, with the impact of COVID-19 for three years and the economic downturn, the number of newborns in China had been falling in the next 5 years, which failed to meet their expectations [8].

For this situation, the Chinese government published the three-child policy to encourage births in 2021 [9]. But whether the three-child policy will lead to a rebound in China's birth population. Whether the newborns will remain falling like two-child policy after the introduction of three-child policy. The discussion of the above questions is very important. Since accurately grasping the trend characteristics of population change, understanding the changes bring great challenges for population security and economic and social development deeply, play an important role in the long-term population development [10]. The topic of this essay based on the National Bureau of Statistics of China, using data from 1921-2021 to forecast the trend of newborn population after China's three-child policy.

2. Methods

2.1. Data Source

The data for this lecture is collected from the National Bureau of Statistics of China, using 80 years of birth data to forecast the newborns after the introduction of China's three-child policy.

2.2. Data Description

Since the number of newborns needs to be analyzed over time, the study uses the data spanning eight decades, which is more likely to get an accurate result.

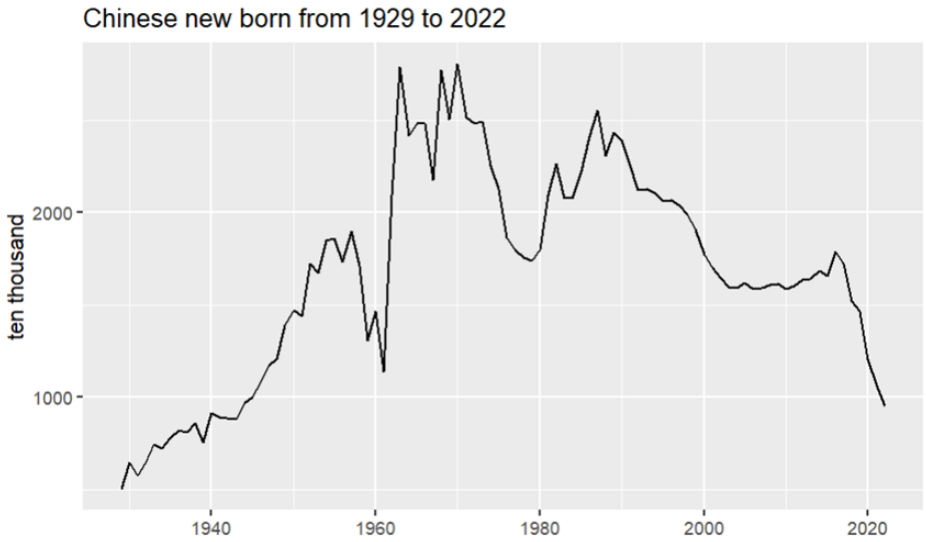

Fig. 1 Chinese new born from 1929 to 2022

Fig 1 is the time series of the Chinese newborns from 1929-2022, which is an annual data. It is clearly that there is an apparent trough between 1959-1961, it can be attributed to the widespread famine in China at the time.

2.3. Method Selection

According to Fig 1, it is apparently that there is no seasonality in the data. However, there is a small ebb and flow in the number of births every two or three years. So the author decides to use different methods to make predictions. To be precise, Arima, Holt's Method, Change Point Method and Functional Data Analysis Method will be included in the essay.

3. Results and Discussion

3.1. Arima Model

The autoarima function's results tell us that the study should use the Arima (0, 1, 0) model, but the table 1 shows the p-value is much smaller than 0.05, indicating that the Arima model is not applicable to this set of time series.

Table 1. Results from the Ljung-box test (Arima 1,0,1)

Model	P-value	ACF1
Arima (1,0,1)	0.008212	-0.0925397

3.2. Holt's Method and The Damped Holt's Method

Due to the Arima model is not acceptable, holt's method and the damped holt's method can be used to make a prediction. The results are showed in the fig 2 and fig 3 below.

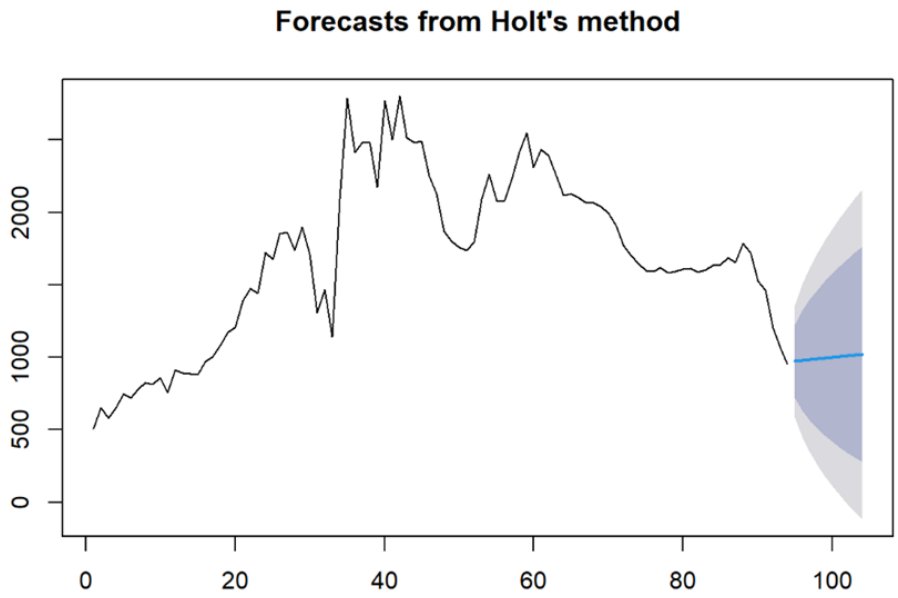

Fig. 2 Forecasts from Holt's method

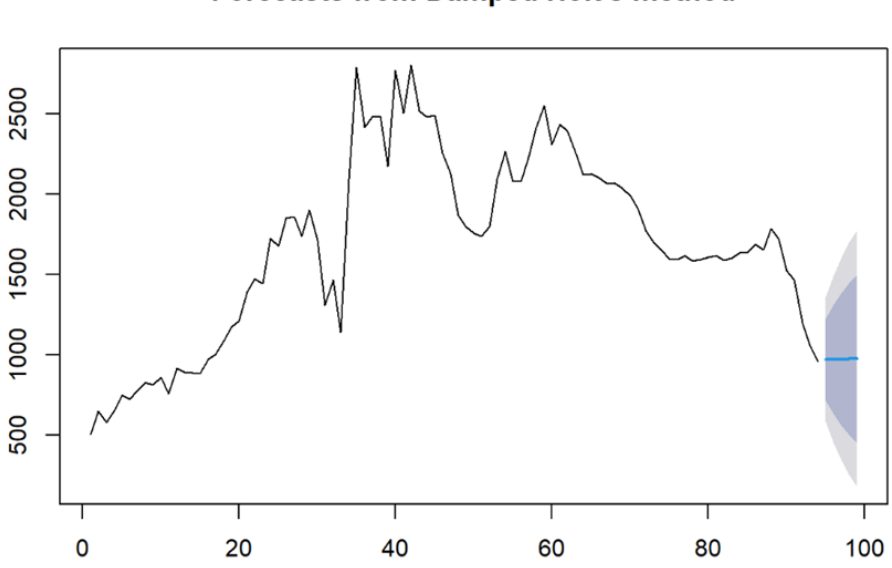

Fig. 3 Forecasts from Damped Holt's method

Overall, the forecast from holt's method and the damped holt's method show an upward trend, which indicates that the introduction of three-child policy plays a role in the number of births in China. However, holt's method has many limitations. It can only combine the initial data with the final data to predict the direction of the future data, it represents that the result from holt's method may not be accurate, but it still has important reference value.

3.3. Change Point Model

Fig 4 is the lag plot of the data. Noticing that in all lag plots, the darker dots are all clustered in the lower left and the lighter dots are clustered in the center, which suggests that the data from the very beginning and the very end of this time series are highly correlated. As a result, the method of Change Point Analysis can be used to predict the trend.

Fig. 4 Lag plot for the raw data

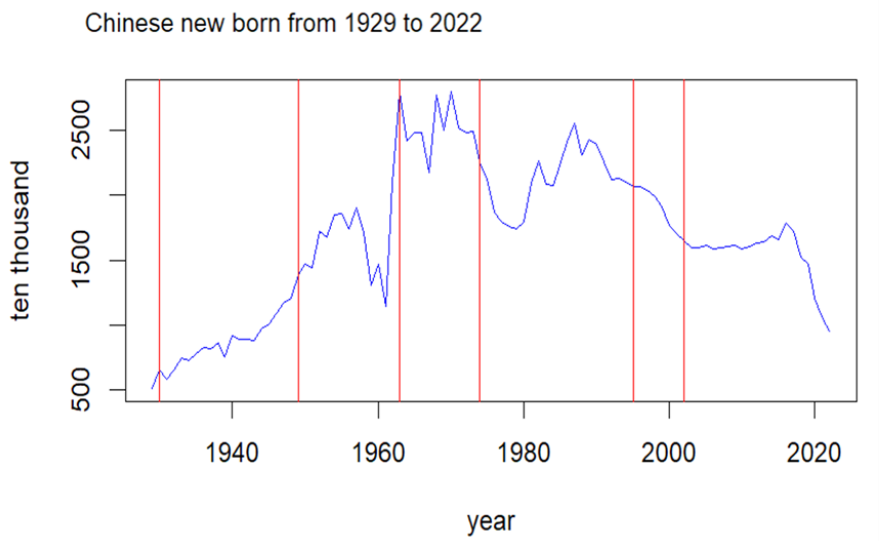

Fig. 5 Chinese new born from 1929 to 2022

Using the process stream function in the cpm package, several change points can be got in the raw data: 1930 1949 1963 1974 1995 2002 (fig 5). Since there is a ten months gap between the introduction of the policy and the birth of the new child, so the attention can be paid to what happened in the previous years and find some explanation.

First of all, the change point in 1930. During that time, China was in a civil war, and the people did not have enough to eat. As a result, the number of births in the China had a certain decline at that time. In addition, there is a change point in 1949, the founding year of new China. At that time, the society was stable and the people's desire to have children was generally strong. So the number of births in China kept growing until 1961, the time of the great famine. Subsequently, in 1973, the one child policy was introduced, which limited the number of births in each family. Therefore, the number of newborns declined for a while. Finally, in 1994 and 2002, due to the economy in China was depressed and the publication of “family planning” policy, the figure for the Chinese newborns kept falling.

The following chart is the residuals from the Arima (1,0,1) method for the last period of the data, from 2002 to 2022. The results from table 2 and fig 6 show that the residuals are non-autocorrelated and can be considered as white noise.

Table 2. Results from the Ljung-box test (Arima 1,0,1 with non-zero mean)

Model	P-value	ACF1
Arima (1,0,1)	0.09814	0.0760428

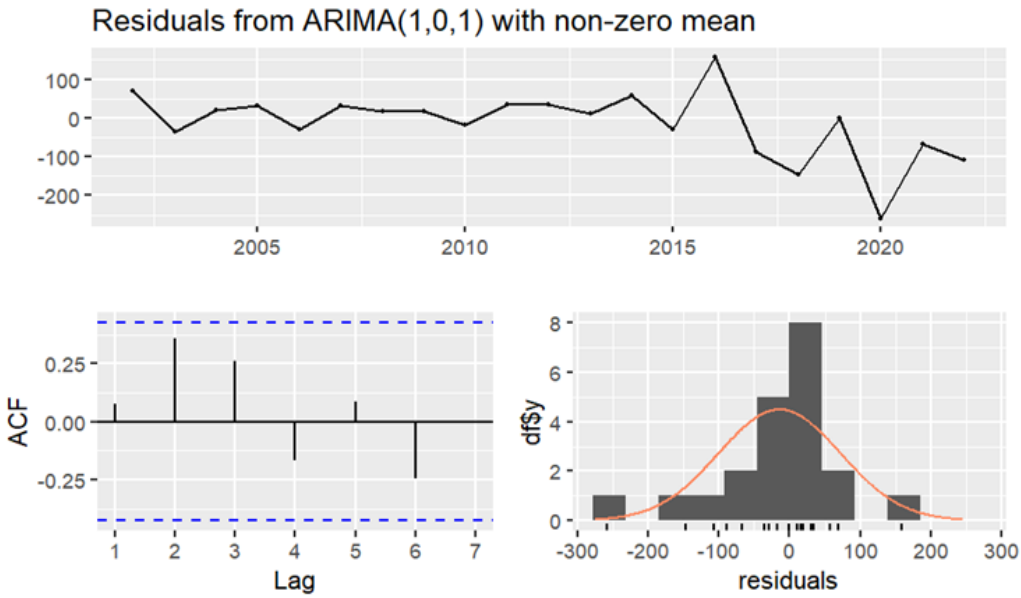

Fig. 6 Residuals from Arima (1,0,1)

Apart from the Arima model, the ETS model can also be used to make predictions. After checking the residuals, the results from table 3 and fig 7 indicate that the residuals are also non-autocorrelated and can be considered as white noise.

Table 3. Results from the Ljung-box test (ETS)

Model	P-value	ACF1
ETS	0.2761	-0.05403321

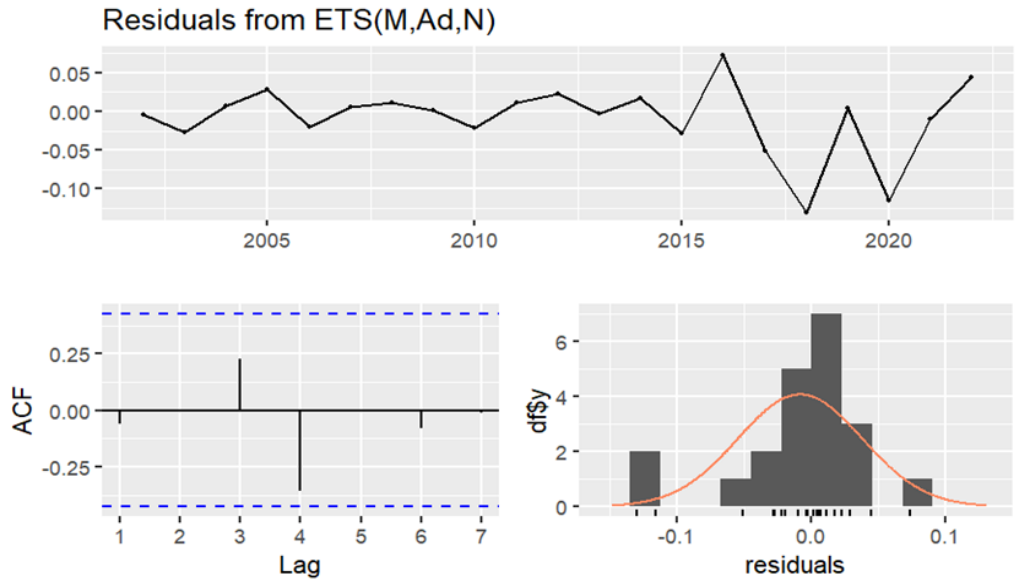

Fig. 7 Residuals from ETS

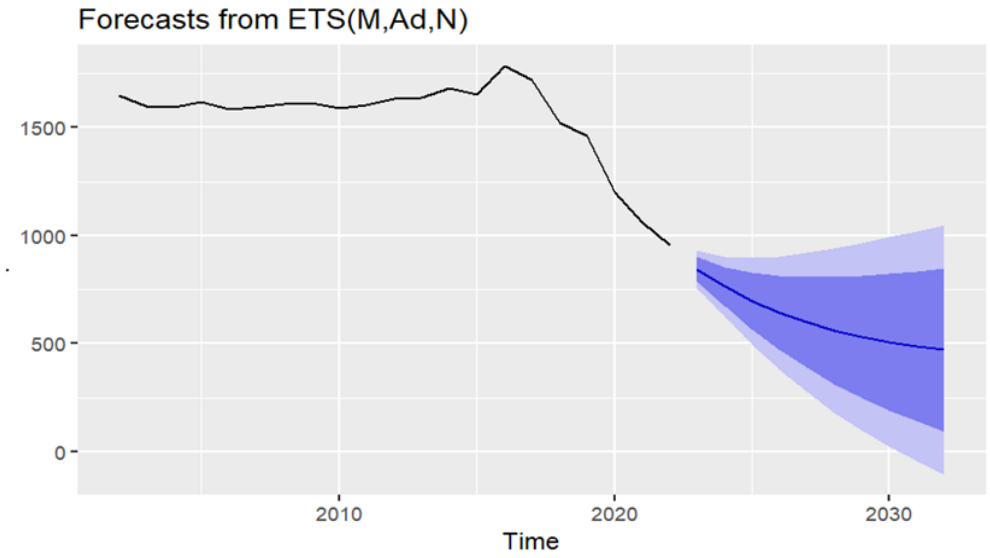

Fig. 8 Forecasts from ETS (M, Ad, N)

As can be seen from the fig 8, the number of Chinese newborns will maintain a downward trend, which indicate that the publication of three-child policy may not work.

Nevertheless, what cannot be ignored is that with only 21 points in the last period, it's hard to make an accurate prediction. Thus, another method called Functional Data Analysis can be used to get the result.

3.4. Functional Data Analysis

The fig 9 shows that for interior points, five basis functions contribute to computing the value of any point. The endpoints, however, are computed from a single basis function. The b-spline basis is used in the model.

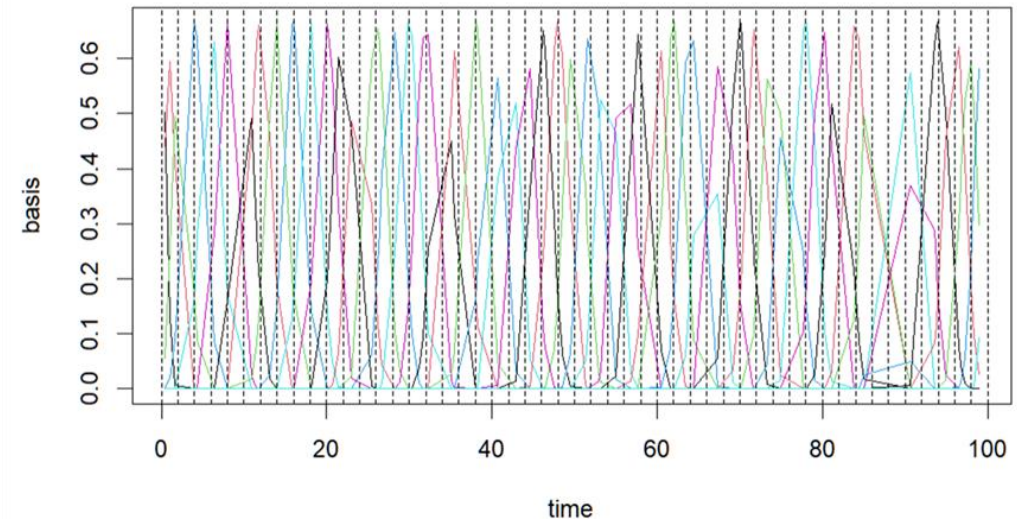

Fig. 9 Basis functions and locations of the knots

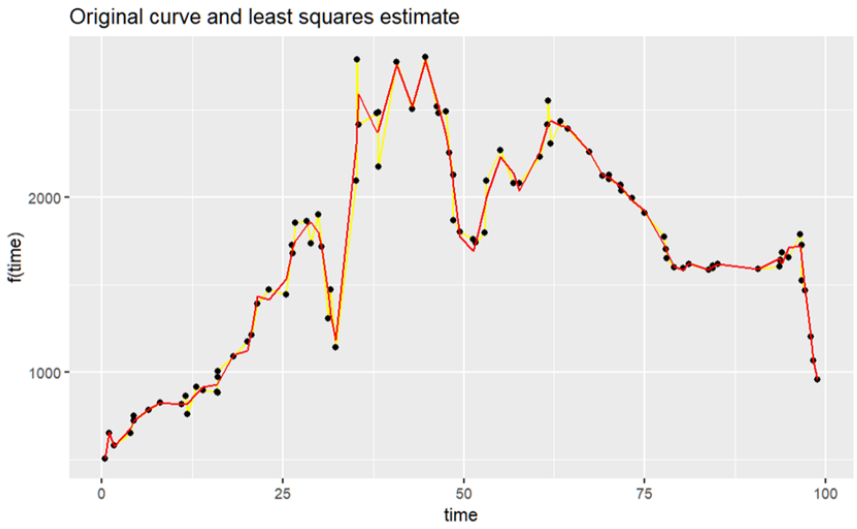

Fig. 10 Original curve and least squares estimate

Using data to plot the points of the data (black dot), the original curve (yellow lines), and least squares estimate (red lines), the result is shown as fig 10.

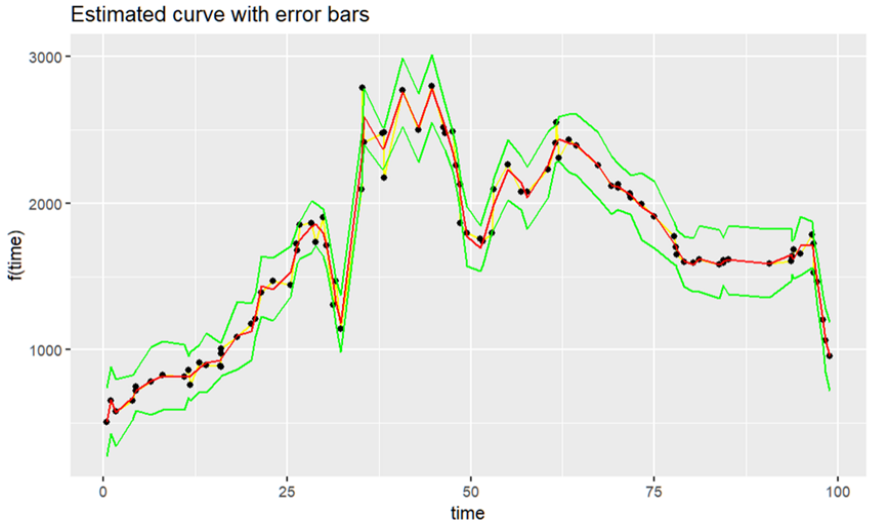

Fig. 11 Estimated curve with error bars

Working through the matrix calculations to estimate the variance of the noise and the error bars for data (fig 11).

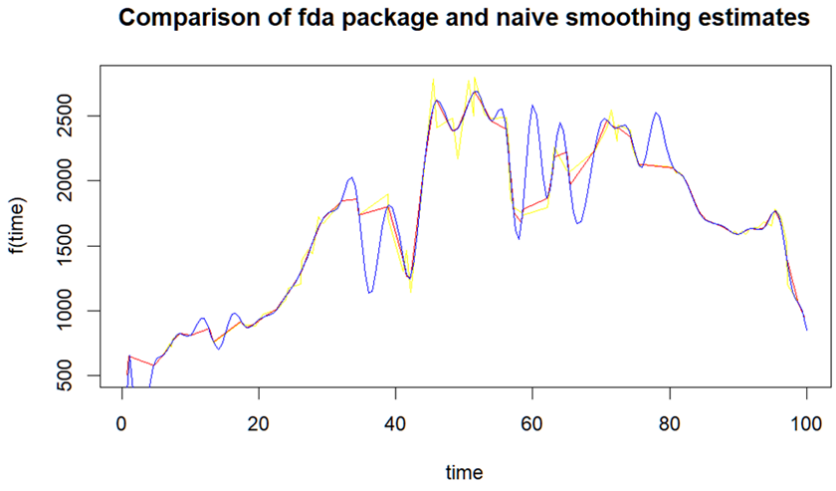

Fig. 12 Naïve smoothing estimate without adjustment

In this step, firstly the smooth.basis() is used to estimate the naïve smoothing estimates. With the original data, it is clear that fig 12 represents a downward trend.

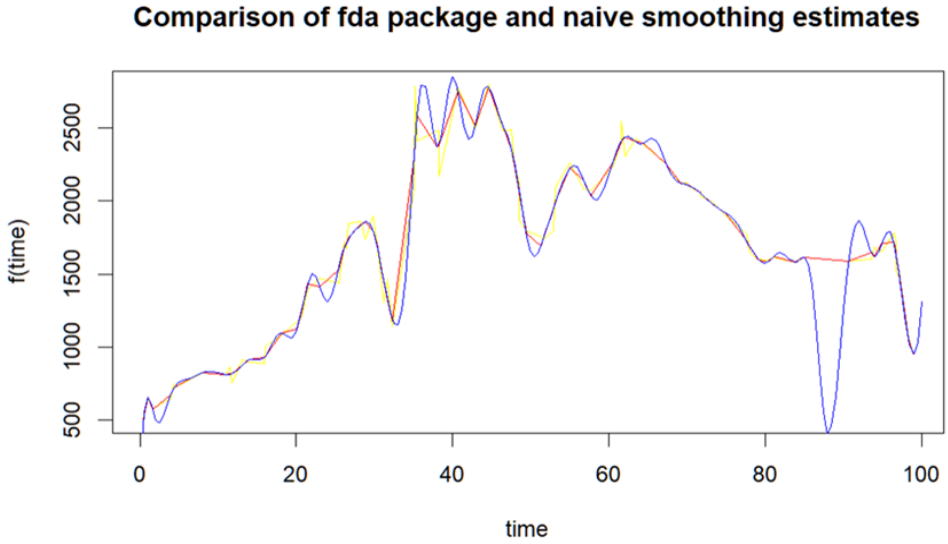

Fig. 13 Naïve smoothing estimate with adjustment

In this step, the parameter in smooth. basis() is changed to adjust the model. With the adjusted data, it is clear that fig 13 represents an upward trend.

To sum up, without any adjustments, the functional data analysis shows a decreasing trend for the newborns in China in the near future. However, if the data is combined with a parameter that is related to the world birth trend, this paper can get a relatively small increasing trend in the near future.

4. Conclusion

From the research, different methods of prediction show different results. In Arima model, it shows that the newborns in China have an increasing trend without any adjustment. Nevertheless, the residual of the Arima model is not white noise, which indicates the raw data is too complex to use Arima model. The models of holt and change point analysis show after the publication of three child policy, the newborns in China have an upward trend. With functional data analysis method, this paper can get that without the adjustment, it still shows a downward trend in the near future. However, after combining the data with a parameter that is related to the world birth trend, a small increasing trend can be gotten in the near future.

This research helps to investigate population development strategies and policy systems, promote long-term balanced population development, scientifically formulate national economic and social development plans, promote high-quality economic development and provide statistical information support.

However, due to different methods have different limitations and the limited data range, this study fails to make a prediction in terms of newborns in China with 100% accuracy. Hopefully in the near future, there will be better models with a wider range of data to make more accurate predictions.

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