Analysis of the impact of the Olympic Games on the economic growth of host countries based on the ARIMA model

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Abstract. The purpose of this paper is to investigate the impact of the Olympic Games on economic growth, with a particular focus on changes in gross domestic product (GDP) in China and the United States. By applying the ARIMA model, the GDP trends of the two countries during the period when they do not host the Olympic Games are predicted. The construction of the ARIMA model involves three core steps when dealing with time series data. First, the collected data are analyzed in depth and reasonable assumptions are made on this basis. Next, in view of the characteristic volatility of time series data, the difference method is used to eliminate non-stationarity and ensure the smoothness of the data series. Finally, by combining the observations with the lagged observations of the moving average model residuals, to ensure that the model can accurately capture the characteristics of the time series data. After completing the model construction, this paper further compares the changes in GDP and tourism indicators of the two countries before and after the Olympic Games. Through the comparative analysis, it is confirmed that hosting the Olympic Games has a positive contribution to the economic growth of the two countries. These conclusions not only provide valuable references for policy makers, but also provide strong support for the economic impact assessment of cities hosting the Olympic Games in the future.

Keywords: Olympic Games, GDP, ARIMA, Tourists.

1. Introduction

The Olympic Games, as one of the most influential sports events in the world, has always received wide attention from governments and people [1]. Hosting the Olympic Games is not only an important demonstration of a country's sporting prowess and international image, but also considered an important driving force for the economic growth of the host country [2]. However, there have been different views and controversies in the academic circle about the impact of hosting the Olympic Games on the economic growth of the host country [3].

In recent years, with the successful hosting of the Olympic Games in several countries and cities, more and more scholars have begun to pay attention to this topic. A study by Ding Huanfeng, Zhu Yuxi, and Sun Xiaozhe (2022) published in the Journal of Shanghai Institute of Physical Education and Sports points out that there are significant differences in the impact of hosting the Olympic Games on the long-term economic development of different host countries. Through a synthetic comparative analysis of the economic data of the host countries of the last five Olympic Games, they found that only the 2008 Beijing Olympic Games provided a long-term boost to economic growth. While other Olympic Games host countries did not perform well in terms of economic growth after the Olympic Games, and even experienced an economic downturn [4]. At the same time, some scholars have also conducted in-depth studies on the economic impact of cities hosting the Olympic Games. Yang Jie and Zhao Wei (2017), in a paper published in National Circulation Economy, argued that the hosting of the Olympic Games has both positive and negative impacts on the city's economy. City governments need to effectively avoid the negative impact factors and expand the positive impacts on the basis of scientific planning, so that the Olympic Games can become an opportunity for urban economic development [5]. In addition, Chen Min's (2013) study published in Neijiang Science and Technology explores the impact of the Olympic Games on local cities using the 2012 London Olympics as an example. He argued that the Olympic Games were an opportunity to develop London's local economy, but at the same time, there were also some disadvantages [6]. Against the background of these studies, Wu Jiongwei's (2009) doctoral dissertation, completed at the Capital

Institute of Physical Education and Sports, provides a comparative analysis of the changing patterns of economic indicators and related industries in the places that hosted the previous five Olympic Games. His study aims to discover the changing patterns of economic indicators and related industries in each host site after the Olympic Games, and to provide empirical insights for Beijing's post-Olympic economic development [7].

In summary, the impact of hosting the Olympic Games on the economic growth of the host country is a complex and diversified topic. This paper aims to synthesize the research results of the previous researchers and further explore the impact mechanism, factors and effects of hosting the Olympic Games on the economic growth of the host countries, with a view to providing useful references and lessons for the future Olympic host countries.

2. Data source

The sources of the data are shown in Table 1.

Table 1. Data source

Database Names	Data Websites	Data Type
National Data	https: //data.stats.gov.cn/easyquery.htm?cn=G0104	Tourism
Knoema	https: //cn.knoema.com/	GDP, Tourism
World Bank	https: //data.worldbank.org.cn/	GDP, GDP growth rate
Human Development Reports	https: //hdr.undp.org/en	HDI
Gapminder	http: //gapm.io/dhapiscore_whr	Happiness Score
UN Data	http://data.un.org/	GDP, Tourism
Statista	https: //www.statista.com/chart/5424/the-massive-costs-behind-the-olympic-games/	The costs behind the Olympic Games

3. ARIMA Model

3.1. Model Building

3.1.1. Model Selection

Since the data selected in this paper are the GDP of each year of the two countries, these data can be understood as a collection of series consisting of discrete numbers obtained at a series of moments, which exactly satisfies the definition of time series, so we consider the collected data as time series. In the discussion for the time series, the construction of the ARIMA model can be roughly divided into three parts. Firstly, the data provided are analyzed and assumptions are made. Secondly, since the type of data targeted by the model is a time series, it is bound to fluctuate. In order to eliminate non-stationarity and make the time series smooth, the method should make a reasonable differential substitution for some values. Finally, the correlations between the observations and the residuals of the moving average model applied to the lagged observations are merged so that the final results are consistent with the specificity of the time series data. Given the soundness of the above theory, we choose to use ARIMA for data forecasting.

3.1.2. Model Establishment

In this paper, we use SPSS software to forecast the GDP of China and the United States respectively. Since the United States hosted the 1996 Summer Olympics in Atlanta, we used GDP from 1991 to 1996 to predict what GDP would have been in the next five years without the 1996 Olympics. Since China will host the Winter Olympic Games in 2022, we collected the GDP value of China from 2017 to 2021 and used ARIMA model to predict the GDP value of China without hosting the Olympic

Games in 2022. Then the predicted value and the real value were compared to get the impact of the Olympic Games on the GDP of the two countries.

The flowchart of model establishment is as follows Figure 1.

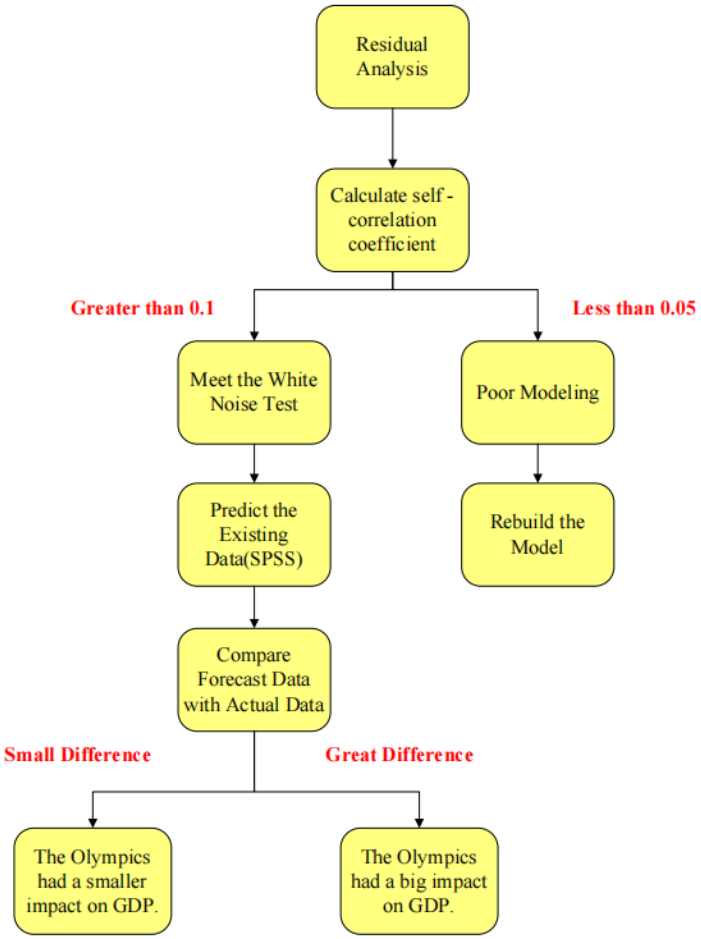

Figure 1. Modeling Flowchart

3.1.3. Model Test

For the collected series, we first perform a model residual test[8]. The residuals are analyzed by the value of the Q statistic (first n order autocorrelation coefficient) denoted as p. If p is greater than 0.1 then the white noise test is satisfied, this indicates the residuals are not correlated and the analysis can continue to the next step[9-10]. Conversely when $p<0.05$ then the model is proven to be poor.

The formula for calculating autocorrelation coefficient:

$$\sum_{i=1}^{n} \frac{(x_i-u)(x_{i+h}-u)}{\sum_{i=1}^{n}(x_i-u)^2} \quad (1)$$

Table 2. Autocorrelation coefficient of U.S. GDP

Autocorrelation Coefficient Q	Statistical Magnitude	Value p
Q1	0.001	0.970
Q2	0.081	0.960
Q3	0.225	0.974
Q4	0.766	0.943
Q5	2.020	0.845

Table 3. Autocorrelation coefficient of China GDP

Autocorrelation Coefficient Q	Statistical Magnitude	Value *p*
Q1	0.002	0.969
Q2	0.772	0.680
Q3	2.396	0.494

As we can see from the Table 2 and 3, the first-order autocorrelation coefficient to the first-6th-order autocorrelation coefficient is greater than 0.1 for the U.S. The first-order autocorrelation coefficient to the first-3rd-order autocorrelation coefficient is also greater than 0.1 for China. both of them pass the white noise test, which proves the feasibility of using ARIMA method to forecast the data.

3.2. Reasonability Verification

3.2.1. From the perspective of GDP

Based on the established model and the available historical data, the changes in GDP of China and the United States in the absence of the Olympic Games are predicted separately . And we will compare it with the changes in GDP of China and the United States in the factual scenario of hosting the Games to validate the reasonability of our proposal.

In the absence of the Olympics, the GDP of the United States showed a trend of growth followed by a steady decline. During the period when the Olympics were held, the GDP of the United States continued to grow and exceeded the projected figures in 1998, as shown in Figure 2 below. It can therefore be deduced that the Olympic Games did contribute to the growth of the GDP of the United States, which shows that the hosting of the Olympic Games has brought about a positive impact on the United States.

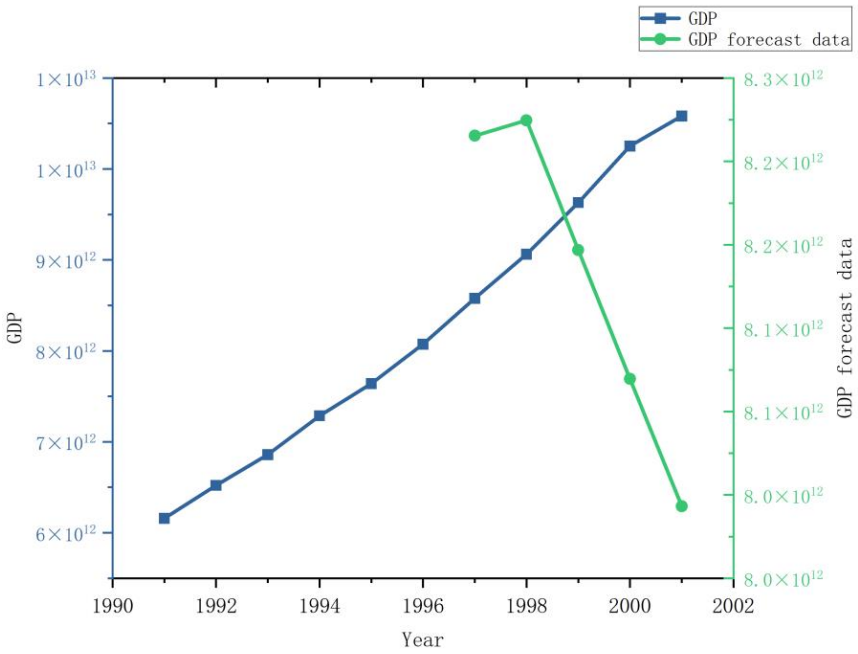

Figure 2. U.S. GDP trends and forecasts between years

In both cases, China's GDP continues to grow. While China's GDP projections for 2018-2020 were higher than the actual figures, the actual figures for 2020 happened to jump and directly exceed the projections, as shown in Figure 3 below, again illustrating the positive impact of hosting the Olympics on China.

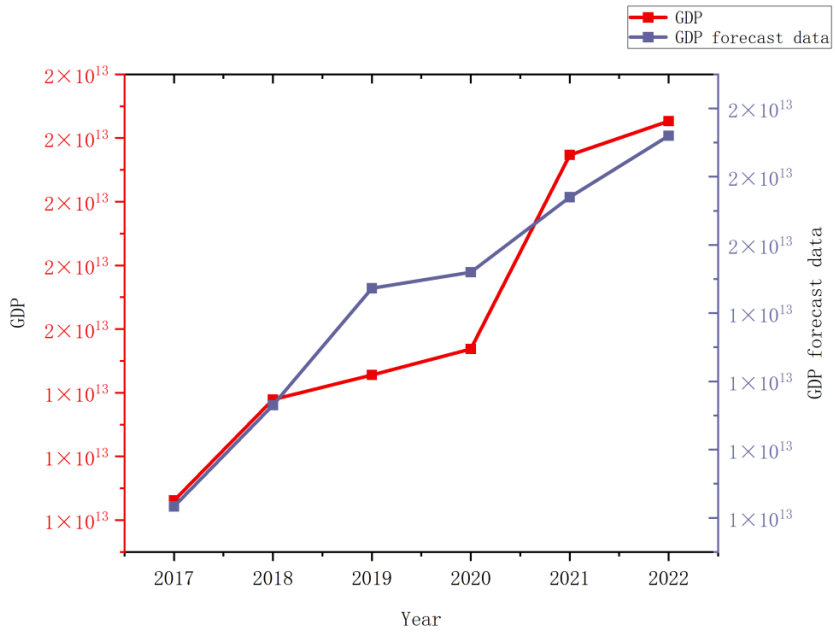

Figure 3. Trends in China's GDP between years and projections

3.2.2. From the perspective of tourism

Due to the volatility of U.S. tourism data, it will be discussed only from the perspective of factual data. As we can see from Figure 4, both the number of tourists and international tourism receipts show a two-round trend of increasing and then decreasing. The number of tourists peaked during the 1996 Olympics, while international tourism receipts generally showed a fluctuating upward trend, indicating that the Olympics were successful in boosting the local tourism industry in a short period of time.

Because of the absence of tourism data for China in 2019-2022, combining with the huge impact of the epidemic on tourism in recent years, the changes in China's tourism industry are not analyzed in this paper.

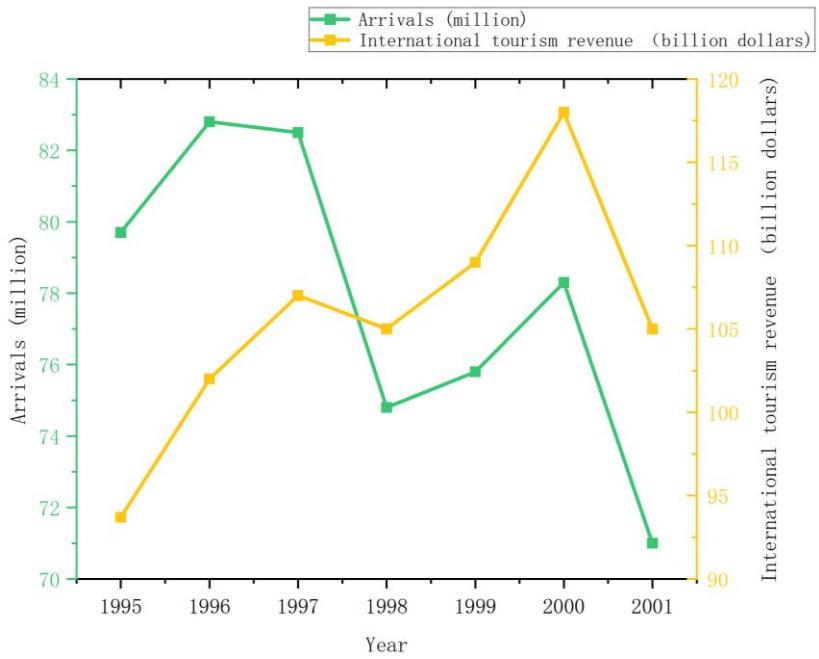

Figure 4. China Inter-annual trends and forecasts of tourist arrivals

3.2.3. From the perspective of Overall

When considering in general, we can equally justify the choice of the United States and China as

permanent host cities. In terms of economic, as the world's first and second largest economies, they are strong enough to bear the pressure of the initial investment. In terms of event hosting, both the U.S. and China have successfully hosted the Summer and Winter Olympic Games and are experienced in hosting events. In terms of international status, the United States, as the world's only superpower, and China, as the largest developing country, as well as their status as permanent members of the United Nations, have strong international influence and appeal which can effectively ensure the holding of the Olympic Games. In terms of carrying capacity, the two countries have a large land area and strong environmental carrying capacity, which can effectively accommodate the continuous influx of many tourists. Also they can directly utilize existing venues and resources. For one thing, it saves the huge expenses of building the venue to achieve cost saving; for another thing, it can reduce the damage to the natural environment. Both will jointly promote the sustainable development of the Olympic Games.

4. Conclusion

Based on an analysis of the GDP and tourism indicators of the United States and China before and after the Olympic Games, this paper finds that the economic growth of the United States showed a significant upward trend during the Olympic Games, and that the real GDP exceeded the predicted values. This indicates that the Olympics made a positive contribution to the economic growth of the United States, further proving that hosting the Olympics had a positive impact on the United States. Secondly, China's GDP has also continued to grow over the forecast period, with real GDP in 2020 exceeding the forecast despite being slightly lower than the forecast for 2018-2020. Again, this proves the positive impact of the Olympics on China's economic growth. However, due to the volatility of U.S. tourism data, this paper can only analyze the actual data. The results show that the tourism industry in the United States experienced an increasing and then decreasing trend during the Olympics, but overall, the Olympics succeeded in boosting the local tourism industry in a short period of time. On the other hand, due to the lack of data on China's tourism from 2019-2022 and the great impact of the epidemic on tourism in recent years, this paper does not analyze the changes in China's tourism in depth.

In summary, the Olympic Games not only positively impacted the economic growth of the United States, but also promoted the economic growth of China. In terms of tourism, the Olympics boosted local tourism to a certain extent despite data limitations and the impact of the epidemic. These findings provide valuable reference information for policymakers and future Olympic host cities.

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