Analysis and Prediction of the Real Economic Health of the Country based on ARIMA Model

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Abstract

The study used an ARIMA model to forecast China's GDP and GGDP, employing 7 consecutive years of data as the training set, using the next 3 years of data as the test set, and using a 2-year step for rolling forecasts. The results of the study show that the correlation coefficient of the ARIMA model is close to 1, indicating that the model fits well. In forecasting China's GDP and GGDP for the next 10 years, the study introduced the GGDP indicator and analyzed its impact on the relationship between the country's economic growth and the natural environment. a higher value of the GGDP indicator implies that the country's economic growth has a lower negative impact on the natural environment, i.e., economic growth is more harmonious with the natural environment. This further validates the advantage of GGDP as an alternative GDP indicator. By comparing and analyzing the prediction results of GDP and GGDP indicators, the study finds that GGDP indicator has stronger explanatory power in assessing the relationship between economic growth and environmental impact. as a comprehensive economic assessment indicator, GGDP not only takes into account the factors of economic growth, but also environmental factors, which can reflect the relationship between national economic growth and environmental protection more comprehensively. This helps to provide more scientific and comprehensive economic decision-making and environmental management solutions, and promote sustainable development and ecological civilization.

Keywords

Economic Health; ARIMA Model; GDP; GGDP.

1. Introduction

The greening of GGDP evaluation indicators and the System of Environmental-Economic Accounting (SEEA) is a hot topic in ecological and economic research[1]. GGDP encourages a low-carbon economy and energy conservation, dramatically reducing CO_2 emissions, helping protect the earth's ecology, and mitigating the effects of global climate change.

As a comprehensive indicator, GGDP takes into account not only traditional economic growth factors, but also environmental factors. By encouraging a low-carbon economy and energy conservation and emission reduction, GGDP can drive the transformation and upgrading of industrial structure and prompt enterprises to adopt more environmentally friendly and sustainable production methods, thus significantly reducing greenhouse gas emissions such as carbon dioxide. This helps to protect the

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earth's ecological environment and mitigate the impact of global climate change on human society and natural ecosystems.

In addition, the introduction of GGDP can prompt countries and regions to pay more attention to ecological civilization and sustainable development, and to strengthen policies and measures for ecological environmental protection and resource conservation and utilization. Through the implementation of economic instruments such as environmental taxation and carbon emissions trading, enterprises and individuals can be pushed to pay more attention to environmental protection in their economic activities and reduce the over-exploitation of natural resources and environmental pollution. This helps to build a green economic model, promote sustainable economic growth, and lay a more solid foundation for future economic development.

Overall, GGDP, as a comprehensive economic assessment indicator, has the potential to promote a low-carbon economy and environmental protection. By introducing GGDP and applying it in policy and practice, we can promote the harmonious development of economy and environment and achieve a win-win situation of economic growth and environmental protection.

Considering the background information and restricted conditions identified in the problem statement, we need to solve the following problems:

- **Problem 1:** Determine whether your model shows that the global transition from GDP to GGDP is worthwhile, and compare the potential benefits of mitigating the impact of climate change with the potential disadvantages of efforts to change the status.
- **Problem 2:** This problem asks for an in-depth analysis of how a shift from GDP to Gross Global. GGDP might impact a chosen country.

Our work is shown in Figure 1.

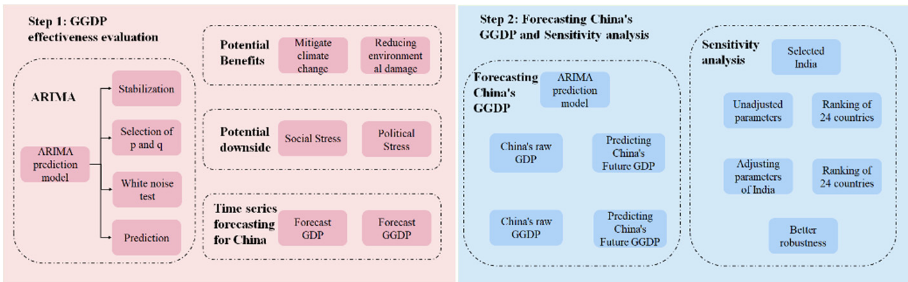

Figure 1. Flow chart of our work

2. Notations

The necessary mathematical notations used in this paper are listed in Table 1.

Table 1. Notations used in this paper

Symbol	Description
σ_j	The standard deviation of the index
$\widetilde{x}_i$	Forward index data
p	Number of steps
q	Number of moving average terms
d	Differential times

3. GGDP Validity Assessment

There may be resistance to using GGDP as the primary measure of a nation's economic health because it requires governments and businesses to reduce their environmental impact [2]. However, if we do

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not take action to mitigate climate change, its negative impacts on the global economy and society could be even more severe. Studies show that the extreme negative GPP of northern mid-latitude ecosystems increased by 10.6% between 2000 and 2016 compared to 1982-1998. This is mainly due to the impact of climate warming and drying, especially in areas such as northern temperate grasslands and farmlands around the growing season, where the impact is significant. Thus, a warm-dry climate has a greater impact on ecosystem productivity, and the negative impact of climate extremes on terrestrial carbon sinks is increasing, which will pose a significant threat to the globally sustainable development level [3][4]. The following figure reflects the impact of climate change on global temperature and sea level.

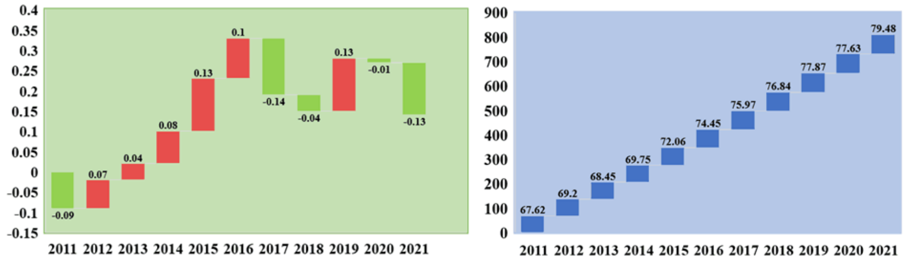

Figure 2. Global average temperature change and global sea level rise change graph

As can be seen from the graph, the global average temperature from 2011-2021 is on an overall increasing trend, while the global sea level is steadily rising. It is not difficult to predict that global climate change will harm human production and life, which warns that countries should focus on sustainable development while developing their economies.

3.1 Autoregressive Integrated Moving Average Model

To demonstrate that GGDP is a better measure of a country's actual economic health than GDP. We make forecasts using autoregressive integer moving averages (ARIMA), a statistical analysis model that uses time-series data to predict future trends. The basic idea of ARIMA is that over time, the data series formed by the forecast is considered a random series, and a model can be used to approximate the series. Once this sequence is determined, the model can predict future values based on the past and present values of the time series. The ARIMA algorithm flow is shown in the following figure.

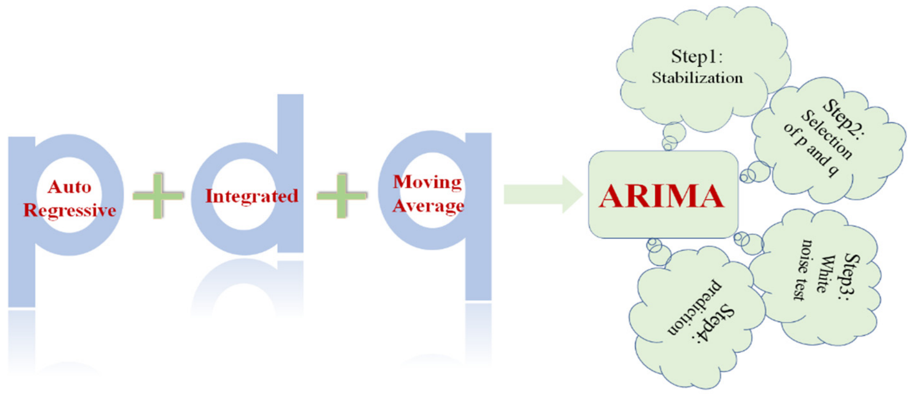

Figure 3. Flow chart of ARIMA

The ARIMA model consists of an autoregressive (AR) model and a moving average (MA) model. the AR model describes the relationship between current and lag values and predicts future values using historical data. The autoregressive model must satisfy the requirement of smoothness. The MA model uses a linear combination of past residual terms to observe future residuals.

The following equation gives the p-order autoregressive process.

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$$y_t = \mu + \sum_{i=1}^{p} r_i y_{t-i} + \varepsilon_t \tag{1}$$

Among y_t is the current value, μ is a constant term, p is the order, y_i is the autocorrelation coefficient, ε_t is the error.

The moving average model is concerned with the accumulation of error terms in the autoregressive model; the moving average method is effective in eliminating random fluctuations in forecasts; the equation defining the q-order autoregressive process:

$$y_t = \mu + \varepsilon_t + \sum_{i=1}^{q} \Theta_i \varepsilon_{t-i} \tag{2}$$

q is the number of moving average terms, Θ_i is the autocorrelation coefficient, ε_{t-i} is the error time of time t and $t-i$, and is the white noise process of variance.

The autoregressive moving average model can be written as the following equation.

$$y_t = \mu + \sum_{i=1}^{p} r_i y_{t-i} + \varepsilon_t + \sum_{i=1}^{q} \Theta_i \varepsilon_{t-i} \tag{3}$$

The model is established by transforming the data into static data through difference, then regressing the dependent variable only its lag value and the random error term's present value and lag value. AR is an autoregressive term; MA is the moving average, and p is an autoregressive term. q is a moving average item, and d is the number of differences made when the time series becomes stationary.

✧ Select p and q

ACF (autocorrelation function) and PACF (partial correlation function) evaluate the linear relationship between historical data and current values. The formula for ACF is.

$$ACF(q) = \frac{Cov(X_j, X_{j-q})}{Var(X_0)} = \frac{\frac{1}{n-q}\Sigma_{j=q+1}^{n}(x_j - \overline{x})(x_{j-q} - \overline{x})}{\frac{1}{n}\Sigma_{j=1}^{n}(x_j - \overline{x})^2} \tag{4}$$

The formula for PACF is very complex, so we will not list it in this paper.

✧ Q-test:

If the residuals are white noise, the model can identify the pattern of the time series data, i.e., the model is acceptable, and we should use the Ljung-Box Q test. The formula is as follows.

$$Q(q) = n(n+2) \sum_{j=1}^{q} \frac{A\tilde{C}F(j)}{n-i} \tag{5}$$

Step 1 Stabilization test

To use the ARIMA model, the time series must be stationary. We use the Augmented Dickey fuller unit root test to test for smoothness. The time series is stable if the ADF test yields a p-value less than 0.05. If it is unstable, we transform the non-stationary process into stationary using the difference method. As can be seen in Table 2, the time series becomes stable after first-order differencing.

Step 2 Select p and q

The autocorrelation function (ACF) and partial autocorrelation function (PACF) are used to determine the values of p and q. The confirmation method is shown in the table below.

Step 3 White noise test

If white noise is obtained, the valuable information in the time series has been extracted, and the rest are random disturbances that cannot be predicted and used. If the residual series pass the white noise test, the modeling can be terminated because there is no information to continue extracting. We test

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whether the Q-test fully identifies the model. the ARIMA model for GGDP is ARIMA(2,1,1), while the ARIMA model for GDP is ARIMA(2,1,2). The output of the white noise test for this model is white noise with p>0.05.

Table 2. Confirmation method of p-value and q value

Model	ACF	PACF
$AR(p)$	attenuation tends to 0	truncation after p-order
$MA(q)$	truncation after q-order	attenuation tends to 0
$ARMA(p,q)$	attenuation tends to 0 after q-order	Attenuation tends to 0 after p-order

Step 4 Projections

In order to predict future markets accurately and promptly, we use 7 consecutive years of data as the training set and the next 3 years as the test set. The moving step of the training set is 2. The prediction results for one cycle are shown below. The correlation coefficient R^2 for GGDP is 0.8592, and for GDP is 0.9304. the prediction results of the model are relatively prosperous and can be used.

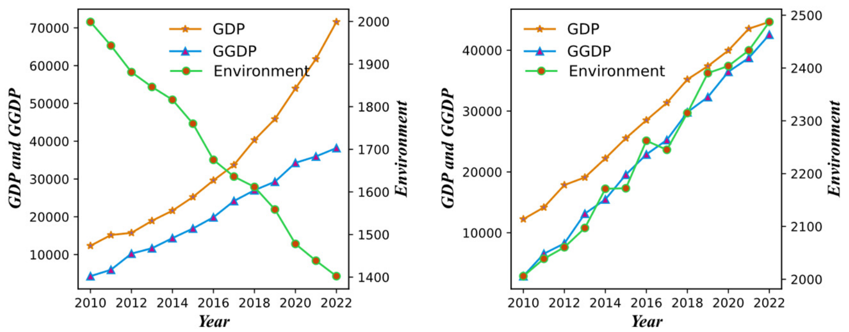

Figure 4. GDP and GGDP growth pattern diagram

As shown in the figure above, the GDP growth model is shown on the left, and the GGDP growth model is shown on the right. The comparison shows that in the GDP growth model, GDP growth is faster, GGDP growth is slower, and the environmental condition is gradually worse; in the GGDP growth model, GDP growth is slower than before, GGDP is steadily growing, and the environmental condition is gradually improving.

Overall, using GGDP as the primary measure of a country's economic health is worthwhile because it helps promote sustainable development and mitigate climate change. Although it requires long-term cooperation and efforts from governments, enterprises, and individuals, it can bring longer-term economic and environmental benefits. GGDP not only absorbs the advantages of traditional GDP accounting but also incorporates natural resources and the ecological environment, unifying economic growth with resources and environment and reflecting the sustainable development of economic growth in an integrated manner.

3.2 Potential Benefits and Downsides

Potential benefits include climate change mitigation and reduced environmental damage, which will help protect natural resources and ecosystems and improve global health and well-being. In addition, using GGDP can promote sustainable economic growth and facilitate technological innovation and industrial upgrading.

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Potential downsides include the additional effort and cost required to convert to GGDP, which would require changes to current measurement and assessment methods. In addition, social and political pressures may arise as some countries may face difficulties in making the green transition.

Climate change has less impact on developed countries and more on developing countries, which are more dependent on environmental resources than developed countries, especially for developing countries that survive and develop by destroying the environment. The environmental vulnerability of the economic development of these countries is also higher. Most developing countries are highly dependent on a stable climate environment due to the low level of industrial development and even near-zero industrial activities in some countries.

4. Economic Health in China

4.1 GDP and GGDP Forecasts

Based on the ARIMA forecasting model, we choose China as a representative. We forecast China's GDP and GGDP in the next decade starting from 2023 and show their original and forecast values of GDP and GGDP in the figure below.

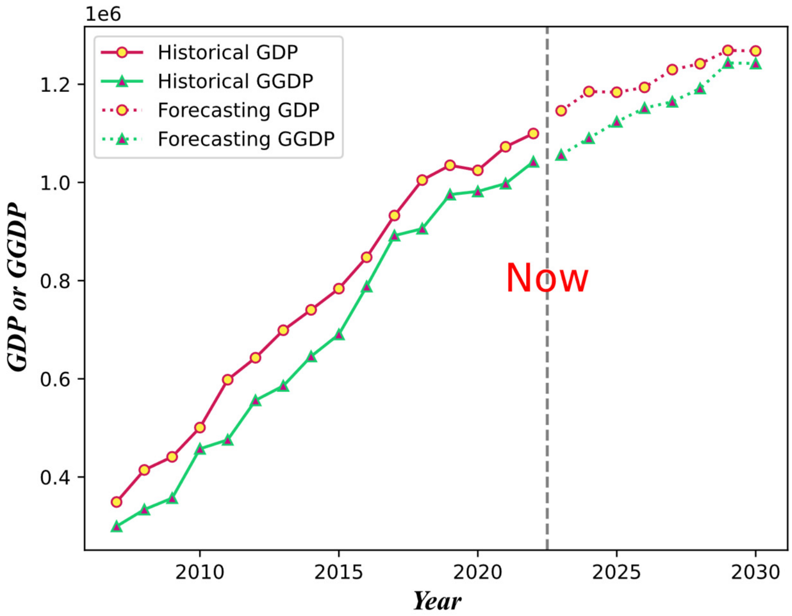

Figure 5. China's GDP and GGDP Forecast Chart

From the figure, it can be seen that the GGDP and GDP of China are predicted to show an increasing trend year by year in the next ten years. The more the values of GGDP and GDP converge as the years grow, the higher the ratio of GGDP to GDP is, and the figure shows that it is worthwhile to use GGDP instead of GDP as a measure of China's economic health.

4.2 GGDP Index

Green GDP and traditional GDP values can be calculated as the Green GDP Index, and this paper uses the Green GDP Index to indicate the higher the positive effect and the lower the negative effect of the national economic growth of that country. The formula calculates the green GDP index.

$$GGDP\ \ \text{index} = GGDP/(GDP \times 100) \tag{6}$$

The predicted results in Figure 10 show that after adopting the GGDP indicator, the green GDP index is getting higher, which indicates the lower the negative effect of national economic growth on nature and the higher the harmony between economic growth and the natural environment. Therefore, GGDP is beneficial for the country's development after replacing GDP.

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When from now (under the current GDP) to the adoption of GGDP, this paper considers the current economic situation and the ability to provide for future generations in this particular country by comparing the future GDP per capita with the GDP per capita of all developing countries, and thus concludes that the economic strength of this country to provide for future generations after the adoption of GGDP is beneficial for the development of the country. As shown in Figure 6.

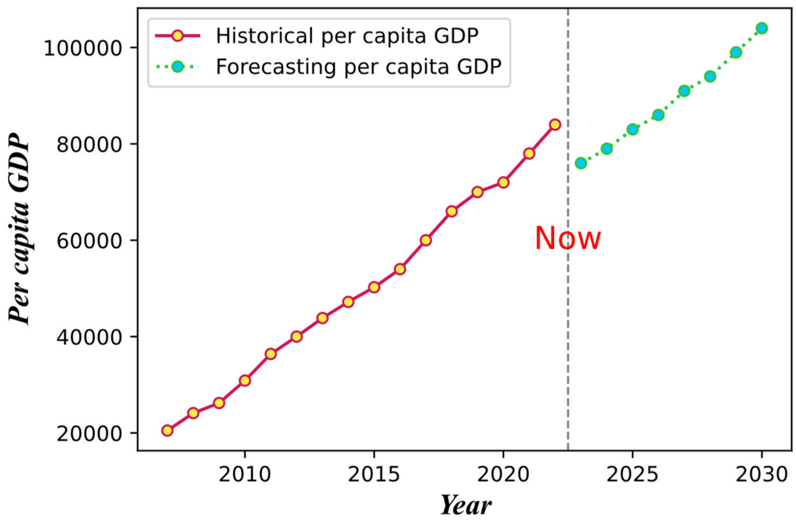

Figure 6. GDP per capita projection chart

4.3 Specific Changes

Any country's transition from GDP to GGDP will significantly impact how they use or conserve natural resources, and we list three specific changes.

■Increase investment in environmental protection, provide more high-quality ecological products through supply-side structural reform and vigorously develop energy conservation and environmental protection projects.

■Pay more attention to R&D and innovation of energy-saving and environment-related technologies to reduce pollutant emissions and save resources, thus enhancing eco-economic efficiency.

■Strictly control environmental pollution and actively promote the transformation of the crude economic growth model to an intensive model with high utilization, high efficiency, low consumption, and low emissions.

5. Model Evaluation

5.1 Strengths

● We have fully visualized the algorithm and data results of the model and compared the effects of GGDP on global climate change more intuitively and clearly.

● ARIMA model only needs endogenous variables and does not need other exogenous variables.

● The data selection is very characteristic in this paper, the year interval of data selection is five years and two years. The data selected in this way is more representative and convincing.

5.2 Weaknesses

● There is no uniform definition of GGDP across countries, and in this paper, we assume that the definition of GGDP is consistent across countries, which will also lead to a small error in our model solving.

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6. Conclusion

With the rapid development of social economy, countries began to regard environmental sustainability as one of the most challenging issues, and began to seek appropriate measures for sustainable economic development. GGDP encourages low-carbon economy, energy conservation and emission reduction, which greatly reduces carbon dioxide emissions, helps to protect the ecological environment of the earth and slow down the impact of global climate change.

The GDP and GGDP are predicted by ARIMA algorithm. The prediction results show that GGDP grows slowly in the GDP growth mode and the environmental conditions are getting worse. In the GGDP growth model, GDP growth is slower than before, GGDP is growing steadily, and the environmental conditions are gradually improving. This fully shows that it is worthwhile for GGDP to replace GDP to measure a country's real economic health.

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