

The Impact of the "Belt and Road" Initiative on the Trade of the Countries Along the Route and the Role of China

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Abstract. Since the launch of the BRI (BRI) in 2013, it has become a key platform for promoting economic cooperation among participating countries. Drawing on the BRI Aviation Trade Index, Maritime Silk Road Trade Index, and various related economic indicators, this paper employs the ARIMA (Auto-Regressive Integrated Moving Average) model and a multi-dimensional comprehensive evaluation model to systematically assess trade and economic growth in BRI countries. The analysis shows that, since the initiative's implementation, trade volumes and gross domestic product (GDP) in these countries have generally been on the rise, with countries maintaining close economic ties with China showing particularly strong performance. Through comprehensive evaluation, the paper further examines the BRI's impact on industrial restructuring, investment flows, and national income, while also identifying the challenges it faces in promoting regional economic development. In response to these challenges, the paper proposes a set of policy recommendations to provide guidance for future international cooperation.

Keywords: The "Belt and Road", Pandas Library, Time Series Analysis (ARIMA) Models

1. Introduction

The BRI (BRI) aims to foster cooperation in various fields, including infrastructure, energy, science and technology, and culture, with the goal of establishing an economic corridor spanning Asia, Europe, Africa, and parts of Oceania. This initiative has not only facilitated trade and investment flows between China and the countries along the BRI route but also promoted the integration of the regional digital economy.

In today's world, the development of information technology has become a key factor in measuring the growth of trade across countries. According to a report by the International Telecommunication Union (ITU), approximately 2.6 billion people worldwide lack access to the internet, with around 63% of the population in African countries along the BRI route remaining unconnected [1]. This highlights the challenges posed by digital economy development for the BRI. Scholars studying the integration of digital technology [2] and digital innovation [3] into the BRI in participating countries [4] have found that the digital economy provides significant economic benefits. Many researchers have focused on analyzing the impact of the BRI from various perspectives, such as the political environment [5], environmental governance [6], institutional development [7], the digital economy [8], transportation infrastructure [9], and general infrastructure development [10]. These studies suggest that the BRI has significantly boosted the economic growth rates of countries along the route by promoting infrastructure investment and trade liberalization. While the initiative is widely recognized for advancing China's global role, less attention has been given to its "inward" investment effects.

As the BRI continues to progress, the impact of China's outward direct investment has been extensively discussed. However, there is still a lack of comprehensive understanding regarding how the BRI influences China's "inward" direct investment. This gap limits the ability to provide effective guidance for the BRI's implementation, particularly in terms of benefiting the countries along the route and establishing a new, sustainable model for outward economic engagement. Therefore, the purpose of this paper is to assess the BRI's impact on trade trends and economic contributions in the

countries along the route through comprehensive data analysis, and to explore the initiative's actual economic effects by employing multi-dimensional modeling analysis.

2. The basic fundamental of ARIMA models

2.1. Analysis of the impact of the initiative on selected industry sectors.

Li studied the impact of the BRI on transportation investment in China and ASEAN countries using a double-difference model [11], and the results showed that the BRI significantly promoted China's transportation investment in ASEAN countries. Henglong used a progressive double-difference model to analyze the impact of offshore ETZs on the economic growth of host countries [12], showing that the establishment of offshore ETZs significantly promotes the economic development of host countries. Wang analyzed the impact of the BRI on the economies [13] of ASEAN countries through GM (1, 1) and FOA-SVR models, focusing on the performance of the shipping industry. These scholars' modeling studies stop at the ASEAN countries and lack the analysis of the economic impact on other countries.

2.2. Analysis of the impact of the initiative on selected industry sectors.

Majid [14] developed a gravity model to find the potential impact of China's BRI on its agricultural exports and the determinants of agricultural exports. On this basis, Zhao quantified the impact of the BRI on global agricultural trade based on the gravity model and the GEPPML method [15]. Ye used the propensity score matching-double difference (PSM-DID) methodology on the impact of the proposed initiative on the construction industry (AEC) to explore overseas markets [16]. The model adopted by these scholars is not wide enough to be applicable and needs to be further extended to other industry sectors.

2.3. A study of the impact of initiatives on technological innovation.

Fengge used the Spatial Durbin Model (SDM) to reveal the impact of initiatives on industrial structure upgrading [17]. Huang adopts a comprehensive approach combining social network analysis and coupling coordination model [18], and uses QAP regression analysis the degree of coupling coordination. LUN uses the DID model to test the impact of the BRI on green technology innovation [19]. The study finds that the BRI has a more pronounced improvement effect on green technology innovation.

In summary, most scholars are accustomed to adopting the double-difference model to study the impact of the BRI. Based on the research results of the previous scholars, this paper further extends the systematic analysis of the trade and economic impacts of the initiative, especially through the time-series analysis and multidimensional comprehensive evaluation model, and explores in detail the specific manifestations of the economic and industrial changes in each country.

3. Models

3.1. Time series analysis (ARIMA) models

The time series analysis model is a method used to forecast and analyze the trends and periodicity of economic phenomena over time. The diagram of the model is shown in Figure 1. By processing historical data, the ARIMA model can help researchers understand the trend of economic variables and thus make predictions for the future. In this paper, the ARIMA model is used to analyze the trends of trade volume, gross domestic product (GDP) and exports to China of the countries along the BRI since the initiative was proposed.

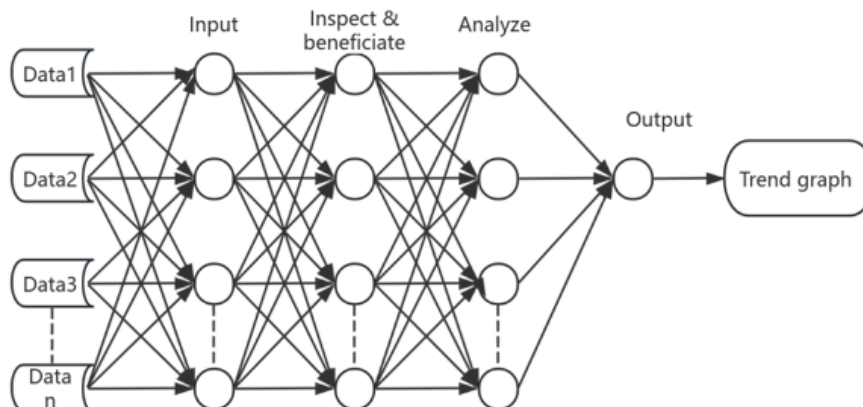


Figure 1. Diagram of the model analysis idea.

The ARIMA model requires the series to satisfy smoothness, and the future values of the series are expressed as a linear function of the current and lagged periods of the lagged and random disturbance terms. In this paper, the data are differenced to eliminate non-stationarity and the order of the model is determined by autocorrelation function (ACF) and partial autocorrelation function (PACF). The results of the ADF test were viewed to analyze whether the hypothesis that the series is not stationary can be rejected significantly ($p < 0.05$) based on the analyzed t-value. The general form of the model is shown in the following equation:

$$Y_t = C + \alpha_1 Y_{t-1} + \dots + \alpha_p Y_{t-p} + \epsilon_t + \beta_1 \epsilon_{t-1} + \dots + \beta_q \epsilon_{t-q} \quad (1)$$

Y_t represents the current value of the time series, ϵ_t is the random error term, and α and β are the parameters of autoregression and moving average, respectively. This model can analyze the long-term trend impact of the "Belt and Road" initiative on the countries along the route, especially the growth trend of trade volume and GDP.

3.2. Multi-dimensional comprehensive evaluation model

In addition to using the ARIMA model to forecast trade trends, this paper also constructs a multi-dimensional comprehensive evaluation model, which comprehensively considers the impact of multiple economic indicators on the economic growth of countries along the route. The evaluation dimensions include trade growth, national income, foreign direct investment, industrial structure and so on. The specific steps are as follows: first, relevant data are extracted from the data sources such as "Belt and Road" aviation trade index and maritime Silk Road trade index, covering the GDP, exports to China and foreign direct investment of the countries along the route. Then, the economic growth is scored according to different evaluation dimensions. Through the weighted average method, the impacts of the dimensions are combined to arrive at the overall economic impact of the BRI on the countries along the route. In the specific implementation, the model first evaluates the trade growth of each country. Then, the model examines the changes in the three major industries in each country, including services, industry and agriculture. Finally, the changes in foreign capital inflows and national income are combined to produce a comprehensive evaluation.

4. Data and experiments

4.1. Data Sources

The data of this paper mainly come from China Belt and Road Network (<https://www.yidaiyilu.gov.cn/>) and China Economic and Social Big Data Research Platform (<https://data.cnki.net/>). The data are mainly the "Belt and Road" aviation trade index, the maritime Silk Road trade index, and the relevant economic data of the countries along the route. These data cover trade, investment and economic growth indicators of countries along the BRI for the 10-year period from 2013 to 2023.

4.2. Data Preprocessing

To ensure the accuracy of data analysis, this paper cleaned and pre-processed the data before analysis. Firstly, the integrity of the data was checked using Excel and duplicates and invalid data were removed. Then, the Pandas library was used to load the data, and the missing values and outliers were processed. In order to improve the accuracy of the model, this paper also standardized some of the variables to eliminate the effect of unit differences on the analysis results.

4.3. Experimental design and steps

In this paper, a time series analysis of the trade volume and GDP of the countries along the route was carried out to assess the trend of change after the "Belt and Road" initiative was proposed. The ARIMA model was used to model and forecast the data from 2013 to 2023, and the growth trend of trade volume and GDP of each country was obtained. By constructing a multidimensional evaluation model, the performance of different countries in the three major industries (services, industry, and agriculture), as well as the changes in foreign investment and national income, were analyzed.

Table 1. ADF test chart.

variability	difference in order	t	P	AIC	critical value		
					1%	5%	10%
Belt and Road Trade Volume Index (BRTI)	0	-1.264	0.645	571.014	-3.516	-2.899	-2.587
	1	-9.024	0.000***	563.374	-3.516	-2.899	-2.587
	2	-5.639	0.000***	560.571	-3.529	-2.904	-2.59

In the first step, the ARIMA model requires the series to meet the smoothness, check the ADF test results, according to analyze the t-value, analyze whether it can significantly reject the hypothesis that the series is not smooth ($P < 0.05$). From the Table.1, the “Belt and Road Trade Volume Index” after the 0th, 1st and 2nd order differencing ADF test results. View the data comparison plot before and after differencing to determine whether it is smooth (not much fluctuation up and down), and at the same time, bias (autocorrelation analysis) is performed on the time series, and its p and q values are estimated based on the truncation. The partial autocorrelation (PACF) plot drags the tail, and the ARMA model can be simplified to a MA (q) model. The partial autocorrelation (PACF) plot is truncated at order p, the autocorrelation (ACF) plot trails, and the ARMA model reduces to the AR (P) model.

Table 2. ARIMA model (0, 1, 1) test sheet.

term	mark	value
Sample size	Df Residuals	79
	N	82
Q-Statistic	Q6(P-value)	0.37(0.543)
	Q12(P-value)	2.449(0.874)
	Q18(P-value)	14.576(0.265)
	Q24(P-value)	16.859(0.533)
	Q30(P-value)	42.354(0.012**)
Information criterion	AIC	657.208
	BIC	664.392
Goodness of fit	R ²	0.854

In the second step, the model test table (as shown in Table.2) was viewed and from the data provided in the analytical (ARIMA) model test table, the ARIMA model was set to ARIMA (0, 1, 1) indicating that the model did not contain an autoregressive term ($p=0$), was treated with first-order differencing to achieve smoothing ($d=1$), and contained a moving average term ($q=1$). The results show that the P-value of the Q-statistic is greater than the significance level (0.05) at lags 6, 12, 18 and order, indicating that the residual series do not have significant autocorrelation at these lagged orders. The goodness of fit metric, R², is 0.854, indicating that the model explains 85 of the variability

in the data. This is a fair indication that the model is able to model most of the variability in the data relatively well.

The third step, ARIMA model requires the model to have pure stochasticity, that is, the model residuals are white noise, view the model test table (as shown in Table.3), according to the P-value of the Q-statistic ($P > 0.05$) to test the model white noise, resulting in the model formula combined with the time-series analysis of the chart for a comprehensive analysis, to obtain the results of the order of the backward prediction.

Table 3. Model Tests.

	modulus	standard deviation	t	P> t	0.025	0.975
Intercept	1.042	0.708	1.473	0.141	-0.344	2.429
ma.L1	-0.627	0.093	-6.723	0	-0.81	-0.444
sigma2	180.471	28.496	6.333	0	124.619	236.322

From the data provided, the key coefficients and their statistical test indicators are central to the analysis. The constant term (Intercept) has an estimated value of 1.042, suggesting that the constant term may not be a major influencing factor in the model, but that its presence still contributes to the model's integrity. For the moving average term (ma.L1), this indicates that the random error in the previous period has a significant effect on the current value and the direction of the effect is negative. The constant term, on the other hand, does not reach the traditional level of significance, but its presence is of practical significance in certain application scenarios, especially in explaining the long-term trend of the time series.

In summary, the system automatically finds the optimal parameters based on the AIC information criterion, and the model results in the ARIMA model (0, 1, and 1) test table with the following model equation:

$$Y_t = 1.042 - 0.627 * \epsilon_{t-1} \tag{2}$$

5. Results

5.1. Trade trends and economic contributions

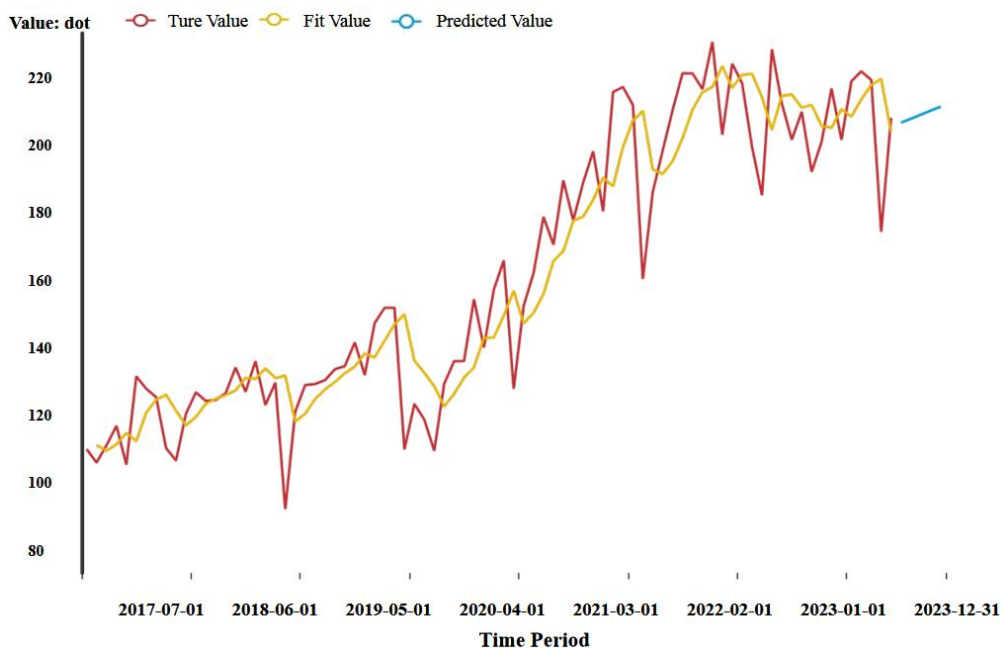


Figure 2. Time series.

The time series analysis of ARIMA model as Figure 2 shows that the model's goodness of fit R^2 is 0.854, and the model is excellent. Since the "Belt and Road" initiative was put forward, the trade

volume and GDP of most countries along the route have shown a significant upward trend. In particular, countries that have maintained stable trade relations with China, such as Uzbekistan, Kazakhstan and Russia, have shown particularly outstanding economic growth. The paper also finds that trade volume in Southeast Asia is growing more rapidly, especially in Vietnam and Malaysia, whose exports have shown steady growth after the implementation of the BRI. The forecasts for the next five years are 196.82, 197.86, 198.91, 199.95 and 200.99 respectively.

5.2. Comprehensive multidimensional evaluation of economic impacts

This paper further assesses the economic impact of the BRI on the countries along the route through the analysis of a multidimensional comprehensive evaluation model. The results show that the industrial structure of most of the countries along the BRI has undergone significant changes under the impetus of the Initiative. The proportion of service sector has been increasing year by year, while the proportion of industry and agriculture has been decreasing accordingly, indicating that the economic structure of these countries is transforming towards modernization. At the same time, national incomes have been increasing, especially in Africa and Southeast Asia, where the growth in national incomes has been particularly significant. As a next step, it is encouraged to optimize the investment structure, invest in high value-added industries in countries along the routes, and increase investment in high-technology industries, such as information technology and clean energy, in order to promote industrial upgrading in those countries.

Chinese direct investment in countries along the BRI has increased significantly, especially in South-East Asia and Africa. Data show that countries such as Timor-Leste and Myanmar have the fastest-growing GDP, and Chinese FDI has played an important role in boosting economic growth in these countries. In addition, investment in some countries, such as Russia and Kazakhstan, has been more volatile, mainly due to their domestic political and economic situation.

6. Conclusions

This paper systematically analyzes the impact of the BRI on the economy and trade of the countries along the route through time-series analysis and multidimensional comprehensive evaluation models. The results show that the Initiative has played a positive role in promoting regional economic cooperation, upgrading bilateral trade and promoting industrial structural transformation. Particularly in South-East Asia and Africa, the implementation of the Initiative has brought significant growth momentum to local economic development. However, the future implementation of the BRI would need to address political, economic and cultural challenges. In that regard, countries were encouraged to establish closer bilateral and multilateral cooperation mechanisms to ensure policy coherence among countries along the route, avoid trade frictions, promote regional stability and development, and continue to contribute positively to global economic cooperation.

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