

Exploring the Impact of Regional Cooperation on Regional Economic and Social Development: An Empirical Study Based on the Belt and Road Initiative

Zhengkun Li*, Kangzhan Wei and Xiaoyue Peng

School of Economics, Jilin University, Jilin, China

*Corresponding author: lizk0621@ mails.jlu.edu.cn

Abstract. Regional cooperation plays a pivotal role in driving both regional and global economic growth, and the Belt and Road Initiative (BRI) stands as a significant catalyst for the economic and social development of the countries and regions along its routes. Based on economic and social data spanning from 2011 to 2019 across 40 countries, this research employs the Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) evaluation method to construct a Regional Economic and Social Development Index. Subsequently, employing a multi-period difference-in-differences model, the study meticulously examines the positive impact of the BRI on the development trajectory of relevant countries. Heterogeneity analysis reveals that the influence of the BRI is notably pronounced in developing nations, China's neighboring countries, and those along the Maritime Silk Road. Our research contributes significantly to elucidating the effects of regional cooperation on regional economic development, thus reinforcing the trajectory of economic globalization. Furthermore, we offer insightful policy recommendations for the future evolution of the Belt and Road Initiative.

Keywords: the Belt and Road; Regional cooperation; Economic and social development.

1. Introduction

The outbreak of the COVID-19 pandemic in early 2020 has been the most significant global health crisis in a century, causing over 600 million infections and claiming more than six million lives worldwide in the past three years. This pandemic has also plunged the world economy into the most severe recession since the Great Depression of the 1930s, with subsequent recovery efforts encountering numerous setbacks and.

On January 4, 2024, the United Nations released the "World Economic Situation and Prospects 2024" report, indicating that while the global economy continues to recover from the trauma of the COVID-19 pandemic, persistently high-interest rates, weak international trade, and increasing climate disasters pose significant challenges to global growth. The escalating uncertainty in international trade exacerbates the issue of disrupted supply and demand chains among nations. What's more, the trend of deglobalization has led to increased trade barriers among multinational corporations, reduced investments, and hindered cross-border production and supply chains, imposing immense pressure on global economic stability and sustainable development. In this context, strengthening international cooperation to promote the openness and development of the global economy becomes particularly crucial.

The year 2023 marked the tenth anniversary of the Belt and Road (the Silk Road Economic Belt and the 21st-Century Maritime Silk Road) Initiative. By the end of that year, the initiative had expanded its reach to over 150 countries worldwide, encompassing a population of 4.4 billion and spanning across Asia, Europe, and Africa. This extensive network connects the East Asian Economic Circle, South Asian Economic Circle, and European Economic Circle, fostering diverse, balanced, and sustainable development in countries along its route. According to the World Bank's report titled "Belt and Road Economics: Opportunities and Risks of Transport Corridors," the Belt and Road Initiative, primarily through infrastructure development, has the potential to reduce global trade costs by 1.8%. Moreover, it could lower trade costs on the China-Central Asia-West Asia Economic

Corridor by as much as 10%, making significant contributions to global trade facilitation and economic growth.

These findings underscore the Belt and Road Initiative's pivotal role in providing essential opportunities and momentum for advancing global trade and economic growth, while also serving as robust support for international cooperation and shared development goals.

As the initial construction phase of the Belt and Road Initiative concludes, scholars have extensively discussed its implementation effectiveness and impact mechanisms. Concerning implementation effectiveness, the academia generally agrees that the Belt and Road Initiative has a positive impact on capacity cooperation, trade investment, and regional development (Zhao & Sang, 2016; Zhang, 2016; Herrero & Xu, 2017; Du & Zhang, 2018; Yao et al., 2019). In terms of impact mechanisms, research mainly focuses on micro and macro levels. At the micro level, existing studies mainly focus on the impact mechanisms of specific projects or industries. Researchers such as Jiang (2018), Liu (2020), and Wang (2022) have studied the influence of infrastructure projects such as railway and port construction on the economic development of countries along the route, while scholars like Sun (2019) and Dunford (2019) have examined the impact of trade facilitation on cross-border enterprises. At this level, researchers examine the investment scale, implementation effects of specific projects, and feedback from relevant stakeholders to gain insights into the impact mechanisms of the Belt and Road Initiative on local economies and societies. At the macro level, existing research primarily focuses on the impact of the Belt and Road Initiative on the global economic landscape and international relations. Scholars such as Foo (2020), Ma (2022), and Liu (2022) mainly study the effects of the Belt and Road Initiative on trade growth, regional integration, and industrial transfers. At this level, researchers analyze data related to cross-border trade, investment, and personnel flow to evaluate the impact mechanisms of the Belt and Road Initiative on the global economy.

Against this backdrop, this paper aims to delve into the economic and social development of countries along the Belt and Road Initiative proposed by China. The research selects various sovereign countries as research samples and utilizes three sets of data from the World Development Indicators (WDI) database by the World Bank, the Trading Economics official database, and the Global Coal Plant Tracker (GCPT) database by the International Energy Agency (IEA). A total of four data indicators from 40 countries along the Belt and Road Initiative route, namely electricity generation, gross enrollment ratio in tertiary education, life expectancy, and merchandise service exports, are collected and used to measure the industrial, educational, medical, and foreign trade development of each country, respectively. An Economic and Social Development Index is constructed as the dependent variable using the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. Subsequently, the impact of Belt and Road-related policies on the economic development of countries along the route is analyzed using methods such as the Difference-in-Differences (DID) model. Finally, through heterogeneity analysis, the extent of influence on different regional countries is further explored, and relevant policy suggestions are proposed to provide theoretical and practical support for the continuous development of the Belt and Road Initiative.

Compared to existing research, this paper's marginal contributions mainly lie in three aspects:

Firstly, this study innovatively constructs an indicator system to measure the impact of the Belt and Road Initiative on the economic and social development of countries along the route, enriching existing research. Many current studies focusing on the economic impact of the Belt and Road Initiative on countries along the route directly adopt GDP as the dependent variable (Cai, 2022). In contrast, this paper innovatively constructs an indicator system for economic and social development, using electricity generation, gross enrollment ratio in tertiary education, life expectancy, and merchandise service exports to respectively measure the energy, education, healthcare, and foreign trade development of each country. This more accurately assesses the impact of the Belt and Road Initiative on the economic and social development of countries along the route, addressing the

shortcomings of existing research and further enhancing the specificity and accuracy of research conclusions.

Secondly, this study not only examines whether the Belt and Road Initiative promotes economic development in countries along the route but also explores the impacts on different types of countries' economic and social development and the roles played by different types of Silk Road Economic Belts. Through heterogeneity analysis, this paper concludes that neighboring countries and developing countries benefit more, and the effect of the Maritime Silk Road is greater than that of the Silk Road Economic Belt. This expands the results of existing research and provides a research basis for further policy formulation and strategic guidance.

Thirdly, this study provides clear policy implications. In recent years, with the proposal of the new development paradigm, the Belt and Road Initiative, as an essential hub connecting domestic and international markets, has demonstrated increasingly significant influence (Xiao, 2023). Meanwhile, China has always played a crucial role in advancing the Belt and Road Initiative, continuously strengthening trade, infrastructure construction, and cultural exchanges with countries along the route. This paper emphasizes that the Belt and Road cooperation initiative contributes to promoting the economic and social development of countries along the route, with a more significant effect on countries along the route and developing countries. This has important practical significance for further promoting economic cooperation along the Belt and Road.

The remaining content of this paper is structured as follows: the first part is the Background and research hypothesis, the second part is the research design, the third part is the empirical testing, the fourth part is the heterogeneity analysis, and the fifth part is the conclusion and policy recommendations.

2. Background and Research Hypothesis

2.1. Background

2.1.1 Background of the Belt and Road

The Silk Road originated in ancient China and served as an ancient overland trade route connecting Asia, Africa, and Europe. The route derived its name from one of the primary commodities initially transported along it - silk. Initially, the Silk Road facilitated the transportation of valuable Chinese goods such as silk and porcelain to the West, meeting the Western demand for luxury goods from the East while also disseminating Chinese culture and technology. Over time, the Silk Road evolved into a crucial conduit for exchanges between the East and the West in various realms including economy, politics, and culture.

In ancient times, transportation along the Silk Road primarily comprised the overland Silk Road and the maritime Silk Road. The overland Silk Road commenced from 202 BC to 8 AD when Emperor Wu of Han dispatched Zhang Qian to the Western Regions, opening up this trade route originating from the capital Chang'an (now Xi'an), passing through regions like Liangzhou, Jiuquan, Guazhou, Dunhuang, Xinjiang, Central Asian countries, Afghanistan, Iran, Iraq, Syria, and ultimately reaching the Mediterranean Sea with Rome as its endpoint. This route was regarded as the convergence of ancient Eastern and Western civilizations across the Eurasian continent.

The maritime Silk Road, on the other hand, originated from the maritime channels for economic and cultural exchanges between ancient China and other regions of the world and was first established during the Qin and Han Dynasties. Starting from coastal cities like Guangzhou, Quanzhou, Ningbo, and Yangzhou, the maritime Silk Road extended through the South China Sea, and the Indian Ocean, and even reached the eastern coast of Africa, forming a maritime trade route referred to as the "Maritime Silk Road."

The Belt and Road Initiative, proposed in 2013 as illustrated in Figure 1, mainly consists of two components: the Silk Road Economic Belt and the 21st Century Maritime Silk Road. The Silk Road Economic Belt originates from mainland China and follows the overland Silk Road to reach Europe.

It traverses through Central Asia and Russia to Europe or extends from Xinjiang through Pakistan to the Indian Ocean, Central Asia, and West Asia to reach the Persian Gulf and the Mediterranean coast. The 21st Century Maritime Silk Road extends from coastal ports in mainland China through the South China Sea to the Indian Ocean, further extending to Europe or the South Pacific Ocean.



Fig 1 Map of the Belt and Road

2.1.2 The full range of Belt and Road achievements

The Belt and Road Initiative is not merely an economic cooperation proposal but also a crucial platform for promoting global economic recovery and achieving shared prosperity among countries (Punyaratabandhu & Swaspitchayaskun, 2018; Tian & Li, 2019; Chen et al., 2019). In terms of policy communication, the initiative has established routine communication channels at multiple levels, platforms, and involving various stakeholders. It is led by top-level diplomacy, supported by intergovernmental strategic communication, facilitated by policy coordination among local and departmental levels, and carried forward through project cooperation among enterprises and social organizations. International cooperation summits such as the Belt and Road Forum for International Cooperation, the World Economic Forum, and the Boao Forum for Asia have enhanced pragmatic cooperation and political mutual trust among participating countries, playing a significant role in regional stability.

In infrastructure construction, the Belt and Road Initiative follows the basic framework of "six corridors, six roads, multiple countries, and multiple ports," accelerating the development of a multi-level and composite infrastructure network. It has essentially formed a comprehensive interconnected pattern known as the "Land-Sea-Air Information Silk Road." Taking the China-Europe freight trains as an example, by the end of June 2023, these trains had accumulated over 74,000 trips, transporting nearly 7 million standard containers, covering more than 50,000 types of goods including automobiles, machinery and equipment, and electronics, with a total value exceeding USD 300 billion. They have become a vital bridge for international economic and trade cooperation. As shown in Figure 2, the volume of China-Europe freight train operations and cargo transport has increased year by year from 2015 to 2022, indicating a clear upward trend. Despite the global economic impact of the pandemic from 2019 to 2022, the freight volume of China-Europe trains has continued to rise against the trend.

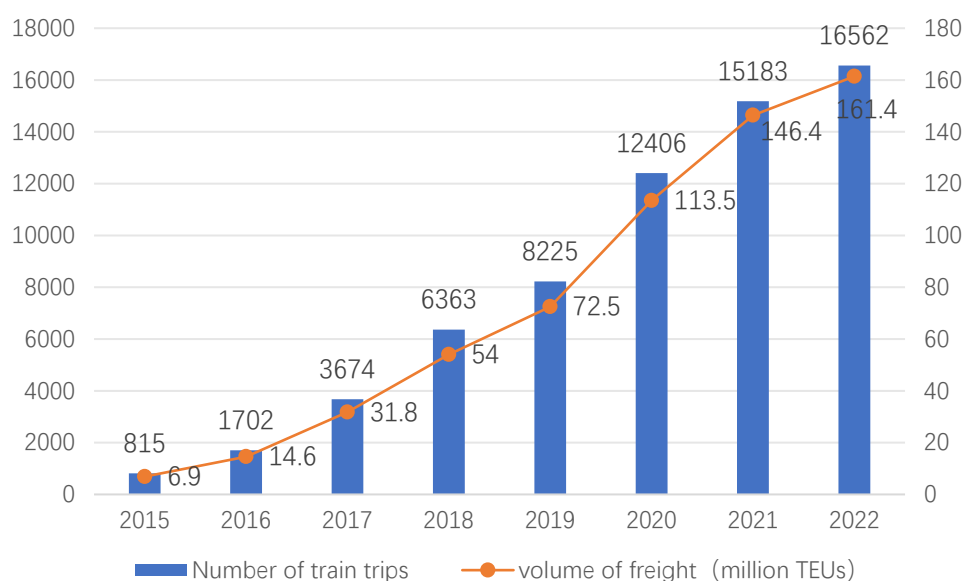


Fig 2 The operation volume and freight volume of China-Europe freight trains from 2015 to 2022

Furthermore, trade and investment cooperation is an essential component of the Belt and Road Initiative (Khan et al.,2018; Chen et al.,2020). Participating countries collaborate through the Belt and Road platform to address issues related to trade and investment liberalization and facilitation, significantly reducing trade and investment barriers, improving the business environment within regions and among countries, establishing free trade zones, expanding trade sectors, optimizing trade structures, diversifying mutual investment and industrial cooperation, promoting the establishment of a more balanced, equitable, and sustainable trade system, developing mutually beneficial economic and trade relations, and jointly expanding and improving cooperation opportunities. Over the past decade of Belt and Road construction, countries have continuously enhanced trade liberalization and facilitation through measures such as signing free trade agreements, participating in import expos, signing cooperation agreements, and holding cooperation summits. As shown in Figure 3, the indices for import trade, export trade, and import-export trade have all increased, albeit with slight declines under the influence of the pandemic.

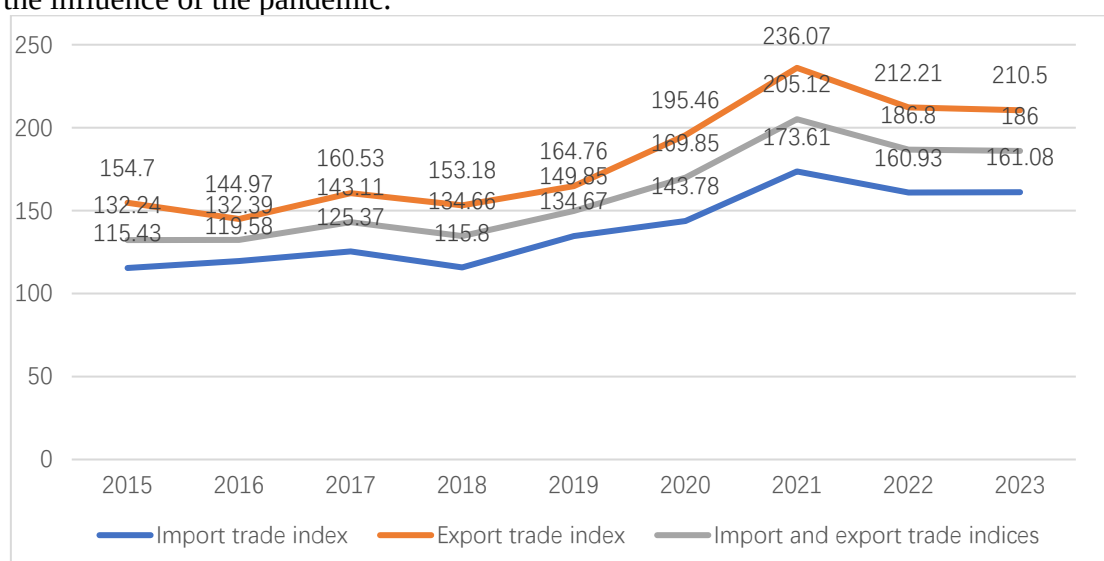


Fig 3 The import trade index, export trade index, and import-export trade index from 2015 to 2023

Financial connectivity serves as a vital pillar of the Belt and Road Initiative. Participating countries and relevant institutions actively engage in various forms of financial cooperation, innovate financing models, broaden financing channels, diversify financing entities, and improve financing mechanisms(Saud et al.,2019). They vigorously promote policy-oriented finance, development

finance, commercial finance, and cooperative finance to support the Belt and Road Initiative, striving to establish a long-term, stable, sustainable, and risk-controlled investment and financing system. Through initiatives such as establishing the Asian Infrastructure Investment Bank (AIIB), the Silk Road Fund, and the Export-Import Bank, countries have enhanced the level of financial cooperation under the Belt and Road Initiative, creating favorable investment conditions for various financial institutions and investment entities. As depicted in Figure 4, the cumulative number of contracts and committed investment amount of the Silk Road Fund have increased year by year, bringing effective investments to participating countries, adding high-quality assets, and enhancing development momentum.

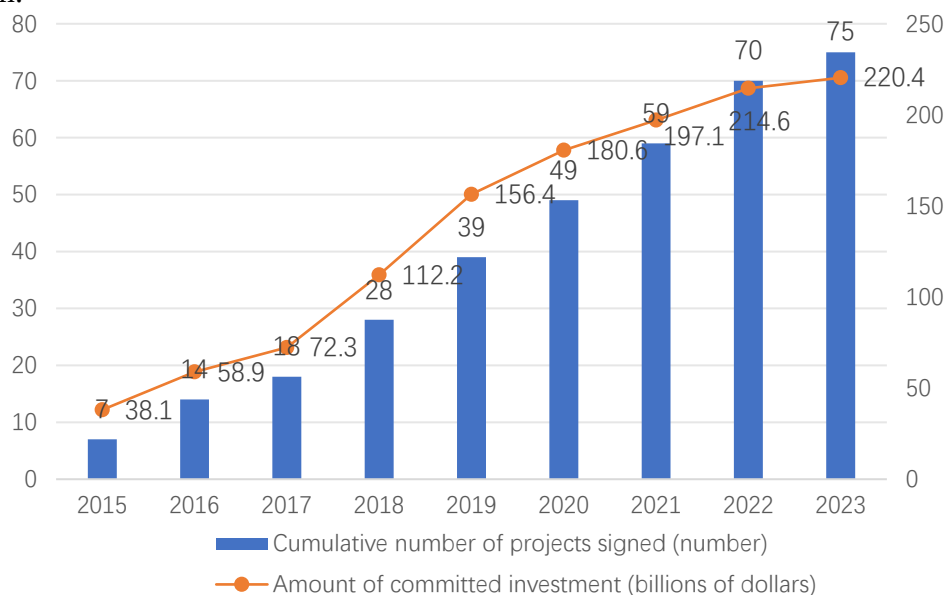


Fig 4 Cumulative number of contracts and committed investment amount of the Silk Road Fund from 2015 to 2023.

Finally, the Belt and Road Initiative has also brought about rich and diverse cultural tourism and educational exchange cooperation. Participating countries in the initiative inherit and promote the spirit of friendly cooperation along the Silk Road, extensively engaging in cultural tourism cooperation, educational exchanges, media and think tank cooperation, and people-to-people exchanges. This promotes mutual learning, cultural integration, and innovation, creating a diverse and interactive pattern of cultural exchanges. In recent years, countries along the Belt and Road have responded to the needs of the times, leveraging their respective advantages in health, green low-carbon, digital economy, and other fields, continuously expanding cooperation areas and innovating cooperation models. This has propelled positive progress in the construction of a healthy, green, innovative, and digital Silk Road, making the international cooperation space even broader.

2.2. Research Hypothesis

2.2.1. The Belt and Road Initiative and Socio-Economic Development along the Route

The Belt and Road Initiative can promote the economic and social development of countries along the route (Haggai, 2016; Huang, 2016), improving local livelihoods mainly through industrial, educational, medical, and foreign trade aspects. Firstly, Chinese state-owned enterprises and some private companies invest heavily in countries along the Belt and Road, deepening cooperation in infrastructure construction and transferring advanced technology through vocational skills training, driving local energy development and industrial park construction, and accelerating local industrialization and urbanization. Education plays a fundamental and leading role in building the Belt and Road. China focuses on promoting cooperation in education connectivity, talent cultivation and training, and Silk Road cooperation mechanisms, attracting students from Belt and Road countries for higher education, nurturing industry-leading and skilled talents, establishing schools in

Belt and Road countries, and enhancing international exchanges in scientific research to improve the cultural quality of local people. Medical cooperation serves as an important link to improve the health levels of people in Belt and Road participating countries, with China providing medical equipment, dispatching medical teams for disease prevention and treatment, and promoting traditional Chinese medicine. Finally, the Belt and Road Initiative enhances political mutual trust between China and countries along the route, with various cooperation agreements facilitating trade and enriching local consumption products, thus raising people's living standards. Based on this, the following hypothesis is proposed:

H 1: The Belt and Road Initiative can propel the economic and social development of countries along the route through industrial, educational, medical, and foreign trade avenues.

2.2.2. Heterogeneous Impact of the Belt and Road Initiative on Regional Development

Considering the differences in economic development levels and developmental needs among countries along the route, the Belt and Road Initiative's impact on their economic and social development varies. Therefore, analyzing the initiative's effect on the economic development levels of countries along the route from the perspective of their differences helps deepen understanding of its actual outcomes and the disparities in development among different countries. This analysis provides a more comprehensive basis for policy-making and strategic planning. This study categorizes countries along the Belt and Road Initiative based on their economic development levels, spatial distances, and economic belt types. This approach helps better identify the development challenges and opportunities each country faces, facilitating the formulation of targeted policies and project plans to maximize the initiative's driving force and achieve common development and mutual benefit goals.

In terms of economic development levels, countries along the Belt and Road Initiative can be divided into developed and developing countries.

Developing countries often face constraints such as inadequate infrastructure, low technological levels, and inefficient production methods. The Belt and Road Initiative prioritizes promoting local infrastructure construction and industrialization in these countries. However, due to long construction cycles and slow returns on investment, the policy's effects may lag. Nevertheless, according to the theory of latecomer advantage, developing countries have the potential to leapfrog economically by introducing, imitating, and learning advanced technologies and systems through the Belt and Road platform. Therefore, the economic development pace of these countries may be faster than that of developed countries.

On the other hand, developed countries usually have relatively well-established infrastructure and mature economic and social systems, allowing them to engage in high-level economic cooperation with China directly. However, their development relies more on foreign trade and advancements in science and technology. Before the Belt and Road Initiative was proposed, China had already engaged in close trade relations with these developed countries. Moreover, breakthroughs in science and technology and the application of research outcomes require considerable time. Consequently, these factors may weaken the Belt and Road Initiative's role in promoting economic and social development in developed countries.

H 2: The Belt and Road Initiative has heterogeneous impacts on the economic and social development of both developed and developing countries.

From the perspective of spatial distance, the countries along the Belt and Road can be divided into neighboring and non-neighboring countries.

Neighboring countries, due to their proximity to China, have lower transportation costs and higher levels of political trust, which makes them more attractive to Chinese enterprises for foreign investment. This means they can more quickly benefit from the convenience brought by infrastructure construction, such as highways, railways, and ports. These facilities not only improve transportation efficiency but also reduce trade costs, thereby promoting economic growth. Additionally, due to their geographical proximity, the Belt and Road initiative promotes more frequent trade and more

convenient commercial cooperation among neighboring countries, contributing to enhancing their economic competitiveness.

The impact of the Belt and Road Initiative on non-neighboring countries is often weaker than that on neighboring countries. Firstly, trade and economic cooperation with non-neighboring countries, especially those that are landlocked, require crossing multiple countries, facing significant administrative barriers and more unstable factors. Moreover, the longer geographical distance brings higher logistics and time costs, which may reduce Chinese enterprises' willingness to invest. Furthermore, cooperation with non-neighboring countries also involves more complex political and cultural differences, making cooperation with these countries more challenging. Studies by Gabriel and Toubal (2010) have shown that cultural differences hurt China's foreign trade activities. Therefore, the following hypothesis is proposed:

H 3: Compared to non-neighboring countries, the Belt and Road Initiative has a greater promoting effect on the economic and social development of neighboring countries.

From the perspective of economic belt types, the Belt and Road Initiative is divided into the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road," thus allowing countries along the route to be categorized into Maritime Silk Road countries and Land Silk Road countries. Compared to Land Silk Road countries, Maritime Silk Road countries are often more significantly impacted by the Belt and Road Initiative, primarily due to the influence of infrastructure and historical-cultural factors (Hu et al., 2020).

Behrens (2011) found that transportation costs determine trade flows, with countries having higher levels of transportation infrastructure facilitating greater international trade flows and more balanced regional economic growth. According to the "Belt and Road Initiative Country Infrastructure Development Index" released in 2017, there is an imbalance in infrastructure development between Land Silk Road countries and Maritime Silk Road countries. Land Silk Road countries, particularly in Central Asia, West Asia, and North Africa, have lower levels of economic development and relatively backward transportation facilities, often requiring initial construction of transportation infrastructure such as railways and pipelines to handle the throughput of Belt and Road goods. In contrast, Maritime Silk Road countries have relatively well-developed infrastructure, allowing them to directly utilize ports for cargo throughput, laying the foundation for trade.

Furthermore, Maritime Silk Road countries often have maritime or island cultures, are more open-minded, and are more receptive to foreign influences. With a long history of international trade, they have more experience in external exchanges and cooperation, enabling them to better capitalize on the development opportunities brought by the Belt and Road Initiative, leading to rapid economic development. Thus, the following hypothesis is proposed:

H 4: Compared to countries along the Land Silk Road, the Belt and Road Initiative has a greater impact on the economic and social development of countries along the Maritime Silk Road.

3. Research Design

3.1. Sample Selection and Data Sources

In this paper, each sovereign state is selected as a research sample, and the research interval is from 2011 to 2019. This paper uses three sets of data. The first set is the economic data such as the level of financial development and employment in different countries, from the World Bank WDI database. The second set is the foreign trade data such as the volume of exports and imports of business services for each country, from the official Trading Economics database. The third set is the resource endowment data such as electricity generation and mineral resources of each country, from the Global Coal Plant Tracker (GCPT) database of the International Energy Agency (IEA). By combining them, we end up with a total of 360 valid observations for 40 countries.

3.2. The Definition of Explanatory Variables

The explanatory variable measures the economic and social development of the countries along the "Belt and Road", which is set as ESD_{it} , representing the economic and social development index of the country i in the year t . The index is obtained by constructing the indicator system through the AHP-TOPSIS method, deriving the index weights, standardizing the data of each indicator, finding the ideal point of economic and social development, and calculating the relative closeness. In this paper, four indicators collected from 40 countries along the Belt and Road: the power generation, the gross enrollment rate of higher education, the life expectancy, and the exports of goods and services are used to measure the development of energy, education, health care, and foreign trade in each country.

The AHP method was first used to assign weights to each indicator. To avoid the influence of subjective factors on the weights, we combined the empirical results of the relevant literature and consulted with instructors and relevant experts, then obtained the importance scores of the evaluation indicators based on the results of the inquiry to form the weight judgment matrix:

$$A = \begin{bmatrix} 1 & \frac{1}{4} & \frac{1}{5} & \frac{1}{2} \\ 4 & 1 & \frac{1}{2} & 3 \\ 5 & 2 & 1 & 3 \\ 2 & \frac{1}{3} & \frac{1}{3} & 1 \end{bmatrix}$$

Compute the product of each row in the judgment matrix M_i , $i=1,2,3,4$. Then calculate the

weighting factors $W_i = \frac{M_i}{\sum_{i=1}^4 M_i}$, then get the matrix of weight coefficients $w = \begin{bmatrix} 0.3146 \\ 0.4694 \\ 0.1371 \\ 0.0789 \end{bmatrix}$. Then function

the consistency test on the judgment matrix: first, find the largest characteristic root of the judgment

matrix $\lambda_{\max}$, then calculate the coherence indicator $CI = \frac{\lambda_{\max} - n}{n - 1}$, n is the order of the judgment

matrix. Finally, calculate the consistency factor $CR = \frac{CI}{RI}$, RI is the average random consistency indicator. Here $CR = 0.0212 < 0.1$, so the weight judgement matrix passes the consistency test.

The indicators of a certain country in each year are then used as the set of programs to be evaluated, then construct the evaluation matrix: the set of programs to be evaluated is set as follows, the evaluation indicator set is $B = (B_1, B_2, \dots, B_n)$. The evaluation matrix is $X =$

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

m represents the total number of programs, n represents the total number of indicators, and x_{ij} represents the value of the indicator B_j in the program A_i . In this paper, i is the i^{th} year since 2011 and j is the serial number of the indicator, so $m=9$ and $n=4$.

Then standardize the data to keep the values of the variables in $[0,1]$. The forward standardization

is $v_{ij} = \frac{x_{ij} - \min x_j}{\max x_j - \min x_j}$, and the reverse standardization is $v_{ij} = \frac{\max x_j - x_{ij}}{\max x_j - \min x_j}$.

Construct the weighted judgment matrix, which is the result of multiplying the weights of the indicators w_j calculated by the AHP method with the standardized evaluation matrix. And.

$$R = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} \begin{bmatrix} w_1 & 0 & \cdots & 0 \\ 0 & w_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & w_n \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

Determine the positive and negative ideal solutions for the evaluated object, where S_j^+ is the maximum value of the indicator j and S_j^- is the minimum one.

$$S_j^+ = \max_{1 \leq i \leq m} (r_{ij}), j = 1, 2, \dots, n; \quad S_j^- = \min_{1 \leq i \leq m} (r_{ij}), j = 1, 2, \dots, n$$

Then calculate the Euclidean distance between the evaluated object and the ideal point. $S^+ = (S_1^+, S_2^+, \dots, S_n^+)$, and $S^- = (S_1^-, S_2^-, \dots, S_n^-)$. Sd_j^+ denotes the distance between the evaluation object i and the positive ideal solution, while Sd_j^- denotes the distance between the evaluation object i and the negative ideal solution.

$$Sd_i^+ = \sqrt{\sum_{j=1}^n (S_j^+ - r_{ij})^2}, i = 1, 2, \dots, m$$

$$Sd_i^- = \sqrt{\sum_{j=1}^n (S_j^- - r_{ij})^2}, i = 1, 2, \dots, m$$

Then calculate the values of relative closeness and rank them in order. Assume that n_i^+ is the relative closeness of the first evaluated object to the ideal point.

$$n_i^+ = \frac{Sd_i^-}{Sd_i^- + Sd_i^+}, i = 1, 2, \dots, m$$

The larger the value of n_i^+ , the better the evaluation object is, meaning the better the economic and social development of the country. The value of n_i^+ is exactly the value of the explained variable, the economic and social development index Y_{it} .

3.3. Empirical Strategy

The double-difference method is widely used to assess the effects of various policies, with the advantage that it can estimate the net effect of a policy by excluding inherent individual differences. Considering that the impact of the Belt and Road Initiative is not only reflected in the regions where the policy was implemented and those not, but also in the same country before and after the implementation of the Belt and Road Initiative. Therefore, this paper draws on Wang Xiaoyu's (2022) approach to use the implementation of the Belt and Road Initiative as a quasi-natural experiment. Because the implementation of the Belt and Road policy has spanned a long period, and the countries or regions joined the Belt and Road initiative at different times, this paper uses the multi-temporal double-difference model to study the impact of the Belt and Road Initiative on the countries along the route:

$$ESD_{it} = \alpha_0 + \alpha_1 Treat_{it} + \gamma Controls_{it} + u_i + \theta_t + \varepsilon_{it} \quad (1)$$

i and t respectively denote the country and the year, ESD_{it} represents the explained variable, i.e., the index of economic and social development, and $Treat_{it}$ is the core explanatory variable, which

represents the Belt and Road Initiative in this paper, expressed as $Treat_{it}=Treat_i \times Post_t$. $Treat_{it}=1$ means that an individual joined the Belt and Road Initiative, otherwise $Treat_{it}=0$. $Controls_{it}$ are the control variables, including:

1. Patent: Measured by the number of patents applied for by a country.
 2. Finance: Measured by the volume of loans to the private sector in a country.
 3. Human Capital (HC): Measured by the number of employed individuals in a country.
 4. Resource Richness (RRD): Measured by the proportion of mineral resources to exports in a country.
 5. Institutional Development (IS): Measured by the logarithm of fiscal revenue in a country.
- u_i stands for the country fixed effects, θ_t stands for the year fixed effects, and ε_{it} stands for the random error term.

3.4. Descriptive Statistics

Table 1 demonstrates the main descriptive statistics results. The results show that the maximum value of the explanatory variables is 1 and the minimum value is 0, with a standard deviation of 0.467, which means that the explanatory variables of the sample are significantly different. The mean value of the explanatory variables is 0.381, which means that about 38.1% of the sample is affected by the "Belt and Road" Initiative, which is suitable for the DID model.

Table 1 Descriptive Statistics

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum	p25	p50	p75
<i>Treat</i>	360	0.381	0.467	0	1	0	1	1
<i>ESD</i>	360	0.496	0.254	0	1	0.288	0.516	0.692
<i>Patent</i>	341	6.599	1.88	0.693	12.053	5.313	6.535	7.428
<i>Finance</i>	342	61.487	34.725	13.225	156.186	35.136	51.354	81.843
<i>HC</i>	360	55.487	9.744	36.78	79.18	49.74	54.71	60.53
<i>RRD</i>	347	4.879	7.715	0	61.071	1.485	2.878	4.477
<i>IS</i>	322	3.328	0.95	2.053	18.598	3.007	3.437	3.62

4. Empirical Test

4.1. Benchmark Regression

The results are shown in Table 2 Column (1) is the estimation without the control variables and fixed effects, column (2) is the estimation controlling the fixed effects of the country and the year, columns (3) and (4) are the estimations adding the control variables respectively based on column (1) and column (2). It is observed that the regression coefficients of the explanatory variables are positive at the 1% significance level, indicating that the "Belt and Road" initiative has played an obvious role in enhancing the economic development of the regions along the route, and the hypothesis 1 has been preliminarily verified. Adding the control variables, the regression results are also in line with economic expectations.

Table 2 The results of benchmark regression

<i>Variables</i>	(1)	(2)	(3)	(4)
	<i>ESD</i>	<i>ESD</i>	<i>ESD</i>	<i>ESD</i>
<i>Treat</i>	0.2453*** (0.0256)	0.2460*** (0.0264)	0.2036*** (0.0283)	0.1939*** (0.0312)
<i>Patent</i>			-0.0062 (0.0079)	0.0451 (0.0615)
<i>Finance</i>			0.0008** (0.0004)	-0.0009 (0.0020)
<i>HC</i>			-0.0012 (0.0017)	-0.0070 (0.0113)
<i>RRD</i>			0.0014 (0.0017)	-0.0014 (0.0055)
<i>IS</i>			0.0458 (0.0375)	-0.2212 (0.1825)
<i>_cons</i>	0.3289*** (0.0211)	0.3285*** (0.0219)	0.2463 (0.1863)	1.2370 (1.0378)
<i>N</i>	360	360	286	286
Industry FE	No	Yes	No	Yes
Year FE	No	Yes	No	Yes
<i>R</i> ²	0.2038	0.2685	0.1765	0.2735

Note: ***, ** or * respectively denotes that the regression results pass the significance test at the confidence level of 1%, 5%, or 10%, and the standard errors of firm clustering robustness are shown in parentheses, as in the tables below.

4.2. Robustness test

The parallel trends and dynamic effect test was conducted to examine the validity of the identifying assumption. The placebo test was employed to check the robustness of the estimated effects by introducing a placebo treatment group. Additionally, the inclusion of lagged one-period control variables was implemented to address potential endogeneity issues and improve the precision of the estimation.

4.2.1 Dynamic effect test

Satisfying the parallel trend assumption is a prerequisite for the double-difference method, i.e., in the absence of Belt and Road-related policies, the changing trends of the economic development of the countries in the experimental and control groups should be parallel. This paper draws on Jacobson et al. (1993) to use the method of event analysis to conduct the parallel trend test. Specifically, the following estimation equation is as follows:

$$ESD_{it} = \alpha_0 + \sum_{k=2010}^{k=2020} \alpha_k Treat_{ct} + \gamma Controls_{it} + u_j + \theta_t + \varepsilon_{it} \quad (2)$$

α_k represents the impact of the Belt and Road Initiative on firms in the pilot region in year k . This paper defines eight dummy variables of the year. pre-4, pre-3, pre-2, and pre-1 represent the four years prior to the implementation of the "Belt and Road" Initiative; Current indicates that the observation period is in the year of the the implementation of the "Belt and Road" Initiative. post1, post2, post3, and post4 represent the four years prior to the implementation of the "Belt and Road" Initiative. The ESD in model (1) is then replaced by the above dummy variables to further regress. The distribution of the estimated coefficients is shown in Figure 5 The horizontal axis indicates the years before and after the implementation of the policy, and the dashed lines indicate the confidence interval with the confidence level of 95%. It is observed that before the implementation of the Belt

and Road Initiative, the confidence intervals of the coefficients are not significantly different from zero, indicating that the acceptance of the parallel trend hypothesis. Starting from the second year after the implementation of the Belt and Road Initiative, the estimated coefficients are significantly positive, implying that the construction of the Belt and Road Initiative can enhance the economic development of the countries along the route.

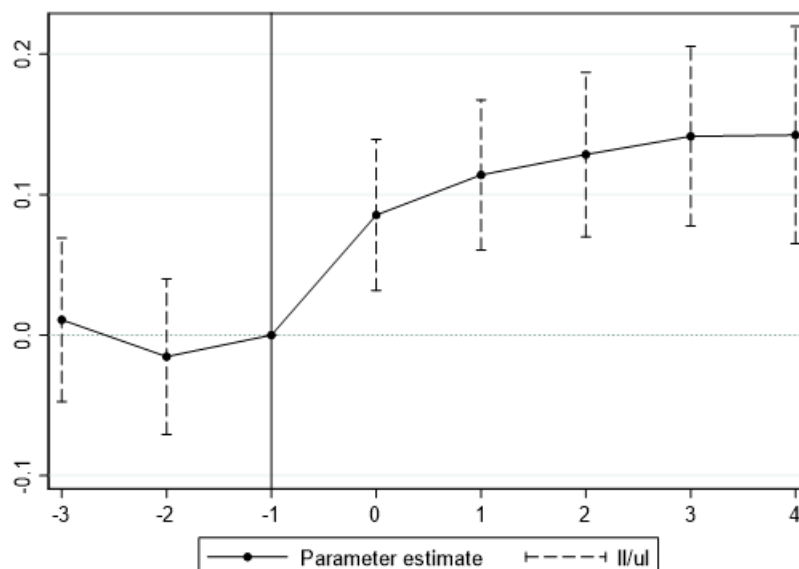


Fig 5 Parallel trend test

4.2.2 Placebo test

To further test that the impact of the Belt and Road Initiative on the countries along the route is not due to other random factors, this paper uses the placebo test to rule out the effect of other confounding factors. The kernel density is plotted by randomly constructing the experimental group and simulating it 1000 times. As can be seen in Figure 6 the estimated coefficients are distributed around 0 and follow a normal distribution, which is in line with the expectation of the placebo test, i.e., the conclusion that the Belt and Road Initiative enhances the economic development of the countries along the routes is not caused by other random factors. And the results of the benchmark regression are robust.

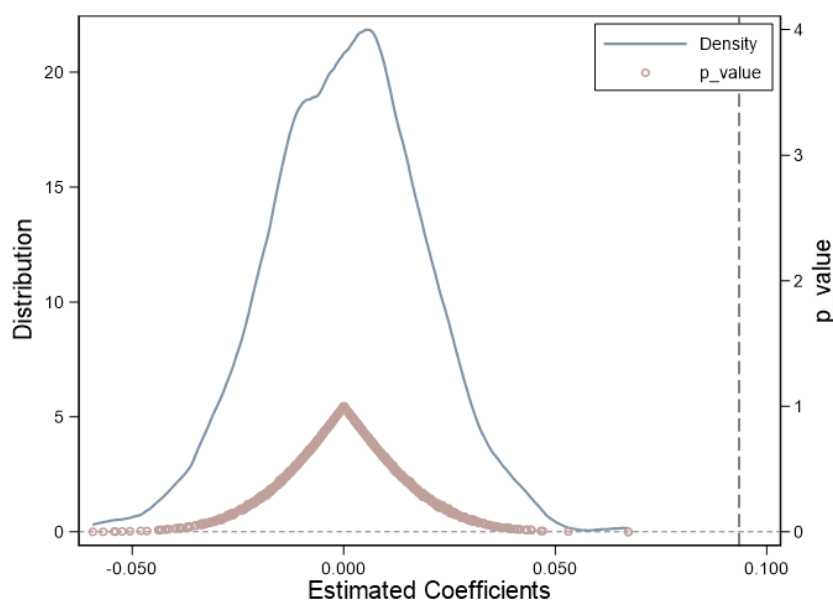


Fig 6 Placebo test

4.2.3 Lag Control Variables by One Period

The results obtained after lagging the control variables by one period in Equation (1) are presented in Column (1) of Table 3. The results after adding the control variables show that the coefficient of the policy variable (*Treat*) is significant and positive, which indicates that the impact of the Belt and Road Initiative on the economic output of the countries along the route is positive, which is consistent with the conclusion of the benchmark regression.

4.2.4 Delete observations in the pilot year

According to the literature, the Belt and Road Initiative took effect in 2015. Therefore, observations from pilot years are excluded, then the regression is conducted according to Equation (1), and the results are shown in Column (2) of Table 3. The results after adding the control variables show that the coefficient of the policy variable (*Treat*) is still significantly positive at the 1 % level, which indicates that the Belt and Road Initiative has significantly contributed to the level of economic development in the countries along the route, in line with the conclusions of the benchmark regression.

Table 3 The results of robustness tests

<i>Variables</i>	(1)	(2)
	<i>y</i>	<i>y</i>
<i>Treat</i>	0.3789*** (0.0512)	0.5682*** (0.0545)
<i>Patent</i>	-0.0002 (0.0001)	
<i>Finance</i>	-0.0015* (0.0010)	
<i>HC</i>	-0.0027 (0.0033)	
<i>RRD</i>	0.0052 (0.0030)	
<i>IS</i>	-0.0105*** (0.0027)	
<i>Patent</i>		0.0001 (0.0000)
<i>Finance</i>		0.0004 (0.0015)
<i>HC</i>		-0.0391*** (0.0088)
<i>RRD</i>		-0.0075 (0.0099)
<i>IS</i>		-0.0172*** (0.0068)
<i>_cons</i>	0.9640*** (0.2330)	2.9575*** (0.5543)
<i>N</i>	285	252
Industry FE	Yes	Yes
Year FE	Yes	Yes
<i>R</i> ²	0.5718	0.5653

5. Heterogeneity Analysis

5.1. Adjacent and Non-adjacent Countries

Drawing inspiration from the research framework proposed by Lu (2019), we classified the nations sharing a land border with China as adjacent countries, while categorizing the remaining nations as non-adjacent countries. Subsequently, we scrutinized the ramifications of the Belt and Road Initiative on the economic progress of these distinct categories of nations. The findings, delineated in columns (1) and (2) of Table 4 underscore the markedly heightened economic growth observed in adjacent countries. This upsurge primarily stems from the substantial influx of Chinese investments into neighboring territories coupled with a higher degree of engagement by adjacent nations.

5.2. Developed and Developing Countries

Our analysis demarcated the countries traversed by the initiative into developed countries and developing countries, followed by conducting regression analyses to account for heterogeneity. As depicted in columns (3) and (4) of Table 4 the coefficients associated with policy variables in developing countries surpass those of developed countries, signifying a more pronounced impetus derived from the Belt and Road Initiative among the former. This phenomenon can be attributed, in part, to the principles of latecomer advantage, whereby developing countries within the Belt and Road Initiative serve as recipients of China's industrial relocation and technological diffusion. Consequently, there is a shift of agricultural labor from less efficient sectors to more productive industrial and service sectors, thereby fostering accelerated economic growth.

5.3. Maritime Silk Road and Continental Silk Road Nations

The Belt and Road initiative is delineated into the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road". Consequently, the nations situated along these corridors are bifurcated into maritime Silk Road nations and continental Silk Road nations, each undergoing distinct regression analyses. As illustrated in columns (5) and (6) of Table 4 the Belt and Road Initiative has exerted a profound influence on bolstering the economic progress of both categories of nations. Notably, maritime Silk Road nations have experienced a more pronounced augmentation in economic vitality, attributed in part to their superior port infrastructure, which facilitates streamlined transportation of goods and fosters enhanced trade facilitation compared to their continental counterparts.

Table 4 The Result of Heterogeneity Analysis

Variables	(1) <i>Adjacent Countries</i>	(2) <i>Non-adjacent Countries</i>	(3) <i>Developed Countries</i>	(4) <i>Developing Countries</i>	(5) <i>Maritime Silk Road Countries</i>	(6) <i>Land Silk Road Countries</i>
<i>Treat</i>	0.9226*** (0.1315)	0.0237 (0.1072)	0.1946 (0.1369)	0.1786*** (0.0332)	0.1390** (0.0564)	0.0221 (0.0877)
<i>patent</i>	-0.0000 (0.0000)	-0.0000 (0.0000)	-0.0000 (0.0002)	-0.0000 (0.0000)	0.0000 (0.0000)	-0.0000** (0.0000)
<i>credit</i>	-0.0047 (0.0068)	0.0006 (0.0018)	-0.0120 (0.0073)	-0.0020 (0.0021)	-0.0073* (0.0039)	0.0049*** (0.0017)
<i>employment</i>	-0.0590 (0.0394)	-0.0330*** (0.0096)	0.1219* (0.0698)	-0.0120 (0.0102)	-0.0424*** (0.0150)	0.0273** (0.0109)
<i>ores</i>	0.0108* (0.0051)	-0.0262 (0.0186)	-0.0409 (0.1723)	-0.0039 (0.0094)	-0.0025 (0.0108)	0.0149 (0.0179)
<i>cz</i>	0.0455*** (0.0132)	-0.0214*** (0.0068)	0.1272** (0.0451)	-0.0165** (0.0074)	0.0017 (0.0152)	-0.0074 (0.0061)
<i>_cons</i>	2.6421 (2.3120)	2.8494*** (0.6210)	-9.5922** (3.6981)	1.6341** (0.6448)	2.9974*** (0.8904)	-1.4093* (0.7272)
<i>N</i>	256	30	261	25	175	111
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
<i>R</i> ²	0.5097	0.9496	0.5569	0.8242	0.7122	0.2401

6. Conclusions and Policy Recommendations

According to the foregoing analysis, the Belt and Road initiative has exerted substantial impetus on the economic and social development of nations along its routes, particularly benefiting neighboring countries and developing nations. Besides, the Maritime Silk Road shows a greater capacity to stimulate economic development among nations along its trajectory compared to the Silk Road Economic Belt. Drawing from these conclusions, the following policy recommendations are delineated in this study:

Firstly, it is imperative to fortify the domestic developmental infrastructure while diligently crafting a novel developmental paradigm. Although the crux of the "Belt and Road" initiative lies in international collaboration, its efficacy fundamentally rests upon domestic advancements. Initially, there must be a profound integration of the "Belt and Road" initiative with domestic regional strategies and strategies aimed at fostering coordinated regional development. Priority should be accorded to enhancing infrastructure, especially in the central and western regions, with a particular emphasis on adapting digital technology to fortify "new infrastructure," thereby furnishing robust support for the establishment of international cooperation platforms. Subsequently, efforts should be directed towards refining the dual circulation of the international and domestic economies. On one hand, expediting the establishment of a unified national market to facilitate the flow of production factors and commodities is quite imperative. On the other hand, it is essential to capitalize fully on both international and domestic markets and resources, deepening economic collaboration with nations along the "Belt and Road" route, thereby actualizing mutually beneficial cooperation.

Secondly, it is crucial to expedite the establishment of a comprehensive open framework characterized by interconnectivity across land and sea, as well as promoting reciprocal exchanges between the eastern and western regions. Presently, China's external openness displays a dichotomy marked by "strength in the east, weakness in the west; strength in the sea, weakness on land." This discrepancy is predominantly attributable to the relatively deficient infrastructure and nascent

industrial systems lacking distinctive advantages in the central and western regions of China. Moreover, there exists a limited level of cooperation with landlocked countries along the corridors of Central Asia, Western Asia, and Eastern Europe. Conversely, the eastern coastal regions exhibit robust economic development and possess well-developed transportation infrastructure, including seaports and airports. Priority should be provided to further enhance domestic transportation networks, particularly in the central and western regions. This entails expediting the construction of border ports in the western regions and leveraging existing initiatives such as the China-Europe Railway Express and the Eurasian Intercontinental Transport Corridor to transform China's inland areas into pivotal hubs of external openness. Additionally, nurturing distinctive industries in the central and western regions and bolstering trade ties with countries along the "Belt and Road" routes are essential measures to actively integrate into the international economic cycle.

Thirdly, it is imperative to develop tailored cooperation strategies with countries along the routes, taking into account their respective national contexts. For developed nations, emphasis should be placed on bolstering collaboration in key areas such as science and technology, finance, e-commerce, and environmental conservation. Encouraging and facilitating communication and exchange among scientists is essential to provide policy support for driving technological progress. In collaborations with developing countries in Central Asia, Western Asia, and Africa, efforts ought to focus on establishing robust "Belt and Road" transportation and information networks, enhancing connectivity, and prioritizing cooperation in sectors such as energy, education, healthcare, and tourism. Moreover, optimizing financial flows through the establishment of a diversified investment and financing system is crucial. Concurrently, fostering cultural and educational exchanges, facilitating personnel mobility, and promoting mutual understanding and trust among nations are essential endeavors. These initiatives are vital for creating a broader space for economic and social development.

Lastly, to further enhance the sustainability and effectiveness of cooperation, it is imperative to strengthen regional balanced development, particularly in impoverished and remote areas. This can be achieved by bolstering infrastructure construction and supporting industrial development to foster equitable economic growth within regions and reduce developmental disparities among them. Additionally, optimizing the layout of Belt and Road projects is essential, with careful consideration of the actual needs and development potential of non-adjacent countries. Priority should be accorded to supporting projects capable of driving local economic growth, creating employment opportunities, and ensuring the sustainability and positive outcomes of endeavors. Furthermore, increasing investment in improving people's livelihoods and elevating living standards in neighboring countries is crucial. This entails augmenting investment in fundamental sectors such as education, healthcare, and social security to enhance people's sense of fulfillment and well-being.

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