



Research article

Evaluation and prediction of the connect index between the Belt and Road countries and China based on the DANP method

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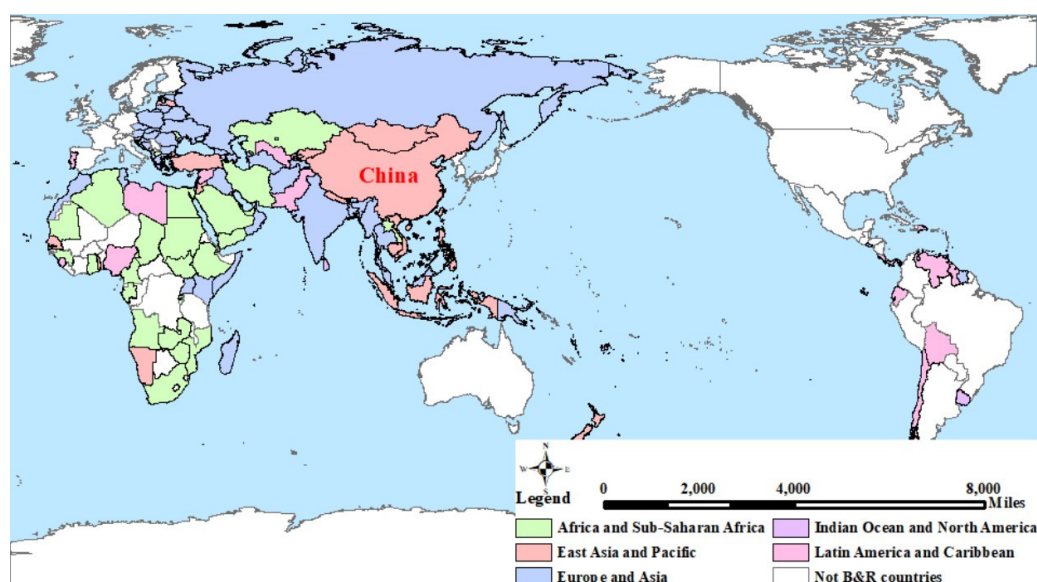
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Abstract: Interconnection is the priority direction of the Belt and Road initiative, which can provide substantial assistance to win-win cooperation. This study establishes a new indicator system from the five dimensions of policy, infrastructure, trade, finance, and people-to-people, evaluates the connect index of 63 Belt and Road countries from 2013 to 2020 based on the DEMATEL-ANP method which removes the potential subjective interference and interaction between indicators, and predicts the trend of the connect index by using the grey model. The findings indicate that the five dimensions of the Belt and Road connectivity have unevenly developed, among which the policy coordination has achieved the least. Singapore, Russia, and Malaysia have the highest connect index, and we can find that the 10 countries with the highest connect index are basically from East Asia & Pacific and Europe & Central Asia, which possess large economic and geographical differences. Moreover, there are 17 “omission areas” characterized by low national income, poor infrastructure, low population density, and small land areas along the Belt and Road. Finally, the Silk Road Economic Belt is facing structural imbalances in connectivity, and the relation features “proximity but not affinity” between China and its neighboring countries. These conclusions are friendly cautions and have constructive policy implications for the Belt and Road countries to achieve high-quality interconnection.

Keywords: Belt and Road; connectivity; DANP; grey model; omission areas

1. Introduction

International trade and maritime transport continue to play a vital role for the economic development of various countries around the world. According to the Global Trade Update report released by the United Nations Conference on Trade and Development (UNCTAD), international trade has maintained a strong growth trend [1,2]. Especially in developing countries, the growth of international trade has accelerated significantly, even higher than the global average [3]. Over the past 20 years, the total global exports of goods have increased from \$6.16 trillion to \$17.07 trillion, with an average annual growth rate of 5.5% [3]. Ninety percent of these goods are carried by vessels, the importance of maritime transportation cannot be overemphasized [4–6]. As early as 2001, China joined the World Trade Organization and opened the door to the world through international trade, which accelerated the economic and trade cooperation with different regions and countries. In 2013, the Chinese government first proposed a strategic initiative to strengthen policy coordination, infrastructure connectivity, unimpeded trade, financial integration, and people-to-people ties to collectively promote complementary advantages and win-win cooperation among the Belt and Road countries. On March 28, 2015, the Chinese government officially issued a white paper entitled *Vision and Actions on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road* [7], proposing to build a community of common interests, collective responsibility, and shared future based on mutual trust, economic integration, and cultural inclusiveness. Over the past eight years, there are 140 countries and 32 international organizations have joined the Belt and Road (Figure 1). And the Belt and Road initiative has achieved many positive results [8–10]. A general connectivity framework consisting of six corridors, six connectivity routes, and multiple countries and ports has been put in place [7,11]. The China Railway Express has become a beautiful business card for the Belt and Road construction. The Authorized Economic Operator (AEO) cooperation between China and the Belt and Road countries has been efficient. Promoting connectivity among the Belt and Road countries is not only a major trend for achieving common prosperity but also a new driving force for a shared future for mankind.



Note: The base map is the standard map GS2016 (1666) downloaded from National Administration of Surveying, Mapping and Geographic Information.

Figure 1. Map of the Belt and Road countries by regions (2020).

However, the differences in economy, policy, and cultural customs of the Belt and Road countries pose more serious challenges to future stability and high-quality interconnection. The external resistance to building the Belt and Road is centered on China's need to establish long-term sustainable economic cooperation with the countries having gaps in infrastructure and political institutions, and differences in cultural histories and trade conditions [12,13]. For example, the five Central Asian countries have been locked in the continental hinterland and unable to enjoy the convenience of infrastructure connectivity; countries such as Azerbaijan, Uzbekistan, and Tajikistan are not fully integrated into global markets due to imperfect infrastructure and great trade gaps; some countries continue to question whether the Belt and Road will become a diplomatic debt trap for China, and some large-scale projects have even been canceled or scaled back for the doubt. At the same time, the developing countries along the Belt and Road lack sufficient funds and capacity for large-scale infrastructure construction [14,15]. Although the Chinese government has financed the Belt and Road by establishing the "Asian Investment Bank" and "Silk Road Fund", it is impossible for the Chinese government to put on a "one-man show" in the face of the huge funding gap for overseas infrastructure construction.

Furthermore, some countries or regions are also sensitive areas with rampant terrorist activities, geopolitical conflicts, territorial and maritime disputes, and international power struggles, which poses a serious challenge to the security of Chinese capital investment and brings incalculable risks [16,17]. Negative factors in some extraterritorial countries have also adversely affected China's cooperation with Belt and Road countries. The rapid growth of the economy and trade has reinforced their dependence on China, bringing about their increasing doubt about the Belt and Road. And the misjudgment of China's strategic intentions has led to trust issues to some extent. Based on the above facts, we can find the lack of connectivity is a crucial reason for the slow progress of the Belt and Road. It is essential to clearly understand and evaluate the current situation as well as to forecast the trend of connectivity between the Belt and Road countries and China.

The remainder of this paper is organized as follows. Section 2 is the literature review; Section 3 is the indicator system and data sources; Section 4 is the research methodology and results analysis; Section 5 is the prediction; Section 6 provides the discussion; Section 7 offers a conclusion and makes several policy recommendations.

2. Literature review

2.1. Connectivity between the Belt and Road countries and China

A growing number of studies focus on the Belt and Road from the perspective of infrastructure connectivity, unimpeded trade, and investment risk [18,19]. For example, Andrić JM et al. [18] evaluated regional risk and total risk of infrastructure projects in different regions of the Belt and Road based on the fuzzy logic method and found that central Asia and Eastern Europe had the highest risk level in the Belt and Road projects, while East Asia had the lowest risk level. Some scholars analyze the potential of economic and trade cooperation between China and the Belt and Road countries and hold that the Belt and Road countries have relatively complementary advantages in resources and economy, and there is great potential and space for bilateral cooperation [20,21]. There are also some studies that have discussed investment risk [22–24]. J. Li et al. [25] established a risk assessment system for Belt and Road countries in four dimensions of politics, economy, society, and investment, and adopted a grey correlation

analysis method to identify and assess the investment risks in the Belt and Road countries.

What's more, some researches focus on that if there are any debt traps, corruption, political controversy, and negative environmental impacts in the process of the Belt and Road interconnection [26,27]. Some scholars question whether the Belt and Road connectivity is an important policy tool of China's geoeconomics strategy [28]. From this point of view, China uses economic power for political and security purposes [29]. However, the extensive recognition and active participation of other countries show that the Belt and Road is not a geopolitical strategy but an initiative seeking "shared prosperity" [30].

In general, most previous studies have explored the interconnection from a singular issue [31–33], while this study evaluates and explores the connectivity between the Belt and Road countries and China from a more comprehensive perspective.

2.2. Connectivity indicators

To evaluate how the development of connectivity between the Belt and Road countries and China is going in a relatively holistic approach, we list the evaluation indicators of connectivity in current research from the five dimensions of policy coordination, infrastructure connectivity, unimpeded trade, financial integration, closer people-to-people ties. The details are shown in Table 1.

Table 1. The connectivity indicators between the Belt and Road countries and China.

Policy coordination indicators	Evaluation object	Date Sources
<ul style="list-style-type: none"> ● Basis of cooperation ● Political mutual trust ● Achievements of cooperation ● Participation of cities in international cooperation ● Participation of cities in major conferences ● The duration of the Belt and Road countries having diplomatic relations with China ● The duration of the Belt and Road countries being in partnership with China ● The number of bilateral agreements signed between Belt and Road countries and China 	<p>Five Connectivity Indexes</p> <p>The Belt and Road Cities Connectivity Index</p> <p>The connectivity indicators of the Belt and Road countries with China.</p>	<p>The Belt and Road Initiative: 2018 Report on Five Connectivity Indexes</p> <p>The Belt and Road Cities Connectivity Index report (2021)</p> <p>Yaowen Chen (2019)</p>
Infrastructure connectivity indicators	Evaluation object	Reference Sources
<ul style="list-style-type: none"> ● Passenger direct flight routes ● Cargo shipping routes ● Direct rail freight ● Transport facilities ● Communications facilities ● Energy facilities ● Whether the Belt and Road countries are connected with China by rail ● Whether the Belt and Road countries are connected with China through direct flights 	<p>The Belt and Road Cities Connectivity Index</p> <p>Five Connectivity Indexes</p> <p>The connectivity indicators of the Belt and Road countries with China.</p>	<p>The Belt and Road Cities Connectivity Index report (2021)</p> <p>The Belt and Road Initiative: 2018 Report on Five Connectivity Indexes</p> <p>Y. Chen et al. [34]</p>

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<ul style="list-style-type: none"> ● Quality of roads ● Railroad infrastructure ● Air transport infrastructure ● Port infrastructure ● Mobile network coverage 	Investment facilitation evaluation system	J. Chen et al. [35]
<hr/>		
Unimpeded trade indicators	Evaluation object	Reference Sources
<ul style="list-style-type: none"> ● Inter-city imports and exports trade volume 	The Belt and Road Cities Connectivity Index	The Belt and Road Cities Connectivity Index report (2021)
<ul style="list-style-type: none"> ● Financial cooperation ● Credit system ● Financial environment 	Five Connectivity Indexes	The Belt and Road Initiative: 2018 Report on Five Connectivity Indexes
<ul style="list-style-type: none"> ● Net barter terms of trade index ● Bilateral trade volume ● China's direct investment flow to the country 	The connectivity indicators of the Belt and Road countries with China.	Y. Chen et al. [34]
<ul style="list-style-type: none"> ● Port efficiency ● Financial environment 	Trade facilitation index system	J. Zhang and Z. Wu [36]
<hr/>		
Financial integration indicators	Evaluation object	Reference Sources
<ul style="list-style-type: none"> ● Level of foreign direct investment (FDI) in cities 	The Belt and Road Cities Connectivity Index	The Belt and Road Cities Connectivity Index report (2021)
<ul style="list-style-type: none"> ● Financial cooperation ● Credit system ● Financial environment 	Five Connectivity Indexes	The Belt and Road Initiative: 2018 Report on Five Connectivity Indexes
<ul style="list-style-type: none"> ● Whether the Belt and Road country and China have signed ● The bilateral currency swap agreement ● The total currency reserve amount 	The connectivity indicators of the Belt and Road countries with China.	Y. Chen et al. [34]
<hr/>		
Closer people-to-people ties indicators	Evaluation object	Reference Sources
<ul style="list-style-type: none"> ● Average weekly inter-city airline seat occupancy rate 	The Belt and Road Cities Connectivity Index	The Belt and Road Cities Connectivity Index report (2021)
<ul style="list-style-type: none"> ● Tourist activities ● Exchanges in science and education ● Unofficial exchanges 	Five Connectivity Indexes	The Belt and Road Initiative: 2018 Report on Five Connectivity Indexes
<ul style="list-style-type: none"> ● The number of Confucius Institutes and Confucius Classrooms in the Belt and Road countries ● Whether the Belt and Road country and China have the same official language 	The connectivity indicators of the Belt and Road countries with China.	Y. Chen et al. [34]

2.3. Overview of main innovations

The innovations in this paper are mainly in the following aspects.

Firstly, the interconnection index evaluation system used in previous studies contains some

indirect and subjective indicators, which inevitably leads to subjective arbitrariness and tends to produce abnormal results inconsistent with the basic judgment of domain experts [34,37]. We selected 13 secondary indicators and 29 tertiary quantitative indicators from five dimensions of policy, infrastructure, trade, financial and people-to-people, reducing the potential subjective interference and enhancing the stability and objectivity of results.

Secondly, previous evaluations tend to use hierarchical analysis and principal component analysis [24,38]. However, the interaction between different dimensions and indicators was ignored in previous studies. This study uses the DEMAEL-ANP method to minimize the interdependence between indicators and more accurately measure the weights of indicators and the trend of the connect index between the Belt and Road and China.

Thirdly, this study provides a detailed list of “omission areas” in the Belt and Road based on multidimensional characteristics such as economic income, infrastructure, population density, and land area. A similar list of “weak countries” was also revealed by the research report on the Five Links Index of the Belt and Road Initiative (2018). However, their list was drawn from a simple country distinction, while our list of “omission areas” is more reasonable and consistent with objective facts.

Finally, this study reveals the serious structural imbalance between One Belt (the Silk Road Economic Belt) and One Road (the 21st-Century Maritime Silk Road), as well as China’s problem of its “proximity but not affinity” with neighboring countries along the route. These important findings should raise alarm bells for all relevant countries. And the suggestions like “active westward” and “partnership rather than alliance” also gave a positive policy implication to the Belt and Road countries.

3. Indicator system and data sources

According to the above Literature Review, many indicators have been considered in an interconnection index evaluation from the five dimensions of economy, infrastructure, trade, financial and people-to-people. However, the evaluation system used in previous studies contains some indirect and subjective indicators, which inevitably leads to subjective arbitrariness and tends to produce abnormal results inconsistent with the basic judgment of domain experts [34,39]. To this end, we selected 13 secondary indicators and 29 tertiary quantitative indicators based on the principles of comprehensiveness, representativeness, availability, and comparability, reducing the potential subjective interference and enhancing the stability and objectivity of results. The indicators’ descriptions and data sources are listed in Table 2.

3.1. Policy coordination

Policy coordination is a vital guarantee for the Belt and Road initiative. Mutual political trust and a sound political environment are necessary considerations for countries to achieve cooperation [40]. On the one hand, a high-quality political mutual trust and political environment facilitate Chinese companies’ investment activities in host countries; on the other hand, it provides a strong guarantee of effective policy communication [41]. The high-level communication frequency, the number of Embassies and Consulates in China, and the cooperation mechanism are seen as the key determinant of mutual political trust [34]. Political stability without violence and the degree of integrity are two critical components of a political environment [42]. To this end, three indicators were selected for mutual political trust as follows: high-level communication frequency (A11); the number of Embassies

and Consulates in China (A12); cooperation mechanism under the Belt and Road (A13). And two indicators were selected for the political environment as follows: political stability without violence (A21); degree of integrity (A22).

3.2. Infrastructure connectivity

Infrastructure connectivity aims to strengthen the interconnection in the fields of transportation, energy, and telecommunication [43,44]. With the joint efforts of the Belt and Road countries, significant progress has been made in the construction of the Belt and Road. By 2020, China's government enterprises have carried out more than 3000 projects in the Belt and Road countries in areas such as infrastructure and energy resources. The connectivity and quality of transportation facilities can effectively measure the degree of infrastructure interconnection. Telecommunication and the Internet are the most popular online communication tools. Besides, energy facilities cooperation is also an essential part of Belt and Road cooperation. Thus, this paper takes into account the following indicators: whether transportation facilities are connected with China (B11); transportation facilities quality (B12); internet penetration rate (B21); telephone line coverage (B22); oil conveying force (B31); natural gas delivery capacity (B32).

3.3. Unimpeded trade

Unimpeded trade is a crucial part of the Belt and Road. By improving the business environment, increasing trade flows, and enhancing investment cooperation, trade barriers can be effectively removed [45,46]. According to Meltzer [47], cross-border trade freedom and business regulation can provide a better business environment for trade cooperation. Tariff levels and total bilateral trade are visual indicators of the situation of trade flows. Expanding bilateral investment agreements and bilateral OFDI flows could make a great difference in invigorating the investment. Thus, the following six indicators have been selected: freedom of cross-border trade (C11); business regulation (C12); tariff level (C21); total bilateral trade (C22); bilateral investment agreements (C31); bilateral OFDI flows (C32).

3.4. Financial integration

Financial integration serves as momentous support for the Belt and Road construction. We are supposed to promote the construction and operation of cross-border cooperation and credit systems, expand the scope and scale of currency swap cooperation, strengthen the strength of financial supervision and cooperation and credit facilitation, as well as enhance currency stability and total reserves. With all these actions, we can effectively reduce the risks and obstacles in the process of financing integration between China and Belt and Road countries [48]. Promoting the operation of currency swaps and financial regulatory cooperation is a beneficial option for expanding the scale of financial cooperation. A credit system with a high level of credit facilitation and credit market regulation can promise a huge and stable financial flow. As for monetary robustness and total reserves, it is a useful strategy to prevent financial crises. To this end, six indicators have been selected, including currency swap cooperation (D11); financial regulatory cooperation (D12); credit facility (D21); credit market regulation (D22); monetary robustness (D31); total reserves (D32).

3.5. Closer people-to-people ties

Closer people-to-people ties are the humanistic basis for building the Belt and Road [49]. Under the Belt and Road Initiative, China has narrowed the cultural gap by establishing hot tourist cities and attracting tourists to China [50] and has deepened people-to-people ties by attracting more foreign students and seeking more scientific cooperation [51]. Thus, this paper adopts the following indicators: the number of hot tourist cities (E11); the number of tourists to China (E12); scientific cooperation (E21); the number of foreign students coming to China (E22).

Table 2. Connectivity indicators description and data sources.

First-level	Second-level	Third-level	Data sources
A policy coordination	A1 Mutual political trust	A11 High-level communication frequency	China Government Network
		A12 Number of Embassies and Consulates in China	The Ministry of Foreign Affairs of the People's Republic of China
		A13 Cooperation mechanism under the Belt and Road	The Ministry of Foreign Affairs of the People's Republic of China
	A2 Political environment	A21 Political stability without violence	WGI
		A22 Degree of integrity	WGI
B Infrastructure connectivity	B1 Transportation facilities	B11 Whether transportation facilities are connected with China	People's Daily Online; Port Code Network; Civil Aviation from Statistics
		B12 Transportation facilities quality	WDI
	B2 Communication facilities	B21 Internet penetration rate	WDI
		B22 Telephone line coverage	WDI
	B3 Energy facilities	B31 Oil conveying force	WTO
		B32 Natural gas delivery capacity	WTO
C Unimpeded trade	C1 Business environment	C11 Freedom of cross-border trade	Economic Freedom of the World Annual Report
		C12 Business regulation	Economic Freedom of the World Annual Report
	C2 Trade accessibility	C21 Tariff level	Economic Freedom of the World Annual Report
		C22 Total bilateral trade	China Statistical Yearbook
	C3 Investment level	C31 Bilateral investment agreements	Department of Treaty and Law, Ministry of Commerce
		C32 Bilateral OFDI flows	China Outbound Investment Bulletin

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D Financial integration	D1 Financial cooperation	D11 Currency swap cooperation	People's Bank of China
	D2 Credit system	D12 Financial regulatory cooperation	China Securities Regulatory Commission
		D21 Credit facility	Global Doing Business Report
	D3 Financial environment	D22 Credit market regulation	Economic Freedom of the World Annual Report
		D31 Monetary robustness	Economic Freedom of the World Annual Report
		D32 Total reserves	WDI
E Closer people-to-people ties	E1 Tourism activities	E11 Number of hot tourist cities	WDI
		E12 Number of tourists to China	China Tourism Statistical Yearbook
	E2 Science and education exchange	E21 Scientific cooperation	WOS
		E22 Number of foreign students coming to China	Concise Statistics on International Students Coming to China

4. DANP method and results analysis

4.1. DANP method

The DANP evaluation method is an organic combination of the decision-making trial and evaluation laboratory (DEMATE) and the analytic network process (ANP). The DEMATE method was first used to obtain the direct influence matrix of indicators at all levels, and then combined with the ANP method to measure the weight of each indicator, which weakened the interactions among indicators and made up for the shortcomings of using the DEMATEL method alone [52,53]. The previous studies tend to use hierarchical analysis and principal component analysis [24,38]. However, the interaction between different dimensions and indicators was easily ignored. Compared to the other evaluations, the DANP method can minimize the interdependence between indicators and more accurately measure the weights, which has a wide range of applications in different areas [52,53].

The process of DANP method can be summarized as follows:

Step 1: Calculate the direct relation matrix

The initial step is to invite several experts to assess the direct influence among the indicators and construct a direct influence matrix A . 0, 1, 2, 3, and 4 represent different levels of influence, ranging from no influence to enormous influence.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

Step 2: Normalize the direct relation matrix

The normalized matrix X can be obtained through:

$$S = \min \left[\frac{1}{\max_i \sum_{j=1}^n a_{ij}}, \frac{1}{\max_j \sum_{i=1}^n a_{ij}} \right], \quad X = S \times A \quad (2)$$

Step 3: Obtain the integrated impact matrix

The integrated impact matrix T can be obtained through $T = X(I - X)^{-1}$, where I is the unit matrix.

Calculate the sum of the rows and columns of the integrated impact matrix T , called D and C values. The sum of D and C is the centrality M , which reflects the importance of each indicator in the index system. The difference between D and C is causing degree R . If R is greater than 0, this factor is a reason indicator. If R is less than 0, the factor is a result indicator.

Step 4: Calculate the unweighted supermatrix

Thought normalize the integrated impact matrix T we can obtain the normalized matrix T^α , and then transpose T^α to obtain the unweighted supermatrix W .

$$T^\alpha = \begin{bmatrix} t_{11}/d_1 & \dots & t_{1n}/d_1 \\ \vdots & \ddots & \vdots \\ t_{n1}/d_n & \dots & t_{nn}/d_n \end{bmatrix} \quad (3)$$

$$d_i = \sum_{j=1}^m t_{ij}, i = 1, 2, \dots, n \quad (4)$$

$$W = (T^\alpha)' \quad (5)$$

Step 5: Calculate the weighted supermatrix

$$W^\alpha = T^\alpha W \quad (6)$$

Step 6: Calculate the limit supermatrix

$$W^* = \lim_{b \rightarrow \infty} (W^\alpha)^b \quad (7)$$

4.2. Results analysis

In this section, we totally invited 11 experts to participate the online questionnaire referring to the relevant literature [54,55]. To ensure the credibility of the evaluation results, experts were selected from various fields, including three experts in international trade and investment, three experts in international politics and economy, two experts in international transportation engineering, three experts in international cultural communication [24,56], and have worked in different organizations, including four experts in research institute, three experts in government agency, and four experts in university. The averaged direct relation 29×29 matrix A (Table 3) was obtained by pairwise comparisons in terms of influences between indicators. To further quantify the indicators' weight, we calculated the unweighted supermatrix W , the weighted supermatrix W^α , and the limit supermatrix W^* in turn. The weight of each indicator is shown in Table 4. Figure. 2 showed the causal distribution diagram after calculating the value of centrality M and cause degree R .

According to the results from the DANP analysis, high-level communication frequency (A11), cooperation mechanism under the Belt and Road (A13), freedom of cross-border trade (C11), total bilateral trade (C22), bilateral investment agreements (C31), and bilateral OFDI flows (C32) play an important role in the process of connectivity building between the Belt and Road countries and China, which have also been reported by Tan and Chin [57] and Chen [58].

The overall weight of the trade, financial, and infrastructure dimensions were more than those of the policy and people-to-people dimensions, which their weights were 0.232, 0.220, 0.212, 0.185

and 0.151 respectively. Especially, unimpeded trade, financial integration, and closer people-to-people ties are the reason indicators. Therefore, the core indicators of connectivity lie in the trade and financial dimension. There are already some literatures have confirmed the indispensable role of unimpeded trade and financial integration [46,59].

In terms of individual indicators, whether transportation facilities are connected with China (B11), transportation facilities quality (B12), Internet penetration rate (B21), telephone line coverage (B22), oil conveying force (B31), natural gas delivery capacity (B32), freedom of cross-border trade(C11), business regulation (C12), C22 Total bilateral trade, Bilateral investment agreements (C31), Currency swap cooperation (D11), credit market regulation (D22), the number of hot tourist cities (E11), the number of tourists to China (E12), scientific Cooperation (E21), the number of foreign students coming to China (E22), total bilateral trade(C22) and bilateral investment agreements(C31) are the reason indicators, and most reason indicators focus on infrastructure and people-to-people dimensions, which shows that infrastructure connectivity and closer people-to-people ties should a primary task in the construction of the Belt and Road. Wang and Selina [60] and Ketels [61] also obtained the same results.

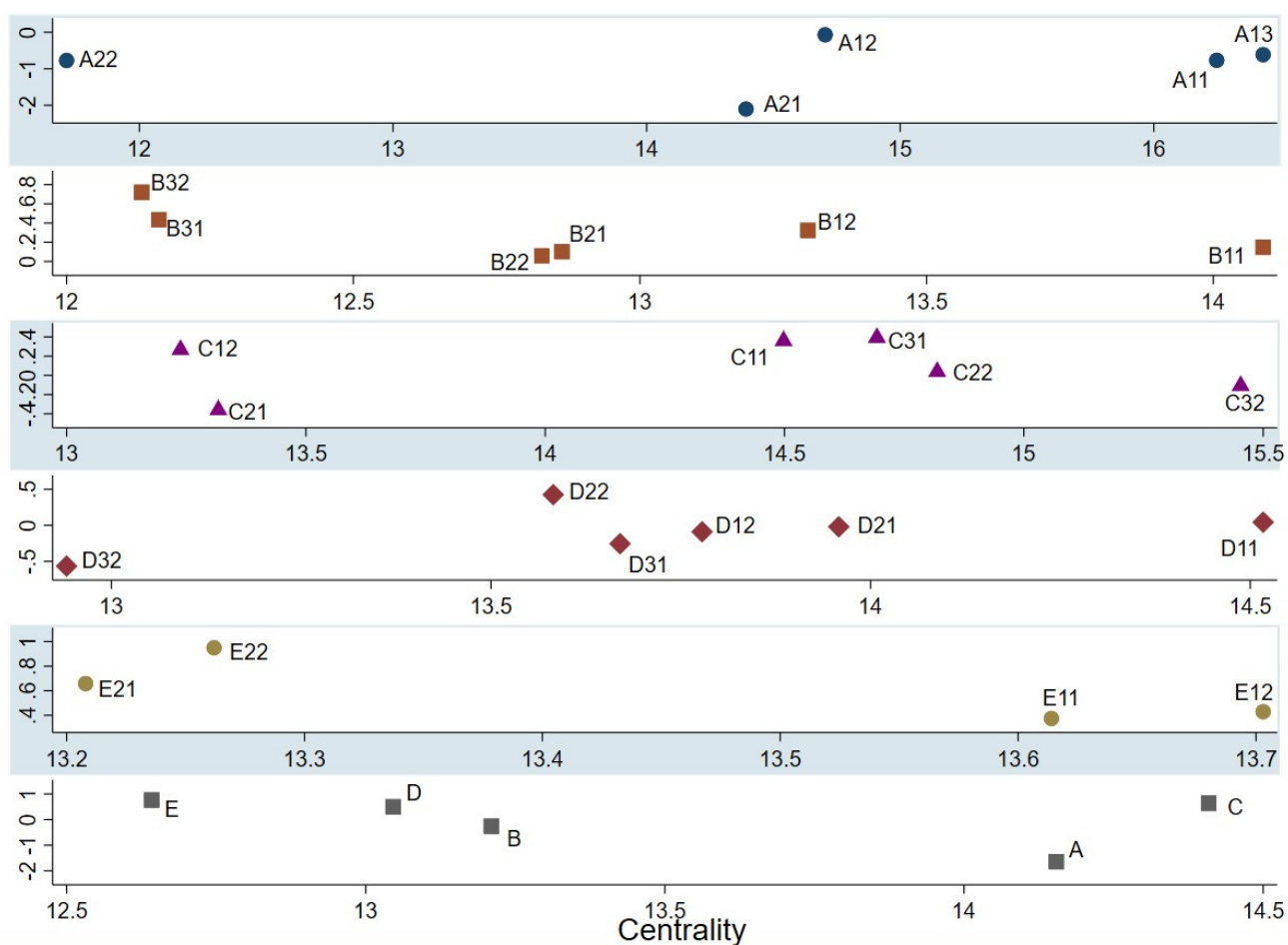


Figure 2. Cause and effect diagram of DANP.

Table 3. Direct relation matrix of DANP.

	A11	A12	A13	A21	A22	B11	B12	B21	B22	B31	B32	C11	C12	C21	C22	C31	C32	D11	D12	D21	D22	D31	D32	E11	E12	E21	E22
A11	0	3.45	3.64	2.82	2.36	2.55	2.09	2.18	2.36	2	2	2.55	2.45	2.64	3	3.18	3	2.82	2.73	2.27	2.27	2.36	2.36	2.45	2.36	2.55	2.45
A12	3.45	0	3	2.91	2.27	2.55	2.18	2.09	2.55	1.64	1.91	2.55	2.09	2.27	2.91	2.73	2.82	2.45	2.45	2.18	1.91	2.18	1.91	2.82	2.45	2.27	2.55
A13	3.45	3	0	2.82	2.27	2.82	2.45	2.27	2.27	2.45	2.36	2.55	2.45	2.82	2.82	3	3.18	2.91	2.82	2.45	2.27	2.55	2.55	2.64	2.18	2.55	2.64
A21	2.91	2.27	2.64	0	2.64	2.18	2.09	1.64	1.73	1.55	1.64	2.09	1.73	2	1.64	1.73	2	1.91	2	1.91	1.73	2.27	2.09	2.18	2.27	2	2.09
A22	2.18	2.18	2.09	2.73	0	1.91	1.73	1.73	1.73	1.36	1.45	1.45	1.64	1.55	1.64	1.91	1.73	1.73	1.91	2	1.91	1.91	1.82	1.64	1.64	1.82	1.64
B11	3	2.36	3.18	2.73	2.09	0	2.64	2.18	2.18	2.36	2.73	2.18	2	2.36	2.18	2.55	2.64	2.36	1.91	2.18	2.09	2.09	2.27	2.36	2.45	2.09	2.36
B12	2.55	1.91	2.64	2.55	2.45	2.64	0	2.27	2.18	2.18	2.45	2.27	1.64	1.82	2.27	2.36	2.73	2.27	2.09	2	2.09	2.18	2.45	2.45	2.27	2	2.18
B21	2.09	1.73	2.27	2.82	2.27	2	2.27	0	3	1.36	1.55	2	1.73	1.73	2.18	2	2.45	2.36	1.91	2.45	1.91	2.27	2.09	2.45	2.36	2.27	2.18
B22	2.45	2	2.18	2.73	2.36	2	2.18	2.91	0	1.18	1.36	2.45	1.45	1.82	2.27	1.91	2.45	2.36	1.64	2.64	1.91	2.45	2.09	2.64	2.27	2.36	1.91
B31	3.09	2.45	2.91	2.45	1.73	2.55	2.18	1.64	2	0	1.91	2.18	1.82	1.91	2.09	2.45	2.45	2.45	1.82	2.09	1.73	1.82	1.82	1.82	1.55	1.64	1.45
B32	2.91	2.18	2.82	2.73	1.64	2.82	2.55	1.73	2.18	2.36	0	2.09	1.73	2	2	2.45	2.36	2.36	1.64	1.91	2	1.91	2	1.73	1.73	2	1.45
C11	2.91	2.36	3	3	1.91	2.64	2.36	2.64	2.36	1.91	2	0	2.64	2.82	2.73	2.91	2.55	2.64	2.45	2.27	2.55	2.45	2.36	2	2.27	2.45	2.09
C12	2.91	2.36	2.55	2.64	2.45	2.09	1.82	1.82	2.09	1.82	1.73	2.36	0	2.64	2.55	2.36	2.73	2.36	2.45	1.91	2.64	2.18	2.18	1.91	1.91	1.82	2
C21	2.64	2.36	3	2.45	1.91	1.73	1.91	1.64	1.64	1.91	1.91	2.64	2.36	0	2.73	2.09	2.73	2.45	2.27	2	2.09	2	2.18	1.64	1.82	1.73	1.82
C22	3	2.55	3.09	2.82	2	2.55	2.27	2.18	2	2.64	2.18	2.82	2.18	2.73	0	2.55	3.18	2.91	2.64	2.55	2.55	2.27	2.36	2.18	2.18	2	1.82
C31	3.09	2.55	3.27	2.82	1.91	2.27	2.36	2.18	1.82	2.64	2.36	2.73	2.45	2.91	2.73	0	3.09	2.91	2.82	2.55	2.55	2.55	2.18	2.18	2.18	2.09	2
C32	3	2.82	3.45	2.91	1.91	2.45	2.27	2.55	2	2.18	2.36	3.09	2.36	2.73	3.18	2.64	0	2.55	2.73	2.64	2.91	2.82	2.55	2.09	2.36	2.09	1.73
D11	3.09	2.45	3.27	2.64	1.82	2.27	1.64	1.91	1.73	2.09	2.18	2.64	2.55	2.45	2.91	2.73	2.82	0	2.91	2.82	2.45	2.64	2.36	2.09	2.18	1.82	2.27
D12	3.09	2.36	2.91	2.45	1.91	2	1.91	2	2.18	1.64	1.64	2.36	2.64	2.36	2.64	2.55	2.64	2.36	0	2.64	2.27	2.45	2.27	1.91	2.18	1.73	1.82
D21	2.91	2.55	2.73	2.64	1.64	2.45	2.18	2.18	2.45	1.64	1.82	2.55	2.36	2.09	2.73	2.18	2.82	2.55	2.55	0	2.64	2.64	2.27	2	2.09	1.82	1.55
D22	2.91	2.36	2.73	3	1.91	2.18	2.27	2.55	2	1.55	1.64	2.27	2.55	2.18	2.73	2.27	2.82	2.55	2.36	2.64	0	2.82	2.64	2	2.09	1.91	1.55
D31	2.45	2.45	2.73	3	2	2.09	1.82	2	1.91	1.73	1.55	2.36	2.36	2.09	2.45	2.27	2.45	2.36	2.45	2.55	2.36	0	2.73	2	2.27	1.73	1.73
D32	2.55	2.09	2.55	2.45	1.64	1.82	1.64	1.82	2	1.91	1.55	2.09	2	2.09	2.45	1.91	2.27	2.18	2.27	2.55	2	2.27	0	1.64	2.18	1.73	1.55
E11	2.55	2.73	2.82	3.18	2.18	2.18	2.45	2.36	2.36	2	1.64	2.27	2.18	2.18	2.36	2.27	2.27	2.09	1.91	2.27	1.91	2.09	2.27	0	3.18	2.36	2.45
E12	2.73	2.73	2.73	3.18	2.27	2.55	2.45	2.27	2.27	2.18	1.64	2.18	2.18	2.27	2.18	2.18	2.36	2	2.09	2.36	2	2.18	2.09	2.91	0	2.55	2.64
E21	3	2.73	2.82	2.82	2.18	2.55	2.18	2.27	2.09	2	1.45	2.09	2.18	2.18	2.09	1.91	2.36	2	2.18	2.36	2	2.45	2.18	2.55	2.36	0	2.91
E22	3.09	2.73	3	2.55	2	2.45	2.18	2.09	2.09	2.09	1.82	2.09	2	2.09	2.27	2.55	2.45	2.64	2.55	2.27	1.91	2.27	2.18	2.82	2.45	2.64	0

Table 4. Connectivity indicator weights and values.

Indicator	Weight	D	C	M	R	Indicator Property	C22	0.040	7.429	7.390	14.819	0.039	Reason Indicator
A11	0.042	7.740	8.508	16.248	- 0.768	Result Indicator	C31	0.040	7.543	7.150	14.693	0.393	Reason Indicator
A12	0.039	7.317	7.387	14.704	- 0.070	Result Indicator	C32	0.041	7.673	7.780	15.453	- 0.107	Result Indicator
A13	0.042	7.908	8.523	16.431	- 0.615	Result Indicator	D11	0.039	7.280	7.237	14.517	0.044	Reason Indicator
A21	0.033	6.144	8.248	14.392	- 2.104	Result Indicator	D12	0.037	6.845	6.933	13.778	- 0.089	Result Indicator
A22	0.029	5.470	6.243	11.713	- 0.773	Result Indicator	D21	0.037	6.969	6.989	13.958	- 0.020	Result Indicator
B11	0.038	7.117	6.969	14.087	0.148	Reason Indicator	D22	0.038	7.004	6.579	13.582	0.425	Reason Indicator
B12	0.036	6.808	6.485	13.293	0.323	Reason Indicator	D31	0.036	6.707	6.962	13.670	- 0.255	Result Indicator
B21	0.035	6.443	6.385	12.829	0.058	Reason Indicator	D32	0.033	6.188	6.754	12.941	- 0.566	Result Indicator
B22	0.035	6.483	6.381	12.864	0.102	Reason Indicator	E11	0.037	6.994	6.620	13.614	0.374	Reason Indicator
B31	0.034	6.298	5.863	12.161	0.434	Reason Indicator	E12	0.038	7.066	6.637	13.703	0.429	Reason Indicator
B32	0.034	6.425	5.706	12.131	0.720	Reason Indicator	E21	0.037	6.933	6.275	13.208	0.658	Reason Indicator
C11	0.040	7.429	7.069	14.498	0.360	Reason Indicator	E22	0.038	7.106	6.156	13.262	0.950	Reason Indicator
C12	0.036	6.753	6.485	13.238	0.268	Reason Indicator	C22	0.040	7.429	7.390	14.819	0.039	Reason Indicator
C21	0.035	6.479	6.839	13.317	- 0.360	Result Indicator	C31	0.040	7.543	7.150	14.693	0.393	Reason Indicator

Note: D, C, M, R are degree of influence, degree of being influenced, degree of centrality, and degree of cause respectively.

4.3. Empirical case analysis

Based on the availability of data, the connect index between 63 Belt and Road countries and China has been obtained. Figure 3 illustrates the differences in the connection level among the Belt and Road countries on average. And the top ten countries are shown in Table 5. There are four countries located in East Asia and Eastern Pacific, five countries located in Europe and Central Asia, and one country located in the Middle East and North Africa. These countries are generally ranked as high-income or upper-middle-income countries except for Indonesia according to the World Bank standards. Singapore, Russian Federation, Malaysia, Thailand, and Poland are the five countries that have a more balanced development dimension and the highest level of interconnection. For example, Singapore is in the top position in three of the five dimensions. Hungary, Qatar, the Czech Republic, Indonesia, and

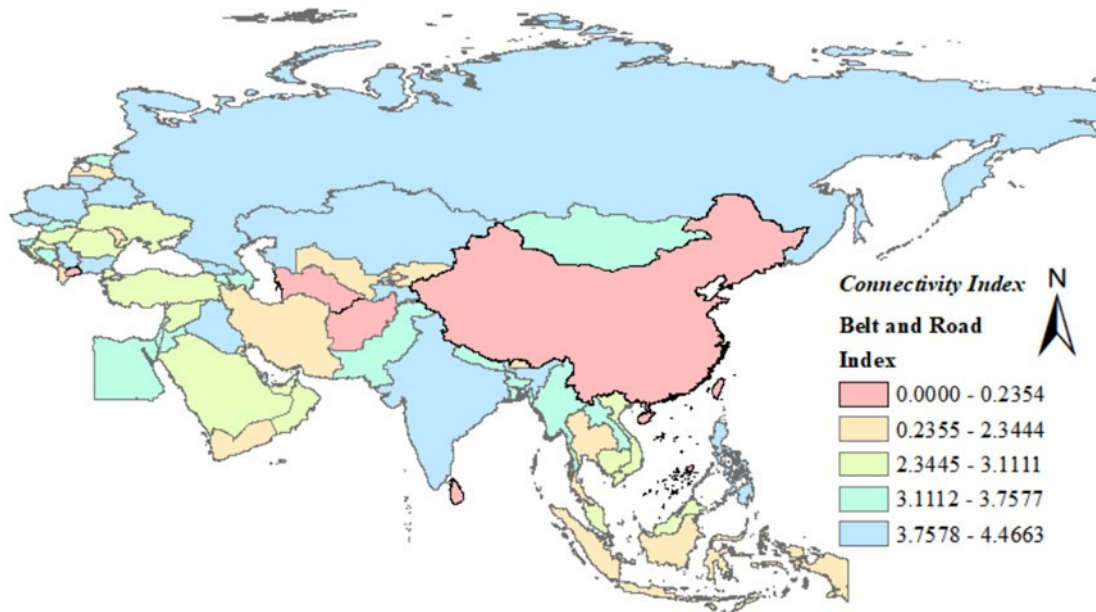
Bulgaria mostly have a leading performance in individual dimensions. To be specific, they are in the top five in at least one of the five dimensions. For instance, Hungary ranked first in Policy Communication and Qatar ranked second in Facility Connectivity.

The five dimensions of connectivity index results show that the average level of connectivity varies less across countries. Financial integration and closer people-to-people ties have relatively higher scores, with the highest reaching 1.265 and 1.316 respectively, while the other three indicators have scores below 1. In terms of the individual dimension, Hungary plays a leading role in policy coordination connectivity with China, with a mean value of 0.370 over the last eight years, followed by Singapore and Malaysia with a mean value of 0.368 and 0.365 respectively. Bahrain has the highest infrastructure connectivity average of 0.798 with China, and Qatar and Brunei followed with 0.772 and 0.755 respectively. Singapore ranks first in terms of unimpeded trade connectivity with China, with an average of 0.951 over the last eight years, followed closely by Malaysia and Vietnam at almost the same level of 0.809 and 0.808 respectively. As for financial integration, Pakistan ranks first with a value of 1.265 followed by the Russian Federation and Thailand with 1.255 and 1.239 respectively. Poland has the highest level of closer people-to-people ties with China with an index of 1.316 for the last eight years, followed by Thailand and Saudi Arabia with 1.260 and 1.253 respectively.

Table 5. Scoring results (top 10) of the connect index.

Country name	A	Country name	B	Country name	C
Hungary	0.370	Bahrain	0.798	Singapore	0.951
Singapore	0.368	Qatar	0.772	Malaysia	0.809
Malaysia	0.365	Brunei Darussalam	0.755	Vietnam	0.808
Lao PDR	0.362	Kuwait	0.742	UAE	0.802
Vietnam	0.358	UAE	0.737	Russian Federation	0.798
Cambodia	0.357	Saudi Arabia	0.727	Thailand	0.797
UAE	0.342	Russian Federation	0.716	Cambodia	0.793
Thailand	0.335	Kazakhstan	0.715	Lao PDR	0.791
Qatar	0.324	Iran, Islamic Rep.	0.712	Mongolia	0.790
Russian Federation	0.322	Oman	0.711	Indonesia	0.789
Country name	D	Country name	E	Country name	F
Singapore	1.265	Poland	1.316	Singapore	4.466
Russian Federation	1.255	Thailand	1.260	Russian Federation	4.344
Thailand	1.239	Russian Federation	1.253	Malaysia	4.302
Malaysia	1.224	Malaysia	1.253	Thailand	4.186
Indonesia	1.218	Czech Republic	1.250	Poland	4.122
India	1.212	Hungary	1.234	Hungary	4.098
Turkey	1.210	Singapore	1.196	Qatar	4.049
Saudi Arabia	1.206	Indonesia	1.189	Czech Republic	3.969
Israel	1.198	Slovak Republic	1.181	Indonesia	3.950
Poland	1.188	Bulgaria	1.170	Bulgaria	3.901

Note: A, B, C, D, E, F is the index of policy coordination, infrastructure connectivity, unimpeded trade, financial integration, closer people-to-people ties, and five-connective respectively.



Note: The base map is the standard map GS2016 (1666) downloaded from National Administration of Surveying, Mapping and Geographic Information.

Figure 3. Distribution of the connectivity index in 63 Belt and Road countries.

5. Grey prediction

5.1. Grey prediction model

Grey prediction is a forecasting method to predict the trend of things by finding the pattern of system changes through correlation analysis [62,63]. The most common and effective method of grey prediction is GM (1, 1) [64], whose process is as follows:

Step 1: Setting the original data sequence $X^{(n)} = (X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n))$, and $X^{(n)} = (X^{(1)}(1), X^{(1)}(2), \dots, X^{(1)}(n))$, where $X^{(1)}(k) = \sum_{i=1}^k X^{(0)}(i)$, $k = 1, 2, \dots, n$.

Step 2: Calculate the neighborhood value generation series $Z^{(1)} = (Z^{(1)}(2), Z^{(1)}(3), \dots, Z^{(1)}(k))$, $k = 2, 3, \dots, n$, where $Z^{(1)}(k) = \frac{1}{2}(X^{(1)}(k-1) + X^{(1)}(k))$, $k = 2, 3, \dots, n$.

Step 3: According to the grey theory, the grey differential equation GM (1,1) about t is established. $\frac{dX^{(1)}}{dt} + \alpha X^{(1)} = \mu$, where α , μ called the development coefficient and ash effect volume respectively. The valid interval of α is $(-2, 2)$ and the matrix formed by α and μ is noted as the grey parameter $\hat{\alpha} = \begin{pmatrix} \alpha \\ \mu \end{pmatrix}$. By calculating α , μ , we can get $X^{(1)}(t)$ and predicted the value of $X^{(0)}$.

Step 4: Construct the data matrix B and the data vector Y

$$B = \begin{pmatrix} Z^{(1)}(2) & 1 \\ \vdots & \vdots \\ Z^{(1)}(n) & 1 \end{pmatrix} = \begin{pmatrix} -\frac{1}{2}(X^{(1)}(1) + X^{(1)}(2)) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}(X^{(1)}(n-1) + X^{(1)}(n)) & 1 \end{pmatrix}, Y_n = \begin{pmatrix} X^{(0)}(2) \\ \vdots \\ X^{(0)}(n) \end{pmatrix} \quad (8)$$

Step 5: Calculate the grey parameter $\hat{\alpha}$, $\hat{\alpha} = (B^T B)^{-1} B^T Y_n$, and bring the resulting $\hat{\alpha}$ into $\frac{dX^{(1)}}{dt} + \alpha X^{(1)} = \mu$, we can get the results of $\hat{X}^{(1)}(t+1) = \left(X^{(1)}(1) - \frac{\mu}{\alpha}\right) e^{-\alpha t} + \frac{\mu}{\alpha}$ and $\hat{X}^{(0)} = (\hat{X}^{(0)}(1), \hat{X}^{(0)}(2), \dots, \hat{X}^{(0)}(n), \hat{X}^{(0)}(n+1), \dots, \hat{X}^{(0)}(n+m))$.

Step 6: Calculate the posterior difference ratio C value and the small error probability p value.

5.2. Prediction results analysis

Since 2013, the Belt and Road connectivity construction has steadily advanced [65]. To further understand the trend of connectivity, we made the following forecasts for this part.

First, according to the results of the economy, transportation infrastructure, population, and land area groupings, we figured out that China has always actively supported other developing countries and promoted connectivity with them (Figures 4(a–d)). In particular, the Belt and Road countries with gaps in transportation infrastructure are ranked first in the connect index. Despite the fact that some countries are currently constrained by the great power game, economic backwardness, and international strategic structure, China's cooperation with developing countries still demonstrates good momentum [30]. For example, the China-Laos Railway was successfully put into operation recently, helping Laos realize the long-cherished dream of transforming itself from a “land-locked country” to a “land-linked country”. The Belt and Road builds a bridge between developed countries, emerging economies, and developing countries [66]. Therefore, enhancing connectivity with developing countries remains a priority option of the Belt and Road initiative.

Secondly, the forecast results of One Belt and One Road show that there are significant differences in the level of interconnection between them (Figure 4(e)). Numerous railroads, highways and other infrastructures, and industrial parks have sprung up, bringing benefits to the Belt and Road [67]. However, both One Belt and One Road involve a large number of countries, a complex and volatile geopolitical situation, and a variety of contradictions. In particular, there are some dissenting voices insisting on subjective and negative questions, such as the “debt trap” [68], the Chinese “Marshall Plan” [69] and the “geopolitical expansion theory” [17]. To prevent the “development pie” [70] from becoming a “governance trap” [71], China must pay attention to the differences between One Belt and One Road, and promote the synergistic development of them.

Finally, as shown in Figure 4(f), China's connect index with its neighboring countries is currently on a rapid rise but there are still some gaps in connectivity with its non-neighboring countries. By December 2020, 16 neighboring countries had signed cooperation documents with China on jointly building the Belt and Road. Especially in terms of facility connectivity, China has made significant progress in cooperation with its neighboring countries [72]. Nevertheless, the current political environment between China and its neighboring countries is experiencing inexhaustible variety, and there are still some countries who do not understand and accept the Belt and Road [73]. For this reason, China is supposed to attach great importance to the interconnection with its neighboring countries and establish peaceful and friendly neighborhood relations.

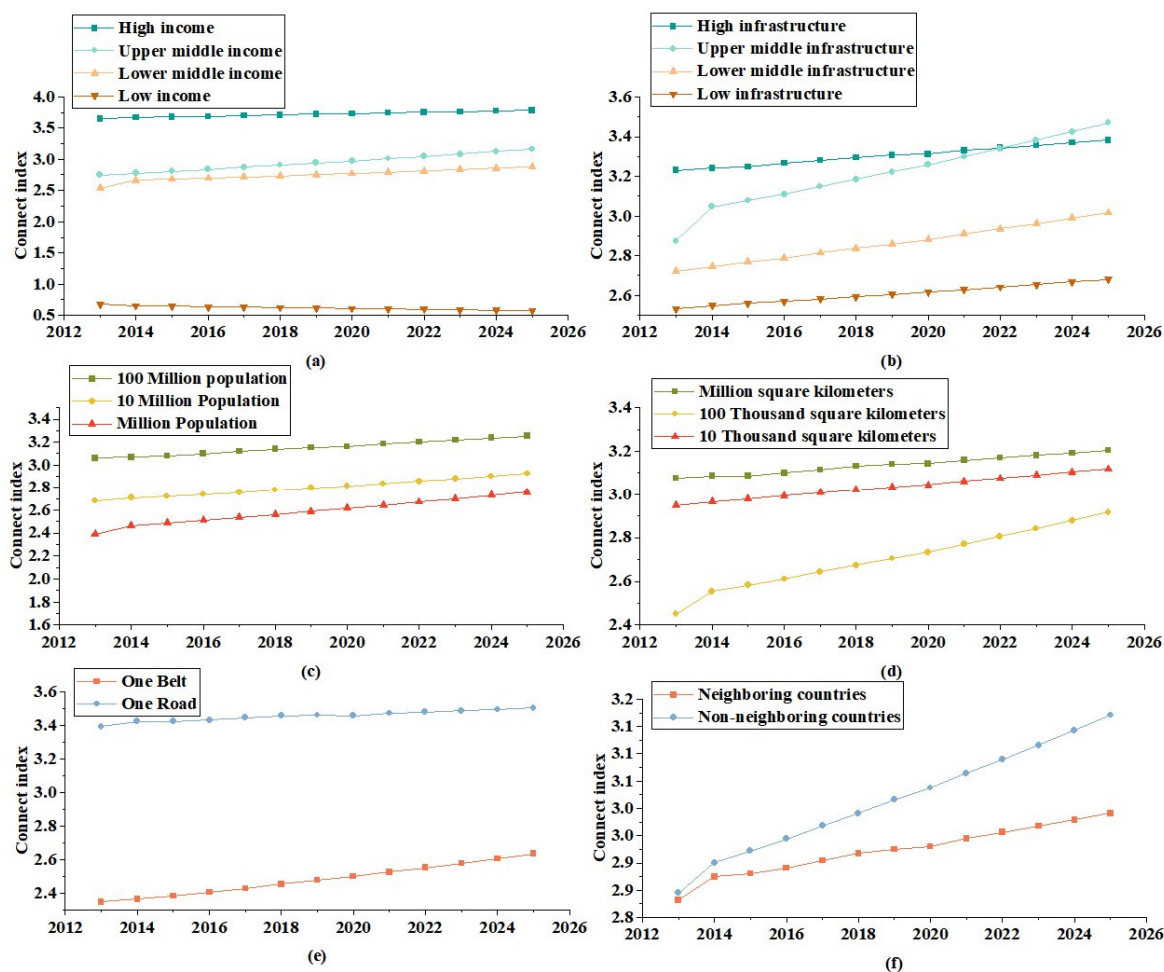


Figure 4. Sub-group prediction results of the Belt and Road countries.

5.2. Robust test

To further ensure the reliability of the research findings, this paper uses the data from 2013 to 2018 to predict the scores of connectivity between China and the Belt and Road countries in 2019 and 2020, and compares them with the actual values. The corresponding results are shown in Table 6. When comparing the predicted value and the actual value, 93% of the errors are within 0.01, indicating that the model predictions are robust.

Table 6. Robust test of prediction.

	Year	High income	Upper middle income	Lower middle income	Low income
Actual value	2019	3.722	2.941	2.754	0.615
	2020	3.731	2.971	2.771	0.607
Predict value	2019	3.720	2.941	2.754	0.615
	2020	3.730	2.975	2.772	0.608

Continued on next page

	Year	100-Million population	10-Million Population	Million Population	
Actual value	2019	3.152	2.796	2.590	
	2020	3.163	2.812	2.616	
Predict value	2019	3.155	2.794	2.589	
	2020	3.173	2.812	2.615	
	Year	Million square kilometers	100-Thousand square kilometers	10-Thousand square kilometers	
Actual value	2019	3.141	2.705	3.035	
	2020	3.143	2.733	3.045	
Predict value	2019	3.140	2.705	3.035	
	2020	3.153	2.736	3.049	
	Year	High infrastructure	Upper middle infrastructure	Lower middle infrastructure	Low infrastructure
Actual value	2019	3.307	3.222	2.859	2.605
	2020	3.312	3.258	2.883	2.617
Predict value	2019	3.310	3.218	2.860	2.604
	2020	3.324	3.254	2.884	2.616

6. Discussion

6.1. Omission areas

Based on the comprehensive judgment of Figures 4(a)–(b), there are 17 countries with low income, poor infrastructure, low population density, and small land area. Generally speaking, we can classify these developing countries as “omission areas” (Appendix 1). It is urgent for us to pay great heed to this key issue. A similar list of “weak countries” was also revealed by the research report on the Five Links Index of the Belt and Road Initiative (2018). However, their study was drawn from a simple country distinction, while our list of “omission areas” is more reasonable and consistent with objective facts.

Why are these 17 developing countries regarded as “omission areas”? This should be determined by a combination of factors such as geographical location, political attributes, and stage of social development. Geographically, most of these developing countries are located in the South, with narrow geographical areas, small populations, and lack of markets and resources. Politically, the above countries had historically been “marginal” countries in globalization [74,75]. In terms of the stage of socio-economic development, these developing countries still face the daunting task of facilitating economic development and improving livelihood improvement. As a result, the Belt and Road has the accountability to provide more opportunities for “omission areas” to strengthen cooperation in interconnection.

In the Belt and Road Initiative, all countries are equal regardless of their size, strength, and wealth. Besides, core and peripheral countries have the same treatment. In other words, the Belt and Road will never become a platform that “resents the poor and prefers the rich” unless it will deviate from its original purpose [76–78]. In the final analysis, strengthening connectivity with “omission areas” is a pressing issue that deserves high priority.

6.2. Structural imbalance between One Belt and One Road

As shown in Figure 4(e), there is a structural imbalance between One Belt and One Road. On the one hand, previous studies have highlighted the importance of the Silk Road on both land and sea [79,80]. On the other hand, our research revealed that One Belt is not functioning as smoothly as we expected, and unremitting efforts are required in terms of improving its connectivity. This is the second important finding which agrees with the initial judgment by Clarke [81] and Sárvári and Szeidovitz [82].

The reasons for the structural imbalance dilemma can be attributed to three objective factors. First, One Belt links the Asia-Pacific economic sphere to the developed European economic sphere, but most One Belt countries (mainly Central Asian countries) are in a “collapse zone”. The Central Asian region enjoys a key geographical position, which naturally can boost its process of interconnection. Second, One Belt is devoid of favorable natural conditions and adequate economic development. Especially the five northwestern provinces of China, from Gansu to Xinjiang, are nearly covered by desert land. The five Central Asian countries are also sparsely populated. These objective conditions slow down the process of interconnection. Third, the security problems caused by the game of great powers, regime change, and violent terrorist organizations in One Belt remain unresolved.

Therefore, to avoid and resolve the above complex problems, the foremost task is to put the “Silk Roads” on both land and sea into practice. In the “New Continental Age”, the structural imbalance can be alleviated by strengthening the connectivity of One Belt, promoting extensive exchanges and cooperation, and linking the Central Asian “collapse zone” with the European Union and the Asia-Pacific region as close as possible.

6.3. Proximity but not affinity

As shown in Figure 4(f), the connectivity gap between China’s neighboring countries and China’s non-neighboring countries is widening rather than narrowing, with China’s neighboring countries scoring low on policy coordination (Appendix 2). The characteristic of “proximity but not affinity” in China’s neighboring connectivity index has exposed China to great challenges.

The potential reasons for “proximity but not affinity” can be illustrated in the following aspects. First, China has the most complex surrounding environment. Both Central Asia and the Southeast Asian region have been strategic locations from the perspective of history and geopolitics [83,84]. China possesses a vast territory spanning Northeast Asia, Southeast Asia, South Asia, Central Asia, and even North Asia. It is surrounded by many countries featuring their different histories, cultures, ethnicities, and political systems. Second, over the past 40 years, China’s economic development rate has maintained a high level. Its Neighboring countries have a complex mindset mixed with a desire to ride on the coattails of China’s economic development and misgiving about interconnection [85,86]. Third, some territorial and maritime disputes between China and its neighboring countries have not been settled. The above-mentioned historical and practical issues are closely intertwined, which will adversely affect the will of connectivity.

7. Conclusions and policy implications

Given the above discussion, there are four main conclusions that we can draw.

First, this study establishes the indicator system to evaluate the connect index in five dimensions

of policy, infrastructure, trade, finance, and people's hearts. It also removes the potential subjective interference and interaction between indicators by the DANP method. The evaluation system can also be served as a tool to provide some useful information and have methodological implications for similar researches.

Second, the results indicate that the five dimensions of connectivity have not developed in a balanced manner, and the connect index gives a clear reflection of economic and geographical differences. How to promise a balanced development of interconnection has become a conundrum for the Belt and Road initiative. These are new findings in the research scope on the connectivity and has several policy implications for the B & R countries.

Third, we also found there are some "omission areas" of interconnection in the Belt and Road. These 17 countries (Appendix 1) are all characterized by low national income, poor infrastructure, low population density, and small land areas. Not drawn from a simple country distinction, our list of "omission areas" is more reasonable and consistent with objective facts. Such a finding is of great significance since how to avoid the marginalization of "omission areas" merits more global attention.

Finally, two other important findings are also crying for our cogitation and concern. One of them is the structural imbalance between One Belt and One Road, and the other is the relation featuring "proximity but not affinity" between China and its neighboring countries. As the primary regional and strategic backbone of the Belt and Road Initiative, the connectivity of One Belt and China with its neighboring countries is urgent for instant improvement. These important findings can raise alarm bells for all relevant countries.

The policy implications of this paper are as follows:

First, policy communication is currently the weakest part, which is reflected in the key findings of the "omission areas", the structural imbalance, and China's "proximity but not affinity" with its neighboring countries. If policy coordination is not in place, the other connectivity will be problematic [87–89]. Countries named "weak areas" have huge differences in national circumstances and embrace very complex historical and geographical factors. Consequently, it is all the more urgent for China and the Belt and Road countries to acquire some tactical skills and political wisdom to promote the full alignment of strategies and policies. Besides, they are supposed to actively propel the development of bilateral and multilateral cooperation mechanisms, such as forums, summits, as well as international conferences between think tanks and policy research institutions.

Second, the low scores in terms of facility connectivity indicate that there is still some space for improvement in infrastructure connectivity. Therefore, on the premise of respecting the sovereignty, security, and religious customs, attention should be paid to the protection of biodiversity and the ecological environment as much as possible, and to properly deal with the relationship between local labor and trade unions. What's more, the Belt and Road initiative needs to strengthen international cooperation in the anti-corruption campaigns, righteously safeguard national interests and images in overseas construction, and avoid letting infrastructure construction become a "noose" that will weaken its influence.

Finally, our key findings indicate that there are three "weak areas" in the Belt and Road. Since these areas are the primary regions and strategic dependencies, it is particularly crucial to address these dilemmas. For this purpose, the Belt and Road countries should abandon the exclusive "center-marginal" view, bridge the development gap between developed and developing countries, and prevent small, poor, and weak countries from being "marginalized". Moreover, China should actively pursue a partnership rather than confrontation or an alliance with other countries, a westward Belt and Road

initiative, closer interconnection of the “weak areas”, as well as a virtuous circle of “sea-land confrontation” and less “Eurasian continental geopolitical competition”.

There are still some limitations in this paper. Firstly, we only selected 63 countries along with Belt and Road as evaluation objects, but there are 140 countries and 32 organizations that have participated in the Belt and Road initiative. Therefore, future studies need to further expand the number of evaluation objects. Secondly, as the promotion of green Belt and Road has become a new consensus, some green development indicators can be selected into the green connectivity evaluation system, such as the number of the cooperation project in green infrastructure, green energy, green trade, green finance and green technology. Thirdly, the follow-up researchers can pay attention to dynamic monitoring and surveillance of the Belt and Road connectivity.

Acknowledgments

We are grateful for the financial support provided by the National Natural Science Foundation of China (No.71463010, No.72164007 and No.72064005), the Natural Science Foundation of Guangxi Province (No.2020GXNSFAA159041), the Philosophy and Social Science Planning Research Project of Guangxi Province (No.21FYJ053) and research participants for their suggestions for the design of this study.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1

List of “Omission Areas” in the Belt and Road

Country name	Region	Income group	Infrastructure Rank	Population (10,000)	Land area (sq.km)
Afghanistan	South Asia	Low income	66	390	652,860
Albania	Europe & Central Asia	Upper middle income	34	28	27,400
Bhutan	South Asia	Lower middle income	52	7.716	38,144
Iran	Middle East & North Africa	Lower middle income	41	840	1,600,000
Iraq	Middle East & North Africa	Upper middle income	45	400	434,128
Kyrgyz Republic	Europe & Central Asia	Lower middle income	50	66	191,800
Lebanon	Middle East & North Africa	Upper middle income	57	68	10,230
Moldova	South Asia	Upper middle income	38	5.405	300
Maldives	Europe & Central Asia	Upper middle income	58	26	32,890
Montenegro	Europe & Central Asia	Upper middle income	63	6.217	13,450
Nepal	South Asia	Lower middle income	39	290	143,350
Serbia	Europe & Central Asia	Upper middle income	36	69	87,460
Syrian Arab Republic	Middle East & North Africa	Low income	35	180	183,630
Turkmenistan	East Asia & Pacific	Upper middle income	42	13	14,870
Timor-Leste	Europe & Central Asia	Lower middle income	65	60	469,930
Ukraine	Europe & Central Asia	Lower middle income	69	440	579,290
Yemen, Rep.	Middle East & North Africa	Low income	71	300	527,970

Note: The data of infrastructure ranking is gathered from *the Belt and Road Countries Infrastructure Development Index Report 2021*.

Appendix 2

Average of the connect index of Chinese neighboring countries in the Belt and Road

Country name	Mean-A	Mean-B	Mean-C	Mean-D	Mean-E	Mean-F
Afghanistan	0.206	N/A	N/A	N/A	N/A	0.206
Bhutan	0.048	N/A	0.398	0.999	0.849	2.294
Brunei Darussalam	0.322	0.755	0.640	1.072	N/A	2.789
India	0.318	0.482	0.735	1.212	N/A	2.747
Indonesia	0.208	0.547	0.789	1.218	1.189	3.950
Kazakhstan	0.272	0.715	N/A	1.170	1.130	3.287
Malaysia	0.365	0.652	0.809	1.224	1.253	4.302
Mongolia	0.301	0.601	0.790	1.090	0.942	3.724
Myanmar	0.309	0.468	0.756	1.028	0.973	3.533
Nepal	0.285	0.386	0.608	1.065	N/A	2.344
Philippines	0.239	0.461	0.699	1.156	1.088	3.643
Russian Federation	0.278	0.716	0.798	1.255	N/A	3.047
Tajikistan	0.229	N/A	0.707	0.989	0.784	2.709
United Arab Emirates	0.342	0.737	0.802	1.160	N/A	3.040
Vietnam	0.358	0.497	0.808	1.151	N/A	2.814

Note: N/A means the value is missing due to the absence of original data.



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