

The Belt and Road Initiative and the Deepening of Global Trade Networks

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Abstract: After the Belt and Road Initiative (BRI) was introduced, its main goal has been to construct a community of shared future for mankind. This paper examines the positive effects of BRI on the participating countries from the perspective of trade networks. It applies the Harmonized System (HS) 6-digit product export data in the CEPII-BACI database from 2009 to 2018. The paper constructs a trade network without China at the product level and measures the PageRank centrality, reflecting the position of a country in this network. Then it adopts a difference-in-differences (DID) method to examine the impact of BRI on the trade networks of these countries. The main findings are as follows: First, BRI has significantly deepened the trade networks of these countries. The PageRank centrality of these countries increased by 2.7% to 12.9%. Second, the heterogeneous effect analysis suggests that geographically, trade networks along the 21st Century Maritime Silk Road are strongly promoted. Third, the results of the difference-in-differences-in-differences (DDD) show that the trade networks of BRI countries trading key products were more strongly promoted. Moreover, BRI countries in the communities of China, Singapore, or India developed more extensively in their trade networks. Fourth, the positive effect of BRI can be explained through six aspects: policy coordination, facilities connectivity, unimpeded trade, financial integration, people-to-people bonds, and industry-chain cooperation.

Keywords: Belt and Road Initiative (BRI), Trade Network, PageRank Centrality, Difference-in-differences Method (DID)

I. INTRODUCTION

When visiting Kazakhstan and Indonesia in September and October 2013,

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Chinese President Jinping Xi introduced the major initiatives of jointly building the Silk Road Economic Belt (SREB) and the 21st Century Maritime Silk Road (MSR). Since its inception, the Belt and Road Initiative (BRI) has pursued extensive consultation and joint construction, and has steadily promoted policy coordination, facilities connectivity, unimpeded trade, financial integration, and people-to-people bonds. President Xi pointed out that “trade is an important engine of economic growth”, and that the scale of trade between China and the BRI countries had continuously expanded. From 2013 to 2020, the trade volume of goods between China and the BRI countries increased from \$1.04 trillion to \$1.35 trillion,¹ and its share in China’s total trade in goods increased from 25% to 29.1%.² At the same time, trade linkages between BRI countries have also strengthened, with a World Bank Research Group study indicating that BRI has increased trade linkages between these countries by 4.1%.³ The Outline of the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and Vision 2035 of the People’s Republic of China emphasized the promotion of high-quality BRI development as the key aspect of China’s advancement of high-standard economic liberalization and the development of a new scenario centering on win-win cooperation. This outline also stressed China’s need to rely on its advantage of an enormous market to promote international cooperation, achieve mutual benefits, enable BRI to steadily attain joint progress, and promote efforts to build a community with a shared future for mankind. At the third symposium on the construction of BRI in November 2021, President Xi stressed the necessity to unswervingly advance the high-quality development of the joint construction of BRI and make new and greater contributions to promoting the building of a community with a shared future for mankind. Since the financial crisis, the slowing of globalization, the trade friction between China and the US, and the COVID-19 pandemic have increased overall global economic uncertainty.⁴ Currently, the most

1 In this paper, the word “country” is used to refer to “country or region”.

2 This data comes from *China’s Belt and Road Trade and Investment Development Report 2021*.

3 Baniya, Nadia Rocha and Michele Ruta, Trade Effects of the New Silk Road: A Gravity Analysis, *Journal of Development Economics*, Vol. 146, 2020, p. 102467.

4 Asian Development Bank, Global Value Chain Development Report 2021: Beyond Production, <https://www.adb.org/publications/global-value-chain-development-report-2021> (Last Visited on November 16, 2021).

important concern of every country in the world is to find a way to achieve global economic recovery and establish win-win cooperation. Therefore, in order to keep building the BRI and boost the global economy, China should not only pay attention to the economic effects that BRI has on China, but also comprehensively assess and examine whether and how BRI can promote the trade competitiveness of its countries, which is directly related to building a community with a shared future for mankind.

A trade network is an important indicator to measure a country's trade competitiveness in the context of specialized global value chains (GVCs),⁵ because it considers a country's global trade links from the perspective of intricate international trade relationships, and reflects a country's trade status and competitiveness in the world more comprehensively. The social network method is used to analyze trade networks, and research based on it originated in sociology. Granovetter (1985) first proposed the concept of "the problem of embeddedness" (behaviors and institutions are constrained by social relations) to study the impact of social relations within enterprises.⁶ On this basis, many scholars have begun to apply this method to study trade networks, which involves using international trade data to construct a global trade network index intended to explore the typical characteristics and influencing factors of world trade networks.⁷ Compared with traditional empirical analysis methods such as the gravity model, the advantage of trade network analysis is its ability to holistically depict the characteristics of the system and incorporate the heterogeneity and complexity of each member.⁸ The literature mainly

5 Junjie Hong and Hui Shang, The Conjoint Circulation Theory of China's Open Economy: Theory and Argumentation, *Social Sciences in China*, Vol. 1, 2019, pp. 42–64; Shuzhong Ma, Wanwan Ren and Guojie Wu, Characteristics of a Country's Agricultural Trade Network and Its Impact on the Division of Global Value Chains – Based on the Perspective of Social Network Analysis, *Journal of Management World in China*, Vol. 3, 2016, pp. 60–72.

6 Mark Granovetter, Economic Action and Social Structure: The Problem of Embeddedness, *American Journal of Sociology*, Vol. 3, 1985, pp. 481–510.

7 Ma Angeles Serrano and Marián Boguná, Topology of the World Trade Web, *Physical Review E*, Vol. 1, 2003, p. 15101; Diego Garlaschelli and Maria I. Loffredo, Structure and Evolution of the World Trade Network, *Physica A: Statistical Mechanics and Its Applications*, Vol. 1, 2005, pp. 138–144.

8 Luca De Benedictis and Lucia Tajoli, The World Trade Network, *The Journal of World Economy*, Vol. 8, 2011, pp. 1417–1454.

emphasizes the determinants of trade networks from the perspectives of geography, population, technology, economy, institution, openness, and policy.⁹ However, very few studies examine the determinants of trade networks from the perspective of policy shocks, which provides a beneficial topic for this paper to research trade networks' deepening effect of BRI by implementing the difference-in-differences (DID) event shock analysis method.

In fact, the literature studying the impact of BRI from different aspects is gradually increasing, such as investment,¹⁰ GVCs,¹¹ financing constraints,¹² productivity,¹³ low-carbon economy¹⁴ and economic development.¹⁵ Additional research analyzes the impact on national trade. Baniya et al. (2020) used geo-referenced data and Geographical Information System (GIS), finding that the time of trade transportation between capitals, ports, and major cities of BRI countries increased dramatically since the implementation of BRI, which greatly contributed to the total amount of bilateral exports of the BRI countries.¹⁶ Yu et al. (2020) analyzed China's export data from 2008 to 2016, and concluded that the BRI significantly improved the index of China's potential for trade to the BRI countries.¹⁷ Lu et al. (2021) examined firm data from the China Customs Import and Export Database from 2010 to 2015 and

9 Antoine Berthou and Helene Ehrhart, Trade Networks and Colonial Trade Spillovers, *Review of International Economics*, Vol. 4, 2017, pp. 891–923; *Supra* n. 8.

10 Julan Du and Yifei Zhang, Does One Belt One Road Initiative Promote Chinese Overseas Direct Investment? *China Economic Review*, Vol. 47, 2018, pp. 189–205; Shu Yu, Xingwang Qian and Taoxiong Liu, Belt and Road Initiative and Chinese Firms' Outward Foreign Direct Investment, *Emerging Markets Review*, Vol. 41, 2019, p. 100629.

11 Zhibiao Liu and Fuxiang Wu, Double Embedding of Global Value Chain under the Belt and Road Initiative, *Social Sciences in China*, Vol. 8, 2018, pp. 17–32.

12 Si Xu et al., The Belt and Road Initiative and Chinese Firms' Financial Constraints, *China Industrial Economics*, Vol. 7, 2019, pp. 155–173.

13 Guijun Wang and Hui Zhang, The Belt and Road Initiative and the TFP of China's OFDI Enterprises: A Perspective on Investing in Developed Countries, *The Journal of World Economy in China*, Vol. 5, 2020, pp. 49–72.

14 Ya Chen et al., How Can Belt and Road Countries Contribute to Global Low-carbon Development? *Journal of Cleaner Production*, 2020, p. 120717.

15 Hong Song, The Construction of Country Image in the New Framework of China's Openness – Empirical Evidence from the Belt and Road Initiative, *China Economic Quarterly*, Vol. 1, 2021, pp. 241–262.

16 *Supra* n. 3.

17 Linhui Yu et al., Does the Belt and Road Initiative Expand China's Export Potential to Countries along the Belt and Road? *China Economic Review*, Vol. 60, 2020, p. 101419.

used DID to analyze city-level data from the China City Statistical Yearbook to find that BRI significantly boosted the high-quality exports of Chinese firms.¹⁸ It is worth noting that most of these papers focus on China's exports to BRI countries or bilateral exports between these countries. However, there is no in-depth discussion on whether and how BRI has facilitated the development of China's trade networks with these countries, which makes it impossible to comprehensively and thoroughly test the positive effects of BRI on the building of a community with a shared future for mankind. This provides opportunities for this paper to achieve a research breakthrough.

Since the implementation of BRI, the “five connectivities”(policy coordination, facilities connectivity, unimpeded trade, financial integration, people-to-people bonds) have been the focus of cooperation, which has greatly facilitated communication and connectivity as well as trade network expansion among the BRI countries. Additionally, in its report “The Belt and Road Initiative Progress, Contributions and Prospects 2019”, the Office of the Leading Group for Promoting the Belt and Road Initiative recognized industrial cooperation as another form of progress that BRI has achieved. The BRI countries have been further integrated into the international division of labor, and industry-chain cooperation has become a new driving force to rapidly develop their trade networks.¹⁹ Therefore, this paper argues that BRI will promote the development of trade networks in BRI countries through the following six channels: policy coordination, facilities connectivity, unimpeded trade, financial integration, people-to-people bonds, and industry-chain cooperation.

The first channel is policy coordination. BRI can promote the development of trade networks among BRI countries by demonstrating policy coordination. By the end of January 2020, 138 countries and 30 international organizations signed more than 200 cooperation agreements with China, and BRI was included in important documents of the Shanghai Cooperation Organization

18 Shengfeng Lu et al., Does “the Belt and Road Initiative” Promote High-quality Exports – Evidence from Firms in China, *China Industrial Economics*, Vol. 3, 2021, pp. 80–98.

19 Office of the Leading Group for Promoting the Belt and Road Initiative, The Belt and Road Initiative Progress, Contributions and Prospects, https://www.gov.cn/yaowen/liebiao/202311/content_6916832.htm?mc_cid=8d8547b4a1 (Last Visited on November 24, 2023).

(SCO), the United Nations (UN), and the G20. The successful hosting of two Belt and Road Forums for International Cooperation also promoted cooperation and mutual trust among participating countries and international organizations. With the signing and implementation of cooperation documents between China and other countries, BRI has been a model for policy coordination, meaning that BRI countries have not only strengthened their own policy coordination and political mutual assistance with other countries, but also further attracted and encouraged other countries to join BRI, thus strengthening the development of the trade networks of BRI countries. Wang et al. (2019) determined that strong policy coordination can promote trade through three channels: increasing mutual trust, signing free trade agreements, and strengthening top-level political cooperation.²⁰ Yang and Liu (2015) noticed that the deterioration of political relations significantly reduced China's trade with other East Asian countries.²¹

The second channel is facilities connectivity. The trade cost of facilities connectivity is important for deepening the BRI trade network. China has continuously cooperated with BRI countries to build shipping, railway, and other infrastructure networks. As mentioned in the Big Data Report on Belt and Road (2018), by April 5, 2018, a total of 7,891 China-Europe freight trains had run with 65 domestic routes and traveled in 43 domestic cities stably, connecting 42 cities in 14 European countries. Breakthroughs have been made in major cooperation projects such as the China-Thailand, China-Laos, and Hungary-Serbia railways, along with Khalifa Port in the United Arab Emirates and Hambantota Port in Sri Lanka. In addition, economic cooperation corridors have also been gradually promoted, which include the New Asia-Europe Continental Bridge Economic Corridor, the China-Mongolia-Russia Economic Corridor, and the China-Central Asia-West Asia Economic Corridor. Inadequate infrastructure investment is a problem for many BRI countries, and

20 Jue Wang, Ang Li and Mao Zhou, The Impact of Bilateral Political Relational Distance on China's Export Trade: A Research Based on the UNGA Vote Data, *Contemporary Finance & Economics in China*, Vol. 1, 2019, pp. 96-107.

21 Gongyan Yang and Hongzhong Liu, Political Relations, Trade Flows, and the Economic Power: Evidence from East Asia, *World Economics and Politics in China*, Vol. 12, 2015, pp. 110-130.

infrastructure investment driven by facilities connectivity can greatly reduce the cost of trade for these countries. For example, the improvement of traditional infrastructure can facilitate the cross-regional flow of factors, reducing the transport cost of goods from inland areas to borders or ports.²² Furthermore, the development of new infrastructure like the Internet can reduce information asymmetry, lowering the cost of information barriers to trade and helping BRI countries to overcome bottlenecks obstructing the development of trade networks.²³

The third channel is unimpeded trade. BRI can use the spillover effect of unimpeded trade to promote the expansion of trade networks in BRI countries. This initiative has improved unimpeded trade in its participant countries. Since the first Belt and Road Forum for International Cooperation in 2017, China, BRI countries, and international organizations have actively promoted customs inspection and quarantine cooperation, and as of the end of January 2020, China and the BRI countries agreed on food quarantine access for more than 50 kinds of agricultural products. In addition, China established green channels with Kazakhstan, Tajikistan, and Kyrgyzstan to facilitate rapid customs clearance of agricultural products, shortening customs clearance time by up to 90%. Improved levels of unimpeded trade in BRI countries not only significantly reduce customs clearance time when trading with China, but also use spillover effects to influence trade clearance with other countries, which broadens the scale of unimpeded trade, thereby deepening trade networks between BRI countries and other countries. Portugal-Perez and Wilson (2012) noticed that unimpeded trade promotes the development of a country's exports,²⁴ while Hoekman and Shepherd (2015) discovered that unimpeded trade not only promotes the trade growth of multinational enterprises in developed countries, but also contributes to a remarkable reduction in the trade costs of small and

22 Chongen Bai and Dongxin Ji, Road to Export: Evidence from China's National Trunk Highway System, *The Journal of World Economy in China*, Vol. 1, 2018, pp. 101–122.

23 Štefan Bojnec and Imre Fertő, Impact of the Internet on Manufacturing Trade, *Journal of Computer Information Systems*, Vol. 1, 2009, pp. 124–132.

24 Alberto Portugal-Perez and John S. Wilson, Export Performance and Unimpeded Trade Reform: Hard and Soft Infrastructure, *World Development*, Vol. 7, 2012, pp. 1295–1307.

medium-sized enterprises (SMEs) in developing countries.²⁵

The fourth channel is financial integration. The easing effect of financing constraints of financial integration is another important channel for BRI to promote the development of trade networks. At present, China and the BRI countries have continuously explored new modes of international investment and financing, strengthened multilateral financial cooperation, and improved the construction of the financial market system in order to ensure the steady development of the financial markets of these countries. By the end of 2018, the Asian Infrastructure Investment Bank (AIIB) had 93 members, whose approved loans had exceeded \$7.5 billion, generating more than \$40 billion in investments. Nowadays, the BRI countries have many infrastructure construction projects and extensive prospects for production capacity cooperation. The easing effect of financing constraints resulting from financial integration will boost the development of trade networks. The new-new trade theory implies that enterprises need to overcome the fixed costs of searching for market information and establishing overseas sales channels, while the financing constraints will lead to enterprises being unable to bear these fixed costs, thus restricting their exports. Lu and Sheng (2015) explained that firms with stronger financing capabilities can export, while firms with the strongest financing capabilities can make foreign direct investments.²⁶ Chaney (2016) suggested that if firms must pay a fixed entry cost to gain access to foreign markets and are limited by financing constraints, only firms with sufficient liquidity are able to export.²⁷

The fifth channel is people-to-people bonds. The cultural spillover effect of people-to-people bonds in the BRI can further promote the integration and growth of trade networks among BRI countries. After BRI was introduced, cultural exchanges have been productive and diverse, and international

25 Bernard Hoekman and Ben Shepherd, Who Profits from Unimpeded Trade Initiatives? Implications for African Countries, *Journal of African Trade*, Vol. 2, 2015, p. 51.

26 Yue Lyu, and Bin Sheng, Do Financial Constraints Affect Firms' Internationalization? An Empirical Analysis Based on China's Firm, *World Economy Studies in China*, Vol. 9, 2015, pp. 13–21.

27 Thomas Chaney, Liquidity Constrained Exporters, *Journal of Economic Dynamics and Control*, Vol. 72, 2016, pp. 141–154.

collaboration has been continuously enhanced, creating a robust foundation for generating public opinion. By the end of January 2020, the number of BRI countries, with which China has concluded mutual visa-free agreements covering different passport types, had exceeded 57. The number of BRI countries reaching agreements to simplify visa procedures had exceeded 15. In 2018, as many as 30.54 million foreign tourists travelled to China, with many coming from BRI countries, such as Singapore, Vietnam, and Russia. The process of people-to-people bonds is also beneficial to increase the sense of identity and trust between countries, regions and cultures. This effect will further spill over into product trade, helping the trade goods of BRI countries to gain recognition and trust from other countries, thus developing their trade network. Shi (2016) proposed that cultural identity can reduce the cost of contract implementation during the transaction process and thus promote trade.²⁸ Xu et al. (2015) analyzed the influencing factors of high-end manufacturing trade networks in the BRI countries, and observed that cultural factors such as religion and language were important factors that affected trade networks.²⁹

The sixth channel is industry-chain cooperation. The value chain upgrading effect of industry-chain cooperation is also one of the channels through which BRI promotes the development of trade networks in its countries. BRI has promoted the formation of an industry chain for inclusive and shared development. China has reached industrial cooperation agreements with more than 40 BRI countries, and established numerous cross-border economic cooperation zones with Kazakhstan and Laos. Accompanied by the undertaking and transfer of production processes, as well as the learning and overflow of advanced technologies, the BRI countries have naturally promoted the depth of their participation in regional value chains or GVCs,

28 Bingzhan Shi, Cultural Identification and International Trade, *The Journal of World Economy in China*, Vol. 5, 2016, pp. 78–97.

29 Helian Xu, Tianyang Sun and Lihong Cheng, Trade Patterns and Influence Factors of High-end Manufacturing on “One Belt and One Road” – A Study Based on the Exponential Random Graph Models, *Finance & Trade Economics in China*, Vol. 12, 2015, pp. 74–88.

and facilitated the upgrading of value chains while sharing, cooperating and being integrated with other BRI countries and additional countries in the industrial chain. A country's participation in GVCs will profoundly affect the development of its trade network, as enterprises increase worldwide purchasing or exporting of intermediate goods when they participate more extensively in the international division of labor, which further promotes their trade links with other countries, thus facilitating the expansion of their trade networks. Yao et al. (2019) determined that the degree of industrial integration and the network of intermediate goods between China and the BRI countries have continued to develop.³⁰ Yang (2019) argued that a country's trade in value added can make a significantly positive contribution to economic links, thus favoring the development of its trade network.³¹

Therefore, based on the existing literature, this paper measures the PageRank centrality index of the country-product dimension by using the bilateral export data at the product level (HS 6-digit) of the world's countries in the CEPII-BACI database sourced from 2009 to 2018, and empirically researches the impact of the implementation of BRI on the trade networks of the BRI countries, using the estimation method of the DID model. Compared with existing studies, the contributions of this paper are mainly in the following three aspects. First, in terms of the research theme, this paper examines the promotion effect of participation in BRI on the development of trade networks in the BRI countries based on social network analysis, which enriches the literature on the impact of BRI. It not only verifies the role of BRI in improving the trade competitiveness of the BRI countries, but also highlights the contributions of BRI to inclusive global economic growth, in order to comprehensively and objectively evaluate the contribution of BRI to building a community of shared future for mankind. Second, in terms of the research content, this paper uses

30 Xing Yao et al., China's Level and Status of Industry Convergence in the Belt and Road Initiative: Industry Comparisons, Regional Gaps and Associated Factors, *Economic Research Journal in China*, Vol. 9, 2019, pp. 172–186.

31 Jijun Yang, The Effect of Value-added Trade on Global Economic Linkages, *Social Sciences in China*, Vol. 4, 2019, pp. 26–48.

DID to empirically test the effects and internal mechanisms of BRI on the trade networks of the BRI countries, thus further extending the discussion focus of BRI's effect on the trade network from what to why. Third, in terms of research data, compared with the country-level³² and city-level³³ data used in most of the previous BRI studies, this paper uses the latest and highly detailed country-product dimension export trade network data, which contains 5,077 kinds of products from 223 economies throughout the world from 2009 to 2018 with as many as 7,188,754 observations. It is a broader and more comprehensive sample of observations before and after the introduction of BRI.

The structure of this paper is as follows: the second part introduces the empirical method, data, and variables; the third part analyzes the empirical results, including the benchmark regression, robustness check, placebo test, heterogeneity analysis, DDD analysis based on the key products of BRI and trade network communities, and analyzes the BRI mechanism to promote the development of trade networks; the fourth part is the conclusions and inspirations.

II. EMPIRICAL SPECIFICATION AND DATA

A. Specification

This paper chooses the time when BRI was introduced as the node of the event shock and used DID estimation strategy to study the impact of BRI on countries' product-level trade networks. Specifically, this paper refers to Lu et al. (2019)³⁴ to construct the following empirical model:

$$\ln \text{PageRank}_{pct} = \beta \text{treat}_c \times \text{Post}_t + \mathbf{X}_{ct} \boldsymbol{\theta} + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (1)$$

32 Xiaobin Tang and Maosheng Cui, Research on the Dynamic Change of Goods Trade Network Structure and Its Impact Mechanism of Countries along the Belt and Road, *Journal of Finance and Economics in China*, Vol. 7, 2020, pp. 138–153.

33 *Supra* n. 3; Yue Lyu, and Yaning Wei, Firms' Trade Network and Domestic Value Added of Exports in Global Value Chains, *The Journal of World Economy in China*, Vol. 12, 2020, pp. 50–75.

34 Yue Lyu, et al., The Effect of the Belt and Road Initiative on Firm's OFDI: Evidence from China's Greenfield Investment, *Economic Research Journal in China*, Vol. 9, 2019, pp. 187–202.

Where p represents the 6-digit product of HS 1996 version, c represents the country, and t represents the time; $\ln \text{PageRank}_{pct}$ is the logarithm of PageRank centrality; $\text{treat}_c \times \text{Post}_t$ is the interaction term of the dummy variable treat_c of whether it is a BRI country³⁵ (1 if it is a BRI country, 0 otherwise) and the dummy variable Post_t of the time effect of the treatment group (1 for 2013 and after, 0 otherwise); In addition, X_{ct} represents a series of time-varying control variables controlled in this paper, μ_{pc} is the product-country fixed effect, δ_{pt} is the product-time fixed effect, and ε_{pct} is the random error term.

B. Description of Variables

1. Dependent Variable: PageRank Centrality

This paper uses the PageRank centrality calculated based on the PageRank algorithm as the dependent variable. From the perspective of a country, like the traditional trade network indicators, when a product from a country has a greater PageRank centrality, this product is sold to more countries, which means that it is in a more central position in the global trade network and occupies an important position in global trade. For another, from the perspective of trading partner countries, a product with a higher PageRank centrality from a country has a greater influence on this country's trading partner countries in its trade network. For example, a country has established closer trade relations with China and other trading powers. In addition, studies show that the increase of a country's PageRank centrality has other welfare impacts. Hong and Shang (2019) learned that a country's PageRank centrality can reflect its ability to control resources and can promote its ability to form a strong leading capacity in the international division of labor network.³⁶ Lu and Wei (2020) also saw that PageRank centrality has a major role in shaping the position of GVCs.³⁷ Bao and Dan (2021) argued that PageRank centrality can reflect the degree of

35 For information on the BRI countries, refer to the Belt and Road Network data on each country, <https://www.yidaiyilu.gov.cn/jcsjpc.htm> (Last Visited on August 16, 2024).

36 Junjie Hong and Hui Shang, The Determination Mechanism of Centrality in International Trade Networks, *Journal of International Trade in China*, Vol. 10, 2019, pp. 1–16.

37 *Supra* n. 33.

integration of an individual into the overall network as well as the size of its influence, which can help this individual to diversify its risk and uncertainty.³⁸

This paper constructs a trade network matrix to prepare for calculating PageRank centrality. HS 1996 products with different t each year have their own trade network matrix. Each node in the matrix is a country trading with other countries. The edge indicates whether a country exports to another country, and has a direction. Thus, the overall trade network is composed of the node and the edge combined with the direction. Specifically, A^{pt} represents the matrix of product p in year t , a_{ij} is the element of whether country i exports to country j in the matrix, $a_{ij}=1$ means that country i 's actual exports to country j are above 0, otherwise $a_{ij}=0$.

The PageRank algorithm is required to calculate PageRank centrality. The revised PageRank algorithm used in this paper is as follows: Firstly, the initial value is set, and an initial value of PageRank centrality of $1/N$ is assigned to each country, making the sum 1. N is the total number of countries in the current year. Secondly, the PageRank centrality of all countries is iterated. Step k $PageRank(k)_{pit}$ is obtained by $PageRank(k-1)_{pit}$ iteration of step $k-1$. Specifically, the PageRank centrality calculated in the previous step of each country is equally assigned to its export destination country with the weight of the country's export degree ($outdegree_{pit} = \sum_j a_{ij}$) based on the probability of α . In addition, $(1-\alpha)/N$ is added to the PageRank centrality of all countries to solve the problem that some special directed networks cannot converge normally, such as the import black hole network³⁹ and the circle network. α is set at 0.85 in reference to Brin and Page (1998)⁴⁰. Finally, repeat the previous step. The change in the PageRank centrality of each country will become increasingly slighter. When the PageRank value of all countries no longer changes, the calculation stops and the final PageRank centrality of each country will be

38 Qun Bao and Jiali Dan, Network Centrality, Shared Business Ties and Share of Large Business Partners, *Economic Research Journal in China*, Vol. 10, 2021, pp. 189-205.

39 A node with an output of 0 is represented in the trade network as a country with no exports.

40 Sergey Brin and Lawrence Page, The Anatomy of a Large-scale Hypertextual Web Search Engine, *Computer Networks and ISDN Systems*, Vol. 30, 1998, pp. 107-117.

obtained. The specific calculation formula is as follows:

$$PageRank(k)_{pit} = \alpha \sum_{j=1}^N a_{ji}^{pt} \frac{PageRank(k-1)_{pjt}}{outdegree_{pjt}} + \frac{1-\alpha}{N} \quad (2)$$

Where p is the HS 6-digit product, i is the country, t is the year, α is set to 0.85,⁴¹ a_{ij} is whether country i exports to country j , $PageRank(k)_{pit}$ is the PageRank center obtained by the k^{th} iteration, the out-degree centrality $outdegree_{pit} = \sum_j a_{ij}^{pt}$, and N is the total number of countries. It should be noted that, as this paper explores the impact of BRI on the trade network of the BRI countries, China, the initiator of BRI as well as a big trading country, will have an important impact on the PageRank centrality of the BRI countries. Therefore, it is impossible for this paper to distinguish whether the increase in the PageRank centrality of these countries is the result of the strengthening of trade cooperation with China or the increase in trade links with other countries throughout the world. As a result, when measuring the centrality of each country's PageRank, this paper excludes China's trade with other countries to more clearly identify the effect of the deepening of the trade network between the BRI countries and other countries throughout the world.

2. Control Variables

Hong and Shang (2019) discovered that the development of a country's trade network is affected by its comparative advantages, including production, market, and trading.⁴² Among them, the comparative advantage of production is related to technological progress⁴³ and population structure,⁴⁴ the comparative advantage of market mainly refers to the market size of the home country,⁴⁵ and

⁴¹ *Ibid.*

⁴² *Supra* n. 36.

⁴³ Yifu Lin, Development Strategy, Viability and Economic Convergence, *China Economic Quarterly*, Vol. 1, 2002, pp. 269-300; Robert Stehrer and Julia Wörz, Technological Convergence and Trade Patterns, *Review of World Economics*, Vol. 2, 2003, pp. 191-219.

⁴⁴ Wei Tian and Miaojie Yu, Firm's Export Intensity and Import Intermediates Trade Liberalization: An Empirical Study from Chinese Firms, *Journal of Management World in China*, Vol. 1, 2013, pp. 28-44; Fang Cai, Understanding the Supply-side Perspective of China's Economic Slowdown, *Economic Perspectives in China*, Vol. 4, 2016, pp. 14-22.

⁴⁵ *Supra* n. 7.

the comparative advantages of trading relate to the institutional environment⁴⁶ and the degree of openness.⁴⁷ Specifically, (i) Technological progress (*ln Tech*): the progress a country gains in terms of technology can provide a comparative advantage for its trade, improve its trade patterns, and thus promote the development of its trade network. Therefore, this paper introduces the number of resident as well as non-resident patent applications (logarithmic treatment) as a proxy variable to control the level of a country's technological progress. (ii) Demographic structure (*Labor*): a strong demographic structure can improve a country's human capital and raise productivity by guaranteeing a sustainable new labor force and optimizing the efficiency of labor resource allocation, thus providing a robust foundation to expand trade networks. In this paper, the proportion of the labor-age population to the total population is used to measure the demographic structure. (iii) Market size (*lnPop*, *Urban*): the market size of the home country has an important impact on the trade network, and countries with a large market size often have sufficient capital and advanced innovative technology to ensure the development of their trade networks. Therefore, this paper chooses the total population (logarithmic treatment) and the level of urbanization (the proportion of urban population to the total population) to comprehensively consider the extent of a country's market size. (iv) Institutional environment (*Institution*): a robust institutional environment can not only guarantee the long-term stable operation of the domestic economy, but also attract foreign resources and trade flows, thus enabling a country to continuously develop into a trade network hub. In this paper, institutional quality is chosen as an indicator to measure a country's trade environment. (v) Degree of openness (*Tariff*): the degree of openness is another important factor affecting the development of trade networks. It is reflected in the fact that when the degree of openness to the outside world increases and the tariff level continuously reduces, the cost of the country obtaining imported intermediate inputs will continue to decrease. As a result, its export profits will increase, and the trade network will eventually become even denser. Therefore, this paper

⁴⁶ *Supra* n. 29.

⁴⁷ *Supra* n. 8.

uses the weighted average tariff of imported products from each country to indicate its degree of openness. The descriptive statistics of variables are as follows.

C. Data Description

This paper uses merged data from the CEPII-BAC database of the French

Table 1: Descriptive Statistics of Variables

Variable	Variable Interpretation	Observations	Average Value	Standard Deviation	Minimum	Maximum
<i>lnPageRank</i>	PageRank centrality	7,188,754	-5.362	0.691	-7.303	-0.432
<i>lnTech</i>	Number of patent applications	2,000	3.627	3.684	0.000	13.316
<i>Labor</i>	The proportion of working-age population to the total population	1,825	0.636	0.070	0.472	0.864
<i>lnPop</i>	Total population	1,993	15.318	2.338	9.204	21.025
<i>Urban</i>	The proportion of urban population to the total population	1,993	0.600	0.236	0.104	1.000
<i>Institution</i>	Institutional quality	1,910	-0.057	0.909	-2.384	1.873
<i>Tariff</i>	The weighted average tariff of products	1,407	1.654	0.689	0.000	3.601
<i>lnODA</i>	Net value of foreign aid	1,749	2.888	7.276	0.000	24.262
<i>lnLSCI</i>	Liner transportation connectivity index	1,573	2.690	1.009	-0.601	4.708
<i>Burden</i>	Customs procedure burden (1 means extremely low efficiency, 7 means extremely high efficiency)	1,198	1.383	0.220	0.531	1.867
<i>Finance</i>	The proportion of savings currency bank assets in GDP	1,682	0.640	0.558	0.003	8.203
<i>Tourism</i>	The proportion of international tourism expenditure in imports	1,550	0.068	0.045	0.002	0.281
<i>lnDVA</i>	Export domestic value-added	1,760	14.748	4.921	0.000	21.559

Center for International Economic Research, the World Development Index (WDI) database, and the Worldwide Governance Indicators (WGI) database. Among these, PageRank centrality is calculated by using the 1996 version of HS 6-digit product-level bilateral trade data for all countries in the CEPII-BACI database. In addition, the number of resident and non-resident patent applications, the proportion of the working-age population to the total population, the total population, and the level of urbanization (the proportion of urban population to the total population), and the weighted average tariff of products are from the WDI database, while the institutional quality⁴⁸ data is from the WGI database. The sample time dimension of this paper is from 2009 to 2018, involving 223 economies and 5,077 kinds of products.

III. EMPIRICAL RESULTS AND ANALYSIS

A. Baseline

To verify the promotion effect of the trade network of BRI countries, this paper conducts an econometric analysis according to formula (1), and the regression results are shown in Table 2. In column (1), this paper only conducts regression on the core explanatory variable $treat_c \times post_t$. Preliminary results show that the implementation of BRI significantly promotes the development of trade networks of BRI countries, with PageRank centrality increasing by 12.9%. This result passes the 1% significance level test. In addition, in the baseline regression, this paper considers the impact of technological progress, population structure, domestic market size, institutional environment, and degree of openness on the trade network. Therefore, in column (2), it controls the number of resident and non-resident patent applications, the proportion of working-age population to the total population, the total population, and the

⁴⁸ This includes the measurement of six dimensions: voicing power and accountability system, political stability and elimination of violent terrorism, government efficiency, supervision quality, rule of law level and corruption control. In this paper, the influence of each dimension is comprehensively considered, and the average value is chosen to measure the quality of a country's institution.

Table 2: Baseline Regression Results

	(1)	(2)	(3)	(4)	(5)
$treat \times post$	0.129*** (0.024)	0.033** (0.017)	0.027** (0.010)	0.027*** (0.010)	0.028** (0.011)
Control Variable		√	√	√	√
Country-fixed Effect			√	√	
Time-fixed Effect			√		
Product-fixed Effect			√		
Product-time-fixed Effect				√	√
Product-country-fixed Effect					√
Observations	7,188,754	5,252,023	5,252,021	5,251,787	5,204,727
R ²	0.006	0.359	0.533	0.542	0.810

Note: Standard errors clustered to the country-time level are shown in parentheses, ***, **, and * denote significance levels of 1%, 5% and 10%, respectively, as in the table below, which will not be reported repeatedly due to space constraints.

level of urbanization (proportion of urban population to the total population), the institutional quality, and the weighted average tariff of products. The regression results indicate that the coefficient and significance resemble those in column (1), which further confirms the views of this paper. Thirdly, since the dependent variable is PageRank centrality of country-product dimension, there may be an influence caused by the unobservable factors of time, country, and product level. Therefore, in column (3), this paper further controls fixed effects of time, country, and product, and the estimated coefficient of the core explanatory variable is still robust. That is, BRI will significantly promote the deepening and development of the trade network of the BRI countries, and the PageRank centrality of these countries increased by 2.7%. Finally, this paper further controls the more stringent joint fixed effects, including product-fixed, time-fixed, and country-fixed effects, and the regression results are shown in column (4). This paper simultaneously controls product-time and product-country fixed effects, and the regression results are shown in column (5). The coefficient of $treat_c \times post_t$ is still significantly positive, thus verifying the basic conclusions of this paper.

B. Robustness Check

1. Parallel Trend Test

DID has a most basic premise assumption: there should be the same trend of change in the treatment and control groups before the shock, which refers to the parallel trend assumption. This paper referred to the method of Liu and Qiu (2016),⁴⁹ and set up the following regression equation to conduct the parallel trend test:

$$\ln \text{PageRank}_{pct} = \beta_k \sum_{k=-3}^5 \text{treat}_c \times \text{post}_{2013+k} + \mathbf{X}_{ct} \boldsymbol{\theta} + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (3)$$

To more directly display the trend before and after the shock, k is used to represent the time interval from the shock year. k in 2013 is denoted as 0; if it is before 2013, k is negative; otherwise, k is positive. Other conditions are consistent with the baseline regression model. The test results are shown in Figure 1. It can be found that when $k < 0$, the coefficients of the interaction terms are all near 0; when $k > 0$, the coefficients of the treatment group are significantly improved compared with the control group, and with the extension of the shock time, the coefficients show a trend of gradual increase, thus the variables passed the parallel trend test.

2. Consideration of Time Trends in Treatment Groups

Compared with other BRI countries, there may be a fixed trend of change in their trade networks. For example, the Maritime Silk Road has highly efficient transportation, is large-scale, emphasizes globalization, and features a trade network⁵⁰ that is more developed over time. Therefore, this paper refers to Li et al. (2016)⁵¹ and adds the time trend of the treatment group in column (1) of Table 3 to control the possible change trend of the treatment group. The regression results show that the core explanatory variable was still positive and

49 Qing Liu and Larry D. Qiu, Intermediate Input Imports and Innovations: Evidence from Chinese Firms' Patent Filings, *Journal of International Economics*, Vol. 103, 2016, pp. 166–183.

50 Wanling Chen and Chuantian He, Game between Parties and Economic Orientation of the Maritime Silk Road, *Reform in China*, Vol. 3, 2014, pp. 74–83.

51 Pei Li, Yi Lu and Jin Wang, Does Flattening Government Improve Economic Performance? Evidence from China, *Journal of Development Economics*, Vol. 123, 2016, pp. 18–37.

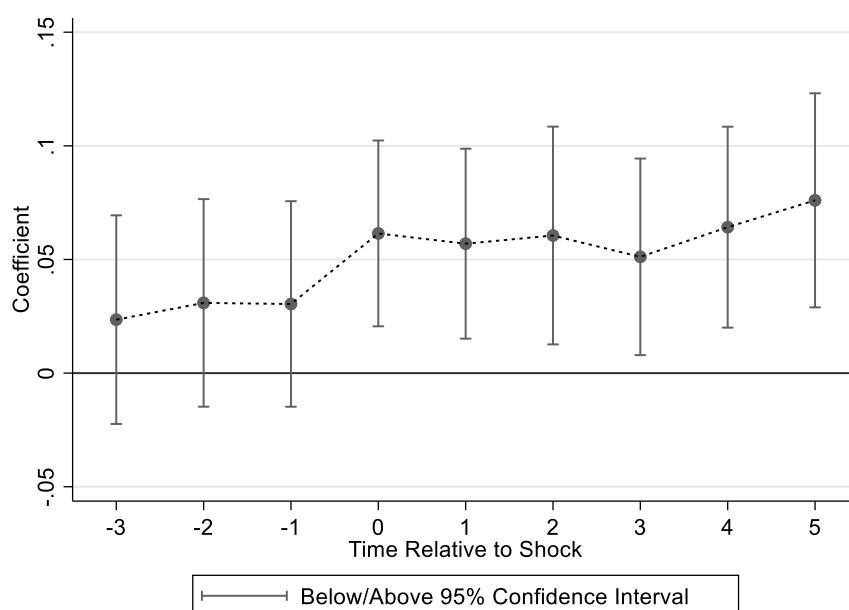


Figure 1: Parallel Trend Test

passed the 1% significance test. It verifies that BRI can significantly promote the development of trade networks of BRI countries.

3. Anticipatory Effects

Since the world economy was slowly recovering before the introduction of BRI, strengthening inter-regional cooperation and exchanges has been an important driving force for promoting global economic development and has become a trend. Considering that some countries may anticipate the proposal of this policy and change their trade status in advance, which disproves the hypothesis of parallel trends, this paper also tests whether the introduction of BRI has anticipatory effects. In this paper, the samples from 2012 and later are set as 1 and recorded as $post_{2012}$. After interacting with the variable $treat$, they are added to the benchmark regression. The regression results are shown in column (1) of Table 3. It indicates that the coefficient of $treat \times post_{2012}$ is not significant and is negative, showing that there is no anticipatory effect.

4. Placebo Test

First, it is assumed that BRI was introduced before 2013. The prerequisite for using DID for analysis is that there is no significant difference in the change trend of PageRank centrality between the treatment and control groups before the shock. Therefore, if the samples before the shock were selected, there should be no significant difference in PageRank centrality between the treatment and control groups. Therefore, this paper conducts the first placebo test, and selects the samples before the introduction of BRI, that is, before 2013, for regression. The regression results show that the coefficient of *treat* is not significant, and thus pass the test.

Table 3: Robustness Check Regression Results I

	Time Trends in Treatment Groups (1)	Anticipatory Effect (2)	Placebo Test I (3)
<i>treat</i> × <i>post</i>	0.029*** (0.001)	0.033*** (0.012)	
<i>treat</i> × <i>year</i>	-0.000 (0.000)		
<i>treat</i> × <i>post</i> ₂₀₁₂		0.019 (0.019)	
<i>treat</i>			0.011 (0.025)
Control Variables	√	√	√
Product-time-fixed Effect	√	√	√
Product-country-fixed Effect	√	√	
Observations	5,204,727	5,204,727	2,245,066
R ²	0.810	0.811	0.427

Note: All subsequent regressions control for control variables as well as product-time fixed effects and product-country fixed effects. Due to length limitations, they are not repeated in this table.

Second, randomly select treatment groups and shock time points. In addition, this paper conducts the second placebo test and repeats 500 random

selections of treatment groups and shock time points for regression analysis. The Kernel Density Plot of the estimated coefficients after random selection and regression reveals that the mean value of the obtained regression coefficients is close to 0, and the empirical results of this paper pass the robustness check.

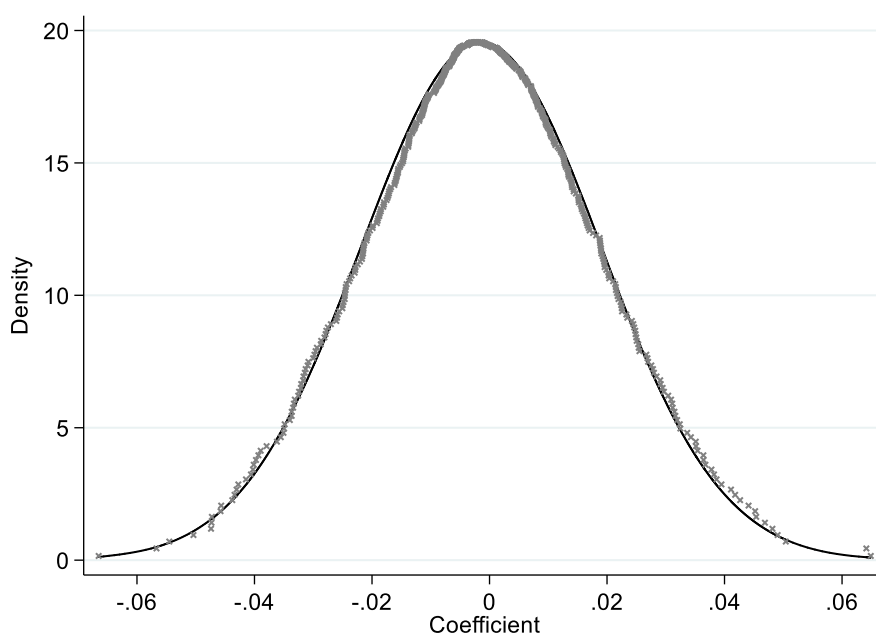


Figure 2: Placebo Test II: Kernel Density Map of Randomly Selected Estimated Coefficients

5. Alternative Dependent Variables

In this paper, PageRank centrality is used to measure the characteristics of a country's trade network for a product, but other indicators can reflect the characteristics of this network. To make the results of this paper more robust, it also refers to Ma et al. (2016),⁵² changes the measurement method of trade networks, and selects the most typical centrality index relative point degree (*ndeg*) to replace it with another one. In addition, the measurement of PageRank

⁵² *Supra* n. 5.

centrality is based on whether a country exports, and it does not include the export intensity of a country. Therefore, this paper uses two weighted centrality measures: strength and disparity, which consider the export intensity of each country for robustness.⁵³

The expressions of relative point degree (*ndeg*), relative point strength (*strength*), and node difference (*disparity*) are as follows:

$$ndeg_{pit} = \sum_j \bar{a}_{ij}^{pt} / (N-1) \quad (4)$$

$$strength_{pit} = \sum_j \bar{w}_{ij}^{pt} \quad (5)$$

$$disparity_{pit} = \frac{(N-1) \sum_j \left(\frac{\bar{w}_{ij}^{pt}}{strength_{pit}} \right)^2 - 1}{N-2} \quad (6)$$

Among these, p represents the product, i and j represent the countries, t represents the year. $\bar{a}_{ij}^{pt}$ represents whether there is direct trade (including import or export) between country i and country j , and if there is trade, it is 1. N is the number of countries in the network, $\bar{w}_{ij}^{pt}$ is the average import and export value of country i and country j divided by the largest average import and export value of the two countries in the network in that year. The measures of relative point degree (*ndeg*), relative point strength (*strength*), and node difference (*disparity*) resemble how PageRank centrality was previously measured, which all exclude trade between China and other countries. Relative point degree (*ndeg*) reflects the breadth of a country's exports in the trade network, and relative point strength (*strength*) reflects the trade intensity of a country in the trade network, considering not only whether a country imports and exports, but also its import and export values. Node difference (*disparity*) reflects the degree of dispersion of a country's trade distribution, which means whether its trade is concentrated or dispersed. If the trade distribution between a country and other countries is even, the *disparity* is 0. If a country's trade is concentrated in one country, the *disparity* is 1.

It can be seen that from column (1) to column (3) in Table 4, the

⁵³ Ibid.

implementation of BRI can promote the increase of the relative point degree and relative point intensity of a country, and reduce its difference of nodes, which passes the significance level test of 1%. That is, when the robustness check employs other indicators of the trade network, it still supports the core conclusions of this paper.

In addition, since the above relative point degree (*ndeg*) and relative point strength (*strength*) indicators do not consider the import and export networks of each country separately, which means that when they use an undirected network, it is impossible to identify whether BRI promotes the import or export network of its countries. This paper further constructs the directed network of distinguishing between exports and imports of countries throughout the world, and respectively constructs the relative export degree (*noutdeg*) and relative export intensity (*noutstr*) from the perspective of export network and constructs the relative import degree (*nindeg*) and relative import intensity (*ninstr*) from the perspective of import network. The specific indicators are calculated as follows:

$$noutdeg_{pit} = \sum_j a_{ij}^{pt} / (N - 1) \quad (7)$$

$$noutstr_{pit} = \sum_j w_{ij}^{pt} \quad (8)$$

$$nindeg_{pit} = \sum_j a_{ji}^{pt} / (N - 1) \quad (9)$$

$$ninstr_{pit} = \sum_j w_{ji}^{pt} \quad (10)$$

Like the previous paragraph, a_{ji}^{pt} indicates whether country i exports to country j . If they export, it is 1. w_{ji}^{pt} is the export of country i to country j divided by the largest export in the network that year. The results from column (4) to column (7) in Table 4 show that the results of relative export degree (*noutdeg*), relative export intensity (*noutstr*), relative import degree (*nindeg*), and relative import intensity (*ninstr*) are all significantly positive. The results show that BRI did not only promote the development of the export network of the BRI countries, but also promoted the development of the import network. A further comparison of the coefficients of column (4) and column (6) along with a comparison of the coefficients of column (5) and column (7) show that BRI has a stronger role in promoting the export network of its countries than the

import network.

6. Eliminating Resource-based Products

Since PageRank centrality is calculated based on whether a country exports a certain product and considering some products such as resource-based products naturally have more trade destinations, some countries with more resource-based products have a particularly high PageRank centrality index without considering the export value, which causes that the PageRank centrality of resource-based products cannot reflect the true centrality of a country. Therefore, this paper refers to the definition of resource-based export products in the World Trade Report 2010: Trade in Natural Resources, and matches the 2-digit industry codes of the Standard International Trade Classification (SITC) 3rd Edition, including fisheries, raw materials, fuels, and minerals,⁵⁴ with the 6-digit industry codes of the HS 1996 version. The samples of these resource-based products are excluded to check for robustness. The regression results are shown in column (8) of Table 4. These indicate that the coefficients of the core explanatory variables are positive at the 5% significance level after the exclusion of the exports of these resource-based products, reflecting that BRI still has the effect of promoting the trade network of these countries.

7. Staggered DID

BRI includes two economic belts, the SREB and the MSR, and comprises 64 countries (39 SREB countries and 25 MSR countries). In fact, since BRI was introduced in 2013, more and more countries have signed BRI cooperation documents with China. By the end of January 2020, China had signed 200 of these documents with 138 countries and 30 international organizations. The rising number of countries signing these documents with China has demonstrated an upward trend every year, from 5 countries in 2013 to 61 countries in 2018. From 2013 to 2018, a total of 119 countries signed cooperation documents with China.

⁵⁴ The 2-digit industry codes of SITC 3rd Edition resource products are: Fisheries (03), Raw materials (21, 23, 24, 25, 26, 29), Fuels and Minerals (27, 28, 32, 33, 34, 35, 68).

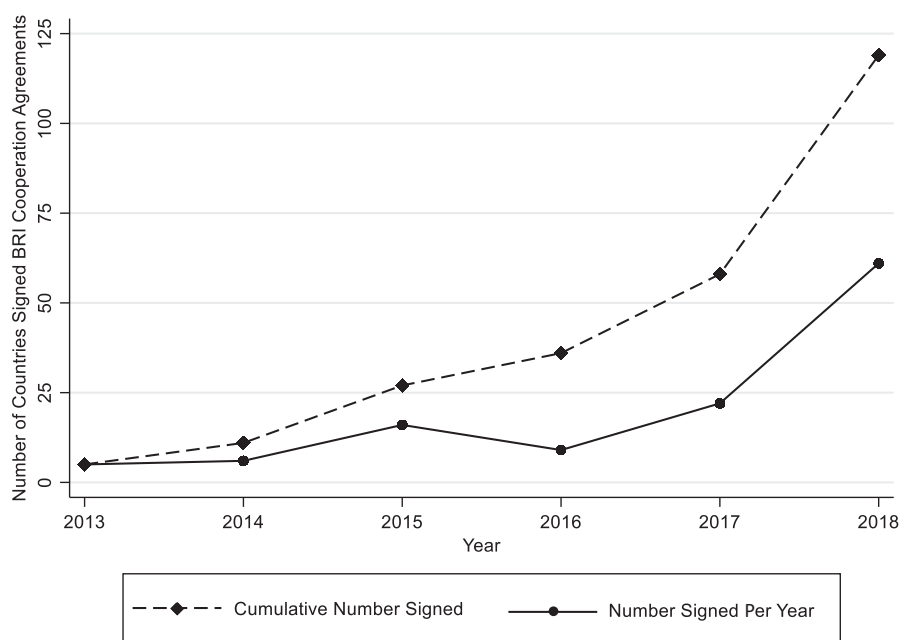


Figure 3: The Trend of Countries Signing the Belt and Road Initiative Cooperation Agreement

To make the core results of this paper more robust, this paper considers the potential impact of the subsequent signing of BRI cooperation documents on the trade networks of various countries and uses the staggered DID model to conduct a robustness check. The regression model is as follows:

$$\ln PageRank_{pct} = \beta sign_{ct} + X_{ct}\theta + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (11)$$

Different from the baseline regression, if a country signed BRI cooperation document in the year, the country's $sign_{ct}$ in the year and thereafter is recorded as 1, otherwise it is recorded as 0. According to the column (9) of Table 4, it can be found that the results based on staggered DID still support the conclusion that BRI will promote the development of trade networks in various countries after considering the different time nodes of cooperation agreements signed by different countries.

In addition, by referring to the method of Beck et al. (2010), this paper conducts a parallel trend test on staggered DID.⁵⁵ The results are shown in Figure 4. These show that the regression coefficients of countries before signing cooperation documents (shocks) are all around 0, which passes the parallel trend test. The effect of countries signing the BRI cooperation documents on the centrality of PageRank is significantly positive.

Table 4: Robustness Check Regression Results 2

	Alternative Dependent Variables							Eliminating Resource-based Products	Staggered DID
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	lnndeg	lnstrength	ln disparity	lnnoutdeg	lnnoutstr	lnnindeg	lnninstr	lnPageRank	lnPageRank
<i>treat</i> × <i>post</i>	0.075*** (0.013)	0.152*** (0.019)	-0.035*** (0.007)	0.006*** (0.001)	0.008*** (0.001)	0.002*** (0.001)	0.006*** (0.001)	0.027** (0.011)	
<i>sign</i>									0.009*** (0.001)
Observations	5,204,727	5,204,727	5,204,671	5,204,727	5,204,727	5,204,727	5,204,727	4,686,583	5,204,727
R ²	0.943	0.918	0.807	0.982	0.928	0.948	0.910	0.807	0.810

C. Heterogeneity Analysis

BRI has included the SREB and MSR since it was introduced. Therefore, it is necessary to explore the heterogeneity of their effects on promoting the trade networks of BRI countries. For this reason, this paper refers to Chen and He (2014)'s method of differentiating MSR countries from SREB countries,⁵⁶ and classifies these countries as MSR countries (including the three routes of China-Red Gulf and the west coast of the Indian Ocean, China-South Asia and the Persian Gulf, and China-Southeast Asia). Other BRI countries are classified as SREB countries to conduct heterogeneity analysis. The regression model is as follows:

$$\ln \text{PageRank}_{pct} = \beta_{sea_c} \times \text{Post}_t + \mathbf{X}_{ct} \boldsymbol{\theta} + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (12)$$

$$\ln \text{PageRank}_{pct} = \beta_{land_c} \times \text{Post}_t + \mathbf{X}_{ct} \boldsymbol{\theta} + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (13)$$

⁵⁵ Beck, T., Levine, R. and Levkov, A., Big Bad Banks? The Winners and Losers from Bank Deregulation in the United States, *The Journal of Finance*, 2010, Vol. 65, No. 5, pp. 1637-1667.

⁵⁶ Wanlin Chen and Chuantian He, The Game of the Maritime Silk Road and Its Economic and Trade Positioning, *Reform*, No. 3, 2014, pp. 74-83.

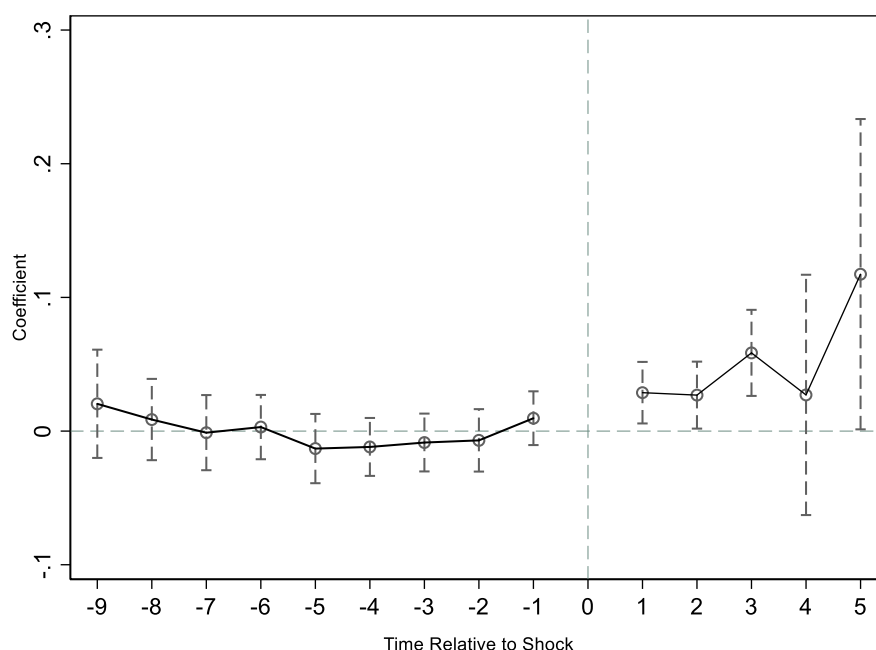


Figure 4: Staggered DID Parallel Trend Test

Among them, $sea_c \times Post_t$ is the interaction term of whether it is the MSR country dummy variable and the treatment group time effect dummy variable. $land_c \times Post_t$ is the interaction term of whether it is the SREB country dummy variable and the treatment group time effect dummy variable. The results are presented in Table 5, where group (1) is only for the MSR countries, and group (2) is only for the SREB countries.

The results show that the implementation of BRI has a significant promoting effect on the development of the trade network of Maritime Silk Road (MSR) countries, but not on Land Silk Road (LSR) countries. This paper argues that there are three possible reasons for this result: first, in terms of political risk, MSR countries have stable political situations compared with SREB countries, thus overseas investment and other economic risks are lower.⁵⁷ Second, in terms of trade and infrastructure, they have extensive

⁵⁷ *Supra* n. 34.

coastlines and ideal shipping conditions. Most MSR countries are located along important shipping routes, sea lanes, or coastal economic belts, and have more convenient shipping infrastructure. Last, in terms of trade liberalization, MSR countries have a higher degree of openness because of their more open trade environment. For example, Singapore, an ASEAN member, is a highly open free trade port and basically has zero tariffs. As a result, MSR countries can more effectively benefit from BRI's trade network deepening effect.

Table 5: Heterogeneity Analysis Regression Results

	(1)	(2)
<i>sea×post</i>	0.060*** (0.018)	
<i>land×post</i>		0.003 (0.011)
Observations	3,935,073	4,358,400
R ²	0.815	0.820

D. DDD Based on BRI Key Products and Trade Network Community

1. Analysis of BRI Key Products

Vision and Proposed Actions Outlined on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road issued by the National Development and Reform Commission, the Ministry of Foreign Affairs, and the Ministry of Commerce clearly mentions that in-depth industry cooperation should be strengthened to achieve complementary advantages among countries, specifically involving the following industries: agricultural and aquatic products processing, agricultural machinery, mariculture and ocean fishing, biopharmaceuticals, coal mining, oil and gas mining, new energy, deep processing of energy resources, food and beverage processing machinery, construction engineering consulting services, information and communication technology, building materials, and other industries. Therefore, this paper first matches the 4-digit industries of the 3rd edition of the International Standard

Industry Classification (ISIC Rev.3) with the 6-digit industry code of the HS 1996 version, and then identifies the key products involved in BRI. Finally, this paper sets the following DDD model for analysis:⁵⁸

$$\ln \text{PageRank}_{pct} = \beta_1 \text{treat}_c \times \text{post}_t \times \text{product}_p + \beta_2 \text{treat}_c \times \text{post}_t + \mathbf{X}_{ct} \boldsymbol{\theta} + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (14)$$

In this equation, if a product is one of the key products involved in BRI, the *product* is denoted as 1, otherwise denoted as 0. According to the regression results in column (1) of Table 6, the implementation of BRI has a more positive impact on the development of the trade network consisting of key products of BRI.

2. Analysis of Communities

The trade networks include some countries that trade more closely within the region, and the trade links between them form trade communities. Within these communities, members trade more with each other and have less contact with countries outside the community. To explore whether the trade networks of the BRI countries have developed more effectively within the community of China in the global trade network during the implementation of BRI, this paper conducts further community analysis of the trade networks⁵⁹ at the national level in 2009 and 2018.⁶⁰ It should be noted that this requires an undirected weighted matrix. Thus, this paper constructs the following trade network matrix by referring to Xiao et al. (2017)'s method:⁶¹ the directed weighted matrix of $N \times N$ for year t is represented by the matrix B' , where t equals to 2009 or 2018.

58 Other dual interaction terms and separate terms in the model will be absorbed by the joint product-country and product-time fixed effects, thus they are not controlled.

59 Since the bilateral trade data at the product level is too complicated, to make the analysis results more intuitive, this paper sums them up to the national level for community analysis.

60 Since the composition of countries in the community changes every year, to make the results more robust, this paper selects the data of the first and last two years (2009 and 2018) for community analysis. In addition, this paper analyzes the community situation of the implementation year of BRI (2013) and the triple-difference regression. Due to length limitations, it is not reported in the main body. Interested readers can ask the author for the regression results.

61 Hao Xiao et al., Complex Network Analysis for Characterizing Global Value Chains in Equipment Manufacturing, PLOS ONE, No. 12, 2017, p. 0169549.

b_{ij} is an element in row i and column j of the matrix B^t , representing the export value of country i to country j . On this basis, this paper further constructs the undirected weighted matrix W , where the element is $w_{ij}=(b_{ij}+b_{ji})/2$.

In community analysis, modularity is often used to measure the quality or structural strength of community divisions in a network. The algorithm constructed by Newman and Girvan (2004) calculates the density of intra-community connections relative to inter-community connections.⁶² The formula is as follows:

$$Q = \frac{1}{2m} \left[w_{ij} - \frac{D_i D_j}{2m} \right] \delta(c_i, c_j) \quad (15)$$

In this formula, Q is the modularity and its value is between -1 and 1. $D_i = \sum_j w_{ij}$ measures the sum of the weights of the edges of node i . m is the sum of all the connected edges in the network, $m = \sum_{i,j} w_{ij} / 2$. If nodes i and j belong to the same community C , $\delta(c_i, c_j)$ is 1, otherwise 0.

In addition, this paper uses the BGLL algorithm, which is suitable for hierarchical community structure analysis in weighted networks. The calculation is mainly divided into two steps. The first step assumes that each node is an independent community, and then calculates the modularity increment of node i after joining its neighboring nodes one by one. When the maximum modularity increment is positive, node i is added to its node community, otherwise, node i remains in the original community. Repeat until no more merges occur. The second step is to construct a new network within the community divided in the first step, and then use this method to divide the second level of community, and so on until no higher level of community can be divided.

To more intuitively reflect the community situation in 2009 and 2018, this paper uses Ucinet6 to plot the trade network. This paper draws Figure 5 with reference to the method of Zhou et al. (2016)⁶³ to extract the most important

62 M. E. J. Newman and M. Girvan M., Finding and Evaluating Community Structure in Networks, *Physical Review E*, Vol. 2, 2004, p. 026113.

63 Min Zhou, Gang Wu and Helian Xu, Structure and Formation of Top Networks in International Trade, 2001–2010, *Social Networks*, Vol. 44, 2016, pp. 9–21.

information from the entire trade network. Specifically, this paper retains only the data of the largest importing country for each country, which means that the maximum value of each column element in the matrix B' is 1, and the remaining elements are 0. On this basis, this paper reflects the community information⁶⁴ and PageRank centrality⁶⁵ of each country in the figure.

a. Community analysis based on global trade networks

Figure 5⁶⁶ and Figure 6 indicate that: firstly, there were 4 communities in 2009 and only 3 communities in 2018, showing that the multi-centralized pattern of the global trade network is becoming stable. Secondly, from the perspective of the composition of the communities, it shows the three pillars of the society are centered on China, Germany, and the United States. Finally, as depicted in the figures, China-centered and US-centered communities are more

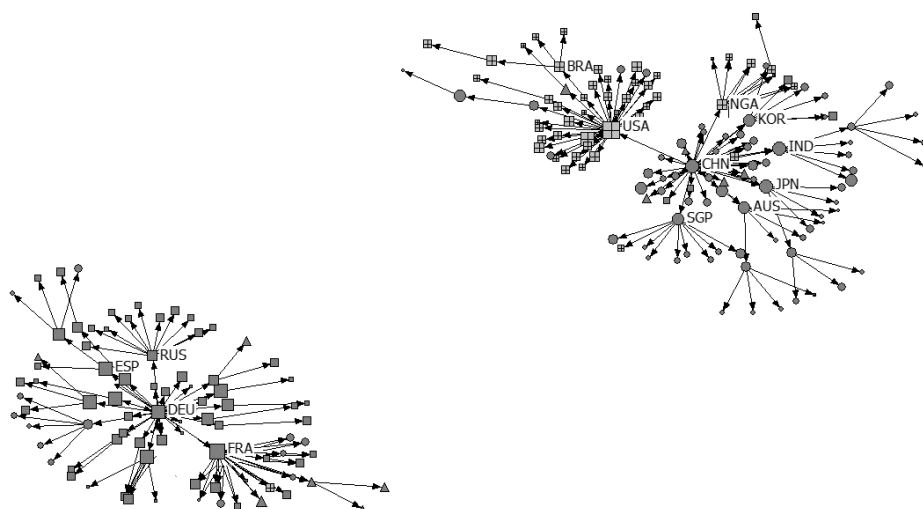


Figure 5: TOP1 Global Trade Network Communities in 2009

64 The community of China is represented by a circle. The community of Germany is represented by a square. The community of the United States is represented by a cross square. The other communities are represented by a gray triangle.

65 The PageRank centrality here is the national-level data. When a country has a larger PageRank value, it has larger nodes in the graph.

66 The English abbreviations in Figures 5 and 6 are: CHN China, USA America, DEU Germany, SGP Singapore, AUS Australia, JPN Japan, IND India, KOR The Republic of Korea, NGA Nigeria, BRA Brazil, FRA France, RUS Russia, ESP Spain, TUR Turkey, GBR England, and ZAF South Africa.

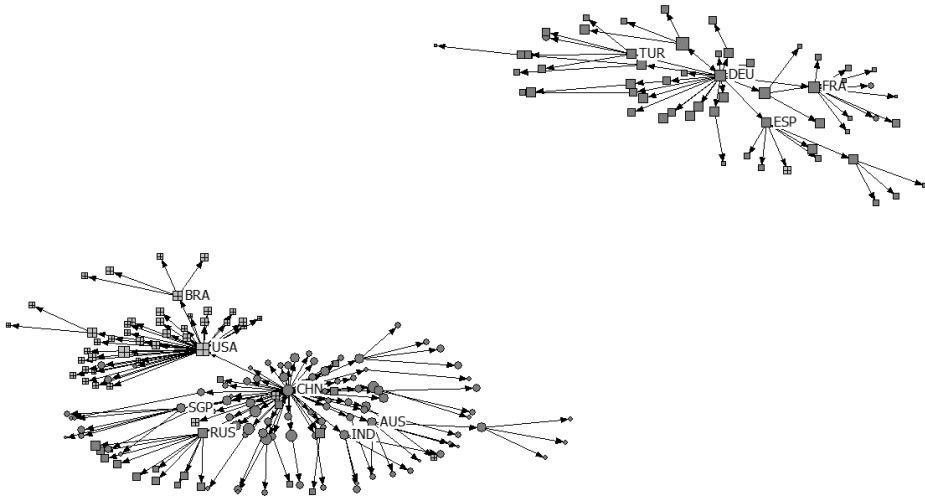


Figure 6: TOP1 Global Trade Network Communities in 2018

closely connected than Germany-centered communities.⁶⁷

Combined with these community analysis results, this paper sets up a DDD regression model, which is as follows:

$$\ln \text{PageRank}_{pct} = \beta_1 \text{treat}_c \times \text{post}_t \times c_community_c + \beta_2 \text{treat}_c \times \text{post}_t + \beta_3 \text{post}_t \times c_community_c + \mathbf{X}_{ct} \boldsymbol{\theta} + \mu_{pc} + \delta_{pt} + \varepsilon_{pct} \quad (16)$$

If a country is in a community of which China is a member, $c_community$ is recorded as 1, otherwise 0. At the same time, to ensure robustness, this paper uses the communities of 2009 and 2018 respectively for regression analysis, which are represented by $c_community_{2009}$ and $c_community_{2018}$ in Table 6. The results are shown in column (2) and column (3) of Table 6. The coefficients of the three interaction terms are positive and pass the 1% significance test, indicating that if the BRI countries are in the community centered on China, the promoting effect on the development of their trade networks will be stronger.

⁶⁷ It should be noted that the TOP1 trade network chart contains countries with different communities (represented by different shapes and colors) in different sectors, because the calculation method of communities differs from that of the TOP1 trade network chart, but this does not affect the main analysis results of this paper.

b. Community analysis based on sub-trade networks of BRI countries

First, according to Figures 7⁶⁸ and 8, the numbers of sub-trade network communities of BRI countries in 2009 and 2018 are very stable, with three major communities every year, including the community centered on Russia (RUS), the community centered on Singapore (SGP), and the community centered on India (IND).⁶⁹ Second, the TOP1 network figures of 2009 and 2018 shows that the connections between the MSR Singapore and Indian communities are closer than those between the Russian community, which is mutually confirmed with our research conclusions. Finally, as the 2018 figure demonstrates, the overall trade network of the BRI countries shows a trend of

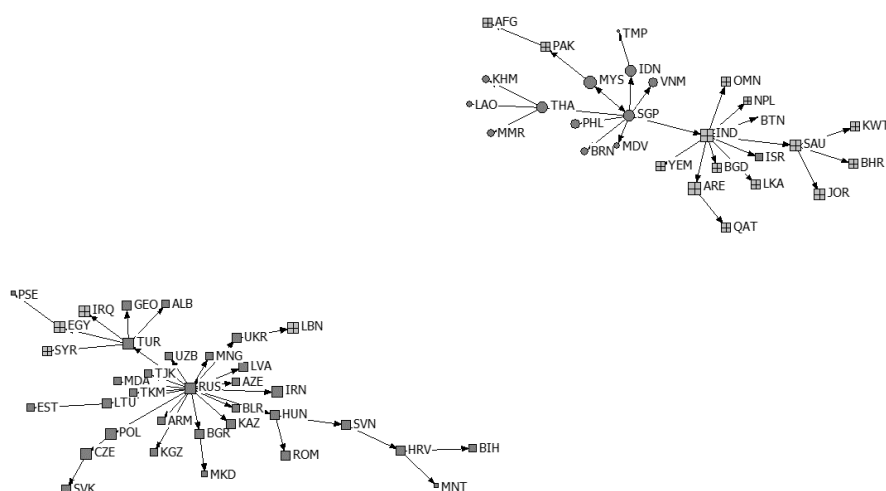


Figure 7: 2009 TOP1 Sub-trade Network Communities of BRI Countries

68 The English abbreviations in Figures 7 and 8 are: AFG Afghanistan, ALB Albania, ARE UAE, ARM Armenia, AZE Azerbaijan, BGD Bangladesh, BGR Bulgaria, BHR Bahrain, BIH Bosnia and Herzegovina, BLR Belarus, BRN Brunei Darussalam, BTN Bhutan, CZE Czech Republic, EGY Egypt, EST Estonia, GEO Georgia, HRV Croatia, HUN Hungary, IDN Indonesia, IND India, IRN Iran, IRQ Iraq, ISR Israel, JOR Jordan, KAZ Kazakhstan, KGZ Kyrgyzstan, KHM Cambodia, KWT Kuwait, LAO Laos, LBN Lebanon, LKA Sri Lanka, LTU Lithuania, LVA Latvia, MDA Moldova, MDV Maldives, MMR Myanmar, MNE Montenegro, MNG Mongolia, MYS Malaysia, NPL Nepal, OMN Oman, PAK Pakistan, PHL Philippines, POL Poland, PSE Palestine, QAT Qatar, ROU Romania, RUS Russia, SAU Saudi Arabia, SGP Singapore, SRB Serbia, SVK Slovakia, SVN Slovenia, SYR Syria, THA Thailand, TJK Tajikistan, TKM Turkmenistan, TLS Timor-Leste, TUR Turkey, UKR Ukraine, UZB Uzbekistan, VNM Vietnam, YEM Yemen.

69 Communities in which Russia belongs are represented by squares. Communities in which Singapore belongs are represented by circles. Communities in which India belongs are represented by cross squares.

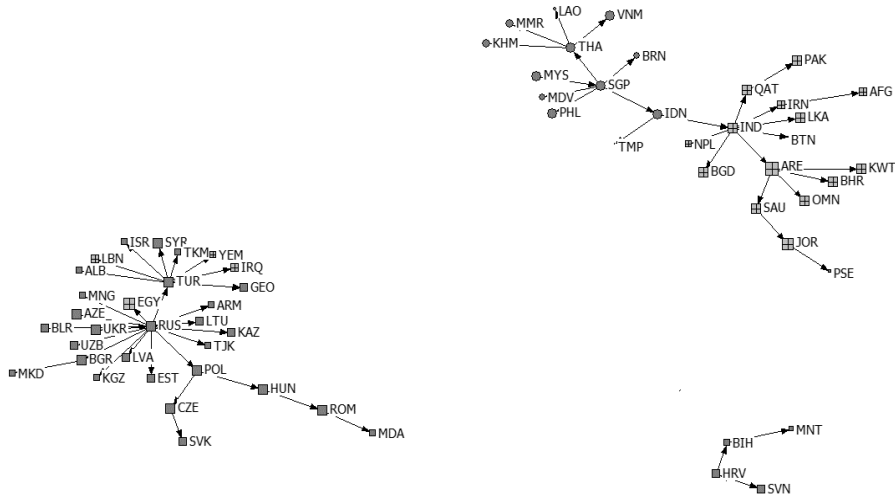


Figure 8: 2008 TOP1 Sub-trade Network Communities of BRI Countries

decentralization, and the overall TOP1 network is more dispersed, indirectly showing that BRI has extensively promoted the development of the trade network of these countries, which have generally benefitted from it.

Combined with the analysis results of sub-trade network communities of BRI countries, this paper sets the following DDD regression model, which is as follows:⁷⁰

$$\begin{aligned}
 \ln \text{PageRank}_{pct} = & \beta_1 \text{treat}_c \times \text{post}_t \times \text{RUS_community}_c + \beta_2 \text{treat}_c \\
 & \times \text{post}_t \times \text{SGP_community}_c + \beta_3 \text{treat}_c \times \text{post}_t \\
 & \times \text{IND_community}_c + \beta_4 \text{treat}_c \times \text{post}_t + \mathbf{X}_{ct} \boldsymbol{\theta} \\
 & + \mu_{pc} + \delta_{pt} + \varepsilon_{pct}
 \end{aligned} \tag{17}$$

If a country is in a Russia-centered community, then *RUS_community* is denoted as 1, otherwise denoted as 0. If a country is in a Singapore-centered community, then *SGP_community* is denoted as 1, otherwise denoted as 0. If a country is in an India-centered community, *IND_community* is denoted as 1, otherwise denoted as 0. Similarly, this paper uses the communities of 2009

70 As *RUS_community*, *SGP_community*, and *IND_community* belong to the subsets of *treat*, if the interaction items of *RUS_community*, *SGP_community*, and *IND_community* are further controlled, it will cause collinear problems.

and 2018 respectively to perform regression analysis. The results are shown in columns (4) and (5) of Table 6. Among the three communities, only the Singapore-centered community *SGP_community* has a significantly positive coefficient of triple interaction terms, indicating that BRI has a stronger effect on this community in promoting the trade network of BRI countries. The possible reason is that Singapore-centered community is in Southeast Asia, surrounded by a vast coastline and extensive sea routes, where it has very convenient trade conditions.

Table 6: Regression Results of BRI Key Products and Global Trade Network

Community Analysis					
	(1)	(2)	(3)	(4)	(5)
<i>treat</i> × <i>post</i> × <i>product</i>	0.005*** (0.002)				
<i>treat</i> × <i>post</i> × <i>c_community</i> 2009		0.095*** (0.024)			
<i>treat</i> × <i>post</i> × <i>c_community</i> 2018			0.085*** (0.024)		
<i>treat</i> × <i>post</i> × <i>RUS_community_2009</i>				0.008 (0.011)	
<i>treat</i> × <i>post</i> × <i>SGP_community_2009</i>				0.061*** (0.015)	
<i>treat</i> × <i>post</i> × <i>IND_community_2009</i>				0.036 (0.029)	
<i>treat</i> × <i>post</i> × <i>RUS_community_2018</i>					0.006 (0.011)
<i>treat</i> × <i>post</i> × <i>SGP_community_2018</i>					0.063*** (0.015)
<i>treat</i> × <i>post</i> × <i>IND_community_2018</i>					0.043 (0.029)
Other Interactive Items	√	√	√	√	√
Observations	5,204,727	5,204,727	5,204,727	5,204,727	5,204,727
R ²	0.810	0.811	0.811	0.811	0.811

E. Mechanism Analysis

Based on the mechanism analysis in the literature review, this paper explores the BRI mechanism to promote the development of the trade network of BRI countries from six channels: policy coordination, facilities connectivity, unimpeded trade, financial integration, people-to-people bonds, and industry-chain cooperation.⁷¹ Table 7 shows the descriptive statistics of each channel variable. Specific introduction of each channel variable: (i) Policy coordination (*lnODA*): the logarithm of a country's net foreign aid⁷² in the WDI database is used as a proxy variable for the demonstration effect of policy coordination, because aid to a country can gain the political favor of the donor country and promote the development of its political relationship.⁷³ Therefore, when a country gives more foreign aid, it has a greater demonstration effect of policy coordination. (ii) Facilities connectivity (*lnLSC*): the logarithmic value of the liner transportation connectivity index of each country in the WDI database is used as a proxy variable for the trade cost effect in facilities connectivity. It comprehensively considers a country's shipping infrastructure, including the number of ships, container carrying capacity, maximum ship size, service volume, and the number of companies deploying container ships in a country's ports, reflecting the status of a country's global shipping network. Therefore, when a country's liner transportation has a larger connectivity index, it has a greater effect in reducing trade costs. (iii) Unimpeded trade (*Burden*): the WDI database is used as a proxy variable for the spillover effect of unimpeded trade to reflect a country's level of unimpeded trade by considering the burden of customs procedures in each country (a score of 1 indicates extremely low customs efficiency, and a score of 7 indicates extremely high customs efficiency). (iv) Financial integration (*Finance*): referencing Jiang and Zhang

71 Due to the fact that the PageRank centrality of each country is based on the year-country-product dimension data, rather than bilateral level data, channel variables are all selected from the year-country dimension data. In addition, consistent with the previous analysis, this paper also excluded China's data from the mechanism analysis.

72 Due to data limitations, the time span of net foreign aid is from 2009 to 2016.

73 Xuetong Yan and Yueming Liu, *Suggestions for Promoting the Development of China-Africa Relations*, *World Economics and Politics in China*, Vol. 1, 1994, pp. 66-68.

(2016), the size of a country's financial market is measured by using the ratio of savings currency bank assets to GDP in the WDI database.⁷⁴ If a country's financial market is larger and more developed, it will be subject to less financing constraints during the export process, which means there is a stronger easing effect of financing constraints. (v) People-to-people bonds (*Tourism*): the proportion of international tourism expenditure to imports in the WDI database is used as a proxy variable for people-to-people bonds to measure the expenditure of a country's tourism industry. International tourism means that residents can directly engage in cultural exchanges within other countries, thus more effectively reflecting cultural spillover effects. (vi) Industry-chain cooperation (*lnDVA*): this paper uses the log value of each country's export domestic value-added in the UNCTAD-EORA Global Value Chain database as the proxy variable for the value chain upgrading effect of industry-chain cooperation because export domestic value-added can reflect a country's participation in the value appreciation of regional or global value chains.⁷⁵

The regression results of mechanism analysis are shown in Table 7. The regression results of the policy coordination mechanism appear in column (1) of Table 7. BRI has significantly promoted the foreign aid of BRI countries. As BRI aims to construct a community with a shared future for mankind, it has promoted policy coordination between BRI countries and other countries throughout the world. It has also taken on an exemplary role of attracting more countries to participate, thus increasing the amount of BRI countries, which can further deepen the development of their trade networks. Column (2) shows the regression results of facilities connectivity. BRI has significantly promoted the liner transport connectivity index of BRI countries, thus verifying the trade cost effect of BRI on facilities connectivity of these countries. Column (3) shows the regression results of unimpeded trade, and it shows that the regression coefficient of the core explanatory variable is significantly positive. The level

⁷⁴ Guanhong Jiang and Xinyue Zhang, *Sophistication of the Financial Sector and Outward Direct Investment: An International Study*, *Journal of International Trade in China*, Vol. 1, 2016, pp. 166–176.

⁷⁵ In addition, this paper further considers the impact of export value-added, which was not reported in the main text. Interested readers can request the regression results from the author.

of unimpeded trade in BRI countries has increased and the mechanism of facilitation spillover effects of unimpeded trade has been verified. Column (4) shows the regression results of financial integration. It indicates that after the implementation of BRI, the financial market size of BRI countries increased, promoting the mitigation effect of financing constraints, and the financial integration channel was also verified. Column (5) shows the regression results of people-to-people bonds. It illustrates that after the implementation of BRI, the tourism expenditure of BRI countries increased, which demonstrating that BRI promoted cultural communication, identification and trust between BRI countries and other countries, and the cultural spillover effect has been remarkable. Column (6) shows the regression results of industry-chain cooperation. The BRI promoted the export domestic value-added of BRI countries, reflecting the upgrading effect of the value chain in industry-chain cooperation.

Table 7: Mechanism Testing Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
	Policy Coordination	Facilities Connectivity	Unimpeded Trade	Financial Integration	People-to-people Bonds	Industry-chain Cooperation
<i>treat</i> × <i>post</i>	0.055*** (0.021)	0.076*** (0.025)	0.039*** (0.008)	0.065*** (0.015)	0.005*** (0.002)	0.060*** (0.010)
Control Variables	√	√	√	√	√	√
Country-fixed Effect	√	√	√	√	√	√
Time-fixed Effect	√	√	√	√	√	√
Observations	1,123	1,086	1,021	1,300	1,153	1,301

IV. CONCLUSION

This paper calculates the 6-digit product-level trade network indexes (PageRank centrality) of countries throughout the world from 2009 to 2018, excluding China's influence, and focuses on the introduction of BRI in 2013 as a policy shock to empirically study its promotion effect on the trade networks of BRI countries. The main conclusions of this paper are as follows:

First, this paper finds that BRI significantly promotes the development of trade networks in BRI countries, which is indicated in the DID estimation results. The increase of PageRank centrality in the countries along the BRI routes reaches 2.8%–12.9%. Second, the regression results pass a series of robustness checks, such as the parallel trend test, consideration of time trends in treatment groups, anticipatory effect, the placebo test, alternative dependent variables, eliminating resource-based products, and Staggered DID. Third, the heterogeneity analysis results show that BRI has a significant effect on the development of trade networks in MSR countries, but not SREB countries. At the same time, this paper finds that the trade networks of key products of the BRI will be promoted powerfully after the introduction of this initiative. The analysis of global trade network communities revealed that BRI has a stronger effect on the deepening of trade networks of BRI countries with China as the central community. From the viewpoint of the communities of BRI countries, this initiative has a better effect on the development of trade networks of BRI countries with Singapore as the central community. Finally, this paper finds that the introduction of BRI can promote the deepening of trade networks in BRI countries based on policy coordination, facilities connectivity, unimpeded trade, financial integration, people-to-people bonds, and industry-chain cooperation, which can promote trade networks and further deepen the trade networks of these countries.

COVID-19 hindered the regional flow of factors, while the global trade network and the GVCs specialization have undergone restructuring and adjustment during crisis transmission. High-quality BRI co-construction is undoubtedly an important opportunity to stimulate the momentum of global economic and trade growth amidst a crisis. BRI relies on policy coordination, facilities connectivity, unimpeded trade, financial integration, people-to-people bonds, and industry-chain cooperation to positively promote trade networks with participating countries and achieve its highest goal of building a community with a shared future for mankind. BRI has not only promoted the development of trade networks among BRI countries, but also served as an

important task for China to achieve high-quality economic liberalization.

First, we should continue to promote the growth of China-focused BRI countries, form a China-centered leading regional value chain that encompasses the surrounding areas, and ensure the security of China's industrial and supply chains. To prevent the risks of epidemics and global trade uncertainties, and stimulate new driving forces of China's high-quality economic development, it is still necessary to continuously strengthen industrial chain cooperation with BRI countries, open up and form the factor circulation chain of upstream and downstream industries with these countries, establish agglomerated industrial cooperation parks, and build a competitive, safe, and stable BRI-based regional value chain. Second, we should explore new models of win-win cooperation with BRI countries through the five links mechanism to create a robust external environment for China's high-quality economic development. It is necessary to further strengthen policy coordination to form a broad consensus on international cooperation. We should also use demonstration to attract more potential BRI participants to promote the signing of intergovernmental cooperation documents between China and additional countries or international organizations to jointly build BRI. Meanwhile, we should accelerate the implementation of cooperation agreements and promote the development of more in-depth and high-quality cooperation projects. Moreover, we should further enhance China's cultural soft power to maximize the cultural spillover effect of people-to-people bonds as well as enrich and explore official and non-governmental cultural exchange platforms. We can jointly promote BRI cooperation mechanisms between China and BRI countries, and attract more overseas talents to construct BRI. Last, by complementing the advantages of these countries, high-quality co-construction of BRI is beneficial for exploring and practicing the implementation of new driving forces and directions for China's high-quality economic development, such as digital economy and green development. By continuing to strengthen cooperation with SREB countries and promoting high-quality facilities connectivity, it is promising to continue building international economic cooperation corridors, increasing

traditional and new infrastructure investment in BRI countries with weak infrastructure, advancing the development of digital economy and trade in BRI countries, and exploring new models of win-win cooperation. In addition, China should actively explore and stimulate the potential of cooperation with SREB countries, continue to strengthen in-depth cooperation with Russia and India by increasing its investment in energy infrastructure equipment with Russia, improving its energy cooperation mechanisms to continue deepening its strategic cooperation with Russia on traditional and green new energy, exploring its digital economy cooperation with India on emerging technologies in the fields of AI, IOT, and the Internet. These measures will improve and expand its cooperation with Russia and India in Europe and Asia.