The Reciprocal and Symbiotic Effects of Industrial Relocation between China and BRI Countries

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Abstract: *Reciprocity and symbiosis are essential to the creation of "a community with a shared future for mankind", and industrial relocation is a key strategy for implementing the Belt and Road Initiative (BRI). This paper investigates the reciprocal and symbiotic effects of industrial relocation between China and BRI countries, and performs an empirical test using the Eora global supply chain database of 2002-2020. Our findings suggest that there has been an increasing level of industrial reciprocity and symbiosis between China and BRI countries, but great differences exist across sectors and regions; industrial relocation between China and BRI countries is conducive to two-way industrial reciprocity and symbiosis primarily through regional value chain cooperation and an increasing level of industrial agglomeration. The most substantial effects have been observed in industrial relocation involving developed BRI countries, in medium- and high-tech sectors, and following the announcement of the BRI.*

Keywords: *Belt and Road Initiative (BRI), reciprocity and symbiosis, global value chains (GVCs), industrial relocation*
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1. Introduction

The concept of symbiosis initially emerged from the field of biology and was subsequently adopted in the realm of economics to denote mutually beneficial relationships between economic entities. Reciprocity and symbiosis thus exemplify a mode of shared economic advancement in which mutually dependent entities derive advantages from one another's progress (Yuan, 1998). In 2013, President Xi Jinping unveiled the Belt and Road Initiative (BRI) during his diplomatic tour to Central Asia and Southeast Asia. The BRI aims to foster regional collaboration at an elevated level and on a broader global scope through an open and inclusive platform for international cooperation for mutual benefits. The inherent nature of such collaboration exemplifies the vision of the "a community with a shared future for mankind" within the framework of reciprocity and symbiosis (Shen, 2019). Industrial relocation between BRI countries plays a crucial role in facilitating two-way industrial collaboration, regional reciprocity, and symbiotic development. However, certain Western nations and international organizations have raised concerns regarding the intentions of the BRI, asserting that it is being utilized by China as a geopolitical instrument. The 20th National Congress of the Communist Party of China (CPC) has emphasized the need to enhance

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the high-quality development of the BRI[1]. The level of attention and controversy surrounding the BRI necessitate a comprehensive examination of the reciprocal and symbiotic effects of industrial relocation between China and the BRI countries, both in theoretical and empirical terms. The results of our study offer theoretical backing and empirical substantiation for the adoption of high-quality BRI industrial collaboration, and also address the motivations behind the BRI.

The relevant literature falls into two categories. One type of literature focus on the behaviors and theories of industrial symbiosis. Early research on industrial symbiosis from the perspective of industrial ecology held that an industrial ecosystem similar to the natural ecosystem could be created by emulating the material and energy circulations of biological ecosystem (Frosch and Gallopoulos, 1989). Industrial symbiosis applies this ecological metaphor in industrial ecology to the behaviors between enterprises (Chertow, 2000) in order to create a knowledge sharing and transactional network to increase resource efficiency and corporate competitiveness (Laybourn and Morrissey, 2009) and to foster industrial ecosystems (Lombardi and Laybourn, 2012). With the advancement of symbiosis theory, some scholars have urged for research on industrial symbiosis within the framework of industrial economics as well. They believe that industrial symbiosis as an objective economic phenomenon refers to the integration, coordination, and integration of various industrial value components based on an increasingly sophisticated division of labor (Hu, 2008). Industrial ecosystem results from industrial symbiosis and evolution (Li and Liu, 2013), and industrial-service integration makes such a symbiotic industrial ecosystems easier to identify (Hu and Yang, 2022). Furthermore, the rapid development of industrial clusters has drawn academics' attention to the significance of symbiosis between entities within an industrial cluster, leading many to conclude that cooperation and competition between businesses in a cluster are conducive to symbiosis stability and that symmetrical reciprocity is the most stable form of symbiosis in an industrial cluster (Liu and Wei, 2015). Within each cluster, organizational co-governance, environmental coherence, value co-creation, and ecological symbiosis all strengthen the interdependence of factors and supported the stability and evolution of their respective symbiotic system (Hu, 2022). With respect to the concept, conditions, and functions of industrial symbiosis, however, most studies have yet to go beyond theoretical discussions and qualitative analysis.

The other type of literature examines the symbiotic effects of industrial relocation. According to many of these studies, industrial relocation is the precursor for symbiosis, and through inter-regional industrial relocation, industries from different regions can achieve interdependence, complementarity, interconnection, and collaborative innovation that can foster a symbiotic economy (Zhu and Ou, 2016). Some academicians have begun to investigate the issue of reciprocity and symbiosis in the process of industrial relocation as research on the distribution of interests among participants in the process of industrial relocation has expanded. According to Cheng et al. (2013), industrial relocation is a process in which industrial symbiosis develops and industrial value creation strengthens, allowing participants to benefit from industrial interactions and integration. Industrial relocation is crucial in nurturing a regional industrial chain system for coordinated development, complementary advantages, and industrial symbiosis (Liu et al., 2022). Under intra-product division of labor, the government should also enact policies that strengthen the chain and agglomeration effects of cluster industrial relocation for the symbiotic development of relocated industries (Liu and Liu, 2021). Some researchers have extended their discussions on the reciprocity and symbiosis of China's domestic industrial relocation to the industrial relocation between China and BRI countries as well. They advocated supporting the interactions of "symbiotic system" and "symbiotic environments" for industrial relocation, realizing the significant opportunity for jointly developing the BRI, balancing domestic circulation with international circulation, and facilitating industrial relocation in a differentiated manner for reciprocal and symbiotic

[1] Xi Jinping. *Hold High the Great Banner of Socialism with Chinese Characteristics and Strive in Unity to Build a Modern Socialist Country in All Respects* - Report to the 20th National Congress of the Communist Party of China. Beijing: The People's Press, 2022, page 33.

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industrial development in both countries (Zhang and Li, 2021). Liu et al. (2020) argued that China's industrial relocation to BRI countries facilitates the reciprocity and symbiosis as embodied by the upgrade of value chains on both sides. In particular, when China and Southeast Asian countries are complementary in their respective industrial structure, there is a need to construct overseas industrial parks in these countries that are mutually beneficial (Zhang et al., 2023). Although such studies have investigated symbiosis in the process of industrial relocation, very few studies have probed into the creation of reasonable industrial symbiosis indicators based on the theory of symbiosis in order to reveal the reciprocal and symbiotic effects of industrial relocation and to discuss their internal mechanisms.

In this paper we therefore aim to present a theoretical framework for assessing the effects of international industrial relocation on industrial symbiosis within the context of the BRI. Further, we conduct an empirical test using country- and sector-level data to derive reliable conclusions. In comparison to the existing literature, our contributions are the following: (i) The level of manufacturing symbiosis between China and BRI countries is assessed based on indicators of integration, interactivity, and coordination. (ii) The theoretical basis for the manufacturing symbiosis between China and BRI countries through industrial relocation is examined from a symbiotic perspective. This analysis explores the effects of industrial relocation on China and BRI countries and enhances our understanding of the reciprocal and symbiotic effects inherent in such relocations. (iii) An empirical analysis is conducted to evaluate the reciprocal and symbiotic effects of industrial relocation between China and BRI countries. This analysis provides empirical evidence that can be used as the basis for proposing systematic measures and offering policy recommendations for the promotion of high-quality industrial cooperation between China and BRI countries.

2. Mechanism Analysis and Research Hypotheses

2.1 The Effects of Industrial Relocation on Industrial Reciprocity and Symbiosis

The central implication of industrial symbiosis is the integration, interaction, and coordination between the different value components of the same industry and the economically interrelated business components of different industries through a specific mechanism (Hu, 2008). Industrial reciprocity and symbiosis highlight the state of increasing integration, interaction, and coordination, constituting a relationship of complementarity, interconnection, and collaborative division of labor for win-win outcomes and shared growth. In light of this, we examine the reciprocal and symbiotic effects of industrial relocation in terms of integration, interaction, and coordination specifically.

Integration through industrial symbiosis focuses predominantly on industrial complementarity and interdependence between both sides during the value addition process. From the perspective of symbiosis, technology complementarity, product supply and demand, and the combination of business components can all promote integration (Hu, 2008). Under the global value chain's (GVC) division of labor, cross-regional industrial relocation may also optimize market division of labor across a broader space and permit certain production and processing activities to be carried out in regions with comparative advantage, fostering more complementary business links to maximize comparative advantages (Liu and Hu, 2011). Favorable industrial interconnections can appear on both the investment and demand sides as a result of intensifying industrial relocations under the GVC mode. From a demand perspective, interconnectedness between countries may increase demand for intermediate inputs in both countries; from an investment perspective, complementarity and interconnectedness between countries may encourage both countries to invest in intermediate and final products and expand manufacturing. Such an increase in the transaction of intermediate inputs as a result of industrial relocation may thus accelerate changes in industrial investment and demand on both sides and contribute to a strengthening of industrial interdependence and integration. Consequently, we presume that industrial relocation between China and BRI countries has strengthened the industrial integration between both sides.

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Interactions through industrial symbiosis are concerned with the two-way interconnectedness of industries in the process of cooperation for mutual benefit and win-win results. Strictly speaking, this means that successful industrial interactions within the framework of symbiosis must result in gains, which are realized through participation in GVC division of labor and trade in intermediate inputs. In the process of economic globalization and international division of labor, countries may engage in vertical specialization in a particular process of product manufacturing and exchange with each other through trade in intermediate inputs, which increases interactivity between the upstream and downstream links of the value chain (Hummels et al., 2001). According to gradient relocations theory, countries at the upstream links of the value chain relocate certain manufacturing processes to countries at the downstream links, and countries at the downstream of the value chain develop their domestic industries through R&D cooperation with upstream countries and other forms of reverse gradient relocation while simultaneously accessing industrial technologies, services, and other resources from upstream countries. In the interim, upstream countries can free up more resources for R&D of more sophisticated manufacturing processes in order to achieve domestic industrial upgrades. Both upstream and downstream countries will benefit from the process of industrial relocation, developing a mutually beneficial relationship characterized by two-way interactions (Wang and Lu, 2019). We therefore presume that industrial relocation between China and BRI countries has increased industrial interactions in both directions.

Coordination of industrial symbiosis focuses primarily on the collaborative division of labor between both sides during the industrial relocation process. Cross-regional industrial relocation has optimized international industrial structures and resource allocations through the cross-regional flow of production factors, thereby increasing the level of international industrial coordination. Additionally, orderly industrial relocation has facilitated the cross-regional coordination of various work processes within the same industry through division of labor (Fu, 2019). Participating in the international division of labor enables the host country to develop its own industrial capabilities as it undergoes an improvement in its industrial structure and the sophistication of its services. Through reasonable division of labor, coordination, and cooperation, both sides can attain coordinated development characterized by industrial interdependence and orderly operations (Li and Liu, 2011). Industrial relocation under the concept of "community with a shared future for mankind" places a greater emphasis on the shared benefits of cooperation, which is conducive to the development of a more balanced industrial division of labor between China and BRI countries. Thus, we can hypothesize that industrial relocations between China and BRI nations have increased industrial coordination between both sides.

Hypothesis 1: Industrial relocation between China and BRI countries enhances industrial reciprocity and symbiosis, characterized by two-way integration, interactivity, and coordination.

2.2 The Intermediate Mechanism of the Industrial Reciprocal and Symbiotic Effects of Industrial Relocation

There has been a decentralization of the various manufacturing and processing links of products due to the intensifying international division of labor and the rise of GVC industrial relocation. Regional economies can optimize resource allocation and industrial structure more effectively by participating in GVC division of labor and cooperation through industrial relocation (Ma et al., 2016; Li and Cai, 2017). With a growing level of regional value chain cooperation, businesses choose to locate themselves close to a large market in order to access a higher rate of return and reduce transportation costs, thereby increasing industrial concentration in a given region. Theoretically, regional value chain cooperation and industrial agglomeration will foster further industrial integration, interaction, and collaboration within this region (Ellison and Glaeser, 1997), which is conducive to industrial reciprocity and symbiosis. Hence, we presume that industrial relocation between China and BRI countries is conducive to the level of reciprocity and symbiosis for industrial development in both countries through value chain cooperation, industrial agglomeration, and other channels and mechanisms (see Figure 1).

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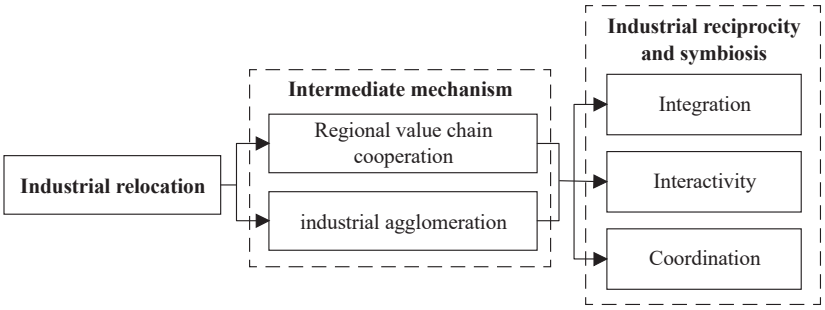

Figure 1: Avenues and Mechanisms of the Industrial Reciprocal and Symbiotic Effects of Industrial Relocation

2.2.1 Industrial relocation promotes industrial reciprocity and symbiosis by fostering regional value chain collaboration

Regional value chain cooperation enables trade and cooperation between economies within a region through regional coordination or division of labor based on participants' respective technological and market strengths. According to theoretical research and empirical evidence from Ma and Sheng (2018), the collaboration of regional value chains facilitates the exchange of production factors between regions, thereby providing an avenue for the utilization of surplus capacity and funds within a region. This collaboration also promotes industrial interaction and coordination by attracting relevant service institutions through external vertical or horizontal division of labor. According to the theory of industrial integration, the establishment of regional value chains accelerates mutual complementarity and integration between industries or sectors in the course of industrial innovation and value addition. Moreover, according to research on industrial cooperation between China and BRI countries, the establishment of regional value chains between China and BRI countries facilitates the exploration of advantageous industries and resources in the region and fosters a new model of reciprocal and symbiotic value chains with a better division of labor compared to the case without BRI participation (Liu and Liu, 2019). If industrial relocation can enhance regional value chain cooperation, it can promote industrial reciprocity and symbiosis in both countries through regional value chain cooperation.

According to the relatively new theory of economic geography, the process of industrial relocation is distinguished by the separation of value chain processes. This means that manufacturing processes often move away from firms' central headquarters amid deepening division of labor (Duranton and Puga, 2005). The relocation of high-end processes within the value chain tends to occur in regions that possess more advanced technology, higher degrees of informatization, and a greater concentration of professional services. In contrast, low-end processes within the value chain tend to move to places where there is a plentiful supply of labor and cheaper production costs. This phenomenon, known as GVC-based industrial migration, has resulted in a further division of labor and increased collaboration within regional value chains (Ding, 2011). Industrial relocation thus has the potential to facilitate the adjustment of industrial structure and enhance the allocation of resources across different regions through the transmission and diffusion of resource factors, and this process plays a crucial role in promoting regional value chain cooperation (Ye, 2014). Furthermore, the regional integration and strategic alignment of product, industrial, and service chains based on the comparative advantages of countries within the region can facilitate the development of a regional industrial framework and a well-defined system of division of labor. These factors can then contribute to the enhancement of regional value chain collaboration. The BRI encompasses countries situated at various points throughout the value chains, including both upstream and downstream positions. According to Peng and Lin (2021), the value chain division of labor system involves the fragmentation of manufacturing processes for a particular product

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across multiple BRI countries. This collaborative effort forms the BRI regional value chain, and the extent to which a country relies on intermediate inputs from other countries in its exports serves as an indicator of the level of regional value chain cooperation.

2.2.2 Industrial relocation fosters industrial reciprocity and symbiosis by increasing industrial concentration

Industrial agglomeration, as a spatial organizational form of division of labor, occurs through a process of deepening spatial division of labor, increasing efficiency, and decreasing transaction costs (Kou, 2021), and the organizational basis and premise for industrial reciprocity and symbiosis are established by industrial agglomeration. As a result of deepening international division of labor, the production of individual goods has become segmented into numerous specialized industrial clusters that, through the exchange of intermediate goods, constitute a vast multinational manufacturing network. Furthermore, as a result of the effects of increasing return to scale and positive externalities, manufacturing activity tends to concentrate, thereby facilitating interaction, integration, and coordination between industries within a manufacturing network. However, industrial agglomeration as a form of regional organizational can be either the spatial agglomeration of the same industry or the interdependence, interconnection, and interaction of different industries or upstream and downstream industries. Such agglomeration generates symbiosis, synergy, and other benefits (Chen et al., 2020), thereby increasing the level of industrial reciprocity and symbiosis. Thus, we presume that industrial relocation promotes industrial reciprocity and symbiosis between nations by fostering industrial agglomeration.

Under the effects of the division of labor cumulative causation, industrial relocation promotes industrial agglomeration. Industrial relocation has increased the spatial division of labor and given rise to specialized agglomeration in smaller regions and diverse agglomeration in larger regions in the context of the GVC division of labor. In order to optimize their profits, multinational corporations relocate their manufacturing processes to nations with comparative advantages, thereby creating close ties between technology, manufacturing, and markets. Investments by multinational corporations stimulate investments by upstream and downstream firms in the industrial chain, resulting in regional industrial agglomeration and interregional industrial chain clusters (Lyu and Yang, 2006). Specialized division of labor within a region enhances industrial correlations between nations. However, industrial relocation has also contributed to the acceleration of industrial agglomeration. This has led to the emergence of the market proximity effect, cost of living effect, and positive externalities, which in turn have a positive feedback effect on industrial relocation, creating cumulative causation that speeds up industrial agglomeration (Krugman, 1991). In addition to industrial specialization and diversification, industrial relocation between China and BRI countries has accelerated the formation of industrial clusters in specific regions, prompting the relocation of additional regional value chain processes. Cumulative causation resulting from forward and reverse links has thus accelerated regional industrial concentration.

The above theoretical analysis suggests that industrial relocation promotes industrial reciprocity and symbiosis between countries by fostering regional value chain cooperation and increasing industrial agglomeration. Therefore, we propose the following hypothesis.

Hypothesis 2: Industrial relocation between China and BRI countries promotes industrial reciprocity and symbiosis by advancing regional value chain cooperation and boosting industrial agglomeration.

3. Estimation and Analysis of Industrial Reciprocity and Symbiosis

3.1 Creation of Indicators

Based on the previous definition of symbiosis, this section will create indicators for estimating industrial symbiosis between China and BRI countries on the three dimensions of industrial integration, interaction and coordination.

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3.1.1 Integration

From the standpoint of value-added trade, the supply and demand of intermediate products may reflect the supply and demand of final products. Referencing Hu and Li (2009), we assess the extent of industrial integration between nations based on the investment ratio and demand ratio. The following equation is used to calculate the extent of integration between both countries in the same industry:

$$RH_{ic,ir}=(IIR_{ic,ir}+IDR_{ir,ic}+IIR_{ir,ic}+IDR_{ic,ir})/4 \quad (1)$$

In equation (1), subscript i is industry, c means China, and r refers to any BRI country. $RH_{ic,ir}$ denotes the level of industrial integration between industry i in China and industry i in BRI country r, and is calculated by taking the average value of the following four indicators:

(i) The investment ratio of China's industry i ($IIR_{ic,ir}$), which is calculated with the following equation:

$$IIR_{ic,ir}=\frac{VAI_{ic,ir}}{TI_{ir}} \quad (2)$$

In equation (2), $VAI_{ic,ir}$ denotes the value-added investment of China's industry i in country r's industry i, and TI_{ir} is the total investment in country r's industry i. $IIR_{ic,ir}$ reflects the percentage of total investment in country r's industry i from China's industry i.

(ii) The demand ratio of China's industry i ($IDR_{ir,ic}$), which is calculated with the following equation:

$$IDR_{ir,ic}=\frac{VAC_{ir,ic}}{TO_{ic}} \quad (3)$$

In equation (3), $VAC_{ir,ic}$ refers to the consumption of value-added from China's industry i by country r's industry i, and TO_{ic} is the total output of China's industry i. $IDR_{ir,ic}$ reflects the percentage of total output of China's industry i consumed by country r's industry i.

(iii) The investment ratio $IIR_{ir,ic}$ of BRI country r's industry i, which is calculated with the following equation:

$$IIR_{ir,ic}=\frac{VAI_{ir,ic}}{TI_{ic}} \quad (4)$$

In equation (4), $VAI_{ir,ic}$ is the value-added investment by country r's industry i in China's industry i, and TI_{ic} is the total investment of China's industry i. $IIR_{ir,ic}$ reflects the percentage of total investment in China's industry i from country r's industry i.

(iv) The demand ratio ($IDR_{ic,ir}$) of BRI country r's industry i, which is calculated with the following equation:

$$IDR_{ic,ir}=\frac{VAC_{ic,ir}}{TO_{ir}} \quad (5)$$

In equation (5), $VAC_{ic,ir}$ is the consumption of value-added from country r's industry i by China's industry i. TO_{ir} is the total output of country r's industry i. $IDR_{ic,ir}$ reflects the percentage of total output of country r's industry i consumed by China's industry i.

Among the above indicators, $IIR_{ic,ir}$ and $IDR_{ic,ir}$ measure the degree of China's industry i's integration into BRI country r's industry i in terms of investment and demand, whereas $IDR_{ir,ic}$ and $IIR_{ir,ic}$ measure the degree of integration of BRI country r's industry i into China's industry i in terms of demand and investment.

3.1.2 Interactivity

Rapid development of GVC division of labor has resulted in the creation of a continuous and vertical trade chain involving numerous countries specializing in a variety of product manufacturing processes, and the imports and exports of countries have made product manufacturing an increasingly interdependent process (Hummels et al., 2001). From the perspective of value-added in trade, the

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level of foreign value-added in a country's exports reflects the degree of vertical specialization of the country. High foreign value-added in export commodities is indicative of close international trade ties and robust interdependence between upstream and downstream industries. We measure the level of industrial interactions between countries by the proportion of foreign industrial value-added in a country's industrial exports, referencing Pan and Li (2018). The following equation measures industrial interactivity between countries:

$$HD_{ic,ir}=(\theta_{ic,ir}+\theta_{ir,ic})/2 \tag{6}$$

In equation (6), $HD_{ic,ir}$ denotes interactivity between China's industry i and BRI country r's industry i, $\theta_{ic,ir}$ is interactivity between China's industry i and country r's industry i, and $\theta_{ir,ic}$ is interactivity between country r's industry i and China's industry i. Specific equations are as follows:

$$\theta_{ic,ir}=\frac{FVA_{ic,ir}}{E_{ic}} \tag{7}$$

$$\theta_{ir,ic}=\frac{FVA_{ir,ic}}{E_{ir}} \tag{8}$$

In equations (7) and (8), $FVA_{ic,ir}$ is value-added of export in China's industry i from country r's industry i, and E_{ic} is the total exports of China's industry i. $FVA_{ir,ic}$ is value-added of country r's industry i from China's industry i, and E_{ir} is total exports of country r's industry i.

3.1.3 Coordination

According to the theory of symbiosis, the quality parameter reflects the intrinsic nature of symbiotic units, and the degree of symbiosis reflects the level of correlation between the quality parameters of symbiotic units; therefore, the degree of symbiosis is a good indicator of interregional industrial coordination (Hu, 2008). Using the domestic value-added of industrial exports as the quality parameter, we calculate the degree of symbiosis based on trade in value-added for various countries to represent the level of industrial coordination between countries. The following equation measures industrial coordination between countries.

$$XT_{ic,ir}=(1/|\delta_{ic,ir}-1|+1/|\delta_{ir,ic}-1|)/2 \tag{9}$$

In equation (9), $XT_{ic,ir}$ is the coordination between China's industry i and BRI country r's industry i, and $\delta_{ic,ir}$ and $\delta_{ir,ic}$ are the degree of symbiosis[2] measured by quality parameters of China and country r, the equations of which are as follows:

$$\delta_{ic,ir}=\frac{dVAX_{ic}/VAX_{ic}}{dVAX_{ir}/VAX_{ir}},\ (dVAX_{ir}\neq 0) \tag{10}$$

$$\delta_{ir,ic}=\frac{dVAX_{ir}/VAX_{ir}}{dVAX_{ic}/VAX_{ic}},\ (dVAX_{ic}\neq 0) \tag{11}$$

In equation (11), VAX_{ic} is domestic value-added of exports from China's industry i, and VAX_{ir} is domestic value-added of exports from country r's industry i. $\delta_{ic,ir}$ reflects change in domestic value-added VAX_{ic} of exports from China's industry i due to change in domestic value-added of exports VAX_{ir} from country r's industry i, and $\delta_{ir,ic}$ is change in domestic value-added of exports VAX_{ir} from country r's industry i due to change in China's domestic value-added VAX_{ic}.

[2] Based on the symbiosis theory, the most ideal state of symbiosis (positive symmetrical symbiotic state) is reached when $\delta_{ic,ir}=\delta_{ir,ic}>0$. According to the method for calculating the degree of symbiosis and the optimal state of positive symmetrical symbiosis, the closer the degree of symbiosis nears 1, the better the state of symbiosis becomes. In this paper, therefore, we measure coordination by the absolute value of the difference between the degree of symbiosis and 1, and take its reciprocal via mathematical transformation. Higher value means better coordination.

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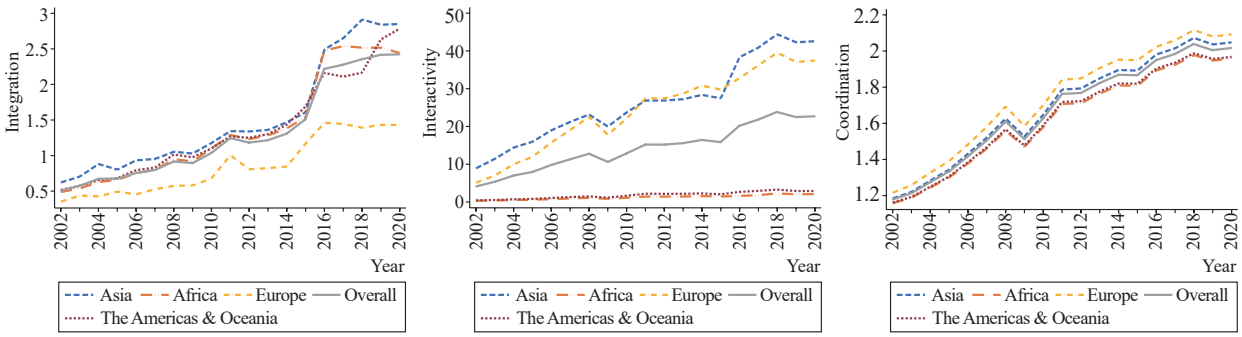
3.2 Analysis of the Estimated Results

On the basis of the Industrial Reciprocity and Symbiosis Index derived from the perspective of trade in value-added in the previous section, we calculate the integration, interactivity, and coordination between China and BRI countries using the Eora global supply chain database (2002-2020) and analyze their reciprocal and symbiotic characteristics.

3.2.1 Analysis of region-specific reciprocity and symbiosis in manufacturing

To analyze differences in the level of reciprocity and symbiosis between various continents, we divide BRI countries into the four regions of Asia, Africa, Europe, and the Americas and the Oceania, for calculating the overall and region-specific integration, interactivity, and coordination indices between China and BRI countries from 2002 to 2020 (see Figure 2). As shown in Figure 2, the manufacturing integration, interactivity, and coordination indices between China and BRI countries all increased from 2002 to 2020 (solid lines in the graph), indicating a rising level of reciprocity and symbiosis in manufacturing. There has been an upward trend in the integration, interactivity, and coordination indices between China and BRI regions for a variety of reasons. The three indices between China and Asia are greater than those between China and the other three regions. Specifically, China has the highest indices with East Asia and Southeast Asia. China has the maximum level of reciprocity and symbiosis with East Asia and Southeast Asia, relative to other regions. This may be due to China's geographical proximity and cultural affinity with East Asia and Southeast Asia, which include developed economies like Singapore and South Korea with technological prowess and developing economies like Thailand and Myanmar with a low-cost advantage, as well as a relatively complete regional supply-demand structure. Hence, there is a high degree of two-way reciprocity and symbiosis between China and East Asia and Southeast Asia.



(a) Integration (b) Interactivity (c) Coordination

Figure 2: Change in the Level of Manufacturing Reciprocity and Symbiosis between China and BRI Countries in Various Regions

3.2.2 Reciprocity and symbiosis analysis for specific manufacturing sectors

To further analyze the reciprocity and symbiosis between China and BRI countries with regard to specific manufacturing sectors, we estimated the integration, interactivity, and coordination indices between China and BRI countries for the sectors from 2002 to 2020 and drew trendlines (see Figure 3). As shown in Figure 3, the integration, interactivity, and coordination indices between China and BRI countries in various manufacturing sectors are on the rise. This suggests that the level of reciprocity and symbiosis between China and BRI nations in these manufacturing sectors is on the rise. The "electrical and mechanical equipment" and "textiles and apparel" industries have a relatively high degree of reciprocity and symbiosis. Infrastructure interconnectivity as a critical priority of the BRI's

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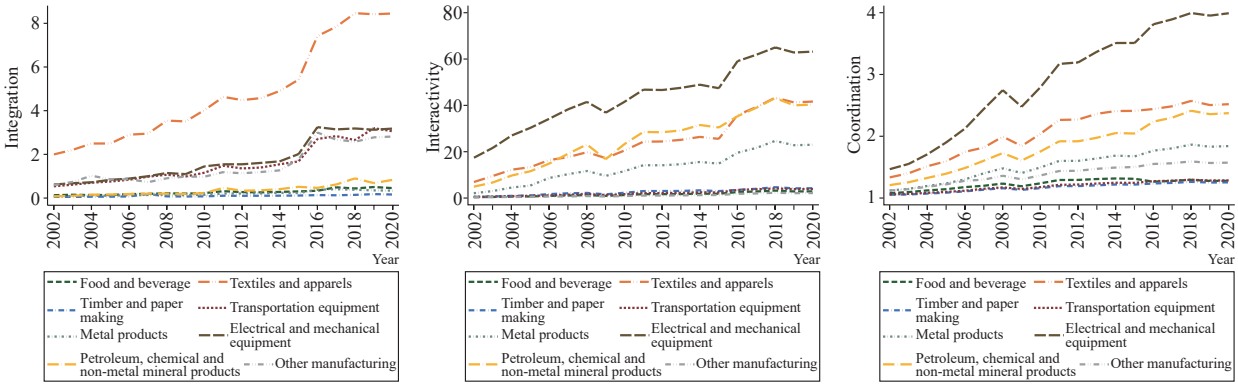

(a) Integration (b) Interactivity (c) Coordination

Figure 3: Change in the Level of Reciprocity and Symbiosis between China and BRI Countries for Manufacturing Sectors (2002-2020)

development may have created a demand for electrical and mechanical equipment necessary for the construction of roads, bridges, ports, and other infrastructure projects in BRI countries. Due to China's cost-competitiveness, technological prowess, and comprehensive supply chains, it can readily provide this type of equipment. In the labor-intensive textile and apparel industry, China's steep increase in labor wages has resulted in the relocation of textiles processing to more cost-competitive BRI nations. In the interim, China has prioritized the transition and upgrade of technological processes and design.

4. Empirical Design

In the preceding section, we estimated integration, interaction, and coordination between China and BRI countries and identified an upward trend in industrial reciprocity and symbiosis. In this section, we will develop an econometric model to analyze whether industrial relocation between China and BRI countries contributes to industrial reciprocity and symbiosis on both sides.

4.1 Specification of the Econometric Model

In the majority of studies, the trade gravity model has been utilized to analyze bilateral and multilateral trade relations. This model assumes that economic and trade cooperation between two countries is directly proportional to their combined economic output and inversely proportional to their geographical proximity. In accordance with the practice of the vast majority of academics, we employ the logarithmic form of the gravity model in our empirical research and incorporate institutional distance, economic distance, cultural distance, and geographical distance into the following baseline regression model.

$$\ln Y_{ic,ir}^{t}=\beta_0+\beta_1\ln ITR_{ic,ir}^{t}+\beta_2\ln D_{cr}^{t}+\beta_3\ln Z_{ic,ir}^{t}+\varphi_t+\lambda_r+\eta_i+\varepsilon_{ic,ir}^{t} \quad (12)$$

In equation (12), $Y_{ic,ir}^{t}$ is the Reciprocity and Symbiosis Index calculated based on trade in value-added, and represents the level of reciprocity and symbiosis between China's industry i and country r's industry i in period t, i.e. integration, interactivity, and coordination. $ITR_{ic,ir}^{t}$ is the status of relocation between China's industry i and country r's industry i in period t; D_{cr}^{t} is the variable of distance between China and country r in period t. $Z_{ic,ir}^{t}$ is a set of other control variables in period t. φ_t, λ_r, η_i and $\varepsilon_{ic,ir}^{t}$ denote time-fixed, country-fixed, and industry-fixed effects, as well as stochastic error term, respectively.

4.2 Variable Measurement and Explanations

4.2.1 Industrial relocation

Research on the flow of product value under the GVC mode from an input-output perspective

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reveals a clear picture of the path and region for the relocation of product value, as well as the current status and trends of international industrial relocation. Referencing Wang and Wu (2017) for measuring industrial relocation, we define change in foreign industrial value-added due to change in domestic final demand as the home country's industrial relocation overseas.

In a GVC, an increase in a country's production volume is attributable to the following factors: First, an increase in domestic final demand; second, an increase in overseas final demand; third, an increase in overseas intermediate demand. Assuming that *a*, *b* and *c* countries constitute a global value chain, when country *a* exports to country *b*, industrial relocation from country *b*'s industry *i* to country *a* consists of the following three components: (i) Value-added from the final products exported by country *a*'s industry *i* to country *b* due to country *b*'s final demand ($DVA_FIN_{ia,b}$); (ii) value-added from the intermediate products exported by country *a*'s industry *i* to country *b* for the latter's manufacturing of domestic final products due to country *b*'s final demand ($DVA_INT_{ia,b}$); (iii) value-added from the intermediate products exported by country *a*'s industry *i* to country *b* for country *b*'s manufacturing of intermediate products to be exported to country *d* and finally for country *d* to manufacture final products to be exported to country *b* and finally absorbed by country *b* ($DVA_INTREX_{ia,b}$). When country *a* exports to country *d*, industrial relocation from country *b*'s industry *i* to country *a*'s industry encompasses the following two components: (i) Value-added from intermediate products exported by country *a*'s industry *i* to country *d* due to country *b*'s final demand for country *d* to manufacture final products to be exported to country *b* and absorbed by country *b* ($DVA_INT_{ia,d}$); (ii) value-added of intermediate products exported by country *a*'s industry *i* to country *d* due to country *b*'s final demand for country *d* to manufacture intermediate products to be exported to country *b* and for country *b* to manufacture domestic final products ($DVA_INTREX_{ia,d}$)[3].

After a decomposition of aggregate trade flows, industrial relocation from country *b*'s industry *i* to country *a* becomes:

$$T_{ib,a} = DVA_FIN_{ia,b} + DVA_INT_{ia,b} + DVA_INTREX_{ia,b} + DVA_INT_{ia,d} + DVA_INTREX_{ia,d} \quad (13)$$

In equation (13), *a*, *b* and *d* represent three countries, and *i* is industry.

Based on Wang et al.'s (2015) estimation framework for trade in value-added, we extend Wang and Wu's (2017) method for estimating one-way industrial relocation to two-way industrial relocation to calculate the aggregate volume of industrial relocation between China and BRI countries with the following equation:

$$ITR_{ic,ir} = T_{ic,r} + T_{ir,c} \quad (14)$$

In equation (14), $T_{ic,r}$ is the amount of industrial relocation of China's industry *i* to BRI country *r*, $T_{ir,c}$ is the amount of industrial relocation of BRI country *r*'s industry *i* to China, and $ITR_{ic,ir}$ is the total amount of two-way relocation between China and BRI country *r*'s industry *i*.

4.2.2 Control variables

In this paper, our control variables consist of the following two categories: First, the variable of distance. The distance of political systems (*POL*) is measured by the mean absolute values of differences in the rules of law, corruption control, the right of discourse and accountability, regulatory quality, government efficiency, and political stability between China and the BRI country; economic distance (*ECO*) is measured by the product between the square of difference of China's and the BRI country's constant-price GDP per capita in 2010 divided by the product between both countries, constant-price GDP in 2010. Cultural distance (*CUL*) is measured by the power distance index, individualism

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index, masculism, and uncertainty avoidance index published by Hofstede, and the missing values are substituted with the mean cultural distance with neighboring countries; geographical distance (*DIS*) is measured by the distance between the capitals of both countries times oil price of the year. Second, other control variables: GVC participation rate (*GVC_P*) is calculated based on forward and backward industrial participation rates to reflect the degree of a country's industrial participation in the GVC; absolute value of the GVC status (*GVC_D*) is measured by the absolute value of difference between China's and the BRI country's industrial value chain status to reflect the difference of the two countries in GVC status. Absolute difference of revealed comparative advantages (*RCA_D*) is denoted by the difference of the revealed comparative advantage indices of China and the BRI country to reflect the level of industrial competition between both countries. The value of free trade agreement (*FTA*), which reflects the economic and trade partnership between countries, is 1 if an FTA between China and the BRI country is in place; otherwise, the value is 0[4].

4.3 Data Source

Based on Eora global supply chain database, we calculate industry-level indicators such as industrial relocation and industrial symbiosis. Given the unavailability of data for some countries, our samples involve a total of 121 BRI countries over the period of 2002 to 2020, focusing on C4-C11 manufacturing sectors[5]. Data for measuring the distance of political systems is from the World Governance Indicators (WGI) database, data of economic distance is from the World Bank's database (WDI), data of cultural difference is from Hofstede, and data for measuring geographical distance is from the CEPII database, and data of free trade agreements is from the WTO database. To reduce the impact of outliers, we have winsorized all continuous variables at 1% in our empirical test.

5. Analysis of Empirical Results

5.1 Baseline Regression

Before conducting an empirical estimation, we perform a test of the correlation between explanatory variables using the coefficient of correlation and variance inflation factor (VIF), and the results suggest that the explanatory variables in this paper are free from serious multicollinearity[6]. Based on the model specified above, we further use the fixed effects to evaluate the reciprocal and symbiotic effects of industrial relocation between China and BRI countries with regression results shown in Table 1. In columns (1) through (3), we perform a regression analysis of industrial integration, interactivity and coordination between both sides to explain that industrial relocation between China and BRI countries has increased industrial integration, interactivity and coordination, resulting in a higher level of industrial reciprocity and symbiosis. Columns (4) through (6) are the regression results after including the control variables, and the results also suggest that industrial relocation has significantly positive effects on the industrial integration, interactivity and coordination for both sides. In order to mitigate possible endogeneity problems such as reverse causality, we introduce a one-phase lag to the core explanatory variable and control variables for verification[7], and the results suggest that industrial relocation has significantly positive effects on the two-way industrial integration, interactivity and coordination, which further supports our research conclusions, i.e. industrial relocation between China and BRI countries has increased the level of two-way industrial reciprocity and symbiosis. Thus, Hypothesis 1 is verified.

[4] For the specific calculation and descriptive statistics of indicators, available on request from the author.

[5] Manufacturing sectors include food and beverage (C4), textiles and apparels (C5), timber and paper making (C6), petroleum chemical equipment and mineral ore products (C7), metal products (C8), electrical and mechanical equipment (C9), transportation equipment (C10), and other manufacturing (C11).

[6] For the test results of variable correlation, available on request from the author.

[7] For the regression results, available on request from the author.

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Table 1: Baseline Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)
	ln *RH*	ln *HD*	ln *XT*	ln *RH*	ln *HD*	ln *XT*
ln *ITR*	0.2872***	0.0610***	0.0292***	0.2850***	0.0612***	0.0301***
	(0.0055)	(0.0016)	(0.0011)	(0.0054)	(0.0015)	(0.0011)
Control variable	No	No	No	Yes	Yes	Yes
Fixed effects of time/ industry/country	Yes	Yes	Yes	Yes	Yes	Yes
N	17,630	17,630	17,630	17,630	17,630	17,630
R^2	0.6837	0.6831	0.8988	0.709	0.7202	0.899

Note: ***, ** and * denote significance levels at 1%, 5% and 10% levels. Numbers in parentheses are robust standard errors. The same below.

5.2 Robustness Test

In this paper, we perform a robustness test of the baseline regression results from the following aspects to ensure the credibility and validity of the research conclusions: (i) Substitution of the core explanatory variable. Industrial relocation between China and BRI countries is measured by the amount of two-way industrial relocation $ITR_{ic,ir}$ as a share of global output; (ii) substitution of the explained variable: The integration, interactivity and coordination between one industry and all the other industries of another country are recalculated to substitute two-way industrial integration, interactivity and coordination; (iii) substitution of samples: A retest is performed for 64 BRI countries after matching 71 BRI countries in the *BRI Trade and Cooperation Big Data Report* released by the BRI Big Data Center in 2018 with the existing 121 countries. All the above regression results suggest that industrial relocation between China and BRI countries has increased the level of two-way industrial reciprocity and symbiosis after the substitution of variables and sample size. The overall results are consistent with the regression results in the preceding section, i.e. the regression results in this paper are robust[8].

5.3 Endogeneity Problem

In order to further reduce the endogeneity problem between two-way national industrial relocation and industrial reciprocity and symbiosis, we seek to identify an instrumental variable highly correlated with industrial relocation but exogenous to industrial reciprocity and symbiosis, i.e. this instrumental variable may influence industrial reciprocity and symbiosis only through industrial relocation. As far as correlation is concerned, the labor resources of host countries will significantly influence industrial relocation between countries. In particular, it has a significant effect on labor-intensive industries. As far as exogeneity is concerned, the premise for industrial reciprocity and symbiosis to occur between two nations is the existence of a vehicle of correlation, i.e. the symbiotic interface. As the symbiotic interface, industrial relocation serves as the basis for industrial reciprocity and symbiosis between two nations. The labor force of a host country will influence industrial reciprocity and symbiosis through the interface of industrial relocation, and has no direct effect on industrial reciprocity and symbiosis. In other words, the exclusivity constraint of the instrumental variable is satisfied. Table 2 presents the regression results of the instrumental variable. As can be seen from the first-stage regression results, the labor force of the host country is significantly conducive to industrial relocation between China and BRI countries. Specifically, the LM statistic of the under-identification test is 263.67, and the Wald F statistic of the weak instrumental variable test is 265.38, which have passed the under-identification test and the weak instrumental variable test. In general, this instrumental variable is valid. The second-

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Table 2: Estimated Results of the Instrumental Variable

	(1)	(2)	(3)	(4)
	Stage 1	Stage 2		
	ln *ITR*	ln *RH*	ln *HD*	ln *XT*
LAB	0.0364*** (0.0022)			
ln *ITR*		0.2231*** (0.0437)	0.1392*** (0.0134)	0.0183** (0.0089)
Control variables	Yes	Yes	Yes	Yes
Fixed effects of time/ industry/country	Yes	Yes	Yes	Yes
N	17,372	17,372	17,372	17,372
R^2	0.7104	0.7079	0.6779	0.8983

stage regression results indicate that the effects of industrial relocation are significantly positive for two-way industrial integration, interactivity and coordination, which is generally consistent with the baseline regression results. It is thus verified that two-way industrial relocation between China and BRI countries has increased the level of industrial reciprocity and symbiosis between China and BRI countries.

5.4 Heterogeneity Analysis

5.4.1 Regional heterogeneity based on different levels of development

The BRI involves over 100 countries, including both developed and developing countries. There are significant differences in terms of the level of cooperation and correlation between China and countries at different levels of economic development. The question is whether any differences exist in the two-way industrial reciprocal and symbiotic effects of industrial relocation between China and BRI countries at different levels of economic development? Answer to this question helps China and BRI countries to engage in targeted cooperation for industrial relocation and increase the level of two-way industrial symbiosis. According to the World Bank's classification criteria, we introduce the country dummy variable *D1* for different levels of economic development to divide BRI samples into developed and developing countries. Specifically, we assign the value of 0 to developing countries and the value of 1 to developed countries to discuss the heterogenous two-way industrial reciprocal and symbiotic effects of industrial relocation to BRI countries at different levels of development with regression results shown in Table 3, which have led to the following findings:

China's industrial relocation involving both developing and developed BRI countries is conducive to two-way industrial reciprocity and symbiosis. Judging by the integration as revealed in column (1) of Table 3, the symbol of ln *ITR*×*D*1 is significantly negative, which means that China's industrial relocation has a more significantly positive effect for developing BRI countries than for developed BRI countries. A possible reason is that China's complete manufacturing system and infrastructure construction capabilities provide developing BRI countries with favorable technology support and superior capacity for the manufacturing industry. Moreover, the capital and resource advantages of BRI countries and their urgent demand for manufacturing development are more conducive to integrated industrial development in the process of two-way industrial relocation. As can be seen from interactivity and coordination in columns (2) and (3) of Table 3, the symbol of ln *ITR*×*D*1 is significantly positive, indicating that China's industrial relocation involving developed countries create more significantly positive effects on industrial interactivity and coordination compared with developing countries. A possible reason is that developed countries boast a better investment climate, infrastructure, and

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Table 3: Estimated Results of Regional Heterogeneity

	(1)	(2)	(3)
	ln *RH*	ln *HD*	ln *XT*
ln *ITR*	0.2878***	0.0576***	0.0283***
	(0.0054)	(0.0015)	(0.0011)
ln *ITR*×*D*1	-0.0206***	0.0259***	0.0124***
	(0.0069)	(0.0020)	(0.0014)
Control variables	Yes	Yes	Yes
Fixed effects of time / industry / country	Yes	Yes	Yes
N	17,630	17,630	17,630
R^2	0.7091	0.7229	0.8994

relatively complete legal system (Deng et al., 2019), which is more conducive to industrial interaction and coordination between both sides amid the industrial relocation process.

5.4.2 Industry heterogeneity based on different technology classification criteria

BRI countries are in different stages of industrial development with uneven manufacturing capabilities and technological performance. The different levels of manufacturing technologies exert differentiated effects on the method and correlation of two industrial cooperation. Based on their traditional comparative advantages, some countries have maintained close ties of industrial cooperation with China in low-tech sectors while some other countries have been working closely with China's high-tech sectors. The question, therefore, is whether any differences exist in the manufacturing reciprocal and symbiotic effects of China's industrial relocation involving BRI countries that have different technological levels? To answer this question, we introduce the dummy variable *D2* for sectors with different levels of technology according to the OECD's classification criteria to divide manufacturing to low-tech and medium- and high-tech sectors to discuss the effects of industrial relocation on the symbiosis of different manufacturing sectors for both sides. Specifically, the value of medium- and low-tech sectors is 0, and the value of medium- and high-tech sectors is 1, with regression results in Table 4. As can be seen from the table, industrial relocation helps increase the level of industrial reciprocity and symbiosis between countries no matter for low-tech or medium- and high-tech sectors. Judging by the level of integration in column (1) of Table 4, the symbol of ln *ITR*×*D*2 is significantly negative, which means that industrial relocation for low-tech sectors is more favorable to integrated two-way industrial development, possibly because of the relatively low barriers and threshold of low-tech sectors. Judging by the level of interactivity and coordination in columns (2) and (3) of Table 4, the symbol of ln *ITR*×*D*2 is significantly positive, which means that industrial relocation has a more significantly positive effect on the interactivity and coordination of medium- and high-tech sectors. A possible reason is that China's medium- and high-tech sectors are technologically advanced for BRI countries, and their relocation is conducive to both China's medium- and high-tech industrial upgrade (Liu and Ding, 2018) and coordinated development of medium- and high-tech sectors in BRI countries, which is conducive to the improvement of interactivity and correlation between medium- and high-tech sectors in both countries. Hence, industrial relocation is more conducive to the interactivity and coordination of medium- and high-tech sectors.

5.4.3 Temporal heterogeneity before and after the announcement of the BRI

After President Xi Jinping unveiled the BRI in 2013, the Chinese government has enacted a host of policy preferences and measures to step up China's industrial cooperation with BRI countries and create a community of shared interests, shared future, and shared responsibilities. This marks a new stage of

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Table 4: Estimated Results of Industry Heterogeneity

	(1)	(2)	(3)
	ln *RH*	ln *HD*	ln *XT*
ln *ITR*	0.2990***	0.0567***	0.0159***
	(0.0058)	(0.0017)	(0.0011)
ln *ITR*×*D*2	-0.0175***	0.0056***	0.0177***
	(0.0028)	(0.0008)	(0.0005)
Control variables	Yes	Yes	Yes
Fixed effect of time / sector / country	Yes	Yes	Yes
N	17,630	17,630	17,630
R^2	0.7096	0.7210	0.9047

China's two-way industrial cooperation with BRI countries. The question is whether China's industrial relocation involving BRI countries will promote two-way industrial reciprocity and symbiosis? With the boundary of 2013, we introduce the dummy variable of time *D3* and assign the value of 0 to the period of 2013 and before and the value of 1 to the period after 2013 with regression results shown in Table 5. As can be seen from the results, two-way industrial relocation is conducive to reciprocity and symbiosis for both sides no matter before and after the BRI. The term ln *ITR*×*D*3 is significantly positive no matter when the explained variable is coordination, interactivity or integration. This implies that industrial relocation has a relatively strong effect of promoting two-way industrial reciprocity and symbiosis after the announcement of the BRI. A possible reason is that after the announcement of the BRI, China has increased policy communication, infrastructure connectivity, trade facilitation, financial intermediation, and people-to-people exchanges with BRI countries, which further provide a favorable environment of industrial cooperation for both sides. As such, industrial relocation after the BRI announcement is more conducive to industrial reciprocity and symbiosis in both countries.

Table 5: Estimated Results of Temporal Heterogeneity

	(1)	(2)	(3)
	ln *RH*	ln *HD*	ln *XT*
ln *ITR*	0.2818***	0.0496***	0.0209***
	(0.0056)	(0.0016)	(0.0011)
ln *ITR*×*D*3	0.0056*	0.0205***	0.0164***
	(0.0030)	(0.0008)	(0.0006)
Control variables	Yes	Yes	Yes
Fixed effect of time / sector / country	Yes	Yes	Yes
N	17,630	17,630	17,630
R^2	0.7090	0.7295	0.9033

6. Mechanism Test

Mechanism test indicates that China's industrial relocation involving BRI countries helps promote industrial reciprocity and symbiosis in both sides by promoting regional industrial chain cooperation and increasing the level of industrial agglomeration. By introducing regional value chain cooperation

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and industrial agglomeration as intermediate variables for a test, this paper has revealed the intrinsic rationale of the industrial reciprocal and symbiotic effects of industrial relocation between China and BRI countries. The specific intermediate effect model is as follows:

$$M_{ic,ir}^{t}=\alpha_0+\alpha_1\ln ITR_{ic,ir}^{t}+\alpha_2\ln Z_{ic,ir}^{t}+\alpha_3\ln D_{cr}^{t}+\varphi_t+\lambda_r+\eta_i+\varepsilon_{ic,ir}^{t} \tag{15}$$

$$\ln Y_{ic,ir}^{t}=\phi_0+\phi_1\ln ITR_{ic,ir}^{t}+\phi_2\ln M_{ic,ir}^{t}+\phi_3\ln Z_{ic,ir}^{t}+\phi_4\ln D_{cr}^{t}+\varphi_t+\lambda_r+\eta_i+\varepsilon_{ic,ir}^{t} \tag{16}$$

In the above equations, Z is control variable, and M is intermediate variable, i.e. the proxy variable for the level of regional value chain cooperation and the level of industrial agglomeration, and other symbols have the same definitions with equation (12). If the symbols of $\alpha_1\times\phi_2$ and ϕ_1 are the same, the implication is that M has an intermediate effect in the reciprocity and symbiosis effects of industrial relocation; otherwise, the suppressing effect exists. Specifically, industrial agglomeration (*INC*) is measured by the average proportion of the total value-added of industry *i* in China and various countries to the current-year global value-added of industry *i* referencing Jin et al. (2006). The level of regional value chain cooperation (*RVC*) is defined as follows referencing Peng and Lin (2021):

$$RVC_{ic,ir}=\frac{VAR_{ic,ir}+VAR_{ir,ic}}{EXP_{ic}+EXP_{ir}} \tag{17}$$

In equation (17), $VAR_{ic,ir}$ is value-added of country *r*'s industry *i* in the exports of China's industry *i*, $VAR_{ir,ic}$ is value-added of China's industry *i* in the exports of country *r*'s industry *i*, EXP_{ic} is the total exports of China's industry *i*, and EXP_{ir} is the total exports of country's industry *i*.

The intermediate effect of regional value chain cooperation. As can be seen from column (1) of Table 6, the regression coefficient of industrial relocation (ln *ITR*) is significantly positive at the 1% level, which indicates that industrial relocation between China and BRI countries has a significantly increased regional value chain cooperation. As shown in column (2) of Table 6, regional value chain cooperation has a negative effect on integration while industrial relocation has a significantly positive effect on integration. This suggests that a suppressing effect exists in the regional value chain cooperation when it comes to the influence of industrial relocation between China and BRI countries on two-way industrial integration. A possible reason is the uneven industrial capabilities and disparate industrial structures of BRI countries at various stages of industrial development. Two-way industrial integration has suffered greatly due to inadequate industrial compatibility, resulting in a suppressing effect as shown in the regression results. To address this problem, we further perform a regression test of newly industrialized BRI countries in the same category with China, and the results suggest that industrial relocation between China and BRI countries may increase two-way industrial integration through regional value chain cooperation[9]. Moreover, the results of columns (3) and (4) of Table 6 suggest that regional value chain cooperation has significantly positive effects on interactivity and coordination, and that the regression coefficients of industrial relocation with respect to interactivity and coordination are significantly positive and smaller than the regression coefficients in columns (5) and (6) of Table 1. The implication is that industrial relocation between China and BRI countries may increase two-way industrial interactivity and coordination through regional value chain cooperation. Hence, the intermediate mechanism of regional value chain cooperation in Hypothesis 2 is verified.

[9] With newly industrialized BRI countries as samples, our regression suggests that regional value chain cooperation has a significantly positive effect on integration, and the symbols of and are the same. The implication is that regional value chain cooperation has an intermediate effect for industrial relocation to influence industrial integration. Moreover, the regression results for this sample have also verified the intermediate effect of regional value chain cooperation for industrial relocation to influence industrial interactivity and coordination. For the regression results, available on request from the author.

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Table 6: Regression Results of Regional Value Chain Cooperation's Intermediate Effect

	(1)	(2)	(3)	(4)
	RVC	ln *RH*	ln *HD*	ln *XT*
ln *ITR*	0.0106***	0.3055***	0.0517***	0.0223***
	(0.0004)	(0.0055)	(0.0015)	(0.0011)
RVC		-1.9377***	0.8918***	0.7328***
		(0.1147)	(0.0323)	(0.0227)
Control variables	Yes	Yes	Yes	Yes
Fixed effect of time / sector / country	Yes	Yes	Yes	Yes
N	17,630	17,630	17,630	17,630
R^2	0.6688	0.7137	0.7319	0.9047

Intermediate effect of industrial agglomeration. As can be learned from column (1) of Table 7, the regression coefficient of industrial relocation (ln *ITR*) is significantly positive at the 1% level, indicating that China's industrial relocation involving BRI countries has increased industrial concentration on both sides. As revealed in the regression results of columns (2)-(4) of Table 7, industrial agglomeration has significantly positive effects no matter when the explained variable is integration, interactivity or coordination. Meanwhile, the regression coefficients of industrial relocation with respect to integration, interactivity and coordination are significantly positive and smaller than the regression coefficients in columns (4) through (6) of Table 1. The implication is that industrial relocation between China and BRI countries may increase two-way industrial interactivity, integration and coordination by increasing the level of industrial concentration. In other words, industrial concentration has an intermediate effect for industrial relocation between China and BRI countries to promote two-way industrial reciprocity and symbiosis. Hence, the intermediate mechanism of industrial agglomeration in Hypothesis 2 is verified.

Table 7: Regression Results of Industrial Agglomeration's Intermediate Effect

	(1)	(2)	(3)	(4)
	INC	ln *RH*	ln *HD*	ln *XT*
ln *ITR*	0.1982***	0.2722***	0.0553***	0.0203***
	(0.0096)	(0.0054)	(0.0015)	(0.0010)
INC		0.0644***	0.0296***	0.0493***
		(0.0042)	(0.0012)	(0.0008)
Control variables	Yes	Yes	Yes	Yes
Fixed effect of time / sector / country	Yes	Yes	Yes	Yes
N	17,630	17,630	17,630	17,630
R^2	0.9789	0.7129	0.7299	0.9184

7. Conclusions and Policy Recommendations

We discussed the theoretical rationale of how industrial relocation between China and BRI countries promotes industrial reciprocity and symbiosis on the three dimensions of the integration, interactivity, and coordination using a combination of symbiosis and GVC theory. The level of industrial reciprocity and symbiosis between China and BRI countries was measured using the Eora global supply chain

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database of 2002-2020, and from analyzing this data we reach the following conclusions. (i) The level of China's manufacturing reciprocity and symbiosis with BRI countries has steadily increased, but differences exist across sectors and regions. Specifically, there is a fairly high degree of reciprocity and symbiosis for market-oriented electrical and mechanical equipment and the labor-cost-oriented textile and apparel industry, especially between China and neighboring East and Southeast Asian countries. (ii) The results of our econometric tests provide good support for Hypothesis 1 that industrial relocation between China and BRI countries promotes industrial reciprocity and symbiosis. Such reciprocal and symbiotic effects are realized primarily through the promotion of regional value chain cooperation and industrial agglomeration, which verifies hypothesis 2. (iii) Regional, sectoral, and temporal heterogeneity exists in the reciprocal and symbiotic effects of industrial relocation between China and BRI countries. Greater interactivity and coordination effects have been generated from industrial relocation between China and developed BRI countries and in medium- and high-tech sectors. In addition, the BRI has been conducive to increasing two-way industrial integration, interactivity and coordination, achieving the intended policy effects.

Reciprocity and symbiosis are the driving forces behind industrial relocation between China and BRI countries, and in this paper we have demonstrated the BRI's reciprocal and symbiotic effects and addressed the political concerns of many other countries have regarding China's true intentions with the BRI. Our research conclusions thus have important policy implications for advancing industrial relocation between China and BRI countries and expediting the BRI's "high-quality" development.

First, it is imperative to promote interactions and synergy between the upstream and downstream sectors of the industrial chain in order to increase integration, interactivity, and coordination. Priorities should include: (i) Improving the bilateral and multilateral free-trade networks between China and BRI countries to facilitate trade, and developing free-trade zones to liberalize and facilitate investment and create "high-quality" service platforms for two-way industrial integration and development; (ii) increasing upstream and downstream interactions and mutually beneficial cooperation between China and BRI countries, expediting two-way cultural exchanges, political communication, and infrastructure connectivity, developing sound mechanisms for regional investment promotion and protection, and enhancing regional BRI policy coordination to create a favorable external environment for two-way industrial interaction and development; (iii) encouraging China's advantageous industries to invest abroad, connecting domestic circulation with BRI-centric international circulation, and fostering a multi-tiered regional industrial division of labor system in partnership with BRI countries to coordinate regional upstream and downstream industrial development.

Second, we recommend the Chinese government to facilitate the step-by-step relocation of industries and enhance bilateral and multilateral industrial collaboration between China and BRI countries. The priorities here should encompass the following: (i) Prioritizing collaboration between China and BRI countries in sectors that exhibit a significant degree of mutual interdependence, such as electrical and mechanical equipment and textiles and apparel. This entails promoting the relocation of industries driven by market demands and labor costs, intensifying bilateral and multilateral cooperation in medium and high-tech sectors, and fostering shared development in these sectors among BRI countries through the exchange of technologies and management expertise; (ii) continually advancing industrial cooperation between China and countries in East and Southeast Asia, which serves as the foundation for broader collaboration between China and other BRI countries.

Third, it is essential to stimulate the process of cross-regional integration and local agglomeration of industries while simultaneously establishing cooperative structures for industrial and supply chain collaboration that foster mutual benefits and yield positive outcomes for all parties involved. These priorities should encompass the following: (i) Expanding China's advantageous industrial chains to BRI countries through leading enterprises and the establishment of a regional value chain cooperation

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system for the BRI in terms of capital, technology, branding, and channels; (ii) enhancing the service system for overseas investment institutions and industrial parks, developing integrated industrial cooperation zones with "high quality" standards, and promoting BRI industrial agglomeration by setting up international cooperation zones for industrial relocation between China and BRI countries; (iii) proactively developing supporting industrial systems for China and BRI countries, encouraging collaboration among upstream and downstream enterprises of advantageous industrial chains in their relocations, and enhancing trade facilitation, security protection, and financing support to facilitate BRI regional industrial agglomeration.

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