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Co-coupling Analysis of China's OFDI and Digital Economy Development in Belt and Road Countries

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Abstract: To explore China's OFDI and that of other regions in the collaborative development of digital economy under the construction of the Belt and Road, while studying the synergistic effect between China's OFDI and areas along the national digital economy coordination effect, based on the application of the entropy method (TOPSIS) method of coordination degree model, to build the development coordination degree evaluation model of China's foreign direct investment and national digital economy where areas are gradually developing along the Belt and Road, the model is applied to 38 countries and regions. The research proves that the coupling degree of this composite system between the two subsystems increases year by year, and is gradually close to 1. Research is helpful to test through the digital way to reduce risk and expanding the scope of the earnings of China's foreign direct investment and areas there specific effects between digital economy, new era in order to promote China's OFDI and area development of national digital economy all the way, can provide the new train of thought and the Chinese high quality investment ideas.

Keywords: Belt and Road, Foreign Direct Investment, Digital Economy, Synergy

1. Introduction

The digital economy is increasingly irreplaceable in promoting social development, and the new generation of information technology has been deeply integrated with the real economy, promoting economic restructuring. In recent years, as the level of China's OFDI has increased, there has been a remarkable digital economic breakthrough along the Belt and Road. Using factor analysis method, Zhang concluded by constructing panel data that the digitalization level in Southeast Asia and other places along the Belt and Road has a positive impact on China's investment location choice[1]. Zhou et al. investigated the action mechanism of OFDI of Chinese enterprises on digital economy innovation of along countries, and put forward suggestions for high-quality investment of Chinese enterprises[2]; Ngeow discussed the potential of digital connectivity between Malaysia and China, and concluded that the Belt and Road has a good technological upgrading effect on Malaysia's economic development[3]. Park discussed the impact of China's trade opening to North Korea and specific investment features by studying the ripple effect of the economic influence of Asian countries along the route[4]. Recently, most scholars have demonstrated the interaction mechanism of the two, but mainly focused on their unilateral relationship. However, China's foreign direct investment and

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areas digital economy in the Belt and Road will interact with each other, not just in one direction. According to the influencing factors of comprehensive problem, the paper uses the entropy weight method to select a scientific and reasonable order parameter index of subsystem, and uses the research method of collaborative analysis to build the co-coupling model of the two. The model was also applied to 38 countries of the Belt and Road to make the research results universally applicable to other regions. It will promote the coordinated development of China's outbound direct investment and the digital economy of countries along the Belt and Road.

2. Synergy Effect Analysis between China's OFDI and Digital Economy d\Development of One Belt and One Road

In order to transform the national economy in quality, efficiency, and power, it is an inevitable choice to build a digital industrial agglomeration area. Therefore, under the trend of gradually improving digital infrastructure and digital innovation capability, the agglomeration of the service industry in the host country can make the local enterprises better absorb foreign strategic assets, and improve the development level. Similarly, this industrial agglomeration effect makes it easier for the country to obtain high-level science, technology and management experience through the reverse spillover of OFDI, thus forming a positive interaction of internal and external double cycles and better promoting the high-quality economic development of both sides[5]. On digital technology in addition, China has become the international comparative advantage of developing countries, the "area" all the way along the country's digital economy related investment can produce strong technology spillover effect, urge local perfect infrastructure, at the same time, digital eliminate the factors of production to some extent on the supply and demand information barriers, reduce the supply and demand information asymmetry. As a result, the circulation efficiency of innovative elements such as talent, capital and technology is improved, and then the FDI is attracted[6]. Therefore, in theory, China's OFDI will have a positive effect of mutual promotion and common promotion with the digital economy development among the Belt and Road.

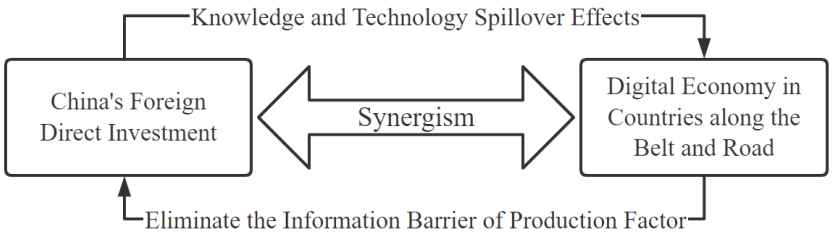

Figure 1. Synergies between China's OFDI and digital economy development in Belt and Road countries.

3. Construction Based on TOPSIS Synergy Degree Model

Constructing the order parameters of these two subsystems, this paper studies the degree of synergy between China's OFDI and the digital economy of the Belt and Road, constructs the evaluation model of the synergy degree of the two, and reveals the evolution law and trend of the system.

Starting from the two order parameters, this paper constructs a collaborative evaluation system of China's OFDI and the digital economy complex system of the Belt and Road. Then it reveals their objective change situation.

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3.1. Determination of Order Parameters

3.1.1. Digital Economy Development Order Parameter Situation

Digital economy in view of the area along the country the establishment of the order parameter, this paper mainly refers to the research on regional financial development indicators by Wang, Cheng et al. and Liu et al.[7][8][9], based on the digital infrastructure, digital competitiveness, digital development environment and digital innovation ability from four aspects to measure the number of countries in the economic development situation. In order to conform to the authenticity, accuracy and rationality of the data obtained, this paper designs an index system as shown in Table 1.

Table 1. Digital economy development order parameter.

Order parameter	Level indicators	The secondary indicators	Unit
Digital economy subsystem（Y）	Digital Infrastructure(Y1)	Fixed broadband Internet users（Y11）	Ten thousand people
		Number of telephone lines per 100 people(Y12)	Pcs
		Number of Internet security servers(Y13)	Pcs
	Digital competitiveness(Y2)	High-tech export ratio(Y21)	-
		ICT product export ratio(Y22)	-
		ICT services export ratio(Y23)	-
	Digital development environment(Y3)	Charge for intellectual property(Y31)	Thousands of dollars
		Contract technical fee(Y32)	Thousands of dollars
		Share of R&D spending(Y33)	-
ICT services export ratio	Digital innovation capability(Y4)	Percentage of R&D personnel(Y41)	-
		The number of patents granted(Y42)	Pcs

3.1.2. Subsystem Order Model

This paper establishes two subsystems respectively for China's OFDI S1 and the digital economy of the Belt and Road countries S2, and their composite system is S={S1,S2}. The subsystem is Sj(j∈[1,2]) and the order parameter is ej=(ej1,ej2,...,ejn), where $\beta ji \le eji \le \alpha ji, n \ge 1, i = 1,2,\dots,n$. (ej1,ej2,...,ejn) is assumed to be a positive index. And $(ejl+1, ejl+2, \dots, ejn)$ is assumed to the negative value. Then the system order degree is:

$$u_j(e_{ji}) = \begin{cases} \frac{e_{ji}-\beta_{ji}}{\alpha_{ji}-\beta_{ji}}, i \in [1,l] \\ \frac{\alpha_{ji}-e_{ji}}{\alpha_{ji}-\beta_{ji}}, i \in [l+1,n] \end{cases} \quad (1)$$

In this paper, the selected order parameters are integrated by linear weighting method to obtain the contribution of each order parameter to the composite system.The entropy weight method is used to determine w_j. First, the original data were standardized, as shown in Equation (2). Where, if $x'ij$ =0,

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it is replaced by the infinitesimal 0.00000001. Secondly, the weight p_{ij} of the JTH evaluation index of the i evaluation object is calculated. Then, the entropy e_j and redundancy d_j of index j are calculated. Where,$k = \frac{1}{ln(n)}$ and, $e_j \geq 0$ satisfy. Finally, the weights w_j of each index are obtained.

$$x'_{ij} = \begin{cases} \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}, (Positive\ \ indicators) \\ \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})}, (Negative\ \ indicators) \end{cases} \quad (2)$$

$$pij = \frac{x'ij}{\sum_{j=1}^{m} x'ij} (i = 1,2, \dots, n; j = 1,2, \dots, m) \quad (3)$$

$$ej = -k \sum_{i=1}^{n} pij\ ln(pij) \quad (4)$$

$$wj = \frac{dj}{\sum_{j=1}^{m} dj} \quad (5)$$

3.2. Synergy Degree Model

For the rational measure of China's foreign direct investment (fdi) and the area of the country's comprehensive digital economy level, which is described in this paper. The degree of coordination model is used to measure the interaction between two systems, and reflect the coordinated development situation between each other. Therefore, they can be analyzed reasonably. The order degree of subsystem j is calculated by linear weighting method, and the weighted sum of the weight and order degree obtained by entropy method also reflects the contribution degree of subsystem to the whole system. C is the degree of coordination, K is the adjustment coefficient, and the value is 2.C∈(0,1),if C is larger, it indicates more synergy. D is the degree of collaborative development, and T is the comprehensive evaluation index of China's OFDI and the digital economy among the Belt and Road. The value α of and β is 0.5.

$$uj(ej) = \sum_{i=1}^{n} uj(eij)wj \quad (6)$$

$$C = \left\{ \frac{U1 \times U2}{\left[\frac{U1+U2}{2}\right]^2} \right\}^K \quad (7)$$

$$D = (C \times T)^K \quad (8)$$

$$T = \alpha U1 + \beta U2 \quad (9)$$

4. Empirical Analysis

4.1. The Data Source

Considering the availability of each order parameter data, 38 countries from 2016 to 2020 were selected, specifically: Singapore, Malaysia, Thailand, Indonesia, Mongolia, Philippines, Vietnam, myanmar, the Czech republic, Estonia, Greece, Poland, Slovakia, Slovenia, Croatia, Lithuania, Latvia, Hungary, Russia, Bulgaria, bosnia and herzegovina, belarus, kazakhstan, Macedonia and

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Montenegro, Romania, Turkey, Georgia, Serbia Data for Kyrgyzstan, Moldova, Ukraine, Uzbekistan, India, Pakistan, Israel, UAE, Iraq, Egypt. The source of China's OFDI is China's OFDI Bulletin. Data on fixed broadband Internet users, number of telephone lines per 100 people, number of Internet security servers, high-tech export ratio, ICT product export ratio, ICT service export ratio, IP access fees, and R&D expenditure were obtained in the World Bank. The contract technology fee, the proportion of R&D personnel, and the number of the three types of patents authorized are all taken from the China Science and Technology database. Because the data of some countries is missing, a linear interpolation method is adopted to complete the data.

4.2. Determine the Weight Index

Table 2. Index weights of digital economy subsystem.

Order parameter	Level indicators	The secondary indicators	Weighted
Digital economy subsystem（Y）	Digital Infrastructure(Y1)	Fixed broadband Internet users（Y11）	0.11307
		Number of telephone lines per 100 people(Y12)	0.03820
		Number of Internet security servers(Y13)	0.13479
	Digital competitiveness(Y2)	High-tech export ratio(Y21)	0.06199
		ICT product export ratio(Y22)	0.11134
		ICT services export ratio(Y23)	0.05093
	Digital development environment(Y3)	Charge for intellectual property(Y31)	0.23447
		Contract technical fee(Y32)	0.07987
		Share of R&D spending(Y33)	0.03252
ICT services export ratio	Digital innovation capability(Y4)	Percentage of R&D personnel(Y41)	0.02475
		The number of patents granted(Y42)	0.11807

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4.3. Analysis of System Order Degree and Coordination Degree

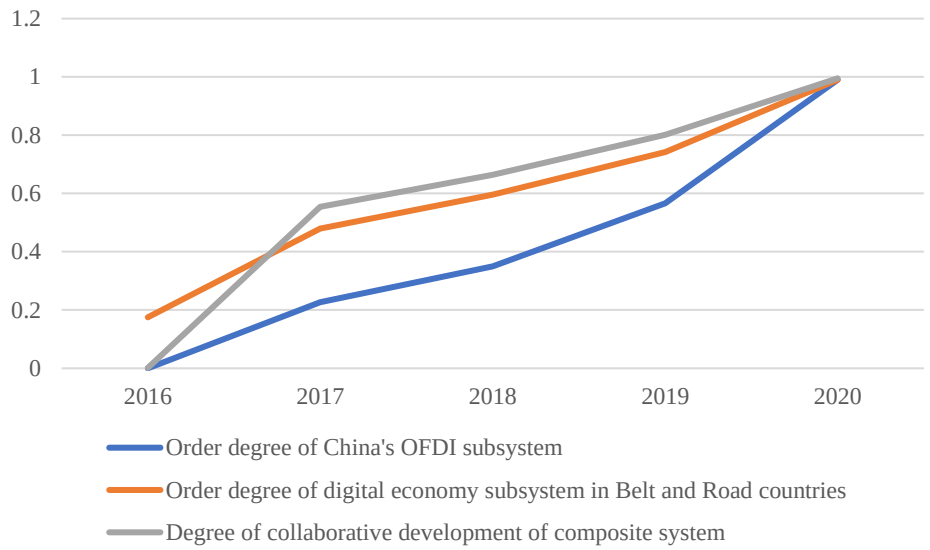

Figure 2. Changes in the order degree and synergetic development degree of China's OFDI and the digital economy of the Belt and Road countries from 2016 to 2020.

System order analysis. From Figure 2, the degree of the order shows an overall upward trend, and the growth rate of the order degree of the former subsystem is obviously stronger than that in the later. The order degree of China's OFDI subsystem increased from 0.000001 in 2016 to 0.99, and the order degree of the digital economy subsystem of the Belt and Road countries increased from 0.17502491 in 2016 to 0.99 in 2020, and reached the peak in 2020. It indicates that the influence degree of them on the composite system increases gradually. Comparing them, it is obvious that in 2016–2019, the order of degree in China's foreign direct investment (fdi) subsystem is generally stronger than in the digital economy subsystems, showing that China's OFDI is ahead of the area along the national digital economy, the area along the national digital economic support and boost; From 2019 to 2020, the degree of the two are gradually getting closer to each other, which proves that driven by China's outward foreign direct investment, the digital economy along the Belt and Road has witnessed significant growth.

System synergy development degree analysis. As can be seen from Figure 2, the synergy degree of China's OFDI and the digital economy gradually increases. The overall changing trend of collaborative system can be divided into two phases:

The first stage: from 2016 to 2017, the two subsystems grew synchronously. During this time, the collaborative development degree of the composite system increased rapidly, from 0.00141421 to 0.554539754, all of which were positive.

Stage 2: From 2017 to 2020, the two order degree in systems grew steadily, while the growth rate of the synergistic development degree slowed down. While the two keep always synergistic, and the synergistic development degree gradually approached 1.

5. Discussion

Therefore, according to the above empirical test conclusion, from the perspective of high-quality development, effective investment should be used to empower the digital economy in the Belt and Road countries. First, China can further leverage its comparative advantages in digital technology, seize the opportunity to make the digital economy a broad stage of international cooperation, use its

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expertise and international experience to improve communication in the digital area, and help investe countries improve their innovation capacity in the digital economy. Second, in the process of actively going global, China should strive for multilateral cooperation, actively negotiate and sign cooperation facilitation agreements, form an institutional basis for friendly cooperation, reduce transaction costs on a global scale, and make investment easier and more convenient. Third, China should ensure that its enterprises go global through diversified financing and government funding support, and shape its strategic choice of new advantages in international cooperation and competition. The government should encourage private investment in the field of digital economy cooperation; encourage private organizations to actively participate in all the "area" construction; improve the quality of investment; with the help of private investment, actively promote Eurasia 5 g communication network upgrades and the Internet to build up the intelligent digital and intelligent transportation; at the same time, help strengthen the efficiency of public services in order to enhance the level of the "area" digital economy of the country.

6. Conclusion

In the context of increasingly fierce conflicts between globalization and values, China's OFDI has an increasingly deep impact on reshaping the local digital economy industrial chain. It is helpful to study its role in promoting globalization in depth. From 2016 to 2020, based on the digital economy development samples of 38 countries and regions along the Belt and Road, this paper effectively detects the synergistic development between China's OFDI and the digital economy and its mechanism. The results show that it has a positive synergistic coupling relationship between them, and China's OFDI significantly drives the development of digital economy level of "One Belt and One Road" countries. As China's cross-border investment deepens, digitization accelerates connectivity. Technological spillover promotes the transformation of single point innovation to cross innovation and fusion innovation. The popularization of intelligent mobile terminals and the comprehensive coverage of high-speed information network accelerate this process, shorten the cycle of technological innovation and knowledge multiplication, and promote the formation of a multi-field coordinated digital economy development system.

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