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EDITED BY
Magdalena Radulescu,
University of Pitesti, Romania

REVIEWED BY
Alexandra Horobet,
Bucharest Academy of Economic
Studies, Romania
Mihaela Simionescu,
University of Social Sciences, Poland

*CORRESPONDENCE
Yi Xiao,
defeather@163.com

†These authors have contributed equally
to this work

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Equilibrium or imbalance? Regional variations and evolutionary traits of two-way FDI coordination level in Yangtze River economic belt

Xiaochun Pan[†], Yi Xiao^{†*} and Zhengjun Liu

School of Economics, Yunnan University, Kunming, China

Based on the VAR model, the two-way FDI data of the Yangtze River Economic Zone from 2005 to 2019 were used as the specimen. The correlation of the two-way FDI was observed using the VAR impulse effect through ADF root test and lag structure laboratory testing. The original study results demonstrated that there have been disparities in the spatial and temporal evolution of FDI and OFDI coordination levels between the eastern, central, and western city groups in the Yangtze River Economic Belt region from 2005 to 2019. The unequal expansion of FDI and OFDI is the phenomena that results in the gap between eastern and western cities. The development of the coupling coordination level between the east and west areas has been unequal due to variances in the natural environment, trade value, corporate expansion, and other variables. Contrarily, the Yangtze River Economic Belt's western urban agglomerations have a lower level of coupling and coordination development than the region's eastern urban agglomerations, with an overall declining phenomena from east to west. The coupling and coordinated development of two-way FDI within the economic belt, which has a significant impact on the rationalization of regional resource allocation, industrial structure optimization, and technology iteration with civilization construction, can be greatly facilitated, in our opinion, by strengthening uncoordinated regional development infrastructure and deepening regional economic-industrial links.

KEYWORDS

two-way FDI, environment economy, foreign investment (inward and outward FDI), Yangtze River economic belt, financial and trade globalization

Introduction

The sixth meeting of China's Central Finance and Economics Commission in 2020 pointed out that it would promote the construction of the Yangtze River Economic Belt and build the Yangtze River Basin Economic Circle to promote the construction of "One Belt, One Road", the development of the Yangtze River Economic Belt and the strategic development of the western region in the new era. Since the reform

and opening-up, China's economy has continued to grow steadily, and from the reform and opening up to the "One Belt, One Road" initiative, all of them indicate China's determination to open up to the outside world. "Through the step-by-step implementation of these two strategies, China has been opening up more and more to the outside world. Generally speaking, the academic community has adopted "Inward Foreign Direct Investment" and "Outward Foreign Direct Investment" as the two strategies of "bringing in" and "going out" respectively. The Yangtze River basin introduces more IFDI, and at the same time, it should export OFDI that matches its imported IFDI, which is not only conducive to the higher investment return of the excess domestic capital, but also the harmonious development of China's foreign relations. And less IFDI is introduced in the central and western regions. The Yangtze River Basin Economic Belt consists of the following 11 provinces and municipalities, namely Guizhou, Sichuan, Yunnan, Chongqing, Hubei, Hunan, Jiangxi, Anhui, Jiangsu, Zhejiang, and Shanghai. Further research on the economic development and economic cooperation between the east and west of the Yangtze River Basin and international can be carried out by measuring the coordinated development level of two-way FDI, therefore, the construct of measuring the coordinated development level of two-way FDI can effectively The development of international economic trade in the Yangtze River Economic Zone can be observed.

The Yangtze River basin flows through important major economic zones in China and is an important representative of China's economy (Zhu et al., 2021). The rapid growth of IFDI and OFDI in the 11 provinces and municipalities in the Yangtze River Economic Zone is historically set against the backdrop of the global popularity of China's "One Belt, One Road" initiative and the rise of the Asian Infrastructure Investment Bank as an emerging force in infrastructure investment (Huang et al., 2018; Zhao et al., 2022). In this context, to study the interaction between the coordinated development of two-way FDI and economic growth in the Yangtze River Economic Belt, the data of two-way FDI in 11 provinces and regions in the Yangtze River Basin from 2009 to 2019 are selected as samples, which not only provide supporting empirical tests for the rationality of national macro policies at the application level but also further expand the new economic geography research framework at the theoretical level (Li, 2021; Xu and Zhou, 2021). Therefore, this study is of great practical significance and theoretical value. Measuring the coordinated development level of two-way FDI for the whole Yangtze River Economic Belt from 2010 to 2020 and analyzing its influencing factors, as well as proposing targeted policy recommendations, can help promote the development of foreign trade and investment and financing in the Yangtze River Economic Belt to integrate faster and better into the journey of building a modernist power in China (Liang, 2021; Yang, 2021).

The marginal contributions and original features of this study are mainly reflected in the following aspects. First, the historical background of the rapid growth of IFDI and OFDI in 11 provinces and cities in the Yangtze River Economic Belt is particularly important, and is closely related to China's "One Belt, One Road" initiative and the global environmental economy and investment trade. The matching effect mechanism of IFDI and OFDI will provide a reference for many countries and regions. Secondly, studying the coordinated development mechanism of two-way FDI among cities in Yangtze River basin will not only benefit the host country's surplus capital to obtain higher investment returns, but also contribute to the harmonious development of China's foreign relations. In this case, the interaction between the coordinated development of two-way FDI and the economic growth of the Yangtze River economic belt will have an important impact on the environmental economy and regional development. The originality of this paper is reflected in the use of VAR model for unit root test and impulse effect analysis, which reveals a consistent cycle of two-way FDI development between regions, and provides a basis for the analysis of the synergy of two-way FDI using coupled coordination degree model in the later paper changes. Finally, the coordinated development level of two-way FDI in the whole Yangtze River Economic Zone from 2005 to 2019 is measured, and the entropy value method, coupling degree and coupling coordination degree are used to analyze its influencing factors, and the coupling coordination degree level of two-way FDI is found to be related to regional economic development, and policy suggestions are proposed to enhance two-way FDI synergy and promote economic development in targeted regions, which can help promote foreign trade and investment financing in the Yangtze River Economic Zone It can not only provide supporting conclusions for the rationality of macro policies formulated by different countries and regions at the application level, but also further expand the research framework of the new economic geography. The research framework of geography, this paper includes the following parts, the second part is the literature review, the third part includes research methodology, data sources, theoretical framework, and coupling coordination model, the fifth part is experiment preparation, including data description, ADF root test, and impulse effect analysis, the sixth part is conclusion and policy implications.

Literature review

Research on FDI and OFDI

Research on IFDI and OFDI has been the focus of research in the field of international direct investment, and the issue of

international spillover of IFDI and OFDI has been discussed more in academic circles (Tuan and Ng, 2004). Among them, there are different views on the technology spillover effect of FDI on host countries, some scholars believe that there is a significant positive spillover effect of IFDI on host countries (Zhang, 2012; Xu, 2021), while some scholars believe that technological innovation in IFDI host countries is not significant or even has a suppressive effect (Ritchie, 2009; Ren et al., 2014; Baprios et al., 2016); and it is quite controversial on whether the reverse technology spillover of OFDI to the home country is significant (Liang, 2014; Shahbaz et al., 2015); the discussion on the technology spillover effect of two-way FDI is less covered in the related literature. Richard et al. (2011) included both IFDI and OFDI in the IDP development theory proposed in the unified analytical framework, arguing that IFDI has technology spillover effects, which in turn will promote OFDI. Since then, many scholars have enriched the research framework from both theoretical and empirical aspects, such as Liang (2021) and Naqeed (2016), and other kinds of literature have studied and analyzed the evolution of two-way FDI. Among the studies on the mechanism of the role of two-way FDI on development between countries and regions, the main focus is on the novel development trends of two-way FDI - industrial iteration, economic development, capital accumulation and market technology development (Massand, 2021; Outreville, 2021; Bashir, 2022). On the one hand, IFDI brings additional channels and market resources for the acquisition of intangible capital such as knowledge, technology and management of host country enterprises, which promotes the accumulation of capital in a broad sense and the embedding of host country market advantages, forming a transitional transformation process from capital inflow to capital stock and improving inter-regional economic competitiveness (Anwar and Iwasaki, 2022; Bouchoucha, 2022). In this process, the production and landing of IFDI industrial projects enhance the localization and integration of foreign enterprises by means of backward and forward linkage of industrial chains, generating economic benefits for the local economy while promoting the iteration of industrial comparative advantages, forming a process of efficiency transformation to quality improvement (Bournakis et al., 2022; Bretas et al., 2022; Broers, et al., 2022). On the other hand, OFDI creates the basis for international cooperation and overseas roots of host country enterprises through resource seeking, market expansion, personnel exchanges and strategic asset acquisitions, forming the process of OFDI flow growth to stock expansion. On the other hand, OFDI creates the foundation for international cooperation and overseas roots of host country enterprises through resource seeking, market expansion, personnel exchanges and strategic asset acquisitions, forming the process of OFDI flow growth to stock expansion; with the adaptive

technological changes and rising costs of production factors in host countries, the outward transfer of some industries realizes the divestment of non-adaptive production links and global production and factor resource re-matching, forming the process of transformation of low value-added production capacity to high quality (Febbraio, et al., 2022); through overseas core asset acquisitions and industrial cooperation, the return of knowledge, technology, process and other elements to the core of the industrial chain and the reshaping of production capacity, strengthening the locational centripetal force for higher quality IFDI, and forming a feed-back process from international external resources to the internal industrial system (Pollock and Biggar, 2020; Konewka et al., 2021). The cycle of the above-mentioned process realizes the spiral of IFDI subsystem and OFDI subsystem from the mutual promotion of scale to the complementary benefits, thus achieving the benign integration at the high quality level and building the bridge between the inter-regional and international cycles at the high quality and high level.

Two-way FDI quality coordination

For how to measure the development level and measurement of two-way FDI quality coordination, there are mainly two ways for now: one is to measure the coordination relationship between each other by introducing the interaction term of IFDI and OFDI quality (Stoian, 2013; Gong; Wang et al., 2021); the other method is to measure the coordination relationship of two-way FDI by drawing on the capacity-coupled system model in physics, such as Jiang and Meng, (2021) and Liang and Luo. (2019) measured the level of interactive development of two-way FDI in China's manufacturing industry based on testing the existence of an interactive relationship between IFDI and OFDI quality using Chinese manufacturing industry segmentation data. For the study on the influencing factors of coordinated development of two-way FDI, the study of Rens et al. (2014) concluded that the factors of simultaneous development of IFDI and OFDI quality in developing countries differ significantly, and the level of economic development and technology gap significantly affect IFDI quality development, but do not have the same impact on OFDI development; Haizhen and Haizhen (2016) used a dynamic threshold regression model The study finds that the single threshold phenomenon of intellectual property protection exists in the technology spillover pathway of China's two-way FDI quality to introduce foreign investment at a higher level and higher quality, further improve the depth and level of China's outward investment, adhere to the "import" and "go out". The representative studies mentioned above mainly answer the

coordinated mechanism of IFDI contributing to OFDI, and in addition, the rapid development of OFDI will further feed into IFDI. Bouchoucha (2022) investigates the influence mechanism of OFDI on IFDI in less developed regions using different research samples. He argues that there is a structural transmission mechanism between OFDI and IFDI, and the former study concludes that OFDI forms a structural transmission mechanism through industrial technology heightening, labor force structure heightening and output value structure heightening to promote the quality level of IFDI; Da Silva-Oliveira et al. (2021) use a model to test the industrial structure mechanism bond of OFDI Huang et al. (2018) studied the exchange rate transmission mechanism and structural transmission mechanism of China's OFDI affecting IFDI from a global macro perspective, and his findings showed that the dual transmission mechanism not only has a significant positive impact on both IFDI scale and quality, but also has a significant positive impact on IFDI quality in resource-rich, technologically advanced high-income countries. The results show that this dual transmission mechanism not only has a significant positive impact on the size and quality of IFDI, but also has a more significant effect on the quality of IFDI in resource-rich and technologically advanced high-income countries. It is an important measure for China to achieve a higher level of opening up, and is an inevitable requirement to cope with the new changes in the international environment and to cultivate new advantages for China to participate in international cooperation and competition under the new situation (Leonard et al., 2016; Luosha, 2014; Lutao et al., 2018; Michael, 2018).

The above-mentioned studies have provided many constructive references on the two-way FDI quality in the relevant countries or regions (Baek, 2016; Jian et al., 2016; Sapkota and Bastola, 2017). However, there are shortcomings in the existing ones: (1) the relationship between IFDI and OFDI as two variables to study them and economic growth respectively, although they can reflect the relationship between IFDI or OFDI scale coordination independently, they cannot reflect the degree of coordinated development of IFDI and OFDI over some time and the mutual influence of their coordinated development degree and two-way FDI quality; (2) Previously, we focused more on the scale of FDI introduction and OFDI going out, but now we emphasize the quality of FDI and OFDI, and the coordinated development of both, which is a new perspective in measuring the coordinated development level of the quality of both; (3) Few scholars have combined the historical background and main findings of the "double-cycle", especially from a certain economic belt (Yangtze River Economic Basin). Few scholars have combined the historical background of the "double-cycle" with the main findings, especially from a certain economic zone (Yangtze River Economic Basin), to give policy inspirations that are more relevant for regional development.

Research methodology

Data sources

This article uses a variety of data collection means, such as Python, Octopus crawler system, etc., to collect a large number of literature related to this topic, through the collation and analysis of this literature, to provide theoretical support for the study; data, the data sources are mainly China's national economy and China's social development statistics bulletin, the study of the Yangtze River Basin 11 subject areas of statistics The data sources are China National Economic and China Social Development Statistical Bulletin, China Statistical Yearbook, China Economic Yearbook, China Industrial Economic Data Website, and China Industrial Economic Data Statistics, etc. In addition, due to the existence of time and space constraints, some data in 2020 could not be collected, so the data of each provincial and urban area from 2005-to 2019 are selected, which are the data of IFDI and OFDI of the 11 provinces and urban areas in the Yangtze River Economic Belt for the past 15 years, respectively.

Theoretical framework

Coupling, originally from physics, was first proposed by Larry Constantine and generally refers to the coefficient of coupling, i.e., the process of coordinated development between two or more systems formed by the interaction of their internal mechanisms. In the classification of coupling, it can be divided from low to high into loosely coupled, tightly coupled, etc. Also, according to the characteristics of the degree of coupling between subsystems, it can be further classified as shared coupling, feature coupling, control coupling, data coupling, etc. In studying the coordinated development level of two-way FDI, the development trend of both is studied by introducing the coupling degree theory.

Based on the coupling degree, we can analyze the degree of mutual influence of two-way FDI (foreign direct investment and foreign direct investment) between Yangtze River basin regions, but it is not sufficient to reflect the level of coordinated development and common development between them, so we introduce the coupling coordination degree to evaluate the level of coordinated development between systems. The coupling coordination degree refers to the comprehensive and holistic characteristics of the subsystem under the satisfaction of data coupling and feature coupling, and the ability of the subsystem to achieve the coordinated development between systems under the advantageous driving and related conditions. The coupling coordination degree index compares the inter-system development capability horizontally and vertically

from the comprehensive aspect and classifies the level of comprehensive and coordinated development of sub-systems into levels based on this, which is more comprehensive compared with the coupling degree.

Coupling coordination model

In this paper, drawing on the coordinated evaluation system method of Yang (2021), we set the FDI system S1 and OFDI system S2 of the 11 provinces and regions in the Yangtze River basin with the comprehensive evaluation functions of development levels as $F1(X)$ and $F2(y)$, respectively, where x and y are the eigenvectors of S1 and S2, respectively, and calculate the respective comprehensive development levels of the FDI and OFDI systems with the following equations.

$$F(X/Y) = \sum_{j=1}^p \omega_j \mu_j \quad (1)$$

In formula (1), W_j is the weight of the indicator, and U_j is dimensionless of the evaluation index.

The determination of indicator weights W_j is based on the entropy value objective assignment method, which determines the weights of indicators by analyzing the degree of correlation between indicators and the amount of information provided by each indicator based on the original information of the objective environment, thus avoiding the bias brought by subjective factors to a certain extent [15].

Let X_{ij} denote the value of the j th indicator of sample i , $i = 1, 2, \dots, n; j = 1, 2, \dots, p$, where n and p are the number of samples and the number of indicators, respectively. The specific steps are as follows.

Step 1. data standardization: Since different indicators have different scale units, data standardization is required to ensure the comparability of indicators, and the article selects the extreme value method of the dimensionless linear method to process the data.

μ_{ij} uses the dimensionless method to dimensionless each evaluation index, and its calculation formula is.

$$\mu_{ij} = \frac{X_{ij} - \min X_j}{\max X_j - \min X_j} \quad (2)$$

In Eq. 2, U_{ij} takes the value range of [0,1], $\max X_j$, and $\min X_j$ are the maximum and minimum values of the j th index respectively.

After data standardization, the entropy values h_j , weights W_j , and S_{ij} denote the data of the i th region of the j th index as a proportion of the index, and n denotes the total number of samples by the entropy value method, respectively, for the FDI and OFDI levels in the 11 provinces and cities in the Yangtze River basin.

Step 2. counterweight transformation of indicators.

$$S_{ij} = X_{ij} / \sum_{j=1}^p X_{ij} \quad (3)$$

Step 3. calculate the entropy value of the indicator U_{ij} .

$$h_j = \frac{1}{\ln 55} \sum_{i=1}^n S_{ij} \ln S_{ij} \quad (4)$$

Step 4. calculate the weights of the indicators.

$$\omega_j = h_j / \sum_{j=1}^p h_j \quad (5)$$

Step 5. calculate the comprehensive evaluation: after the indicators are obtained from the specific indicator weights of the subsystem, the comprehensive evaluation is calculated to measure the degree of contribution of the subsystem to the total system, and the calculation formula is as (5).

The coupling degree of FDI and OFDI is the total strength of the interaction, interdependence, and mutual influence between FDI and OFDI and each element, and the quantitative measurement of the coupling degree of these two subsystems can reflect the coupling and coordination development of FDI and OFDI OFDI. The article will refer to the model established by Liang (2021) for calculation, and the calculation process is as follows.

Define the coupling degree of regional FDI and OFDI system as C .

$$C = \left\{ \frac{F_1(x)F_2(y)}{[F_1(x) + F_2(y)]^2} \right\}^{\frac{1}{2}} \quad (6)$$

C represents the coupling degree between FDI and OFDI systems, and the value range of C is [0,1], when the value of C tends to 1, it indicates that the two-way FDI tends to orderliness, the greater the correlation is, which means that the resonance coupling between the indicators is reached; but when the value of C tends to 0, it proves that the orderliness is none, and at the same time the correlation is smaller, which indicates that the development of FDI cannot make the rapid OFDI development and the development of FDI cannot act on the improvement of OFDI development level [9]. $F_1(x)$ and $F_2(y)$ are the comprehensive evaluation indices of FDI and OFDI OFDI, respectively.

Given that the coupling degree can reflect the coupling degree of FDI and OFDI systems, it is difficult to fully reflect the synergistic effect and overall effect of FDI and OFDI. Therefore, the article uses the coordination degree to synthesize the coupling status of the FDI and OFDI system and the level they are at, and then derive the overall synergy status between them. Thus the introduction of the coordination

TABLE 1 Classification of coupling degree interval types.

Coupling degree value interval	Coupling type	Evaluation of the degree of coupling
$C = 0$	I Coupling degree is 0	The two systems are uncorrelated
$0 < C \leq 0.3$	II Low degree of sexual coupling	Coupling between the two systems is gradually formed
$0.3 < C \leq 0.5$	III antagonistic coupling	Coupling between the two systems already exists to a certain degree of development
$0.50 < C \leq 0.80$	IV Abrasive coupling	The degree of coupling between the two systems is good
$0.8 < C \leq 1$	V high degree of sexual coupling	The two systems promote each other and tend to develop in an orderly manner

TABLE 2 Classification criteria of coupling coordination level.

Coordination D value interval	Coordination level	Degree of coupling coordination
0–0.09	1	Extremely dysfunctional
0.1–0.19	2	Severe disorder
0.2–0.29	3	Moderate disorder
0.3–0.39	4	Mild disorder
0.4–0.49	5	Near dissonance
0.5–0.59	6	Weakly coordinated
0.6–0.69	7	Low coordination
0.7–0.79	8	Moderate coordination
0.8–0.89	9	High coordination
0.9–0.1	10	Extremely coordinated

degree formula gives a very clear picture of the degree of coupling and coordination between the two system [11].

Define the reconciliation index of FDI and OFDI as M.

$$M = \alpha F_1(x) + \beta F_2(y) \tag{7}$$

Define the degree of coordination between FDI and OFDI as D.

$$D = \sqrt{C \times M} \tag{8}$$

M is the comprehensive coordination index, which reflects the contribution of the overall development level of FDI and OFDI to the coordination degree, α and β are coefficients to be determined, and the study regards FDI and OFDI systems as equally important, so both α and β take the value of 0.5, when $F_1(x)$ and $F_2(y)$ both take low and close values, that is, the two subsystems are calculated coupling degree is high, but the development level of both is low. Therefore, the coupling coordination degree model is introduced to measure the level of interaction and coordination of two-way FDI, and further construct the model of coupling coordination degree. D is the coupling coordination degree, a quantitative nature indicator to measure the level of C. The value range of d is in [0,1], and the more the value of d tends to 1, the greater the coordination degree of FDI and OFDI systems, and vice versa, the smaller the coordination degree. If $F_1(x) > F_2(y)$, it is OFDI development

lagging type; if $F_1(x) < F_2(y)$, it is IFDI development lagging type and evaluated based on coupling degree interval type division, as in Table 1 and coupling coordination degree level, interval and type division, as in Table 2.

Impulse response function

In view of the multiple drawbacks of the traditional test methods, this paper proposes to use the impulse effect function in the vector autoregressive (VAR) system to test the synergistic effect of two-way FDI in the Yangtze River Economic Zone. All the variables included in the VAR system are regarded as endogenous variables, which avoids the complicated problems of dividing endogenous and exogenous variables and identifying models, thus solving the endogeneity of research methods based on regression analysis. The impulse response analysis in VAR is not based on parameter estimation, so it can avoid the problems of omitted variables, endogenous variables and heteroskedasticity in the traditional parameter estimation-based test methods. It is because the VAR model has the above advantages and functions that it is well suited for the synergistic effect of two-way FDI.

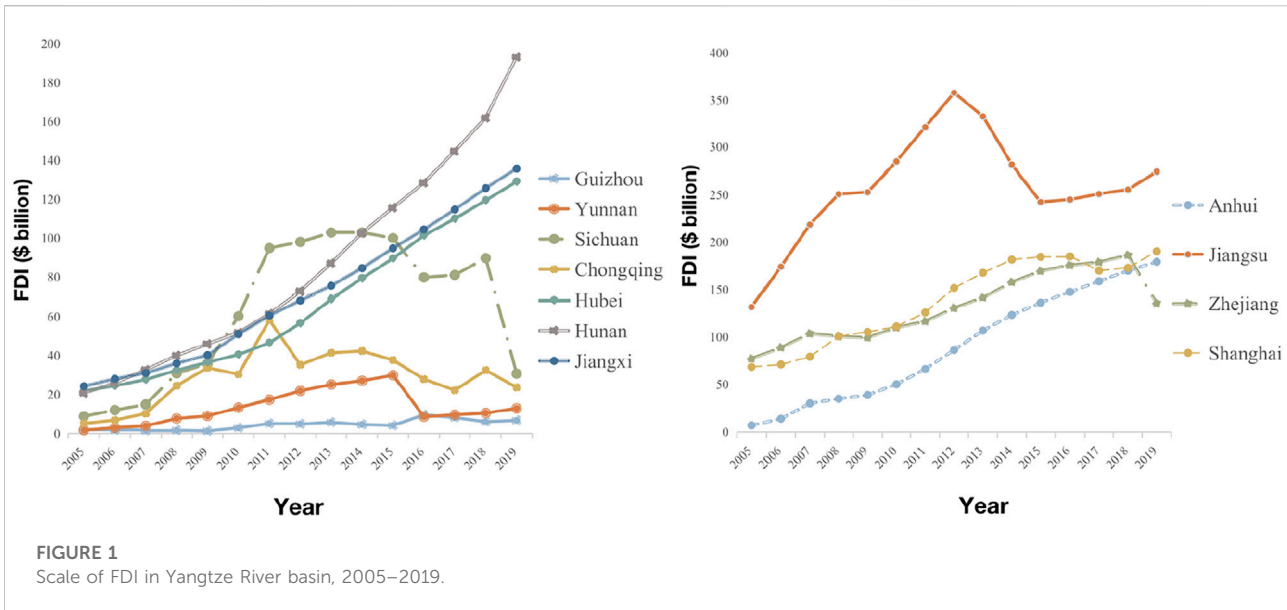
Consider a P-order vector autoregressive (VAR) model.

$$Y_t = B + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + \epsilon_t \tag{9}$$

Where Y_t is a k-dimensional vector of endogenous variables, A_i is the coefficient matrix, and B is a constant vector. ϵ_t is a k-dimensional error vector with covariance matrix Ω . If Eq. 10 is invertible, it can be expressed as a vector moving average model (VMA) as follows.

$$Y_t = C + \sum_{s=0}^{\infty} \Psi_s \epsilon_{t-s} \tag{10}$$

Where Ψ_s is the coefficient matrix and C is the constant vector, which can be derived from A_i and B in Eq. 10, it can be seen that the elements of the i-th row and j-th column of the coefficient matrix Ψ_s represent, the S-period lagged reflection of variable i to the unit shock generated by variable j, i.e., the S-period impulse response of variable i to variable j in the VAR system. An assumption is implied here that the components of the error vector ϵ_t are not correlated with each other. However, the above



assumption does not hold in general, which means that the vector ϵ_t is not a standard vector white noise and Ω is not a diagonal array. For this reason, the following transformation is often made: since the covariance matrix Ω of the error vector is positive definite, there exists a non-singular array P such that $PP' = \Omega$, so that Eq. 11 can be expressed as

$$Y_t = C + \sum_{s=0}^{\infty} (\Psi_s P) (P^{-1} \epsilon_{t-s}) = C + \sum_{s=0}^{\infty} (\Psi_s P) \omega_{t-s} \quad (11)$$

After the transformation, the original error vector ϵ_t becomes the standard vector white noise ω_t . At this point, the i -th row and j -th column elements of the coefficient matrix $\Psi_s P$ represent, the S -period impulse response of the orthogonalized shock of variable i to one standard error of variable j in the system.

Experiment preparation: description and test

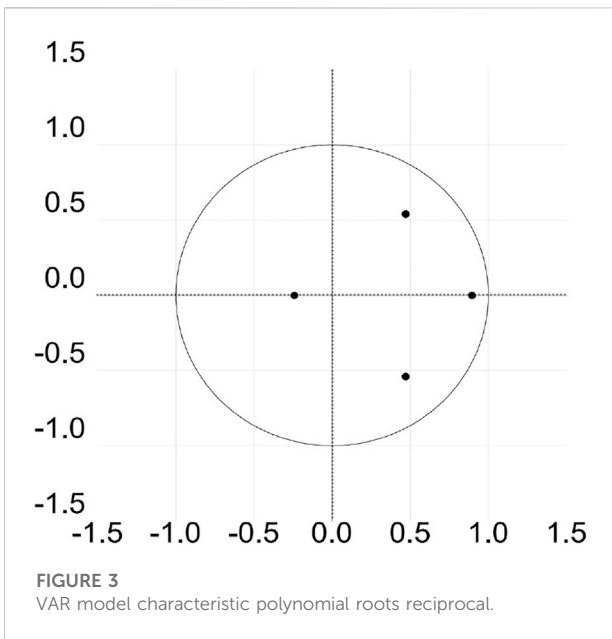
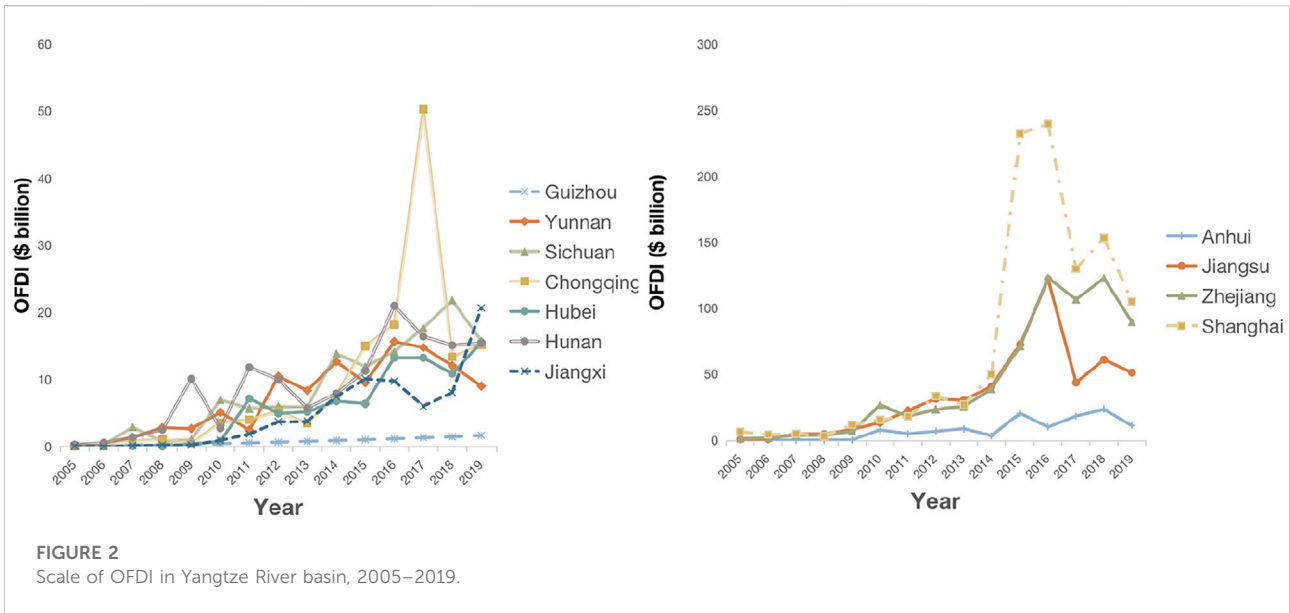
Data description

In this paper, when studying the coordinated level of the development scale of two-way FDI in the 11 provinces of the Yangtze River basin in the last 15 years, the OFDI and FDI of foreign direct investment in the 11 provinces of the Yangtze River basin (Guizhou, Yunnan, Sichuan, Chongqing, Hubei, Hunan, Jiangxi, Anhui, Jiangsu, Zhejiang, and Shanghai) are selected for analysis. From the development trend described in the previous section, there are obvious differences in the level of interactive development of two-way FDI in the 11 provinces, with a large fluctuation level in the early years, and the two-way FDI in each region began to gradually show an upward trend since 2009 and

reached the top of this year in 2015. Foreign direct investment IFDI is used to evaluate the scale level of foreign direct investment received by the 11 provinces and cities in the Yangtze River Basin region, and OFDI is used to evaluate the scale level of foreign direct investment in the 11 provinces and cities in the Yangtze River Basin region.

According to the “China Statistical Yearbook” and “China Economic Data”, the IFDI data of the eastern Yangtze River Economic Belt are shown in Figure 1 below, which shows that the overall level of IFDI from the eastern Yangtze River Economic Belt to foreign direct investment is higher than the development level of the central and western parts of the Yangtze River, and the FDI of the three regions of Anhui, Zhejiang, and Shanghai in the eastern Yangtze River has been in a one-way upward trend in the past 15 years, and in 2018 and 2019 reached the peak of the last 15 years, more than 10 billion U.S. dollars, while for Jiangsu, the FDI IFDI in the last 15 years is in a fluctuating trend, reached the peak of the last 15 years in 2012, at 357.6 billion U.S. dollars, higher than the other three provinces and cities in the eastern region with the level, from 2013 onwards in a downward trend, and briefly rebounded in the last 5 years.

The current situation of IFDI development of foreign direct investment in seven provinces and urban areas in the Yangtze River Central and Western Economic Belt is shown in Figure 1. In the early years (2005–2007), IFDI in seven provinces and urban areas grew slowly, all below the range of 5 billion USD, and since 2008, IFDI in foreign direct investment in three regions, mainly Hunan, Jiangsu, and Hubei, was in a high-speed development trend, and in 2019 reached the peak of nearly 15 years, among which, Hunan Province’s FDI approached USD 20 billion in 2019 and has converged to Shanghai’s IFDI



level, while Sichuan Province’s IFDI transformed from a flat development to a sharp decline in 2019, low to below USD 5 billion, and the other 3 regions’ IFDI has changed less in trend in the past 15 years.

The level of OFDI scale in the eastern Yangtze River region is shown in Figure 2 below, the development level of OFDI in the four regions was in a flat development trend from 2005 to 2013, and the overall difference was not big, maintaining between USD 5 billion, since 2014–2015, the scale of OFDI mainly in Shanghai began to rise massively, and was close to USD 25 billion U.S. dollars, but in 2017 began to be in a downward trend. Anhui,

Jiangsu, and Zhejiang provinces and regions have had an upward trend since 2015, among which, OFDI in Jiangsu and Zhejiang provinces has changed more and increased massively compared with the previous 2014, and OFDI in Zhejiang began to exceed USD 10 billion in 2016, much higher than the 2 regions of Jiangsu and Anhui.

The OFDI development level of 7 provinces and urban areas within 2008 began to be in a fluctuating upward trend, among which, the OFDI development level of Chongqing City reached the top of 7 provinces and urban areas in 2017, which is 5 billion U.S. dollars, and the other 6 provinces and regions with Hunan, Sichuan, Yunnan and Hubei as The rising fluctuation of OFDI development level represented by Hunan, Sichuan, Yunnan and Hubei ranks after Chongqing, while Guizhou Province is in the most lagging region of OFDI development level among the 7 provinces and urban areas in the middle and western reaches of Yangtze River, and the OFDI level of Guizhou Province is only USD 157 million in 2019, which is much lower than the development level of other 10 provinces and urban areas in the Yangtze River basin.

ADF root test

Before measuring the interaction effect of coordinated development of two-way FDI, this paper compares and analyzes the characteristics of various panel unit root test methods, and the ADF test is selected to examine the smoothness of the main variables. And the ADF test was conducted using SPSS22.0, and the results are shown in Table 3 below, it can be seen that for the variable IFDI, the t-statistic of the ADF test for this time-series data is -0.434, the

TABLE 3 ADF test results.

	Differential order	t	p	Threshold		
				1%	5%	10%
Δ infect	-0.434	0.986	-4.668	-3.731	-3.309	-0.434
	-1.580	0.800	-4.988	-3.865	-3.383	-1.580
	-3.696	0.023**	-4.884	-3.822	-3.359	-3.696
Δ lnOFDIit	7.481	1.000	-5.118	-3.918	-3.411	7.481
	1.118	1.000	-5.283	-3.985	-3.447	1.118
	-5.738	0.000***	-5.283	-3.985	-3.447	-5.738

** Indicates significant results at the 5% level.

TABLE 4 Results of lag phase number selection.

Lag	LogL	FPE	AIC	HQ	SC
0	-3.43E+01	1.13E+25	63.35864	6334077	53.03812
1	-323.9865	250e+23	59.53619	5948260	50.21457
2	-3203050	2.71E+23	59.54748	59.45816	50.41 717
3	-3.15E+02	2.25E+23	59.19249	59.06744	50.32861
4	-293.5096	3.02e+22*	56.79681*	56.63603*	57.28920*

Note: * Denotes the lags that should be chosen for the corresponding statistical indicators.

TABLE 5 Lag structure test of VAR model.

Root	Modulus
0.894424	8.94E-01
0.469909-0.539393i	0.715374
0.469909 + 0.539393i	0.715374
-0.241691	0.241 691

Impulse effect analysis

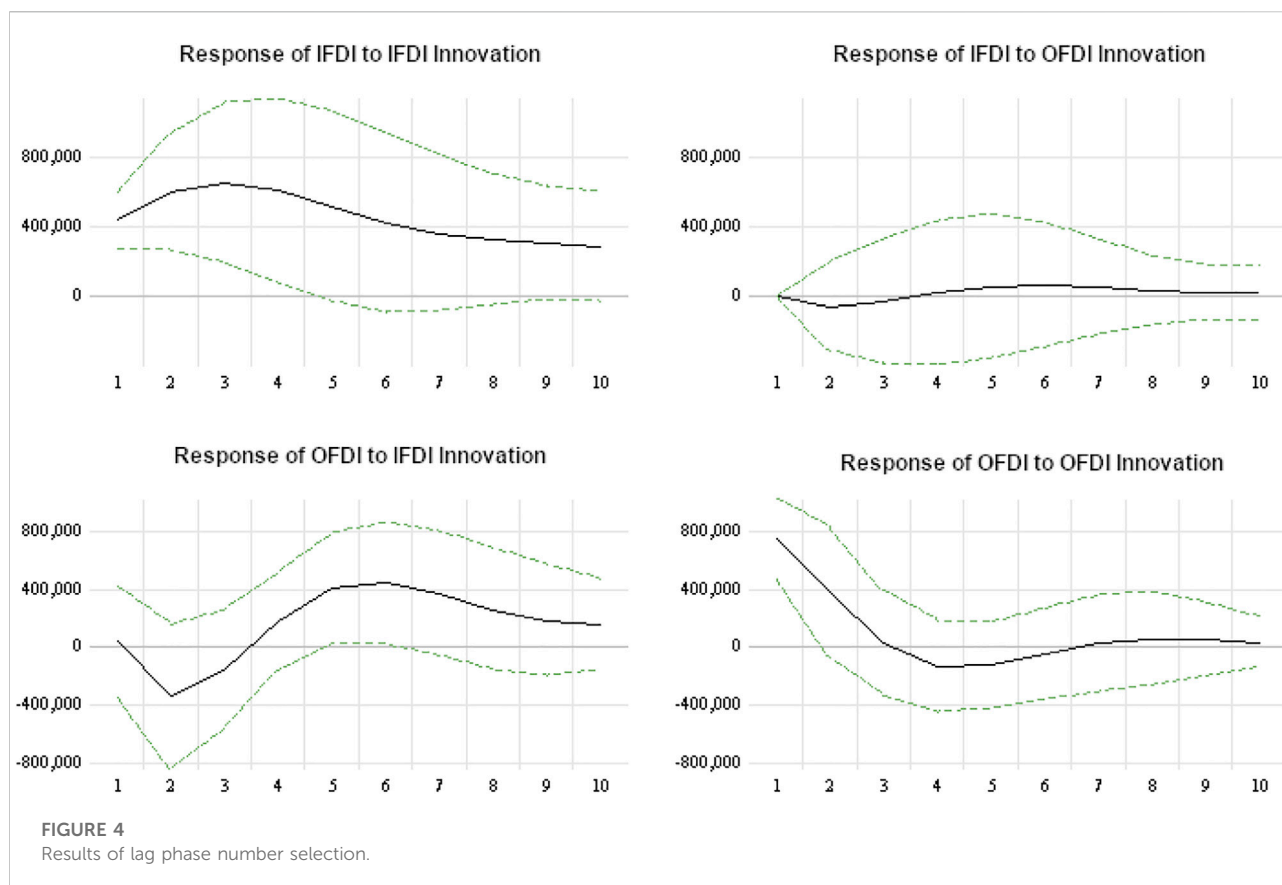
p -value is 0.986, and the 1%, 5%, and 10% critical values are -4.668, -3.731, and -3.309, respectively. $p = 0.986 > 0.1$, which cannot reject The original hypothesis, the series is not smooth. The series was subjected to first-order difference and then an ADF test. The results of the ADF test on the data after first-order difference show that $p = 0.800 > 0.1$, the original hypothesis cannot be rejected and the series is not smooth, so the series is subjected to second-order difference and then the ADF test. The result of the ADF test after second-order differencing shows that $p = 0.023 < 0.05$, there is more than 95% certainty to reject the original hypothesis, and the series is smooth at this time.

For the test variable OFDI, the t -statistic of the ADF test for this time-series data is 7.481, the p -value is 1.000, and the 1%, 5%, and 10% critical values are -5.118, -3.918, and -3.411, respectively. $p = 1.000 > 0.1$, the original hypothesis cannot be rejected and the series is not smooth. The series was subjected to first-order difference and then an ADF test. The result of the ADF test on the data after first-order difference shows that $p = 1.000 > 0.1$, the original hypothesis cannot be rejected and the series is not smooth, and the series is subjected to second-order difference and then the ADF test. The ADF test result of the data after the second-order difference shows that $p = 0.000 < 0.01$, there is more than 99% certainty to reject the original hypothesis, and the series is smooth at this time.

After concluding that the series of two-way FDI is smooth after conducting the ADF test, this paper draws on Huang et al. (2018) to introduce the impulse effect function to verify the impulse interaction between the two-way FDI. Before the inversion of the impulse function, this paper used Eviews 12 to conduct a vector autoregressive analysis of the two-way FDI using the FPE criterion, LogL, red pool information quantity (AIC), HQ criterion, and SC criterion to select the lag phase respectively, from which and the best lag phase was selected as shown in Table 4 below, which shows that the best lag phase is 4.

For a VAR model, a VAR model is stable if the reciprocal of all root modes of the VAR model is less than 1, i.e., if it lies within the unit circle. If the model is unstable, some results are not valid, such as the standard deviation of the impulse response function. As a result of this test, Table 5 and Figure 3 show that the VAR model is stable and can be subjected to impulse response analysis.

Where the endogeneity, individual, and time effects of the variables are taken into account, the parameters are estimated using the generalized moments of the system, and the fixed effects are eliminated in the estimation process using the forward differential Hermlet transform. The impulse response functions of IFDI and OFDI are obtained using 999 Monte Carlo simulations. The results are obtained a Since the impulse response functions need to separate the orthogonal part from the perturbation terms, and the results of the Chorisky decomposition are sensitive to the order of the variables, the



order of the variables is adjusted in this paper to verify the robustness of the results, resulting in Figure 4 below.

The results of the two-way FDI impulse response function are thus obtained. Where the horizontal coordinate on the way indicates the number of lags (years) of the effect of the shock and the vertical coordinate indicates the dynamics of the explanatory variables, it can be found that an exogenous shock of one standard deviation of foreign direct investment IFDI leads to a huge positive fluctuation of OFDI in the second period, and similarly, when OFDI is subjected to an external when the standard deviation of the shock, it is also subjected to a significant positive fluctuation impact. Therefore, by the choice of impulse function, it can be found that FDI and OFDI will have a mutually reinforcing effect.

Empirical result and discussion

This study takes data on the scale of foreign direct investment IFDI and outward direct investment OFDI in 11 provinces and municipalities in the east and west of China's Yangtze River basin from 2005 to 2019 as the research sample, and takes the coordinated development effect of two-way FDI as the research object, on the one hand, combing the evolutionary

effects of two-way FDI in the central and western parts of China and the east in the past 15 years, and modeling the coupling degree and coupling coordination degree. The coordination mechanism of the two-way FDI scale is empirically studied. Firstly, the coordination level of two-way FDI in 11 provinces and municipalities in the Yangtze River basin of China was obtained by assigning data weights according to the entropy method after dimensionless standardization of data and scoring to test the two-system development level of two-way FDI in the past 15 years. Finally, the following Tables 6, 7 are obtained by using the trend analysis method.

As shown in Table 6, Table 7, and Figure 5, the regional coupling degree evolution in the middle and western reaches of the Yangtze River Basin has a decentralized layout, among which, two-way FDI in Guizhou Province has been in a dysfunctional state in the past 15 years, due to its economic factors limited by geographical factors and policy factors, the amount of OFDI is lower compared with other provinces and regions, and the coupling coordination level of two-way FDI is at the bottom of seven provinces and regions in the middle and western reaches. The two-way FDI in Sichuan and Chongqing, led by the Sichuan-Chongqing Economic Circle, is at the front end of the seven provinces and regions, and the coupling degree exceeds 0.7 in more than half of the years in the last 15 years, which is a

TABLE 6 The coupling of two-way FDI in central and western yangtze river economic belt.

Year/Region	Guizhou	Yunnan	Sichuan	Chongqing	Hubei	Hunan	Jiangxi
2005	0.37	0.00	0.79	0.13	0.00	0.52	0.04
2006	0.00	0.39	0.99	1.00	0.00	0.99	0.00
2007	0.00	0.16	0.38	0.74	0.00	0.95	0.26
2008	0.00	0.15	0.99	0.89	0.00	0.73	0.70
2009	0.00	0.51	0.82	0.41	0.32	0.61	0.00
2010	0.00	0.59	1.00	1.00	0.28	0.86	0.34
2011	0.00	0.86	0.99	1.00	0.84	0.77	0.73
2012	0.00	0.49	0.92	0.95	0.99	0.97	0.89
2013	0.00	0.65	0.88	0.97	0.95	0.93	0.85
2014	0.00	0.80	0.95	0.99	0.78	0.76	0.82
2015	0.00	0.63	0.28	0.73	0.17	0.26	0.29
2016	0.00	0.00	0.42	0.96	0.32	0.40	0.26
2017	0.00	0.22	0.77	0.51	0.48	0.48	0.24
2018	0.00	0.73	0.73	0.93	0.34	0.38	0.27
2019	0.00	0.78	0.98	0.93	0.62	0.47	0.77

TABLE 7 The coupling of two-way FDI in eastern yangtze river economic belt.

Year/Region	Anhui	Jiangsu	Zhejiang	Shanghai
2005	0.84	0.39	0.76	0.93
2006	1.00	0.66	1.00	0.75
2007	0.93	1.00	0.92	0.70
2008	0.99	1.00	0.88	0.93
2009	0.52	0.97	0.94	0.75
2010	0.90	0.91	0.72	0.93
2011	1.00	1.00	0.78	0.82
2012	1.00	1.00	0.83	0.76
2013	1.00	1.00	0.83	0.86
2014	0.40	1.00	0.94	0.91
2015	0.44	0.73	0.88	0.95
2016	0.22	0.92	1.00	0.94
2017	0.56	0.77	0.96	0.89
2018	0.60	0.85	0.97	0.88
2019	0.43	0.92	0.83	0.91

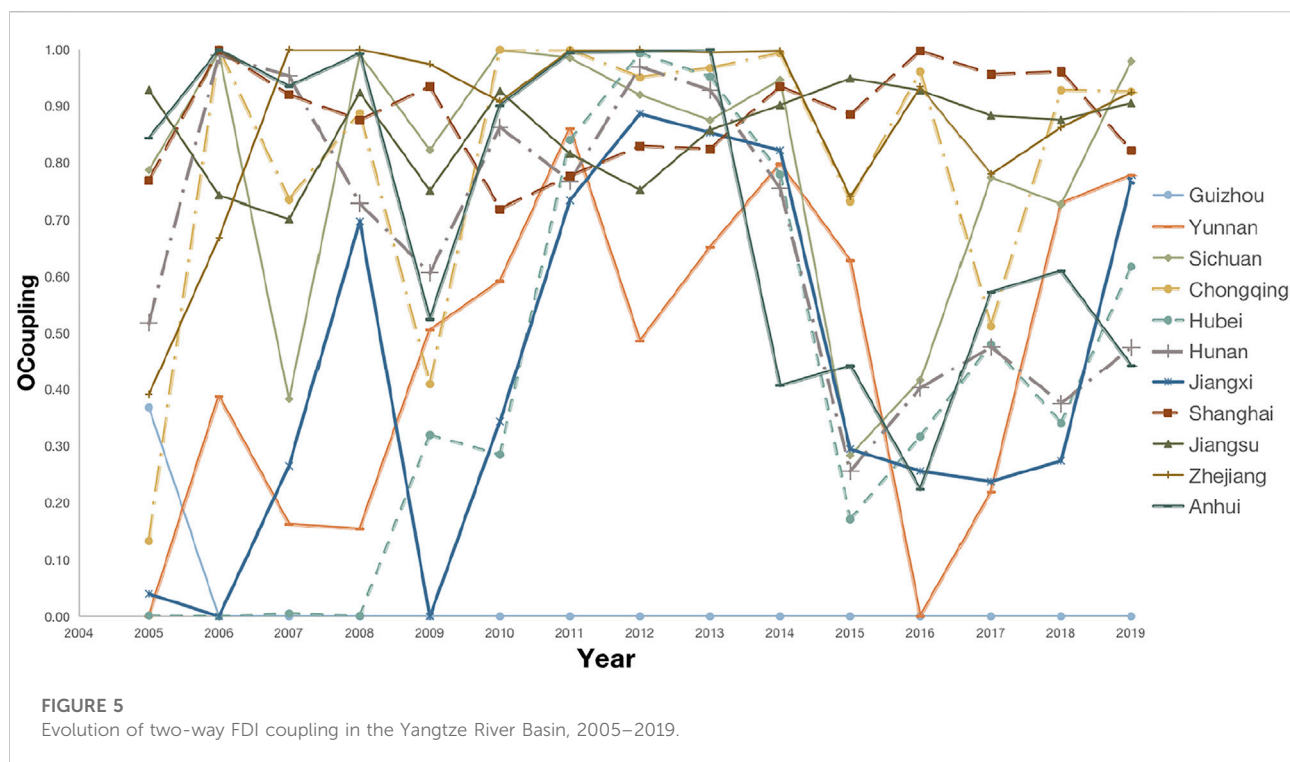
medium and high coupling situation. The two-way FDI coordination level in the middle reaches of the Yangtze River Economic Zone and Yunnan and Jiangxi are lower compared with that in Sichuan and Chongqing, and the trend of change is larger. The two-way FDI coupling coordination level of four provinces and municipalities in the east stream of the Yangtze River is in a high position relative to the central and western regions, and the coupling degree of Anhui has shown a decreasing trend in the past 5 years, especially a rapid decrease in 2013–2014, with a large extreme difference from

TABLE 8 Five-year evolution of coupling and coordination among 11 provinces and cities.

Region/Time	Coupling Degree(c)			Coordination level(D)		
	2019	2014	2009	2019	2014	2009
Guizhou	I	I	I	1	2	1
Yunnan	IV	V	III	2	2	2
Sichuan	V	V	V	3	2	2
Chongqing	V	V	III	3	1	2
Hubei	IV	IV	III	3	2	2
Hunan	III	IV	IV	3	4	4
Jiangxi	IV	V	I	3	2	1
Anhui	III	III	III	4	2	2
Jiangsu	V	V	V	4	1	5
Zhejiang	V	V	V	4	1	3
Shanghai	V	V	IV	3	1	3

the other three regions. The two-way FDI in Zhejiang, Shanghai, and Jiangsu regions has been at a high level, and in most cases in the last 15 years is greater than 0.6, which is a moderate and highly coupled and coordinated situation, which is inseparable from the long-term economic development foundation, foreign investment situation and international trade transactions in Jiangsu, Zhejiang and Shanghai regions. The highly coupled situation brings a high level of coordinated development of two-way FDI in the Jiangsu, Zhejiang, and Shanghai regions at the same time, which is inseparable from the promotion effect of economic development and trade activities.

Taking every 5 years as a cycle - 2019, 2014 and 2009, for example, it can be seen in Table 7 that the 5-years progression



trends of the coupling and coordination levels of the 11 provinces and urban areas in the Yangtze River Economic Belt are as follows, and it can be found that the coupling levels of some provincial and municipal areas have changed significantly, and the foreign direct investment IFDI and OFDI. The coordination level D of OFDI has also changed significantly, and the specific situation of each provincial and urban area in Table 8 is as follows, Guizhou Province in the western part of the Yangtze River Basin, the change of two-way FDI coupling in Guizhou Province has not changed much in 2009, 2014, and 2019, which are all “I coupling is 0”, and the coupling coordination in 2009, 2014, and 2019 are “extremely out of balance”, “severely out of balance” and “extremely out of balance”, indicating that the two-way FDI in Guizhou Province has not changed much in the past 10 years in the three comparisons. For Yunnan Province, the changes in two-way FDI coupling have experienced “III antagonistic coupling”, “V high coupling”, “IV abrasive coupling”, “III antagonistic coupling”, “III antagonistic coupling”, “III antagonistic coupling” and “III antagonistic coupling” in 2009, 2014 and 2019. “In general, the coupling coordination level in 2009, 2014, and 2019 is “severely dysfunctional”, and the situation is better compared with Guizhou Province; the two-way FDI coupling in Sichuan Province of Sichuan and Chongqing Region This indicates that the two-way FDI in Sichuan Province is highly coupled in the five-year comparison, and the coupling of two-way FDI is better, and its coupling coordination level in 2009, 2014, and 2019 has

experienced The coupling coordination level in 2009, 2014, and 2019 has gone through the level of “severe dissonance” to “moderate dissonance”, with a tendency to increase in general; Chongqing City and Sichuan Province are in a similar situation, and the two-way FDI coupling changes in 2009, 2014 and, 2019 have gone through the level of “III antagonistic coupling”, “V high coupling”, and the level of coupling coordination in 2009, 2014, and 2019 is similar to that of Sichuan Province, experiencing “severe dissonance “ to “moderate disorder”, and generally in an upward trend.

The coupling of two-way FDI in the central provinces of Yangtze River is a little bit behind compared with the western provinces, because the OFDI in Sichuan and Chongqing has a big gap compared with the central part of Yangtze River Basin, taking the “wo lakes region” provinces as an example, the change of two-way FDI coupling in Hubei Province in 2009, 2014, and 2019 experienced In 2009, 2014, and 2019, Hubei Province experienced two stages of “III antagonistic coupling” and “abrasive coupling”, and its coupling grew more slowly compared with that of Sichuan and Chongqing, and its coupling coordination level in 2009, 2014 and 2019 experienced “serious Its coupling coordination level in 2009, 2014, and 2019 has experienced the transition from “severe dissonance” to “moderate dissonance”, and is generally in an upward trend; while the coordination situation in Hunan Province is better than that in Hubei Province, thanks to the larger foreign direct investment in Hunan Province, its two-way FDI coupling situation is better, and the change of two-way FDI

coupling degree in 2009, 2014 and 2019 has experienced the change of “severe dissonance” and “moderate dissonance”. The change of two-way FDI coupling in 2009, 2014, and 2019 has gone through two stages of “III antagonistic coupling” and “abrasive coupling”, and its coupling coordination level in 2009, 2014, and 2019 has gone through “mild dissonance” to “moderate dissonance” stage, generally within the range of the decline, which is due to the economic downturn and the impact of the Internet industry in the past 5 years, for Hunan’s local television programs of foreign direct investment has slightly decreased; Jiangxi Province’s two-way FDI coordination fluctuates more, two-way FDI The change of coupling degree in 2009, 2014 and 2019 experienced three stages of “I coupling degree is 0”, “V highly sexual coupling” and “grinding coupling”. In general, the two-way FDI coupling has increased significantly in the past 5 years, and the coupling coordination level in 2009, 2014, and 2019 have gradually transitioned from “extremely dysfunctional” to “severely dysfunctional” and “moderately dysfunctional”. The coupling and coordination level of two-way FDI in Anhui Province is better, and the change of its two-way FDI coupling is “III antagonistic coupling” in 2009, 2014, and 2019, and the change is not significant, but the coupling in Anhui Province in 2009, 2014 and 2019 is “III antagonistic coupling”. However, the coupling coordination level of Anhui Province in 2009, 2014, and 2019 has gradually transitioned from “severe dissonance” to “mild dissonance”.

The two-way FDI coordination and coordination level of the delta provinces and municipalities in the eastern part of the Yangtze River are among the highest in the Yangtze River basin, and the change of two-way FDI coupling in Jiangsu Province is “V highly coupled” in 2009, 2014, and 2019, which is far ahead of the other 10 regions. The coupling coordination level in 2009, 2014, and 2019 gradually changed from “on the verge of dissonance” to “mildly dissonant”, which shows that the two-way FDI coordination in Jiangsu Province is better and FDI and OFDI can form a positive interaction. Zhejiang Province is similar to Jiangsu Province, the two-way FDI coupling changes in 2009, 2014, and 2019 are “V highly coupled”, and the coupling coordination level in 2009, 2014, and 2019 also experienced “moderate dissonance” “The coordination level of two-way FDI is at a stable increasing level; lastly, Shanghai is located at the mouth of the Yangtze River basin and attracts a large amount of foreign direct investment. Lastly, Shanghai is located at the mouth of the Yangtze River basin and attracts a large amount of FDI. The coupling of two-way FDI in Shanghai has changed from “IV abrasive coupling” to “V high coupling” in 2009, 2014, and 2019, and its coupling of two-way FDI is at an increasing level. And the coupling coordination level in 2009, 2014, and 2019 also experienced a decline from “moderate dissonance” to “extreme dissonance” and then rebounded to “moderate dissonance”. The coordination level of FDI and OFDI is in a good trend.

As China’s economy enters a phase of “high level development” since 2015, China should leverage global investment resources and international trade markets, including the “Made in China” and “Created in China” linkages. Instead of focusing only on domestic capital, technology and talent, China should leverage global investment resources and international trade markets, including the linkages between “Made in China” and “Created in China. The three provinces and municipalities in the eastern part of the Yangtze River basin with - Shanghai, Jiangsu and Zhejiang - have the largest total size of FDI and OFDI, their two-way FDI coupling is better and the level of coordination is relatively high. Specific countermeasures are suggested as follows, first of all, we must make full use of global resources and markets, including the important factor of two-way FDI international investment. In order to take the road of “high-quality development”, China’s manufacturing industry must pay full attention to the coordinated development of two-way FDI for the innovation-driven role of industrial progress, and insist on “bringing in” and “going out” “The second thing is that we should make policy formulation and policy development in various aspects. Secondly, policy formulation and resource allocation should be carried out in various aspects. On the one hand, enterprises should be encouraged to actively invest abroad, especially in developed economies and technology-intensive manufacturing industries, in order to take advantage of the technology spillover effect and learn from the advanced experience and excellent models of other countries. On the other hand, we should introduce preferential policies to attract more foreign investment, strengthen the investment and training of research talents, improve the intellectual property protection system, strengthen the supervision of downstream investment and the use of government resources, reduce “false innovation” and “innovation erosion”, and improve the efficiency of the transformation of research results into production.

- 1) The three provinces and cities in the eastern Yangtze River basin should also strengthen their risk control capabilities for foreign direct investment and outward direct investment, and economically developed regions should encourage qualified companies capable of conducting insurance business abroad to actively provide insurance-related services. For overseas partners in Jiangsu, Zhejiang and Shanghai, we should promote credit assessment, evaluate the international risks of the host country of investment, and actively strengthen the multi-dimensional risk prevention and control of overseas investment cooperation. The establishment of a scientific and effective risk response mechanism and a flexible and operable emergency response mechanism is important for Jiangsu, Zhejiang and Shanghai to avoid increasing trade barriers, intensifying trade frictions, investment protectionism and responding to foreign investment emergencies in foreign direct investment. Therefore, all bulk foreign-invested

enterprises in Jiangsu, Zhejiang and Shanghai need to be urged to make equal contributions to prevent potential conflicts and conflict escalation at home and abroad, actively create investment channels for other domestic markets, strengthen the economic, capacity and technology spillover effects of FDI and OFDI, and further enhance the economic vitality and social capital activation in the eastern Yangtze River Basin region.

- 2) The two-way FDI coupling in Hunan and Hubei provinces in the central Yangtze River basin is more coordinated than that in Anhui and Jiangxi provinces, which can complement and optimize related policies. Through the establishment of “legal and technical registration system”, Hunan and Hubei provinces actively respond to the relevant national laws and regulations to encourage enterprises to “go out”, through the “going out” of foreign direct investment “The government should strongly support the enterprises in Hunan and Hubei provinces to go out and reduce the risks faced by enterprises in the process of foreign investment from the national level. As for Anhui and Jiangxi provinces, it is the overall key to establish a service support system and build a general framework for outbound investment by financial institutions with policy banks and joint-stock commercial banks as branches. In addition, Anhui and Jiangxi provinces benefit from their high speed and sustainable development space, but there is also a lack of experience due to advanced technology and management models, for which a FDI data integration platform led by government departments and widely participated by multinational companies and intermediaries should be established to fully support and protect enterprise data, introduce technical support and high-tech capacity of FDI and foreign enterprises, while further enhance the capacity growth of two-way FDI and improve the ability of representative enterprises in Jiangxi and Anhui provinces to judge international and domestic policies, international investment environment, international investment environment and international risks, so as to improve the international competitiveness of enterprises in the two provinces.
- 3) Since the two-way FDI coordination levels in the western region of the Yangtze River basin-Sichuan, Chongqing, Yunnan and Guizhou-differ greatly, especially Guizhou’s two-way FDI coordination and coordination level ranking in the bottom of the development situations, should be discussed by situation. Guizhou Province should take advantage of strategies such as the “Free Trade Pilot Zone” and the “One Belt, One Road” initiative in the central and western regions to strengthen infrastructure development, optimize the domestic business environment, actively participate in international cooperation, promote the healthy and coordinated development of two-way FDI, and promote the implementation of productivity strategy. In view of the complexity of the current prevention and control of the new crown epidemic and the new situation of the world

economic and social development, Sichuan, Chongqing and Yunnan regions can rely on the virtuous synergistic development of two-way FDI to promote the improvement of the innovation capacity of traditional primary, secondary and tertiary industries, and to align foreign investment with the world. We should make efforts to break the bottleneck between two-way FDI synergistic development and industrial structure upgrading, and improve the linkage between two-way FDI synergistic development and industrial structure upgrading and innovation capacity. While actively creating an environment for FDI, the effectiveness and strength of investment in infrastructure reduction and convenience facilities in remote areas of Sichuan, Chongqing and Yunnan Province can be enhanced, so that FDI and outward FDI in the western Yangtze River Basin can gradually shift from “severe dislocation” to “moderate dislocation” or “mild dislocation”. “The investment environment and investment efficiency in the western part of the Yangtze River Basin will be improved, and the market will be opened up to Southeast Asian countries for excellent capital investment. The provinces and municipalities in the western Yangtze River Basin and also pay attention to the government’s awareness of FDI and OFDI services, enhance the government’s escort role and service nature for two-way FDI, and create opportunities for provincial and municipal enterprises and projects in the western Yangtze River Basin to attract FDI projects along the “Belt and Road”. At this stage, it is also possible to further expand FDI in the central and western Yangtze River basin to urban public works construction through government-enterprise cooperation, with the aim of strengthening the development of service industries and service projects in the central and western Yangtze River basin through FDI.

Conclusion and policy implications

With the deepening of China’s economic reform and opening-up process, the development of two-way direct investment (two-way FDI) in the Yangtze River Economic Zone has also experienced a typical gradual trajectory, gradually changing to a two-wheel drive of introducing foreign investment (IFDI) and outward investment (OFDI) at the same time. The research paper incorporates the two-way FDI development in China into a unified analytical framework, elaborates the intrinsic mechanism and synergistic development benefits of the two-way FDI synergistic development at the theoretical level, and examines the spatial impulse effect relationship, regional evolution pattern, and the evolution level of coupling coordination degree of the two-way FDI quantitative synergy through empirical analysis. Under the impulse effect analysis of VAR, it is found that the two-way FDI development in the Yangtze River Economic Zone is changing gradually, and the interaction influence curve of two-way FDI

gradually converges with the advancement of reform and opening up in recent years, showing a high degree of mutual influence. Under the perspective of coupling and coordination, the two-way FDI synergistic development pattern of Yangtze River Economic Zone has experienced a leading transformation from “serious imbalance” to “slight imbalance” and is in a well-coordinated development stage. At the regional level, the results of the coupling and synergy level of the Yangtze River Economic Belt show that the synergistic development of two-way FDI has an obvious east-west gradient effect and a multi-polar dynamic evolution within the region, especially the differentiation level among the eastern, central and western parts of the Yangtze River Economic Belt is very significant.

Based on the above conclusions, for the development of two-way FDI at national and regional levels, it is necessary to pay full attention to the promotion effect of two-way FDI innovation-driven development process on trade and industry in each region. It is necessary to urgently improve the policy shortcomings of OFDI, ease the approval process of domestic enterprises and funds for foreign excellent project investment, strengthen the efficiency and effectiveness of OFDI for foreign investment, and thus enhance the trust base of domestic for FDI. In fully implementing the economic development strategy of “going out”, it is necessary to make a good overall consideration at the national and regional levels, specifically, it can be divided into two aspects: on the one hand, it is necessary to seize the effective combination of quality “going out” and “coming in” investment, and promote the effective combination of quality “going out” and “coming in” investment. “effective combination of investment, promote the synergistic development of China’s IFDI and OFDI, and give full play to the effects of two-way FDI such as technology diffusion, information dissemination, trade activation and optimal allocation of resources to promote industrial structure. On the other hand, we should do a good job of high-level planning by consolidating and strengthening the joint effect of advantageous traditional industries and foreign trade, planning and developing strategic emerging industries, etc., improving the labor efficiency and capital utilization rate of labor-intensive and capital-intensive manufacturing industries, promoting the factor concentration of technology-intensive manufacturing industries, and accelerating the development of manufacturing industries. The transformation and modernization of green, intelligent, informative and service-oriented manufacturing industries will eventually help improve the innovation capacity and efficiency of international trade and traditional manufacturing industries in the country or local region.

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Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

XP: conceptualization, and visualization; YX: conceptualization, data, methodology, formal analysis, charting, writing—original draft, and visualization; ZL: data, methodology, writing—review, and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fenvs.2022.970652/full#supplementary-material>

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