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The impact of two-way FDI on total factor productivity in China and countries of the belt and road initiative

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ABSTRACT

This study utilizes the DEA-Malmquist index method to measure the total factor productivity of 36 Belt and Road countries and establish a dynamic panel model. This study carries out an empirical analysis of whether two-way investment in China and the Belt and Road Initiative can improve total factor productivity. First, the technology spillover of the home country has a significant effect on improving total factor productivity and the technical efficiency index of countries along the route, while the technology spillover of host countries has no significant effect on total factor productivity. Second, in Asia, the technology spillover of host countries has a significant effect on total factor productivity, while the technology spillover of the home country has no significant effect on total factor productivity. Finally, in Europe, the spillover effect of technology in the home country is beneficial to the improvement of resource allocation. Meanwhile, the spillover effect of technology in host countries is beneficial to the improvement of total factor productivity and the technical efficiency index. Therefore, China should continue to increase its investment in Belt and Road countries.

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1. Introduction

The Belt and Road Initiative (BRI) was put forward in 2013 and has been implemented in all aspects. The purpose of BRI is to strengthen the relations between Asian, European, and African countries by increasing trade and investment exchanges within Belt and Road countries. This will create a prosperous economic corridor and a community of shared destiny and bring new economic growth points to countries along the route. BRI is being gradually implemented, and in this process, it is essential for the state to monitor the effects of project implementation on the economies of countries. From an economic point of view, the driving force of economic growth mainly comes from the growth rate of all the factors. It is an important indicator of the quality of economic growth and growth potential. According to the neoclassical

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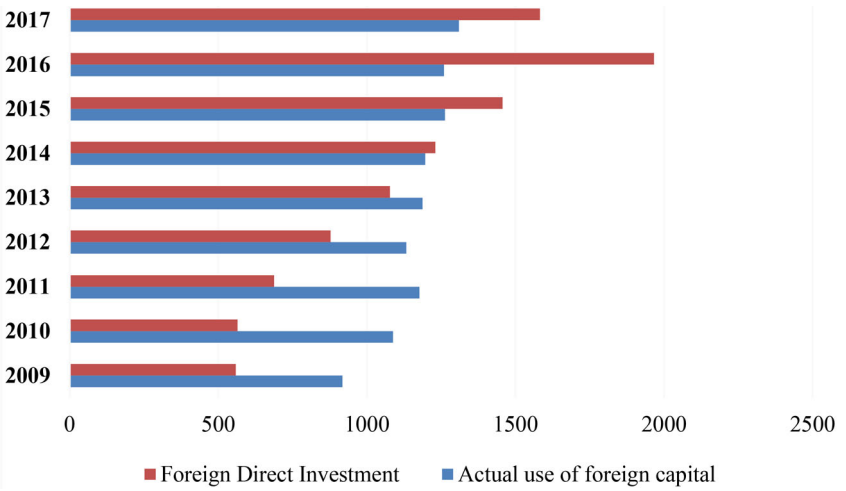

Figure 1. Comparison of China's two-way investment from 2009 to 2016. *Source*: '2017 World Investment Report' (Unit: USD).

economic growth theory, total factor productivity (TFP) is an important engine that drives economic growth, in addition to input factors. Traditional extensive growth that relies on increasing factor input to maintain sustained economic expansion is difficult to sustain. If the country wants to take a long-term sustainable development path, it needs to continuously improve TFP to reflect intensive growth (Chen, 2010). International direct investment (two-way foreign direct investment) is an important factor affecting the growth of a country's TFP. It contains not only the cross-regional flow of general currency capital, but also the transfer process of capital, technology, marketing, and management, and this process may affect the growth of domestic TFP through the effects of technology spillover and resource allocation. With the continuous advancement of BRI and free trade zone strategies, China has gradually played an increasingly important role in the international capital stage as a host country and an investor country.

In the past two years, the international trade recession, Brexit, and other major events have caused instability in the international financial market. Global foreign direct investment (FDI) has shown a downward trend for two consecutive years, and China's FDI has been increasing in 2016–2017 for two consecutive years. It accounts for more than 10% of global foreign investment, and its influence on global FDI continues to expand. China's FDI flow has exceeded the amount of foreign investment for three consecutive years since 2015, becoming a veritable capital large net exporter (Figure 1).

Therefore, it is important to explore whether investment can promote the improvement of TFP in China and Belt and Road countries.

By collating research on TFP, we found that existing research focuses more on the impact of one-way international direct investment on TFP. Relevant research on TFP is quite mature, but research on the impact of two-way investment between China and other countries on TFP is less mature. Therefore, this study focuses on BRI, uses the DEA-Malmquist index method to measure TFP, and builds a dynamic panel model to study the impact of two-way investment between China and countries along

the route on TFP. Sub-sample data are used to compare and analyse the impact of investment between China and countries with different economic levels on the TFP of countries along the route at different regional levels. We examine whether two-way investment can increase TFP, reduce regional economic development differences, and provide important policy inspiration for countries along the route to formulate and implement targeted development strategies that promote the coordinated development of regions along the route.

2. Literature review

2.1. Research on IFDI and TFP

After combining the existing literature, we found that most academic circles at home and abroad are stuck in research on the technology spillover effect of FDI. However, the literature examining the relationship between FDI and the host country's TFP is relatively scarce. These few studies usually introduce FDI as a control variable that affects TFP in the regression model. There are fewer studies that systematically explore the impact of FDI on the host country's TFP. The main points of view are summarised as follows.

First, inward foreign direct investment (IFDI) promotes TFP. That is, the technology spillover effect and technology competition effect produced by FDI can improve the productivity level of the host country. For example, Kinoshita (2001) believed that the combination of capital and technology through IFDI can not only bring advanced production technology and management experience to host countries, but also generate positive technology spillovers to host enterprises through demonstration, training, and competition effects, and it can improve TFP through this kind of positive technology overflow. Gorg and Greenway (2016), Kugler (2006), and Liu et al. (2008) also have reached the same conclusion. Li (2009) used the urban panel data of Pearl River Delta (PRD) in China to investigate whether FDI can promote technological progress. It was found that IFDI in PRD has a significant promoting effect on frontier technological progress. Hu (2010) used interprovincial panel data from 1992 to 2007 in China to test IFDI. The study found that IFDI can significantly promote the development of the service industry technology efficiency index and the technology progress index. Wang and Teng (2015) also found that the IFDI of the service industry can significantly improve productivity through the analysis of the data of the sub-sectors in the service industry, and this is mainly due to the redistribution effect of the capital elements. Wang et al. (2019) show that FDI exerts a significant positive impact on green total factor efficiency by promoting the efficiency of energy and labour factors. Li and Tang (2019) using the instrumental variable method and found that FDI can significantly promote the increase in TFP and trade opening, and there is an obvious substitution relationship between FDI and trade opening. Based on a previous study, Yang and Yu (2021) further explored investment facilitation, an important factor affecting FDI, and found that the spillover effect of investment facilitation through FDI inflows promotes the increase in TFP in Belt and Road countries.

There are some another studies that indicate that IFDI has no significant effect on TFP growth. Hoekman and Djankov (2000) found that the inflow of IFDI has a

negative effect on the productivity spillover of the manufacturing industry. Based on empirical data from Ireland, Barry et al. (2005) concluded that excessive competition from multinational companies inhibits the technology spillover effect of IFDI. Yang and Long (2012) established a fixed-effects model and found that IFDI had a negative effect on green TFP. Xiao et al. (2013) established a spatial error panel model and found that IFDI had a significant inhibitory effect on the TFP of the urban environment in China. Wang and Xie (2015) set up a fixed-effects model with panel data and found that IFDI had no significant effect on the growth of green TFP in China. Chen et al. (2016) constructed a spatial panel model and found that the structure of IFDI had no significant effect on TFP. Li et al. (2016) found that the introduction of IFDI is conducive not only to the progress of green technology, but also to the improvement of the efficiency of green technology by considering energy input and environmental pollution. However, the organic combination of IFDI and fiscal decentralisation will have a significant effect on TFP. Wang et al. (2020) measured low-carbon TFP using the non-oriented EBM-Malmquist-Luenberger model and found that both the depth and breadth of IFDI inhibited the improvement of industrial low-carbon TFP.

2.2. Research on OFDI on TFP

The relationship between outward foreign direct investment (OFDI) and the home country's TFP has always been one of the focuses of domestic and foreign researchers, who are more focused on the reverse technology spillover effects of OFDI. Zhao et al. (2006) investigated the relationship between OFDI and technological progress in China from both theoretical and empirical perspectives. They found that the technological progress of OFDI in target countries with abundant R&D elements was more obvious. Gu and Han (2015) based on the empirical study of China, found that regional market integration and OFDI have significant substitution effects on promoting technological progress and significant complementary effects on optimising resource allocation. After the synthesis of the two aspects, regional market integration and OFDI showed a significant substitution effect on TFP. Zhao et al. (2016) also reached the same conclusion that OFDI is conducive to the improvement of TFP; however, they pointed out that OFDI has no significant effect on the improvement of China's technical level. Huo and Liu (2016) believe that China's OFDI can significantly promote the improvement of domestic TFP, but its impact is not as effective as that of IFDI, import trade, and domestic R&D. Zhu et al. (2019) also showed that reverse technology spillovers of FDI play a positive role in accelerating the development of green all-factor production by promoting regional technological capabilities. Muhammad (2019) used ARDL technique to examine the co-integration between FDI and poverty, the analysis results prove that foreign direct investment has contributed to Pakistan's poverty reduction

However, some other scholars arrived at different conclusions. For example, Zou and Chen (2008) found a synchronous relationship between OFDI and TFP in China. Bai (2009) investigate 14 developed countries, construct the Levinsohn-Petrin (LP) model, and conduct an empirical study. The results show that the effect of OFDI reverse technology spillover on TFP is positive. Lin and Liu (2011) showed that OFDI inhibits the increase in TFP in China. Based on Chinese sub-industry data, Li

et al. (2016) found that the reverse technology spillover effect of OFDI has industry differences, and the influence of the same industry on pure technology progress (EC) and technology efficiency (TC) is also different. Chen and Zhu (2018) used provincial panel data from 2007 to 2014 in China, combined these data with the generalised least squares method, and found that the influence of the OFDI spillover on TFP is not significant.

By pointing out the relationship between investment (OFDI, IFDI) and TFP, we found that most of the current research on these issues focuses on the impact of one-way investment, that is, IFDI or OFDI, on TFP. There are two sides to TFP, namely IFDI and OFDI, so we cannot generalise. Zheng and Ran (2018) used a non-radial, non-angle Slack Based Model (SBM) and DEA-GML index to comprehensively evaluate China's inter-provincial total factor productivity (GTFP) and constructed a dynamic panel model. The impact of two-way FDI on China's GTFP and its regional differences were systematically investigated. Song and Li (2021) uses a non-radial distance function to measure the green economic efficiency of 30 provinces in China, based on the perspective of technological innovation, and to investigate the effect of two-way FDI on green economic efficiency. However, there is still a lack of research on the impact of two-way FDI on TFP. In addition, existing studies on the TFP of major economic organisations are relatively mature, but as BRI was formally put forward in 2013, the scope of member states involved in BRI is still growing. At present, there are few studies on TFP in the area of BRI. Based on previous research, this study focuses on the impact of investment between China and Belt and Road countries on TFP. To improve the economic growth effect of two-way FDI in a targeted manner, we provide a certain experience and reference for the realisation of regional coordinated development. Understanding these issues will have important practical significance for the continued implementation of the 'bring in' and 'going out' strategies in the future and the promotion of the sustainable development of BRI. This study will conduct empirical research presented in the following sections. The Section 2 summarises the relationship between investment (OFDI, IFDI) and TFP, the Section 3 is the mechanism analysis of the relationship between two-way FDI and TFP, the Sections 4 and 5 explain the model and variables, the Section 6 presents the empirical analysis of full samples and sub-samples, and the Section 7 summarises the full text and puts forward policy recommendations.

3. Mechanism analysis of the relationship between two-way FDI and TFP

3.1. The influence mechanism of IFDI technology spillover on TFP

The IFDI technology spillover effect means that foreign businessmen, through capital investment in the host country, can comprehensively cooperate with host country enterprises in terms of technology and market. The advanced technology and management experience brought by IFDI can be popularised and widely used in the host country. Therefore, improving the local technical and production levels of the host country will promote its economic development. Existing studies have found that IFDI mainly affects TFP in the form of technology diffusion. Technology diffusion includes two methods: technology transfer and technology spillover. Of these, the impact of technology spillover on TFP is far-reaching.

According to different spillover channels, influence mechanism can be divided into demonstration, correlation, labour spillover, and competition effects. (1) **Demonstration effect.** It refers to the fact that when multinational enterprises invest in host country enterprises, their technology is more advanced than that of host country enterprises, and plays a demonstrative role for host country enterprises. Host country enterprises improve their technology by imitating the advanced technology and management modes of multinational enterprises. Further, when the host country owns the technical management level, TFP is also improved. Specifically, the introduction of FDI is tantamount to opening the door to exchanges between countries. The entry of multinational enterprises reduces the cost incurred by host country enterprises to obtain new technologies and simultaneously allows host country enterprises to avoid detours in their operations and improve the overall efficiency of the enterprise. (2) **Correlation effect.** It is mainly divided into forward and backward correlation effects. The forward correlation effect refers to the higher quality of the intermediate goods and after-sales service provided to the host country enterprise by the foreign-funded enterprise due to the higher technological level. Host country enterprises use these higher-quality intermediate goods to produce final products, which improves the quality of the final products. The backward linkage effect refers to the fact that multinational enterprises purchase raw materials and parts from host country enterprises to maintain product quality and production. The consideration of cost and other factors provides technical guidance for host country enterprises, thus enhancing their technological level. (3) **Labour spillover effect.** It means that when multinational companies with advanced technology enter the host country, they hire local personnel and train them in business management and technology because of the need for business operations, thus bringing their advanced technology and management experience to local companies. The labour spillover effect is one of the main channels of IFDI technology spillover. It converts the knowledge reserves of multinational companies into productivity and promotes the production efficiency of local companies, thereby increasing TFP. (4) **Technology spillovers formed by the competitive effects of IFDI.** They can be divided into positive and negative effects. The positive effect is when the industry monopoly position of the host country is broken due to multinational companies' investment in the host country. Moreover, the entry of multinational companies into the host country intensifies market competition, which stimulates the innovative technological capabilities of local companies and upgrades their technological level. The negative effect means that when multinational companies with advanced technology enter the host country, they seize the market of local companies, which may affect the income and expenditure of local companies and, even worse, make a large number of local companies that do not have technological advantages go bankrupt.

3.2. The influence mechanism of OFDI technology spillover on TFP

The OFDI technology spillover benefit means that multinational companies in the host country use the form of foreign investment to achieve the purpose of resource sharing and advanced technology absorption and feed the absorbed advanced

technology and management experience back to the parent company through multiple channels. OFDI is an important way to expand the domestic market into the international market and impact economic growth. The spillover benefit of OFDI technology is the main way for OFDI to increase TFP and affect economic growth. OFDI technology overflow can be realised in two ways: direct and indirect. (1) **The direct realisation mechanism** means that multinational companies in the home country set up subsidiaries in the target country by investing in other countries, using geographic advantages to obtain advanced technology and management experience in the target country, and digesting these technological resources to promote home country enterprises' production efficiency and achieve the purpose of improving the TFP of the home country. Specifically, the direct realisation mechanism includes three stages, namely, acquisition of technical resources, transformation of technical resources, and technological innovation. (2) **The indirect realisation mechanism** is a non-technical realisation mechanism. It mainly uses FDI to increase the income or reduce costs of the home country's multinational enterprises and invest more funds in the company's R&D, which indirectly promotes the home country's technology progress. The benefit feedback mechanism is mainly related to OFDI for the purpose of seeking resources. The benefit expansion is made through three main ways. First, production is moved to countries with abundant production factors to achieve the purpose of reducing the input of production factors, thereby reducing costs. Second, the production environment is moved to the target country and production is localised to save tariff costs. Third, the reverse technology spillover of OFDI can be an upgrade to enterprise production technology, thereby expanding sales revenue.

In summary, IFDI is achieved by investment funds, providing technical guidance, and other relevant ways to improve the technological level and TFP of China and Belt and Road countries, meanwhile, a number of foreign companies entering is possible to suppress local businesses development. OFDI is achieved by acquiring the technology and experience of the target country, and this, on the one hand, can reduce costs and increase R&D promotion, and, on the other hand, these resources are digested to improve production efficiency. Through the content analysis of mechanism, we have a comprehensive understanding of the impact of the mechanism of the relationship between two-way FDI and TFP, which provides the theoretical basis for further analysis of the measurement model in this study.

4. Model

To analyse the impact of technology spillover on TFP, we use the classical international R&D spillover model established by Coe and Helpman (1995) and set up the basic model according to the research objective of this study.

$$LnTFP_{it} = \alpha + \beta_1 LnSifdi_{it} + \beta_2 LnSofdi_{it} + \beta_3 Lngro_{it} + \beta_4 Lnavgdp_{it} + \beta_5 Lntra_{it} + \beta_6 Lnind_{it} + \beta_7 Lncre_{it} + \beta_8 Lnfina_{it} + \varepsilon_{it} \quad (1)$$

In this formula, TFP refers to total factor productivity, *Sifdi* refers to IFDI spillover effect, *Sofdi* refers to OFDI spillover effect, the control variable *gro* refers to the

government intervention, *avgdp* refers to the economic development level, *tra* refers to trade level, and *ind* refers to industrialisation degree. *cre* is the level of innovation, *fina* is the level of financial development, and ε_{it} is random disturbance.

Considering the influence of the lag period of the explained variable on the current period and the endogenous problem, a dynamic panel data regression model was obtained in this study by adding the lag term of the explained variable $LnTFP_{it}$ as the explanatory variable, based on formula (1).

$$\begin{aligned} LnTFP_{it} = {} & \alpha + \beta_0 LnTFP_{i,t-k} + \beta_1 LnSifdi_{it} + \beta_2 LnSofdi_{it} + \beta_3 Lngro_{it} + \beta_4 Lnavgdp_{it} \\ & + \beta_5 Lntra_{it} + \beta_6 Lnind_{it} + \beta_7 Lncre_{it} + \beta_8 Lnfina_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

In this formula, $LnTFP_{i,t-k}$ is explained by a variable delay and k denotes the order of the lag. In this study, the generalised moment estimation of dynamic panel data, that is, the GMM estimation method, is selected. The advantage of this method is that it can solve the endogenous problem between the interpreted variable and the explanatory variable by using appropriate tool variables, and it has no special restriction on the unit root. There are three kinds of GMM estimation methods: difference GMM, level GMM, and system GMM estimation. In this study, differential GMM is used to estimate the relationship between two-way FDI and TFP.

To explore how two-way directional FDI affects TFP, the following two models are established by introducing the decomposition items, the technical efficiency index (EC) of TFP and the index (TC) of technological progress.

$$\begin{aligned} LnEC_{it} = {} & \alpha + \beta_0 LnEC_{i,t-k} + \beta_1 LnSifdi_{it} + \beta_2 LnSofdi_{it} + \beta_3 Lngro_{it} + \beta_4 Lnavgdp_{it} \\ & + \beta_5 Lntra_{it} + \beta_6 Lnind_{it} + \beta_7 Lncre_{it} + \beta_8 Lnfina_{it} + \varepsilon_{it} \end{aligned} \tag{3}$$

$$\begin{aligned} LnTC_{it} = {} & \alpha + \beta_0 LnTC_{i,t-k} + \beta_1 LnSifdi_{it} + \beta_2 LnSofdi_{it} + \beta_3 Lngro_{it} + \beta_4 Lnavgdp_{it} \\ & + \beta_5 Lntra_{it} + \beta_6 Lnind_{it} + \beta_7 Lncre_{it} + \beta_8 Lnfina_{it} + \varepsilon_{it} \end{aligned} \tag{4}$$

5. Variable description and data source

5.1. Explained variable

The problem investigated in this paper is the impact of two-way investment between China and Belt and Road countries on TFP. Therefore, the explained variables includes TFP and its decomposition term, this is, technical efficiency index (EC), the change in technical index (TC).

At present, 74 countries have officially confirmed their intention to join BRI. Based on the availability of data, this study selected 36 countries, using the DEA-Malmquist productivity index method to measure the TFP and its breakdown term in

Belt and Road countries from 2006 to 2015. We choose labour input and capital investment as input variables and GDP as the output variable. The countries' GDP data are taken from the 2010 constant GDP, which is provided by the World Bank database.

Labour input is the number of employed people in each country every year. It can be obtained by subtracting the total number of unemployed people from the total national labour force. The national labour force population, unemployment rate, and other related data are derived from the World Bank database.

Capital input is expressed as fixed capital stock. According to previous studies, this study uses a sustainable inventory method to measure fixed capital stock. The formula is as follows:

$$K_{it} = K_{it-1} + I_{it} - D_{it} = (1-\delta)K_{it-1} + I_{it} \tag{5}$$

Here, K_{it} is the year t fixed capital stock expressed by the 2010 constant price, K_{it-1} is the year t-1 fixed capital stock expressed by the 2010 constant price, I_{it} is the year t investment expressed by the 2010 constant price, and D_{it} is the T capital depreciation expressed by the 2010 constant price, and δ is the capital depreciation ratio.

According to Zhang et al. (2004), this study chooses the formation of total fixed capital as the investment amount (I) and employs the depreciation rate calculated by Hall and Jones when studying the fixed capital stock of each country. According to the calculation method of the capital stock of the base period proposed by Shan (2008), fixed capital stock is obtained by dividing the total capital formation of the base period by the sum of the average growth rates of the formation of total fixed capital and the depreciation ratio within the sample time. The capital price index selected in this study is the constant of the price index given by the World Bank database in 2010.

5.2. Core explanatory variable

5.2.1. Technology spillover from china's outward direct investment (sofdi)

China's direct investment in Belt and Road countries can promote the popularisation of advanced technology, improve the production efficiency of enterprises, and thus improve the overall level of TFP. Therefore, this study uses the R&D stock spilled from China through foreign direct investment channels by Belt and Road countries to measure the technology spillover effects of China's foreign direct investment. *FDI technology spillover to China (Sifdi)*

Belt and Road countries can acquire China's advanced technology through direct investment in China, thereby improving TFP. Therefore, this study measures the technology spillover effect of IFDI through the stock of R&D spillover from direct investment in China by Belt and Road countries

In accordance with the LP method, the stock of FDI spilled by China and Belt and Road countries through two-way R&D is calculated. The formula is as follows:

$$Sofdi = \frac{OFDI_{it}}{Y_{it}} \times R\&D_{it} \tag{6}$$

$$Sifdi = \frac{IFDI_{jt}}{Y_{jt}} \times R\&D_{jt} \tag{7}$$

Here, $OFDI_{it}$ represents China's stock of direct investment in country i in year t, $IFDI_{jt}$ indicates that China actually utilised the stock of direct investment in country j in year t, $R\&D_{it}$ indicates the capital stock of China in year t, $R\&D_{jt}$ represents the capital stock of j countries in year t, and Y_{it} and Y_{jt} represent the total fixed capital formation of China and the countries along the route in year t.

Because the capital stock data of Belt and Road countries cannot be obtained directly, this study uses the method of Coe and Helpman (1995) as a reference to calculate the capital stock of Belt and Road countries along with the method of sustainable inventory. The formula is as follows:

$$R\&D_{jt} = R\&Dflow_{jt} + (1-\delta) \times R\&D_{jt-1} \tag{8}$$

$$R\&D_{j0} = \frac{R\&Dflow_{j0}}{\omega + \delta} \tag{9}$$

$$R\&Dflow_{jt} = \mu_{jt} \times GDP_{jt} \tag{10}$$

Here, μ_{jt} represents the stock of R&D as a percentage of GDP in country j in year t and can be obtained by multiplying the GDP of country j in the current year, $R\&Dflow_{jt}$ indicates the level of capital expenditure in country j in year t, ω is the annual growth rate of R&D expenditure, and δ is the capital depreciation ratio. According to previous studies, the depreciation rate is 5%, and $R\&D_{jt-1}$ is the capital stock of country j in year t-1. Based on the principle of data availability, this study finally selected the relevant data from 2006 to 2015 to calculate the above formula and then obtained $Sofdi_{it}$ and $Sifdi_{it}$. The data used in the operation were derived from the World Bank database, China Foreign Investment Bulletin, and China Statistical Yearbook.

5.3. Control variables

5.3.1. Government intervention

In economics, it is generally believed that government behaviour as a 'visible hand' can be used as a solution to stabilise the market when the market fails. Therefore, government intervention plays a key role in the market economy to a certain extent. In this study, the ratio of general government consumption to GDP is used to indicate government intervention, and the data were derived from the World Bank database.

5.3.2. Level of economic development

The uneven level of economic development among countries leads to different levels of TFP. In this study, per capita GDP is used to express the level of economic development in each country. Per capita GDP is obtained by dividing each country's GDP by the total population of each country. Relevant data were derived from the World Bank database.

5.3.3. Level of innovation

Innovation is the source of a country's economic development, and the level of innovation directly affects the level of production efficiency. In this study, the number of patent applications of non-residents along BRI is used to measure the level of innovation in each country. The data were derived from the World Bank database.

5.3.4. Level of trade

The BRI is aimed at promoting the common development of all countries through trade relations between them and realising the win-win vision. Therefore, the level of trade among countries should also be included in the scope of factors affecting TFP. In this study, the trade volume of each country as a percentage of GDP is used to measure the trade level of each country. The data were derived from the World Bank database.

5.3.5. Degree of industrialisation

Industrialisation can effectively improve the economic level of the country, but at the same time, excessive industrialisation will also cause environmental damage. In the current world situation, most developing countries use industrialisation as an effective way to improve the level of the national economy. Developed countries have generally entered the post-industrialisation period; that is to say, they have improved industrial productivity under the premise of protecting the environment. Therefore, the degree of industrialisation may also affect a country's TFP. In this study, the ratio of industrial value added to GDP is used to measure the degree of industrialisation of a country. The data were derived from the World Bank database.

5.3.6. Financial levels

In the course of the development of the world economy, the capital market has always been an important part of the world economy. The financial level of a country plays an important role in all industries as well as in the country's macro-economy. In this study, financial level is regarded as one of the control variables affecting TFP. The credit level represents the index level of financial development. Data were obtained from the World Bank database.

Table 1 lists the average productivity and decomposition items from 2006 to 2015. The TFP of the countries along the route has shown a relatively stable trend in the past 10 years. The growth rate of TFP in 2009 was as high as 47.2%, but only 2012

Table 1. Time evolution of total factor productivity in the Belt and Road countries.

Year	*EC*	*TC*	*PEC*	*SEC*	*TFP*
2006	1.301	1.159	0.973	1.338	1.508
2007	1.047	0.951	1.046	1.000	0.995
2008	1.034	0.991	1.025	1.009	1.025
2009	1.037	1.420	0.990	1.047	1.472
2010	1.022	0.940	1.035	0.988	0.961
2011	0.991	0.977	1.024	0.968	0.968
2012	1.016	0.955	1.028	0.988	0.970
2013	1.046	0.938	1.032	1.013	0.980
2014	1.102	0.944	0.938	1.175	1.040
2015	1.035	0.947	1.028	1.007	0.980
mean	1.009	1.056	1.005	1.035	1.092

Source: World Bank, China Statistical Yearbook and author's calculations.

Table 2. Panel unit root check.

variable	LLC	HT	Breitung	IPS	Fisher
lnTFP	−32.9024***	0.0082***	−13.8388***	−10.8987***	4.3451***
lnEC	−21.6486***	0.0098***	−13.2932***	−7.5130***	4.0641***
lnTC	−1.6511**	0.0143***	−14.9533***	−6.8820***	1.3846*
lnSifdi	−1.2915*	0.1520***	0.6305	−3.4590***	−3.5193
lnSofdi	−8.1842***	0.2300**	−2.9861***	−1.6307**	3.5990***
lngro	−12.7316***	0.2513***	−2.6739**	−2.2631**	3.3267***
lnavgdp	−7.6025***	0.6908	−2.4029***	−0.2341	3.6512***
lncre	−10.5393*	0.5832*	−3.0769	−2.4527*	5.0155***
lntra	−15.2609***	0.4712	1.2414	−1.4477*	3.5066***
lnind	−7.3347***	0.9915	−1.3824*	−0.7967	3.2040***
lnfina	−9.3387**	0.2598*	−2.8745**	0.2049*	4.9746***

Note: *,**, *** 10%, 5% and 1%, respectively. LLC is Adjusted t* statistic, HT is OLS estimator, Breitung is Lambda statistic, IPS is Z-t-tilde-bar statistic, Fisher is Pm statistic.
Source: World Bank, China Statistical Yearbook and author's calculations.

and 2015 witnessed a positive growth in TFP. This result shows that productivity in 2009 has increased significantly, then productivity has shown a downward trend. According to the results of changes (EC) in technological progress (TC), the average annual growth rate of changes in technical efficiency (EC) is 0.9%, and results showed a downward trend from 2006 to 2011. With the rebound, the average annual growth rate of technological progress change (TC) is as high as 3.2%, and the change trend of technological progress (TC) is almost synchronised with the change trend of TFP. This shows the overall situation of Belt and Road countries. TFP growth is the result of the dual promotion of changes in technical efficiency (EC) and technological progress (TC), of which the promotion of changes in technological progress (TC) is more prominent.

6. Empirical analysis

6.1. Panel data stationarity test

Before the regression of the model, the stability test of the variables involved in the model must avoid the phenomenon of pseudo-regression. In this study, five methods of unit root test were used to test the stationarity of the variables, namely, the LLC test, HT test, Breitung test, IPS test, and Fisher test. This study used the software Stata14.0 to conduct unit root tests of the variables. The test results are shown in Table 2, where the core variable of explanation *lnSfdi* cannot pass the Breitung test but can pass the other tests. *Lnavgdp*, *lntra*, and *lnind* in the control variables cannot pass a few tests, but they can pass most unit root tests. According to the results, it can be seen that each variable has good stationarity.

6.2. Full-sample regression analysis

This study selected panel data from 36 countries and regions along BRI as the population sample[1] and used the differential GMM estimation method to carry out regression estimation of the model. The second-order delay value of the interpreted variable was selected as the difference GMM tool variable. In Table 3, Wald values are significant at the 1% level. There is no first-order or second-order autocorrelation between the differences in the random disturbance terms. The Sargan test shows that

Table 3. Difference GMM estimation results.

variable	Equation (8) *lnTFP*	Equation (9) *lnEC*	Equation (10) *lnTC*
L.lnTFP	−0.230**	–	–
	(0.108)		
L2.lnTFP	−0.394***	–	–
	(0.0500)		
L3.lnTFP	0.0203**	–	–
	(0.00840)		
L.lnEC	–	−0.521***	–
		(0.0775)	
L2.lnEC	–	−0.419***	–
		(0.0847)	
L3.lnEC	–	−0.0356	–
		(0.0468)	
L.lnTC	–	–	−0.785***
			(0.0341)
L2.lnTC	–	–	−0.559***
			(0.0382)
L3.lnTC	–	–	−0.102***
			(0.0359)
lnSofdi	0.0157*	0.0265***	−0.00517
	(0.00852)	(0.00773)	(0.00437)
lnSifdi	0.00146	0.00169	−0.00107
	(0.00237)	(0.00368)	(0.00491)
lngro	0.0706	−0.0579	0.0650**
	(0.0688)	(0.0474)	(0.0258)
lnavgdp	−0.298**	−0.345***	−0.178*
	(0.122)	(0.124)	(0.0995)
lntra	−0.0689	0.0513	−0.167
	(0.0419)	(0.0624)	(0.122)
lnfina	0.111***	0.138**	0.0208
	(0.0413)	(0.0651)	(0.0497)
lnind	0.224***	0.300***	−0.111***
	(0.0696)	(0.0717)	(0.0348)
lncre	0.00632	0.00819	−0.00988
	(0.00672)	(0.00866)	(0.00800)
Constant	−1.372***	−2.071***	0.990
	(0.387)	(0.456)	(0.613)
Wald	186.16***	279.99***	5092.79***
AR(1)	−1.5281	−0.4331	0.4516
	(0.1265)	(0.6649)	(0.6515)
AR(2)	0.5605	1.2216	2.8725
	(0.5752)	(0.2219)	(0.1041)
Sargan test	26.44628	29.282	30.51649
	(0.4940)	(0.3474)	(0.2915)
Observations	168	168	168
Number of DMU	36	36	36

Note: *,*,*** represent significant levels of 10%, 5% and 1% respectively. Explain that the number in the variable brackets is the standard error, AR (1), AR (2) and the value in the Sargan test brackets represents the P value.
Source: World Bank, China Statistical Yearbook and author's calculations.

the original assumption that 'all tool variables are valid' is accepted, which indicates that the difference GMM method is valid. The regression results are reasonable. The lag terms of the explained variables in the dynamic equations show significant negative effects, indicating that TFP and its decomposition terms show certain time inertia.

Equation (2) mainly analyses the effect of bidirectional FDI technology spillover on TFP. As far as the result is concerned, among the core explanatory variables, the technology spillover of China's direct investment in Belt and Road countries (*Sofdi*) has a significant positive impact on TFP, and for every 1% increase in the stock of

R&D spillover through the OFDI channel, TFP significantly increases by 016%. This shows that under BRI, Belt and Road countries have achieved improvement in management and scientific and technological aspects by accepting direct investment from China, thus promoting TFP. Although the technology spillover (*Sifdi*) of investment from Belt and Road countries introduced by China has a positive impact on TFP, the result is not significant. To a certain extent, this shows that although China's introduction of FDI from countries along the route can promote TFP in these countries, it is not the main factor affecting TFP improvement. This is likely due to the fact that most of Belt and Road countries are developing countries with poor economic base and are unable to invest in China on a large scale. Therefore, technology spillover through the FDI channel cannot significantly promote the overall improvement of TFP. Overall, the implementation of BRI has promoted mutual investment between China and countries along the route. The goal of promoting TFP is achieved through two-way investment between China and countries along the route.

To explore the effect of two-way FDI technology spillovers on TFP, this study further examines the effect of *Sofdi* and *Sifdi* on the decomposition of TFP, for example, the technical efficiency index (EC) and the pure technical progress index (TC). According to the results of equations (3) and (4), *Sofdi* has a positive effect on the technical efficiency index and is significant at the 1% level. For every 1% increase in *Sofdi*, the technical efficiency index increases by 0.0265%. However, *Sofdi* has a negative effect on the pure technological progress index and is not significant. This shows that the effect of *Sofdi* on TFP is mainly due to its positive effect on technical efficiency, possibly because the spillover effect of direct investment from China in countries along the route has effectively enhanced the level of resource allocation in various countries. This resulted in an improvement in TFP. However, because most of Belt and Road countries are developing countries and the foundation of science and technology is relatively weak, it is impossible to realise progress of science and technology through the external technology spillover of OFDI in a short period of time. *Sifdi* has a positive effect on the technical efficiency index, but a negative effect on the pure technological progress index, and the effect is not significant. This shows that the technology spillover of direct investment from countries along the route in China is mainly through the optimisation of resource allocation to improve TFP, and it has no obvious effect on the progress of science and technology.

The analysis results of the control variables and TFP decomposition regression show that the influence of the government intervention behaviour (*gro*) on the technical efficiency index is the main reason that the influence on TFP is not significant. This shows that although government intervention plays a positive role in TFP, it does not optimise the allocation of resources to improve the efficiency of factor production. The level of economic development (*avgdp*) has a significant negative impact on TFP and its decomposition, which indicates that the higher the level of national development, the more restrained the increase in TFP. A possible explanation is that with the development of the national economic level, it will be increasingly difficult to optimise the allocation of resources or to develop more advanced science and technology, which leads to a bottleneck in the promotion of TFP.

The level of trade (*tra*) is not significant for the return of full-factor productivity, and while the BRI is aimed at promoting economic development through trade with countries along the route, a longer period of time is still needed. As a result, there is still uncertainty about the effect of the promotion of trade on TFP, and a longer period of time is required to be further observed. The level of financial development (*fina*) has a significant positive effect on TFP by 1%. For every 1% increase in the level of financial development, TFP significantly increases by 0.111%. Financial development can promote the improvement of TFP by encouraging technological innovation to improve technical efficiency. The positive effect of the financial development level on the technical efficiency index is the main factor in the improvement of TFP. It can be seen that the level of capital support is an important factor in improving the efficiency of production, and we must pay attention to the development level of the national financial system. The degree of industrialisation of the country (*ind*) has a positive effect on TFP at a 1% significance level, and it mainly contributes to the improvement of TFP through the positive role played by technical efficiency. Most of Belt and Road countries are developing countries, and the industrialisation level of the country is higher in the middle-term development of the previous period. In addition, the results preliminarily prove that the promotion of the degree of industrialisation of countries is an effective way to promote the progress of technological efficiency, thus achieving the purpose of promoting full-factor productivity. The effect of the innovation level (*cre*) on TFP and its decomposition items is positive, but the results are not significant. The innovation level is mainly measured by the number of patent applications of non-residents, which is mainly reflected in the innovation level of enterprises. The low level of overall innovation along BRI may be the main reason for its limited effect on TFP.

6.3. Sub-sample regression analysis

Since there are few samples in Africa, South America, and Oceania in the whole sample, this paper focuses on the empirical study of samples in Asia and Europe along BRI. The difference GMM method is also used to estimate the sub-region samples, and the estimated results are shown in Table 4. From the results of the Sargan statistics and the first- and second-order differences of the random perturbation term, it is shown that the results of the difference GMM estimation of the samples of the sub-region are effective.From the test results of equation (8), we can see that IFDI technology spillover (*Sifdi*) has a positive effect on TFP at a 10% significance level. For every 1% increase in *Sifdi*, TFP in Asian countries increases by 0.0085%. Moreover, it was found from the estimation of Equations (9) and (10) that the effect of *Sifdi* on the technical efficiency index and the pure technological progress index is positive, but the positive effect of *Sifdi* on the technical efficiency index is mainly through the positive effect of *Sifdi* on TFP. This shows that among Belt and Road countries in Asian, the technological spillover of direct investment from various countries in China has played a role in optimising and promoting the allocation of resources and the development of science and technology in Asian countries. In addition, the optimisation of resource allocation has an obvious effect on the promotion of TFP. There is a positive correlation between *Sofdi* and TFP and the technical efficiency index and

Table 4. Empirical results in Asia and Europe.

	Asia			Europe		
variable	Equation (8) *lnTFP*	Equation (9) *lnEC*	Equation (10) *lnTC*	Equation (8) *lnTFP*	Equation (9) *lnEC*	Equation (10) *lnTC*
L.lnTFP	0.0546			−1.359***		
	(0.202)			(0.371)		
L2.lnTFP	−0.364***			−1.051		
	(0.119)			(0.647)		
L3.lnTFP	0.0244			−0.782		
	(0.0196)			(0.628)		
L.lnEC		−0.558			−2.933***	
		(0.372)			(0.957)	
L2.lnEC		−0.469			−0.841***	
		(0.336)			(0.168)	
L3.lnEC		0.0410			0.159	
		(0.0567)			(0.438)	
L.lnTC			−0.736***			−0.503
			(0.104)			(2.381)
L2.lnTC			−0.511***			−0.507
			(0.0490)			(2.010)
L3.lnTC			−0.0812**			−0.459
			(0.0383)			(0.656)
lnSofdi	0.0115	0.0259	−0.0103	0.0256	0.102**	0.0655
	(0.0144)	(0.0223)	(0.00904)	(0.0226)	(0.0453)	(0.0485)
lnSifdi	0.00825*	0.00296	0.000633	0.00735*	0.0293*	0.0147
	(0.00498)	(0.00870)	(0.00353)	(0.00431)	(0.0153)	(0.0265)
lngro	0.0260	−0.0580	0.0690	0.339	−5.055**	−1.752
	(0.0430)	(0.108)	(0.0732)	(0.888)	(2.232)	(10.20)
lnavgdp	−0.159	−0.279	−0.183**	−0.900*	1.967**	0.294
	(0.143)	(0.201)	(0.0929)	(0.475)	(1.003)	(3.131)
lntra	−0.119	0.0455	−0.224**	−0.0634	−3.364**	−1.704
	(0.102)	(0.120)	(0.103)	(0.567)	(1.434)	(7.164)
lnfina	0.156*	0.0638	0.0513	−0.131	0.944***	−0.818
	(0.0807)	(0.119)	(0.0524)	(0.237)	(0.333)	(0.556)
lnind	0.233**	0.313*	−0.123	1.280	1.526***	0.445
	(0.104)	(0.164)	(0.0922)	(1.202)	(0.524)	(5.868)
lncre	0.00324	−0.000127	−0.000163	−0.0107	−0.0180	−0.0532
	(0.00968)	(0.0149)	(0.00723)	(0.00992)	(0.0298)	(0.0544)
Constant	−1.297***	−1.823***	1.107**	−4.616	20.10*	14.13
	(0.502)	(0.572)	(0.534)	(3.226)	(10.28)	(81.21)
Wald	770.95***	234.32***	668.29***	879.39***	241.63***	3105.65***
AR(1)	−1.3909	0.6101	−0.1963	−0.7895	0.8542	0.2000
	(0.1642)	(0.9514)	(0.8444)	(0.4298)	(0.3930)	(0.8415)
AR(2)	−0.3007	−0.2111	2.7525	−0.3157	−0.9798	−0.0628
	(0.7636)	(0.8328)	(0.0059)	(0.7523)	(0.3317)	(0.9499)
Sargan test	8.7520	7.9027	10.8217	0.1801	0.1331	1.8111
	(0.8901)	(0.9276)	(0.7651)	(1.000)	(1.000)	(1.000)
Observations	86	86	86	61	61	61
Number of DMU	17	17	17	13	13	13

Note: Same as Table 2.
Source: World Bank, China Statistical Yearbook and author's calculations.

a negative but not significant correlation between TFP and the pure technological progress index. A possible explanation is that after the implementation of BRI, China has increased its direct investment in countries along the route, but for a shorter period of time. The impact of OFDI on TFP needs to be tested for a longer period.

In the control variables, the level of economic development showed a significant inhibitory effect on the pure technological progress index. For every 1% increase in GDP per capita in Asian countries, the net index of technological progress decreased

by 0.183% and showed a 5% significance level. This shows that a higher level of economic development in the Asian region will inhibit the development of technological progress and thus inhibit TFP, and this estimate is consistent with the full sample estimate. The decomposition term of trade level (*tra*) has a negative effect on the pure index of technological progress at a 5% significance level. The level of financial development (*fina*) has a positive effect on TFP at a 10% significance level. If the level of financial increase is 1%, TFP increases by 0.156%. In Asia, most of the countries are developing countries, and capital support can promote the development of new industrial land quickly and effectively so that TFP can be improved rapidly in the short term. The industrialisation degree (*ind*) significantly promoted TFP and the technical efficiency index (TEP) but inhibited the pure technological progress index (PSI). This shows that, in Asia, where most countries are developing countries, the degree of industrialisation can improve TFP, mainly by optimising the allocation of resources and improving the efficiency of scale.

The estimation results in Europe show that TFP and the technical efficiency index have significant temporal inertia. From the point of view of core variables, *Sofdi* has a positive correlation with TFP and its decomposition terms, and it has a positive effect on the technical efficiency index at a 5% significance level. In most developed countries in Europe, the technology spillover from China's direct investment has played a positive role in optimising the allocation of resources and promoting technological progress, thus improving TFP. Of these, the effect of optimising resource allocation is more obvious. The technology spillover, *Sifdi*, from European countries along BRI to China also has a positive effect on TFP and its breakdown. Among these, the indices of TFP and technical efficiency showed a positive level of 10%. Overall, mutual investment activities between China and European countries along BRI have contributed to the promotion of TFP between them. Technology spillovers from China's introduction of direct investments have been promoted. That is, the effect of *Sifdi* on TFP is more significant. Judging from the estimated results of TFP breakdown, the technology spillover of two-way investment has a positive effect on the allocation of resources and the level of science and technology. Both *Sifdi* and *Sofdi* have a significant effect on optimising resource allocation.

According to the estimation of the control variables, the behaviour of government intervention (*gro*) has an inhibitory effect on the technical efficiency index at a 5% significance level. There is a negative correlation between avgdp and TFP at the 10% level, but a positive correlation between the level of economic development and the technical efficiency index at the 5% level. There are more developed Belt and Road countries in Europe. The higher the level of economic development, the more difficult it is to promote TFP, and accelerating the optimisation of resource allocation is an effective way to improve TFP. The level of trade (*tra*) has a negative correlation with TFP and its decomposition items, but it is only negatively correlated with the technical efficiency index (TPI) at a 5% significance level. This indicates that the trade development of BRI in Europe has a restraining effect on the technical efficiency index, which further affects the promotion of TFP. A possible explanation is that developed countries in the European region have reached a higher level of development, but the domestic market is small, and it is easy to expand the trade to squeeze

domestic enterprises out of the market, which is not conducive to the improvement of domestic enterprises' efficiency. The level of financial development (*fina*) inhibits TFP and the index of technological progress, but the result is not significant, and it is positively correlated with the technical efficiency index at the 1% significance level. Moreover, the financial level of the European region plays an important role in scale economy and resource allocation. The industrialisation degree (*ind*) has a positive correlation with TFP and its decomposition terms, and it has a positive effect on the technical efficiency index (TPI) at a 1% significance level. This shows that the level of industrialisation in Europe is also an important way to promote TFP, and the enhancement of the industrialisation degree has the most significant effect on the efficiency of scale. The correlation between the variables of innovation level (*cre*) and TFP and its decomposition items is not significant, which still needs to be further discussed.

7. Conclusion and suggestions

This study probes the influence of the mechanism of two-way investment between China and the Belt and Road countries on TFP. By using dynamic panel data, this study explores how two-way investment between China and Belt and Road countries affects TFP and its decomposition. In addition, this study divides Belt and Road countries and further analyses the regional differences in the influence of two-way investment on TFP. The following conclusions were drawn.

First, through the empirical analysis of the full sample, it was found that TFP and its decomposition term have obvious temporal inertia. The technology spillover of FDI has a significant effect on TFP and the technical efficiency index of countries along the route. In addition, the level of national economic development has a significant inhibitory effect on TFP and its breakdown. The degree of industrialisation and the financial level of the country also have a significant promoting effect. Government intervention has greatly promoted the advancement of science and technology. In general, China's direct investment in Belt and Road countries can effectively enhance the TFP of each country, and it plays an important role in promoting economic development.

Second, the samples of BRI in Asia and Europe were tested empirically. In Asia, China's imported investment has a significant spillover effect on TFP. In addition, the level of finance and industrialisation is also a crucial factor in promoting the development of TFP. The development of the national economy and the level of trade play an important role in restraining the pure technological progress index. In Europe, the technology spillover effect of foreign investment is helpful in enhancing resource allocation in European countries. The spillover effect of China's attracting foreign capital is beneficial for the improvement of TFP and the technical efficiency index in Europe. Moreover, the level of economic development in European countries has a significant inhibitory effect on TFP and the technical efficiency index.

Based on the above conclusions, this study puts forward the following policy recommendations. First, according to the empirical study of the whole sample along BRI, it was found that China's direct investment in Belt and Road countries can promote the improvement of TFP, and this is mainly done by optimising the allocation

of resources. Therefore, China should continue to increase its investment in Belt and Road countries. At present, most of China's investment projects in Belt and Road countries, are infrastructure and energy development projects. To realise the goal of BRI diversified development, we should give full play to the comparative advantages of other industries in China and promote investment in other industries.

Third, according to an empirical study of the sub-regional samples of Asia and Europe along BRI, China's introduction of foreign capital has a significant effect on TFP both in Asia and in Europe. Therefore, while adhering to the strategy of 'going out', China must not forget to 'bring in'. It should adopt a two-pronged approach, vigorously introduce foreign capital, and pay attention to the quality of introducing foreign capital at the same time. Third, the level of national financial development and the degree of industrialisation are important indices to promote TFP, whether from the whole sample or the sub-regional sample. Therefore, from the perspective of national financial development, the government should pay more attention to the expansion of financial opening, perfect the supervision system of the national financial market, and make the national financial market grow well. Concrete measures can be manifested in encouraging Belt and Road countries to jointly strengthen the construction of financial infrastructure, promote cooperation and training programs for financial talents among countries, widen the channels of national investment and financing, introduce foreign banks and other financial institutions with experience in international investment and financing, improve policy loans for overseas investment, expand the space for preferential interest rates, and improve the efficiency of financial services. To promote the development of national industrialisation, China should actively carry out the international capacity of cooperation and promote the development of new industrialisation.

However, this study has some shortcomings. First, when conducting the empirical research in this study, based on the availability of various data, only 36 Belt and Road countries were selected as the full sample. However, BRI now covers more than 130 countries. The sample of countries is underrepresented, and because of the small number of countries in Africa, Oceania, America, and other regions when data were obtained, only empirical analysis of Asia and Europe was carried out. Second, in the model constructed in this study, only the direct impact of each economic variable on TFP is considered, but the impacts of each economic variable are intertwined and complex. Therefore, the direct and indirect effects of each economic variable on TFP and the complexity of their intertwined effects can be directions for future research.

Notes

1. The 36 countries and regions are Malaysia, Philippines, Singapore, Thailand, Cambodia, Korea, Macao China, Hong Kong, Pakistan, Sri Lanka, India, Kazakhstan, Turkey, Israel, Saudi Arabia, UAE, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Lithuania, Romania, Poland, Slovakia, Slovenia, Russia, Ukraine, Belarus, Egypt, Madagascar, Panama, Morocco, New Zealand, and South Africa.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Bai, J. (2009). Reverse technology spillover effects of OFDI-an empirical test of the impact on China's total factor productivity. *World Economic Research*, *8*, 65–69 + 89.

Barry, F., Gorg, H., & Strobl, E. (2005). Foreign direct investment and wages in domestic firms in Ireland: Productivity spillovers versus labour-market crowding out. *International Journal of the Economics of Business*, *12*(1), 67–84. https://doi.org/10.1080/1357151042000323102

Chen, S. Y. (2010). Green industrial revolution in China: A perspective from the change of environmental total factor productivity. *Economic Research Journal*, *45*(11), 21–34 + 58.

Chen, J. Q., Liu, W., & Du, Z. H. (2016). Spatial effect of reverse inflection point of total factor productivity under environmental regulation-verification based on inter-provincial industrial panel data. *Economic Theory and Economic Management*, *5*, 57–67. https://doi.org/10.3969/j.issn.1000-596X.2016.05.005

Chen, Y. T., & Zhu, T. (2018). Outward direct investment, financial structure and total factor productivity: A study based on China's provincial panel data. *Macroeconomic Study*, *7*, 48–58. https://doi.org/10.16304/j.cnki.11-3952/f.201807.006

Coe, D. T., & Helpman, E. (1995). International RandD Spillovers. *European Economic Review*, *39*. https://doi.org/10.5089/9781451954401.001

Djankov, S., & Hoekman, B. (1998). Avenues of technology transfer: foreign investment and productivity change in the Czech Republic. CEPR Discussion Papers (1883). https://doi.org/10.2139/ssrn.109789

Gorg, H., & Greenway, D. (2016). Much Ado about nothing? Do domestic firms really benefit from foreign direct investment? In H. Görg (Ed.), *Multinational Enterprises and Host Country Development* (pp. 163–189). World Scientific Publishing. https://doi.org/10.1142/9789814749237_0009

Gu, X. S., & Han, L. Y. (2015). Reverse spillover effect of regional market integration and OFDI-empirical evidence from provincial administrative regions of China. *China Management Science*, *23*(3), 1–12. https://doi.org/10.16381/j.cnki.issn1003-207x.2015.03.001

Hoekman, B., & Djankov, S. (2000). Foreign investment and productivity growth in Czech enterprises. *Social Science Electronic Publishing*. https://ssrn.com/abstract=620639

Hu, C. X. (2010). Influence of FDI on total factor productivity of China's service industry-an analysis based on stochastic frontier panel data model. *Journal of Xiamen University (Philosophy and Social Science Edition)*, *4*, 115–122. https://doi.org/10.3969/j.issn.0438-0460.2010.04.015

Huo, X., & Liu, H. (2016). Reverse technology spillover effect of Chinese foreign direct investment. *Journal of Capital University of Economics and Trade*, *2*, 128–135. https://doi.org/10.13504/j.cnki.issn1008-2700.2016.02.001

Kinoshita, Y. (2001). *R&D and technology spillovers via FDI innovation and absorptive capacity*. William Davidson Institute, University of Michigan Business School. https://doi.org/10.2139/ssrn.258194

Kugler, M. (2006). Spillovers from foreign direct investment: within or between industries?. *Journal of Development Economics*, *80*(2), 444–477. https://doi.org/10.1016/j.jdeveco.2005.03.002

Li, J. R. (2009). Research on the relationship between FDI and advanced technology progress and technical efficiency analysis of urban panel data of Pearl River delta based on DEA. *International Economic and Trade Exploration*, *10*, 46–51.

Lin, C. J., & Liu, T. S. (2011). Empirical study on the spillover effects of FDI and OFDI in China. *Technical Economy*, *30*(1), 5–9. https://doi.org/10.3969/j.issn.1002-980X.2011.01.002

Li, B., Qi, Y., & Li, Q. (2016). Fiscal decentralization, FDI and total factor productivity (TFP): Empirical test of dynamic GMM method based on panel data. *International Trade Issues*, *7*, 119–129. https://doi.org/10.13510/j.cnki.jit.2016.07.011

Li, J., & Tang, Y. (2019). Trade opening, FDI and total factor productivity. *Macroeconomic Research*, *9*, 67–79.

Liu, J. Q., Yu, Y., Gao, W. H., & Wang, S. Y. (2008). More effective utilization of fdi by china. *China-USA Business Review*, *7*(8), 13–30.

Muhammad, B. K., Xie, H. B., & Hummera, S. (2019). Direct impact of inflow of foreign direct investment on poverty reduction in Pakistan: A bonds testing approach. *Economic Research-Ekonomska Istraživanja*, *32*(1), 3647–3666. https://doi.org/10.1080/1331677X.2019.1670088

Shan, H. J. (2008). Reproduction of China's capital stock K: 1952–2006. *Quantitative Economics and Technical Economics Research*, *25*(10), 17–31.

Song, X. L., & Li, J. Y. (2021). Does the coordinated development of two-way FDI promote the growth of green economy efficiency? Based on the perspective of technological innovation. *International Business (Journal of University of International Business and Economics)*, *2*, 126–140. https://doi.org/10.13509/j.cnki.ib.2021.02.009

Wang, H., Sun, H., Xiao, H. Y., & Xin, L. (2020). Relationship between environmental policy uncertainty, two-way FDI and low-carbon TFP. *China Population, Resources and Environment*, *30*(11), 75–86. https://doi.org/10.12062/cpre.20200601

Wang, S. L., & Teng, Z. W. (2015). FDI inflow, Factor redistribution effect and service industry productivity in China: An empirical study in different sectors. *International Trade Issues*, *4*, 167–176. https://doi.org/10.13510/jcnki.jit.2015.04.017

Wang, F., & Xie, J. (2015). A study on the growth rate of green total factor productivity in different provinces of China. *Population Science of China*, *2*, 53–62.

Wang, L., Yu, J. X., & Shao, Y. H. (2019). Foreign direct investment and regional green total factor efficiency. *Finance and Trade Research*, *30*(10), 17–30. https://doi.org/10.19337/j.cnki.34-1093/f.2019.10.002

Xiao, P., et al. (2013). Analysis of total factor productivity of urban environment and its influencing factors in China. *Journal of Management*, *11*, 1681–1689. https://doi.org/10.3969/j.issn.1672-884x.2013.11.017

Yang, W. J., & Long, R. Q. (2012). Green total factor productivity growth of regional industry in China-empirical analysis based on directional distance function. *Shanghai Economic Research*, *7*, 3–13. https://doi.org/10.19626/j.cnki.cn31-1163/f.2012.07.001

Yang, D. X., & Yu, J. P. (2021). Investment facilitation, foreign direct investment and total factor productivity of countries along the "Belt and Road". *Economic Survey*, *38*(2), 54–63. https://doi.org/10.15931/j.cnki.1006-1096.20210209.002

Zhao, G. M., Chen, L. Z., & Sun, H. P. (2016). An empirical study on the spillover effect of OFDI reverse technology in China. *Statistics and Decision-Making*, *7*, 67–75. https://doi.org/10.13546/j.cnki.tjyjc.2016.14.030

Zhao, W., Gu, G. D., & He, Y. Q. (2006). Extroversion FDI and technological progress in China: Mechanism analysis and trial demonstration. *Managing the World*, *7*, 53–60. https://doi.org/10.19744/j.cnki.11-1235/f.2006.07.007

Zhang, J., Wu, G. Y., & Zhang, J. P. (2004). China's inter-provincial material capital stock estimation: 1952–2000. *Economic Research*, *10*, 35–44.

Zheng, Q., & Ran, G. H. (2018). Effects of Two-way FDI on green productivity spillover in China: An empirical test based on dynamic panel model. *Statistics & Information Forum*, *213*(6), 55–62.

Zhu, W. T., Lu, C. R., & Gu, N. H. (2019). Research on the influence of OFDI and reverse technology spillover on green total factor productivity. *China Population, Resources and Environment*, *29*(9), 63–73.

Zou, Y. J., & Chen, L. G. (2008). An empirical study on FDI and technology upgrading in China. *World Economic Research*, *5*, 70–77.