

Evaluation of China's OFDI Efficiency in Key Countries along "the Belt and Road" Based on DEA Model and Malmquist Index

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Abstract. With the continuous promotion and development of "the Belt and Road" construction, the economic cooperation and exchanges between China and the countries along "the Belt and Road" have been gradually deepened, and outward foreign direct investment (OFDI) is one of the important channels of economic exchanges between China and other countries. Therefore, the efficiency of outward investment is also getting more and more attention from all walks of life. Based on the panel data of China's direct investment in 26 key countries along "the Belt and Road" from 2014 to 2020, this paper uses DEA model and Malmquist index to conduct a comprehensive analysis and evaluation of China's OFDI efficiency. From the results of the DEA model, China's OFDI efficiency to key countries along "the Belt and Road" is low to medium, and the country differences in investment efficiency are mainly caused by the low scale efficiency (SE). From the results of the Malmquist index, China's investment in key countries along "the Belt and Road" in 2014-2020 is on a declining trend, and the investment efficiency will decrease significantly in 2019-2020 due to the impact of the COVID-19 pandemic. Therefore, we shall further improve the scale efficiency of OFDI, strive to develop advanced technology, encourage innovation, improve the technical progress index, optimize the choice of regional investment, and stimulate its vitality.

Keywords: "The Belt and Road"; OFDI efficiency; DEA; Malmquist index.

1. Introduction and Literature Review

In 2013, President Xi Jinping put forward the strategic concept of innovating cooperation models and jointly building "the Silk Road Economic Belt" and "the 21st Century Maritime Silk Road", aiming to build a new pattern of regional economic cooperation between China and Central Asian countries with "the Silk Road Economic Belt" as the central axis. This strategic concept has received great attention from the international community. The continuous development of "the Belt and Road" in recent years has driven the advancement of China's outward foreign direct investment (OFDI). Since "the Belt and Road" initiative was proposed, China has gradually increased its direct investment in countries along the route. According to the data in 2020 Statistical Bulletin of China's Outward Foreign Direct Investment, China's net outward foreign direct investment reached USD153.71 billion in 2020, up 12.3% year-on-year. To be specific, by the end of 2020, Chinese domestic investors setting up overseas enterprises in 63 countries along "the Belt and Road" achieved USD22.54 billion of direct investment in the current year, a year-on-year increase of 20.6%, accounting for 14.7% of China's OFDI flow in the same period and up 1% as compared with the previous year. From 2013 to 2020, China's cumulative direct investment in countries along route amounted to US\$139.85 billion and covered a wide range, including 61 countries and regions such as Singapore, Indonesia, the United Arab Emirates and Algeria, which shows that "the Belt and Road" initiative has made outstanding contributions to the economic development of China and the countries along the route.

With China surpassing Japan to become the world's second largest economy and the world's second largest OFDI country, the role of China's OFDI will be more prominent, and China's direct investment in countries along "the Belt and Road" has become an important factor to drive the economic development of these countries. Therefore, China's OFDI efficiency in countries along "the Belt and Road" has a high research value and has received wide attention from academia, and many scholars have conducted in-depth research on it from various aspects. In addition, since the Covid-19 pandemic in 2019, China's OFDI projects have also been affected to a certain extent. Therefore, in this special period different from the past, how to cope with the challenges brought by the Covid-19

pandemic to OFDI and improve the efficiency of OFDI has also become a new issue of common concern for policy makers and academic researchers.

Academic research on OFDI along "the Belt and Road" has been fruitful, and the research directions and approaches are very rich and extensive. At present, the research on China's OFDI to countries along "the Belt and Road" can be divided into the following aspects. The first one is studies on the efficiency of China's outward investment in countries along "the Belt and Road" by the stochastic frontier gravity model, which has been widely used in related studies. For example, Li Kaiwen and Zhou Ji [1] selected the panel data of 52 countries along "the Belt and Road" from 2003 to 2014, established a stochastic frontier gravity model and conducted an empirical analysis, concluding that the efficiency of China's OFDI to countries along "the Belt and Road" is low and there is still much room for improvement. Song Lin, Xie Wei and Zheng Wen [2] used a heterogeneous stochastic frontier gravity model to measure the potential and efficiency of Chinese OFDI, and found that there is serious underinvestment in "the Belt and Road" region with high investment potential, and the loss of investment efficiency in the "Silk Road Economic Belt" is more serious. By constructing a host country financial ecology evaluation system and stochastic frontier gravity model, Hu Bing and Wang Xiaofang [3] pointed out that OFDI has efficiency loss in the region, and the improvement of economic, political and credit environment in host country makes it face more market competition, which has a significantly greater negative effect than the positive effect of financial environment on OFDI efficiency. Yan Jiajia, Liu Yongfu and He Yi [4] argued that the efficiency of China's direct investment is at a low level, and the efficiency of investment in developing countries is higher than that of developed countries, which shows a positive time-varying effect, with smooth growth and spatial convergence, while the overall level is gradually improving. Xiong Bin and Fan Yaya [5] examined the efficiency and potential of China's investment in countries along "the Belt and Road" and its influencing factors from two aspects of investment stock and flow, and proved that the efficiency of China's investment with the countries along "the Belt and Road" during 2003-2016 is of great imbalance. The second one is to evaluate and analyze the efficiency of China's OFDI to the countries along "the Belt and Road" by DEA model. For example, Ni Kun and Wang Lei [6] measured the efficiency of OFDI based on DEA-Malmquist index and concluded that the overall investment efficiency and technical efficiency of China is low and needs to be improved. Li Jigang and Ma Yong [7] found that since "the Belt and Road" initiative was proposed, the overall investment efficiency of listed companies along the route has been on the rise, and the policy has an obvious positive effect on the investment efficiency of listed companies along the route. Tian Ze and Xu Dongmei [8] used the super-efficiency DEA and Malmquist index method to comprehensively evaluate the investment efficiency and its changes, and their research indicates that China's investment in the countries along the route is not highly efficient in general, and there are large differences between countries. The investment scale returns of most countries are at the stage of effective or incremental investment. The third one focuses on the efficiency of OFDI in certain countries or regions along "the Belt and Road". For example, Tian Ze, Wang Yili and Jin Shuiying [9] argued that the efficiency of China's investment in key energy countries in Africa is not high, and the efficiency of investment in only a few countries reaches an effective level, while the efficiency of investment in most countries is a low to medium level. In terms of investment risk, Liu Jiaguo, Ye Zhening and Ding Jingjing [10] believed that China's investment efficiency in countries along the "21st Century Maritime Silk Road" is significantly negatively correlated with investment risk, and both high-risk and higher-risk countries show diminishing returns to scale, non-optimal investment efficiency and irrational investment.

In addition, a small number of scholars have chosen research directions or methods that are different from the above-mentioned literature. For example, Li Bing and Tian Shihui [11] used a DEA model to measure the efficiency of IFDI in countries along the route, and concluded that the efficiency of IFDI in countries along the route varied greatly from country to country. After "the Belt and Road" initiative was proposed, the investment efficiency has been significantly improved. Besides, Zu Yu

and Li Zongming [12] analyzed the panel data through a gravity model and proved that Chinese enterprises have a positive impact on the governance of host countries along "the Belt and Road".

In summary, the current research on the investment efficiency of China's countries along "the Belt and Road" is mostly focused on theoretical analysis by mainly using stochastic frontier gravity models, while less literature pays attention to DEA model for research and analysis. Most of them are based on the data when "the Belt and Road" initiative was just proposed, and have not been updated and studied in recent years. In addition, the outbreak of the Covid-19 pandemic since 2019 has brought a lot of uncertainties to China's OFDI, which has also been affected to a certain extent. However, little importance has been attached to the data and efficiency changes of China's OFDI to countries along "the Belt and Road" after the Covid-19 pandemic.

Therefore, in the context of the comprehensive promotion of "the Belt and Road" initiative and the outbreak of the Covid-19 pandemic, how to improve the efficiency of China's direct investment in countries along the route is of great significance to break the bottleneck of China's OFDI and smoothly promote "the Belt and Road" initiative. Therefore, according the existing literature, this paper uses DEA and Malmquist index method to comprehensively evaluate the efficiency of OFDI and its changes based on the panel data of China's direct investment in 35 key countries along "the Belt and Road" from 2014 to 2020, analyzes the impact of the Covid-19 pandemic on China's direct investment in "the Belt and Road" and puts forward the suggestions. It aims to provide a reference for further related research through the comprehensive evaluation of OFDI efficiency, and effective suggestions for improving the efficiency of China's direct investment in countries along "the Belt and Road" and driving the common development of "the Belt and Road" economic zone.

2. Evaluation Model and Indicator

2.1 Evaluation Model

2.1.1 Theoretical Basis of Static Efficiency Measurement - Data Envelopment Analysis (DEA) Model

Data Envelopment Analysis (DEA) model is a non-parametric estimation method to evaluate the relative effectiveness of the same type of decision-making unit (DMU) in the same period, and is often used to measure the efficiency. DEA model uses the data of input and output indicators to derive the production frontier, and determines whether the DEA is effective by comparing the distance between the decision-making unit and the production frontier. The basic DEA models are divided into two types: CCR and BCC models, and the CCR model measures the efficiency of each decision-making unit (DMU) under the assumption of constant returns to scale. However, the returns to scale often do not remain constant in real life, but are increasing and decreasing. Therefore, Banker, Charnes, and Cooper improved the CCR model in 1984 by establishing a model to measure efficiency under variable returns to scale, which is also the BCC model that will be used in this paper in the following form (based on input orientation):

$$\begin{aligned} & \min[\theta - \varepsilon(\hat{e}^T s^- + e^T s^+)] \\ & s. t. \begin{cases} \sum_{j=1}^n X_j \lambda_j + S^- = \theta X_0 \\ \sum_{j=1}^n Y_j \lambda_j - S^+ = Y_0 \\ \lambda_j \geq 0, j = 1, 2, \dots, n \\ \sum_{j=1}^n \lambda_j = 1, j = 1, 2, \dots, n \\ S^- \geq 0, S^+ \geq 0 \end{cases} \end{aligned} \quad (1)$$

where X_j and Y_j are the input vector and output vector of the j th decision unit respectively, θ is the efficiency evaluation value of the decision unit, λ_j is the planning decision variable, S^+ and S^- are the output slack variable and the input slack variable respectively, and ε is the non-Archimedean infinitesimal.

When $\theta = 1$ and $S^+ = S^- = 0$, it indicates that this decision unit DEA is valid and the input minimization and output maximization are achieved in the current decision unit system.

When $\theta = 1$ and $S^+ > 0$ or $S^- > 0$, it means that the decision unit is weakly DEA valid for pure technical efficiency valid, but the scale of inputs and outputs are not matched, and the scale needs to be increased or decreased.

When $\theta < 1$, it means that the decision unit is not DEA valid and non-optimal, and there is still room for improvement.

In the BCC model, the Technical Efficiency (TE) can be decomposed into Pure Technical Efficiency (PTE) and Scale Efficiency (SE), and the relationship between the three can be expressed as $TE = PTE \times SE$.

In summary, considering the reality that there is a variation of returns to scale in China's OFDI, the BCC model is chosen to better approximate the real efficiency of China's OFDI, and the decomposition of overall OFDI efficiency can better identify the composition of efficiency and provide guidance for future development.

2.1.2 Basis of Dynamic Efficiency Exploration - Malmquist Index

The Malmquist index was first proposed by Malmquist in 1953 and then applied to measure productivity by Caves et al. in 1982. The advantage of the Malmquist index is the ability to measure the total factor productivity of a decision unit from a dynamic perspective. Based on the aforementioned BCC and CCR models, the Malmquist index can be constructed to analyze the dynamic changes of China's OFDI efficiency to the countries along "the Belt and Road" from a dynamic perspective during 2014-2020. The Malmquist index $M(x^{t+1}, y^{t+1}, x^t, y^t)$ from period t to period $t+1$ is expressed by the following equation.

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \quad (2)$$

where (x^{t+1}, y^{t+1}) and (x^t, y^t) denote the input and output vector in periods $t+1$ and t respectively, and D^t and D^{t+1} denote the distance functions of the objects examined in periods t and $t+1$ respectively, with the technology level in period t as the reference. In equation (2), when $M < 1$, it implies that total factor productivity decreases from period t to $t+1$; when $M = 1$, it indicates that total factor productivity is constant from period t to $t+1$; when $M > 1$, it means that total factor productivity increases from period t to $t+1$.

Further decomposition of the above equation leads to the EFC index and TEC index, whose expressions are

$$EFC = \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \quad (3)$$

$$TEC = \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \right]^{1/2} \quad (4)$$

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = EFC \times TEC \quad (5)$$

Where EFC is the technical efficiency index, when $EFC < 1$, the technical efficiency decreases and the distance between DMU and production front surface becomes farther; when $EFC = 1$, the technical efficiency remains unchanged, and so does the distance between DMU and production front surface; when $EFC > 1$, the technical efficiency is improved and the distance between DMU and production front surface is drawn closer. TEC is the technical progress index. When $TEC < 1$, technology declines and the production possibility boundary of the whole industry moves inward; when $TEC =$

1, technology remains unchanged and the production possibility boundary of the whole industry remains unchanged; when $TEC > 1$, technology advances and the production possibility boundary of the whole industry moves outward.

2.2 Evaluation Object and Indicator

2.2.1 Evaluation Object

Based on the current situation of China's FDI to countries along "the Belt and Road", This paper strictly follows the requirements of DEA model for sample size and takes into account the availability and validity of data. The sample size is equal to two times the product of input and output indicators (two input indicators and four output indicators are selected in this paper). In terms of the selection of evaluation objects, reference is made to the research results of Zhong Feiteng et al. [13], and the host countries that rank top 26 in terms of OFDI stock along "the Belt and Road" at the end of 2020 have been selected as the evaluation object (DMU), which is of strong representation. The period of data selection is from 2014 to 2020, which will end at the end of 2020 for measurement and analysis of OFDI efficiency of 26 host countries.

Table 1. 26 Host Countries and their Areas

Areas	Country
Southeast Asia	Singapore, Malaysia, Indonesia, Myanmar, Thailand, Laos, Cambodia, Vietnam
South Asia	India, Pakistan, Bangladesh
West Asia and North Africa	Iran, Iraq, Turkey, Israel, Saudi Arabia, UAE, Kuwait, Egypt
East and Central Asia	Mongolia, Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan
Central and Eastern Europe	Czech Republic, Russia

2.2.2 Evaluation Indicator

Based on the principles that the selected indicators should be feasible and practically meaningful, the study selects China's direct investment stock in the host country (USD million) and total labor force in the host country (thousand people) as input indicators for China's OFDI efficiency analysis. Host country GDP (USD million), GDP per capita (USD million), fiscal revenue (USD million), and total import and export trade (USD million) are selected as output indicators. The relevant data are obtained from Statistical Bulletin of China's Outward Foreign Direct Investment, World Bank database, and IMF database.

The specific indicators are described as follows.

1. The stock of China's direct investment in the host country reflects the input of China's OFDI from the perspective of capital.
2. The total labor force in the host country reveals the host country's inputs from a labor force perspective.
3. Host country GDP and GDP per capita measure the economic development of each country, which indicates the total economic volume and economic strength of the host country, thus reflecting the output level of OFDI.
4. Host country fiscal revenue indicates government revenue, and the impact of OFDI on government revenue output.
5. The total import and export trade of the host country reflects the foreign trade of the host country and measures the efficiency of OFDI from a macroeconomic perspective.

Table 2. Evaluation Indicators of Investment Efficiency among 26 Key Countries in 2014-2020

Indicator Type	Indicator	Data Source
Input Indicator	FDI stock to host country	<i>Statistical Bulletin of China's Outward Foreign Direct Investment</i>
	Total host country labor force	World Bank Database
Output Indicators	Host country GDP	World Bank Database
	Host country GDP per capita	World Bank Database
	Host country fiscal revenue	International Monetary Fund Database
	Total import and export trade of the host country	International Monetary Fund Database

3. China's Comprehensive Evaluation of OFDI Efficiency in Key Countries along "the Belt and Road"

3.1 Evaluation of Investment Efficiency Based on DEA Model

Using the input-oriented BCC model, the collected data of each index are substituted into DEAP software to calculate the technical efficiency (TE), pure technical efficiency (PTE), scale efficiency (SE) and returns to scale (RTS) of China's OFDI to 26 key countries along "the Belt and Road" from 2014 to 2020. The data results are shown in Table 3.

Table 3. Evaluation Results of China's Direct Investment Efficiency to the Countries along the Route Based on DEA Model

Host country	2014				2020			
	TE	PTE	SE	RTS	TE	PTE	SE	RTS
UAE	1.000	1.000	1.000	→	1.000	1.000	1.000	→
Egypt	0.130	0.132	0.983	↑	0.829	1.000	0.829	↑
Pakistan	0.046	0.049	0.943	↑	0.140	0.182	0.766	↑
Russia	0.334	1.000	0.334	↓	0.533	1.000	0.533	↓
Kazakhstan	0.293	0.300	0.979	↑	0.246	0.316	0.781	↑
Kyrgyzstan	0.040	0.789	0.051	↑	0.054	0.865	0.062	↑
Cambodia	0.027	0.236	0.114	↑	0.055	0.227	0.244	↑
Czech Republic	1.000	1.000	1.000	→	1.000	1.000	1.000	→
Kuwait	1.000	1.000	1.000	→	1.000	1.000	1.000	→
Laos	0.046	0.481	0.096	↑	0.061	0.381	0.160	↑
Malaysia	0.457	0.594	0.769	↓	0.397	0.432	0.919	↓
Mongolia	0.155	1.000	0.155	↑	0.255	1.000	0.255	↑
Bangladesh	0.301	0.541	0.556	↑	0.443	0.615	0.721	↑
Myanmar	0.031	0.086	0.362	↑	0.084	0.223	0.377	↑
Saudi Arabia	0.756	1.000	0.756	↓	1.000	1.000	1.000	→
Tajikistan	0.049	0.893	0.055	↑	0.045	0.921	0.049	↑
Thailand	0.193	0.373	0.517	↓	0.269	0.501	0.537	↓
Turkey	0.401	1.000	0.401	↓	1.000	1.000	1.000	→
Uzbekistan	0.072	0.268	0.269	↑	0.084	0.260	0.322	↑
Singapore	1.000	1.000	1.000	→	1.000	1.000	1.000	→
Iraq	0.357	0.389	0.917	↑	0.395	0.559	0.707	↑
Iran	0.216	0.254	0.853	↓	0.218	0.296	0.738	↑
Israel	1.000	1.000	1.000	→	1.000	1.000	1.000	→
India	0.167	1.000	0.167	↓	1.000	1.000	1.000	→
Indonesia	0.089	0.194	0.456	↓	0.224	0.363	0.617	↓
Vietnam	0.087	0.088	0.983	↑	0.210	0.957	0.220	↓

Note: "→" indicates constant returns to scale, "↑" indicates increasing returns to scale, and "↓" indicates decreasing returns to scale.

Based on the data above, the analysis is as follows.

1. The overall OFDI efficiency of China to key countries along "the Belt and Road" shows a low to medium level. According to the technical efficiency (TE) analysis, only eight countries including UAE, Czech Republic, Kuwait, Singapore, Israel, Saudi Arabia, Turkey and India have an OFDI efficiency of 1, that is DEA effective, which accounts for 30.8% of the 26 countries. Apart from that, China's investment efficiency in other countries remains at a low to medium level, accounting for nearly 70% of the total. In the study of Tian Ze and Xu Dongmei [8], the overall investment efficiency of China to countries along "the Belt and Road" from 2008 to 2014 is at a low to medium level, which indicates that the OFDI efficiency of China to key countries along "the Belt and Road" in recent years has not developed significantly and needs to be further improved.

2. According to the pure technical efficiency (PTE) analysis, a total of 10 countries such as to UAE, Czech Republic, and Kuwait have been maintained in DEA effective situation (efficiency value = 1), accounting for 38%, which is higher than the technical efficiency (TE) of DEA efficiency. Among the remaining countries only the PTE to Egypt and Vietnam has significantly increased in 2014-2020. The PTE of China's OFDI to Laos, Malaysia, and Uzbekistan is decreasing instead of increasing, while the other countries are steadily increasing but at a slower growth rate, and the investment efficiency still remains at a low to medium level.

3. According to the scale efficiency (SE) analysis, the scale efficiency of China's OFDI to UAE, Czech Republic, Kuwait, Singapore and Israel has been maintained at the DEA effective level of about 19%. In addition to this, the scale efficiency of our investments in Saudi Arabia, Turkey and India has been significantly improved during the five years and reached DEA efficiency in 2020. However, the scale efficiency of our OFDI to 7 countries is decreasing, which accounts for 27% of the 26 countries.

4. China's OFDI efficiency in key countries along "the Belt and Road" is on a growing trend but slowly. China's OFDI efficiency to 26 key countries along the Belt and Road shows a growing trend during 2014-2020, and only three countries, Kazakhstan, Malaysia and Tajikistan, show a decreasing trend, accounting for 11.5% of the 26 countries, while the OFDI efficiency to the remaining 23 countries all show a growing trend. But among those countries that are growing, only a few are increasing rapidly, such as Egypt, Saudi Arabia, Turkey, and India, which only account for 15% of the 26 countries. Besides, the remaining 19 countries' OFDI efficiency is increasing but slowly, and the investment efficiency still remains at a low to medium level.

5. The DEA efficiency of PTE of China's investment in key countries along "the Belt and Road" is much greater than the DEA efficiency of SE. According to the formula $TE = PTE * SE$, we can analyze that the reason why China's OFDI efficiency in many countries cannot reach DEA efficiency is that the scale efficiency cannot reach 1. Therefore, China should pay more attention to the scale efficiency of OFDI and try to improve it in foreign investment in the future.

3.2 Efficiency Dynamization Analysis Based on Malmquist Index

Malmquist Index can reflect the changing trend of China's OFDI efficiency to countries along "the Belt and Road" in terms of year and region dynamically, and DEAP software is used to analyze the data of China's OFDI to 26 host countries along "the Belt and Road" from 2014 to 2020. The evaluation results are as follows.

3.2.1 Analysis of the Average Change in Overall Investment Efficiency

The average value of Malmquist index of China's OFDI to 26 countries along "the Belt and Road" from 2014 to 2020 is 0.955, which indicates that the efficiency of China's OFDI to countries along "the Belt and Road" in 2020 is decreasing compared with 2014. By decomposing the Malmquist index, we can get: $M = EFC * TEC$, which means that the Malmquist index is decomposed into the product of technical efficiency index (EFC) and technical progress index (TEC), and the average value of technical efficiency index is 1.131 and that of technical progress index is 0.906. So we can conclude that the decrease in the efficiency of China's investment in key countries along "the Belt and Road" in 2014-2020 is due to the dynamic change in the rate of technical progress, which decreases by 9.4%

in 2014-2020, while the technical efficiency increases by 13.1%, which indicates that the improvement of technical efficiency has slowed down China's investment in the key countries along "the Belt and Road" to a certain extent. The above analysis shows that the technical efficiency of China's OFDI in 2014-2020 has enhanced under the existing technology, and the factor allocation has been optimized and the factor utilization rate has been improved. However, the rate of technical progress is on a decreasing trend, which implies that the most advanced technical efficiency of China is still a key factor restricting the development and improvement of OFDI efficiency, and China needs to further improve the efficiency of technical progress.

3.2.2 Analysis of the Average Change in Annual Investment Efficiency

By means of calculation, it can be concluded that the OFDI efficiency of China's key countries along "the Belt and Road" from 2014 to 2020 demonstrates a fluctuating trend, with an upward trend from 2014 to 2017, but a decline from 2017 to 2018, followed by a rise again from 2018 to 2019, but a significant decline from 2019 to 2020. The specific values and changes are shown in Table 3 and Figure 1. The following detailed analysis is conducted for the Malmquist index and decomposition.

1. Investment efficiency increased year by year from 2014 to 2017, with an increase of 9.1% and 6.7%, both due to the increase in the technical progress index (TEC), which increased by 10% and 33.1% respectively, but the technical efficiency (EFC) decreased by 20.1% and 30.5% respectively, which largely hinders the improvement of the efficiency of foreign investment.

2. Investment efficiency declined in 2017-2018 by 4%, due to a 13.1% decrease in the rate of technical progress, in contrast to a 6.8% increase in technical efficiency.

3. Investment efficiency rose again in 2018-2019 and peaked at 4.6% in the investigation period as technical efficiency rose by 4.3%, but the rate of technical progress fell by 0.5%.

4. Investment efficiency plunges by 12.6% in 2019-2020, approximately equal to 2015-2015, mainly because there is a significant decline in the rate of technical progress, down by 25.8%, but technical efficiency rises by 24.6%, providing a certain buffer for the decline in investment efficiency.

It can be concluded that TEC is the key factor affecting the change of investment efficiency in most cases. Therefore, attaching importance to technical progress and improving the technical progress index is a crucial choice for China to improve the efficiency of OFDI.

Table 4. Malmquist Index and Decomposition of Investment Efficiency in 2014-2020

Index Year	Malmquist	EFC	TEC
2014-2015	0.860	1.412	0.712
2015-2016	0.951	1.211	0.812
2016-2017	1.018	0.906	1.143
2017-2018	0.978	0.974	1.012
2018-2019	1.024	1.017	1.007
2019-2020	0.898	1.263	0.749

4. Trend Analysis of Investment Efficiency Changes in Each Region

The Malmquist index and decomposition of the efficiency of China's investment in each region of the 26 key countries along "the Belt and Road" from 2014 to 2020 by means of calculation are shown in Table 4. The analysis is as follows.

1. The efficiency of our investment in Southeast Asia is on an upward trend, rising by 0.9% due to a 10.1% increase in technical efficiency, but a 6.2% decrease in the rate of technical progress.

2. China's investment efficiency in South Asia, West Asia and North Africa, East and Central Asia, and Central and Eastern Europe are all on a downward trend, with investment efficiency in South Asia declining by 6%, in West Asia and North Africa by 8.8%, in East and Central Asia by 5.5%, and in Central and Eastern Europe by 4.6%. While the technical efficiency of investment in these regions

are on an upward trend, the reason for the decline in investment efficiency is the decline of the rate of technical progress.

Based on above analysis, we can learn that China's investment focus on countries along "the Belt and Road" has shifted from developed countries to developing countries, among which the investment efficiency in Southeast Asia is in the rising stage from 2014 to 2020 with a greater investment potential. However, the efficiency of China's investment in West Asia and North Africa have declined significantly, indicating that the investment in West Asia and North Africa has a long history and a mature scale, coupled with insufficient technical progress, resulting in a downward trend of investment efficiency. Overall, the technical efficiency of China's direct investment in these five regions is on an upward trend, rising by 10.1%, 37.8%, 14.3%, 3.9% and 5.8% respectively, which contributes to the growth of investment efficiency. However, the rate of technical progress for all five regions is on a downward trend, which implies that technical progress has become an important factor that hinders the growth of direct investment efficiency in countries along "the Belt and Road", and needs further attention. In the future, China should encourage technological innovation and strive to improve the rate of technical progress, which can effectively solve the current problems and further improve the efficiency of China's OFDI to the countries along "the Belt and Road".

Table 5. Malmquist Index and Decomposition of Investment Efficiency by Region in 2014-2020

Index Region	Malmquist	EFC	TEC
Southeast Asia	1.009	1.101	0.938
South Asia	0.940	1.378	0.836
West Asia and North Africa	0.912	1.143	0.880
East and Central Asia	0.945	1.039	0.931
Central and Eastern Europe	0.954	1.058	0.921

5. Analysis of Investment Efficiency Changes after the Covid-19 Pandemic

At the beginning of 2020, the New Coronavirus swept the world, causing a serious blow to people's health and a negative impact on the global economic development, while little literature has paid attention to the impact of the New Coronavirus on China's OFDI. Therefore, the following analysis will study the impact of our country on the OFDI efficiency of the key countries along "the Belt and Road" before and after the outbreak of Covid-19 pandemic.

The analysis of Table 3 and Figure 1 reveals that the efficiency of China's investment in key countries decreases significantly in 2019-2020, down by 12.6%, almost back to 2014-2015, and the main reason is that the rate of technical progress decreases by 25.8%. Although it is due to a variety of reasons, the Covid-19 pandemic is also one of the main influencing factors.

First, the Covid-19 pandemic has exacerbated geopolitical risks, increased global economic uncertainty and restrictions on the flow of production factors, which has led to the suspension or termination of China's OFDI with a significant reduction, and a serious impact on the operations of enterprises that have invested abroad in host countries. Data released by the Ministry of Commerce show that China's outward investment in 2020 achieved overall growth, with an annual outward foreign direct investment of US \$132.94 billion, equivalent to RMB 916.97 billion, up 3.3% year-on-year. Although the amount of China's outward investment showed a counter-trend growth, it was still lower than the growth rate in previous years. Secondly, after the epidemic, China's economy has entered into a phase of "Inward Development", because the domestic market needs to be built after the epidemic with a strong demand of investment, and the government will appropriately guide to contract the resources invested abroad and slow down the pace of economic "Going Out". Finally, the Covid-19 pandemic brings huge losses to the global economy, science and technology development, restricting technical progress and innovation, resulting in a 25.8% decline in the rate of technical progress, which directly affects the efficiency of China's foreign investment.

At present, the Covid-19 pandemic is still prevalent worldwide. In the face of the new environment at present, how China's foreign-invested enterprises can improve the current investment environment, optimize the allocation of resources, and strive to improve the rate of technical progress and the efficiency of foreign investment in the context of the prevalence of the Covid-19 pandemic, has become one of the top issues that foreign enterprises in China need to solve currently.

6. Conclusions and Suggestions

This paper uses DEA model and Malmquist index to make a comprehensive evaluation of China's OFDI efficiency and change trends for 26 key countries along "the Belt and Road", and the conclusions are as follows: 1. From the results of the DEA model, the OFDI efficiency of China to the key countries along "the Belt and Road" is low to medium, and the country differences in investment efficiency are mainly caused by the low scale efficiency (SE). 2. China's investment efficiency in Southeast Asia is on a decreasing trend, which is due to the dynamic decrease in the rate of technical progress, while the increase of technical efficiency has slowed down the decrease of China's OFDI efficiency in countries along "the Belt and Road" to a certain extent. 3. China's OFDI efficiency in Southeast Asia is on an increasing trend, but its investment efficiency in South Asia, while West Asia and North Africa, East and Central Asia, Central and Eastern Europe is decreasing, with the largest decrease in West Asia and North Africa. In addition, the rate of technical progress for all five regions is decreasing, which indicates that technical progress has become an important factor hindering the growth of China's OFDI efficiency in countries along "the Belt and Road" and needs further attention. 4. The efficiency of investment in key countries along "the Belt and Road" is affected by the Covid-19 pandemic in 2019-2020, with a significant decline of 12.6%.

Therefore, in view of the current situation, the suggestions are as follows: 1. It is supposed to further improve the scale efficiency of OFDI, so as to enhance the efficiency of China's OFDI to countries along "the Belt and Road" in general. 2. We need to strive to develop advanced technology, encourage innovation, and improve the technical progress index to enhance the efficiency of outward investment. 3. It is suggested to optimize the regional choice of investment, seize investment opportunities in Southeast Asia, expand the scale of investment and tap the potential for cooperation, while stimulating investment dynamics in other regions, especially in West Asia and North Africa. 4. We should strengthen global cooperation in combating epidemics, curb its spread, improve infrastructure development, and explore investment opportunities to stimulate economic vitality in the context of the Covid-19 pandemic.

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