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Impact of ASEAN Countries' Infrastructure on OFDI Efficiency in China: Based on the DEA-Tobit Model

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Abstract: In recent years, driven by the "Belt and Road" and " 21st Century Maritime Silk Road", China has gradually expanded its outward direct investment in ASEAN countries. This paper takes ASEAN countries as the research objects, uses the standard efficiency DEA model to evaluate the OFDI efficiency of China to ASEAN countries, and further explores the impact of infrastructure construction and other factors on investment efficiency through Tobit model. The results show that the comprehensive technology efficiency of China's OFDI is in the middle level, the pure technology efficiency is in the effective state, and the investment scale efficiency is in the suboptimal state. The regression results show that communication infrastructure significantly promotes OFDI scale efficiency in China; transportation infrastructure quality significantly inhibits OFDI scale efficiency; and the effect of energy infrastructure quality on OFDI scale efficiency is uncertain. Gross domestic product, natural resource endowment, labor resource level and financial development level are positively correlated with scale efficiency, and the level of opening up is negatively correlated with scale efficiency. In the end, the article provides suggestions for further strengthening the investment cooperation between China and ASEAN countries.

1. Introduction

ASEAN (The Association of Southeast Asian Nations) is a close neighbor of China linked by mountains and rivers and an important partner in international cooperation along the Belt and Road Initiative. In the past decade, China and ASEAN have conducted international activities through their own endowment advantages, which have had a significant impact on providing employment, enhancing advanced technology, increasing capital demand and promoting economic growth. Among them, high-quality OFDI (Outward Foreign Direct Investment)is an important part of the internationalization process of Chinese enterprises and an important support for the double cycle, while infrastructure construction, as an important indicator to measure the location advantage of host countries, has an important impact on attracting foreign direct investment.

According to the report of the Asian Development Bank, by 2030, the demand for infrastructure construction in Southeast Asia will be 1.48 trillion US dollars, and the annual demand is nearly 100 billion US dollars. The huge infrastructure construction needs huge funds. It means that China-ASEAN has transformed and upgraded from a strategic partnership to a China-ASEAN community of shared future. It also shows that ASEAN has become an important foreign direct investment area

for China. So how efficient is China's OFDI in ASEAN? Are the country differences obvious? Can the infrastructure construction in ASEAN countries significantly affect the efficiency level of China's outward direct investment? What other factors affect the investment efficiency.

The main contributions of this paper are as follows: (1) The existing literature has few studies on the efficiency of China's direct investment in ASEAN, and most of them use the stochastic frontier analysis method. This paper uses DEA (Data Envelopment Analysis) to evaluate the efficiency of China's direct investment in ASEAN. This non-parametric method has the advantages of being more objective, accurate and concise.2. Existing literature based on the host country infrastructure construction perspective of the influence of the home OFDI no unified conclusion, but provides the direction and ideas of reference, this paper through the subdivision infrastructure construction for communications, transportation, energy infrastructure, through limited panel regression model (Tobit) from three levels study the influence of infrastructure construction on the efficiency of Chinese OFDI.

2. Literature Review

2.1. Research on the Efficiency of OFDI

There are few studies on the efficiency of OFDI using DEA method. For example, Jin Bo [1] (2011) (2011) found that the overall development trend of China's investment is gradually expanded from the decision-making of Chinese enterprises, the ability to adapt to the market environment and realize the operation scale, but the investment of production factors in some countries should be controlled. Tian Ze [2] (2016) found that the investment efficiency of "The Belt and Road" varies greatly through the ultra-efficiency DEA and Malmquist index. Deng [3] (2019) found through the randomized frontier method that China's OFDI was attracted by large markets and countries with rich natural resources and backward institutions.

2.2. Research on Infrastructure Construction and OFDI Efficiency

Domestic and foreign scholars' research on infrastructure and foreign direct investment has a long history and has a rich theoretical framework, but there are still some differences in the empirical research. In a facilitation perspective, Asiedu [4] (2002) Sub-Saharan Africa (SSA) sample found that good infrastructure improves investment productivity and thus improves its FDI efficiency. Kumar [5] et al. (2017) found that countries with good infrastructure endowments permanently improved the investment environment by subsidizing the total investment costs and increasing the investment efficiency of foreign investors, Yao [6] (2017) found from the panel data of 52 countries along the Belt and Road that the improvement of host country communication infrastructure has a significant exclusion effect on China's OFDI. In addition, Faheem [7] (2020) took Pakistan as a sample, based on the Granger causal test and autoregressive distribution lag model, found that there is a long-term two-way causal relationship between infrastructure and FDI efficiency, and this link shows asymmetry.

To sum up, the existing literature has few studies on the efficiency of OFDI in China, and the research methods of the existing literature are stochastic frontier analysis but rarely DEA model. In addition, the existing literature studies the factors affecting the size of national OFDI stock, among which the infrastructure construction of the host country has different conclusions, especially the research on OFDI efficiency in the parent country.

3. DEA Method and Index Selection

3.1. Research Technique

The standard efficiency DEA model, originally proposed by Charnes Cooper and Rhode (1978), is an analytical method for evaluating the relative effectiveness of the same type of decision unit (Decision Making Unit, DMU). Specifically, for all DMU, the common BBC model (based on input orientation) can be used to further analyze the production technology of variable scale remuneration, and derive pure technical efficiency and scale efficiency, namely technical efficiency (Technical Efficiency, TE) = pure technical efficiency (Pure Technical Efficiency, PTE) scale efficiency (Scale efficiency, SE). The specific linear planning is:

$$\min[\theta - \varepsilon(\hat{e}^T S^- + e^T S^+)]$$

$$\text{s. t.} \begin{cases} \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0 \\ \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0 \\ \lambda_j \geq 0, j = 1,2,\dots,n \\ S^- \geq 0, S^+ \geq 0, \sum_{j=1}^{n} \lambda_j = 1 \end{cases} \quad (1)$$

In formula (1)，$\theta(0 \leq \theta \leq 1)$ is the planning target value, which represents the investment efficiency value in the j country, $\theta=1$ means that the investment in the country is relatively effective, $\lambda_j (j = 1,2,\dots,n)$ is the planning decision variable; $S^-(s_1^-, s_2^-, \dots, s_m^-)^T$; $S^-(s_1^+, s_2^+, \dots, s_s^+)^T$ is a relaxation variable.

3.2. Evaluation Objects and Indicators

DEA model has strict requirements for the selection of evaluation objects and evaluation indicators. This paper selects ASEAN Vietnam, Cambodia, Indonesia, Laos, Malaysia, Malaysia, Myanmar, Philippines, Thailand, Singapore and other countries as the research objects. Serious lack of some indicators in Brunei was eliminated, and 99 observed values were selected from 2009 to 2020. As shown in Table 1, this paper selects 3 input indicators and 5 output indicators for reference from Tian Ze (2016). The data are mainly derived from China OFDI Bulletin, World Bank, Global Competitiveness Report, etc.

Table 1: Evaluation index of investment efficiency of ASEAN countries from 2009 to 2020

Indicator type	Name of index	Data sources	Observations
Investment index	Direct investment stock in host country ($1 million)	China's Foreign Direct Investment Bulletin	99
	Total labor force of the host country (person)	The World Bank database	99
	Host country labor market efficiency index	The Global Competitiveness Report, or a report	99
Output indicators	Host country GDP (USD)	The World Bank database	99
	Host country GDP per capita (USD)	The World Bank database	99
	Foreign trade value (USD)	U. N. database	99
	Host country fiscal revenue (USD)	The IMF database	99
	The Host Country Infrastructure Index	The Global Competitiveness Report, or a report	99

4. Investment Efficiency Analysis

4.1. Comprehensive Technical Efficiency

This paper draws on Tian Ze [2] (2016), and first toughened the data indefinitely, as follows:

$$z'_{ij} = 0.1 + \frac{z'_{ij} - b_j}{a_j - b_j} \times 0.9 a_j b_j$$

($a_j$and b_j are the maximum and minimum values of item j)

Then each index data is inserted into DEAP 2.1 software to calculate the comprehensive efficiency (TE) pure technical efficiency (PTE) scale efficiency (SE) and (RTS) benefit of scale of our direct investment in ASEAN countries in 2006-2017. It is the standard to judge the effectiveness and invalidation of DEA.

Table 2: Comprehensive technology efficiency of China's direct investment in ASEAN countries in 2009-2020

year	Philippines	Cambodia	Laos	Malaysia	Burma	Thailand	Singapore	Indonesia	Vietnam
2009	0.735	0.451	1.000	1.000	0.907	1.000	1.000	1.000	1.000
2010	0.936	0.410	1.000	1.000	1.000	1.000	1.000	1.000	0.628
2011	0.747	1.000	0.720	1.000	0.895	1.000	1.000	1.000	0.531
2012	0.875	0.487	1.000	1.000	1.000	1.000	1.000	1.000	0.586
2013	0.766	0.414	1.000	1.000	1.000	1.000	1.000	1.000	0.617
2014	0.789	0.489	0.808	1.000	0.990	1.000	1.000	1.000	0.664
2015	0.812	0.467	0.807	1.000	1.000	1.000	1.000	1.000	0.590
2016	0.822	0.510	0.798	1.000	1.000	1.000	1.000	1.000	0.727
2017	0.915	0.451	0.666	1.000	1.000	1.000	1.000	1.000	0.713
2018	1.000	0.522	0.669	1.000	0.994	1.000	1.000	1.000	0.776
2019	1.000	0.556	0.643	1.000	0.979	1.000	1.000	1.000	0.842
2020	1.000	0.563	0.724	1.000	0.992	1.000	1.000	1.000	0.981

According to Table 2, the overall efficiency of China's direct investment in ASEAN countries is at a medium level. The distribution of comprehensive technical efficiency values is uneven among different countries, and the level of investment efficiency varies greatly. During the investigation, the minimum value of comprehensive efficiency was 0.41, and the maximum was 1, both effective DEA, medium level, low level and very low level. For example, the TE value of Malaysia, Thailand, Singapore and Indonesia between 2009 and 2020 was 1, which was effective in DEA, indicating that the invested resources were fully utilized and completely converted into output. The efficiency of investment in the Philippines was at a moderate level between 2009 and 2017, and after the 2018, the TE value rose to 1, reaching DEA effectiveness. The investment efficiency in Cambodia was at low and very low years except for DEA effectiveness in 20011. Investment efficiency in Laos and Vietnam was low and moderate in the other years except when DEA was effective. The investment efficiency in Myanmar reaches DEA efficiency in half of the investigation period, and the general period is moderate.

The overall level of investment in the sample countries rose, but it was still not very high. Between 2009 and 2020, the average overall efficiency of direct investment in ASEAN countries increased from 0.899 in 2009 to 0.918 in 2020, representing an overall increase of 2.1%. The Philippines has the fastest annual growth rate, at 2.8%. In addition, the minimum value of comprehensive technical

efficiency increased from 0.451 in 2009 to 0.563 in 2017, and the standard deviation of comprehensive technical efficiency among countries decreased from 0.179 in 2008 to 0.152 in 2017, indicating that the difference of comprehensive technical efficiency among countries is narrowing and showing a "convergence" trend.

4.2. Pure Technical Efficiency Analysis

Pure technical efficiency, compared with the scale efficiency, mainly reflects the subject's ability to make decisions and adapt to the market environment.

Table 3: Pure technical efficiency of China's direct investment in ASEAN countries from 2009 to 2020

year	Philippines	Cambodia	Laos	Malaysia	Burma	Thailand	Singapore	Indonesia	Vietnam
2009	1.000	0.991	1.000	1.000	0.995	1.000	1.000	1.000	1.000
2010	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000	0.935
2011	1.000	1.000	1.000	1.000	0.964	1.000	1.000	1.000	0.927
2012	1.000	0.947	1.000	1.000	1.000	1.000	1.000	1.000	0.908
2013	1.000	0.915	1.000	1.000	1.000	1.000	1.000	1.000	0.916
2014	1.000	0.871	1.000	1.000	1.000	1.000	1.000	1.000	0.886
2015	1.000	0.849	1.000	1.000	1.000	1.000	1.000	1.000	0.878
2016	1.000	0.860	1.000	1.000	1.000	1.000	1.000	1.000	0.892
2017	1.000	0.900	1.000	1.000	1.000	1.000	1.000	1.000	0.882
2018	1.000	0.906	1.000	1.000	1.000	1.000	1.000	1.000	0.888
2019	1.000	0.945	1.000	1.000	1.000	1.000	1.000	1.000	0.909
2020	1.000	0.930	1.000	1.000	1.000	1.000	1.000	1.000	0.990

As shown in Table 3, on the whole, most countries are in a state of pure efficiency. During the inspection period, the pure efficiency of China's direct investment in the Philippines, Laos, Malaysia, Thailand, Singapore and Indonesia was in an effective state, indicating that the investment enterprises have a strong ability of business decision-making and the ability of planning and utilization of the invested resources. In Vietnam and Cambodia, the PTE value is above 0.85, and the PTE value in Myanmar except for PTE in 2009 and 2011 was close to 1. The pure technical efficiency of these three countries is less than 1, indicating that without considering the factor of scale, the investment is wasted due to the deviation in business decisions or other reasons, which makes the existing marginal efficiency fails to reach the maximum, and their business decision-making ability needs to be improved.

5. Infrastructure Construction and Investment Efficiency Regression Analysis

5.1. Model and Variables

Considering the bias of the model setting, this paper uses the Tobit model for regression analysis. When the explained variable is limited, the ordinary least squares method will lead to serious biased and inconsistent parameter estimation. The model can effectively solve the problem of data truncation, and the sample time is from 2010 to 2020, including 99 observations. The focus of this paper is the infrastructure development of ten ASEAN countries, and the explanatory variables are divided into communication (tel), transportation (tra) and energy (ene). The explained variables are the scale efficiency of external direct investment (ef), and the control variables are divided into gross domestic product (lngdp), economic opening level (open), natural resource endowment (res), labor supply

(lnlab), and financial development level (fin). As shown in Table 4 below.

Table 4: Description of the main, variable variables

Variable	Variable name	Data handling	Data sources
explained variable	Efficiency of OFDI scale (ef)		
explanatory variable	Communication infrastructure (tel)	The sum of fixed broadband users (per 100) and fixed telephone users (per 100)	WDI
	Transport Infrastructure (tra)	Select the sum of railway freight volume (million ton-km) and air cargo volume (million ton-km)	WDI
	Energy Infrastructure (ene)	The sum of ore and metal exports as a percentage of commodity exports and the sum of fuel exports as a percentage of commodity exports	WDI
controlled variable	gross domestic product (lngdp)	GDP log (2010)	WDI
	Natural resource endowment (res)	Total rents of natural resources as a percentage of GDP	WDI
	Labour supply (lnlab)	The number of labor force is a log number	the World Bank
	Financial development level (fin)	Number of branches of commercial banks	the World Bank
	Level of economic openness (open)	The total import and export trade accounts for its GDP	the World Bank

The following regression equation is established:

$$ef_{it} = \alpha_0 + \beta_1 tel_{it} + \beta_2 tra_{it} + \beta_3 ene_{it} + \sum \gamma X_{it} + \varepsilon_{it} \quad (2)$$

i = 1,2,, 9; t= 2010,2011,, 2020.$ef_{it}$is the scale and efficiency of foreign direct investment, α_0 is the intercept item, $tel_{it}$is communication infrastructure, tra_{it} is transportation infrastructure and $ene_{it}$is energy infrastructure.$X_{it}$is the control variable, and ε_{it} is the random disturbance term.

5.2. Regression Results Analysis

As shown in Table 5, using the Tobit model with explanatory variable regression, according to the estimation analysis of column (1) (2) (3), the estimated coefficient of communication infrastructure (tel) was 0.032,0.037 and 0.036, which was significantly positive at the 1% significance level, indicating a positive correlation between communication infrastructure and the efficiency of China's investment scale in ASEAN OFDI. According to column (2) (3), the estimated coefficient (tra) of transport infrastructure is-0.021 and-0.011, which is significantly negative at the significance level of 10%, indicating that the more developed the transport infrastructure, the smaller the stock of ASEAN OFDI, and the lower the efficiency of China's investment in ASEAN OFDI. The possible reasons are as follows: the development of transportation infrastructure in ASEAN countries is unbalanced, but

there is a continuous investment market development space. The complete transportation infrastructure construction often weakens China's willingness and investment efficiency of OFDI in ASEAN. According to the column (3), the energy infrastructure (ene) of China to asean OFDI scale investment efficiency estimation coefficient failed significance test, no sufficient evidence of energy infrastructure can effectively explain the asean OFDI scale efficiency, the reason may be that the asean countries are mostly energy, resource-rich developing countries, the energy infrastructure development level, the higher the energy utilization and development level will be higher, the higher for the protection and utilization of energy become investors have formed, thus reduce the investment efficiency of investors.

Table 5: Model estimation results

	(1)	(2)	(3)
	ef	ef	ef
tel	0.032**	0.037**	0.036***
	(0.001)	(0.001)	(0.001)
tra		-0.021*	-0.011*
		(0.012)	(-0.001)
ene			0.002
			(0.002)
lngdp	3.452***	4.369***	4.784***
	(0.241)	(0.435)	(0.519)
res	0.168***	0.027**	0.066***
	(0.023)	(0.001)	(0.007)
lnlab	8.531***	6.308*	1.671*
	(0.815)	(0.762)	(0.780)
fin	0.112*	0.043*	0.055*
	(0.059)	(0.036)	(0.025)
open	-0.0058**	-0.00536*	-0.0061**
	(-3.91)	(-3.86)	(-3.43)
_cons	5.925***	5.841***	7.454***
	(2.023)	(1.989)	(2.716)
Obs.	99	99	99

Note: The standard error of regression coefficient is in brackets, and *, * * and * * * are significant at 10%, 5% and 1% levels, respectively

The host country GDP, natural resource endowment, labor level and financial development level have a positive impact on the scale efficiency of ASEAN OFDI in China, indicating that the larger the country, the more stable the general economy, so the higher the investment efficiency; the host country is rich in the natural resources such as minerals, which can meet the needs of China's growing natural resource gap; the multinational enterprises can directly hire labor in the host country, which reduces the labor cost of the enterprise and thus improves the efficiency of OFDI. The higher the level of financial development in ASEAN countries, the richer the financial products and the more open the financial market, which reduces the external financing constraints of multinational enterprises and improves China's willingness and scale investment efficiency in ASEAN OFDI. The level of opening up of the host country has a significant negative impact on the scale and efficiency of ASEAN OFDI. However, with the increase of openness, the requirements for the institutional governance capacity of the host country are also higher. If the government is poorly managed, it will cause a loss of efficiency.

5.3. Robustness Test

In this paper, there may be a bidirectional causal relationship between the scale efficiency of Chinese foreign direct investment in ASEAN (ef) and ASEAN real gross domestic product (lngdp), and there are many unobserved individual effects affecting ef. It is inevitable to miss the control variables selected in this paper. In order to control the endogeneity caused by model bias, this paper uses dynamic panel GMM model to estimate. The advantage of this method is that the individual effect and unobservable time effect of the original equation can effectively avoid the endogeneity problem of the model.

Due to the omission of the control variables in the current regression results, As shown in Table 6 Using the progressive addition of the explanatory variable regression under the systematic GMM model, Progressive addition of explanatory variable regression with different estimation methods (DIF and SYS), Considering the unrobust effects on the Sargan test caused by the heteroscedastic problem of the model, Model (1) (3) (5) Using two-stage robust difference GMM, The estimated results have all passed the differential sequence interference term Arellano- -Band autocorrelation test, No second-order autocorrelation exists for the model interference term. Equation (2) (4) (6) using robust system GMM model, the estimated results show through the identification of Sargan test and Arellano-Band test, in the process of gradually add explanatory variables, the coefficient of all variable symbol no obvious change, the size of the numerical only small difference, that the regression results robust and credible.

Table 6: Robustness test results

	(1)	(2)	(3)	(4)	(5)	(6)
	ef	ef	ef	ef	ef	ef
Tel	0.00354***	0.00296**	0.00331***	0.003*	-0.00293*	0.00312***
	(0.003)	(0.001)	(0.002)	(0.001)	(0.006)	(0.001)
Tra			-0.018*	-0.004*	-0.016*	-0.002*
			(0.000)	(0.000)	(0.000)	(0.000)
Ene					-0.003	0.002
					(0.003)	(0.002)
_cons	3.300***	5.925***	3.650***	5.841***	4.327***	7.454***
	(2.546)	(2.023)	(1.476)	(1.989)	(2.580)	(2.716)
Sargan Test		70.95		68.65		68.45
Ar (2)	-.02596	-0.75	-.3249	-0.03	-.32132	0.01
Wald chi2	5652.38	564939.8	13404.94	254811.9	9446.06	1.09e+10

Note: The standard error of regression coefficient is in brackets, Sagan test and Arellano-Band autocorrelation test give p-value, and *, * * and * * * are significant at the levels of 10%, 5% and 1%, respectively

6. Conclusion and Suggestions

6.1. Conclusion

As China pays more and more attention to enterprises "going out" in EFDI, the analysis results of China's OFDI in ASEAN countries are obtained. The main conclusions are as follows: 1. On the whole, the comprehensive technical efficiency of China's EFDI is at the medium level, there are country differences, but the differences are decreasing; most countries are in the state of pure efficiency, some countries do not achieve pure technical efficiency, and their operational decision-

making ability needs to be improved. The efficiency of investment scale does not all reach the optimal state.2. Communication infrastructure, transportation infrastructure and energy infrastructure of ASEAN countries all have an impact on the scale efficiency of OFDI, among which infrastructure endowment is positive attraction, transportation infrastructure is negative exclusion, and the impact of energy infrastructure is not significant.

6.2. Suggestions

First, Make targeted investment according to the investment environment of ASEAN countries, adjust measures to local conditions, such as Vietnam, Myanmar, Laos and Cambodia, make full use of their cheap and abundant labor, invest in manufacturing and strengthen infrastructure construction, and strengthen production capacity cooperation for countries rich in natural resources such as Indonesia and Myanmar. At the same time mining within ASEAN members or transnational cooperation depth point, such as automation, e-commerce become the breakthrough point of cooperation, the ocean is Indonesia to expand cooperation potential areas, the Philippines docking "area" and strategic logistics corridor development strategy, new expand cooperation in the field of wisdom city, etc.

Second, optimize the scale of national investment. Different types of investments for different ASEAN countries. Currently, most of China's investment in ASEAN is concentrated in Singapore, Indonesia and Malaysia. The problems of inefficiency and increased risk caused by overinvestment in these countries should be avoided.

Finally, Encourage infrastructure construction. Governments of ASEAN countries can extensively mobilize private capital to participate in the construction of connectivity projects through governments and PPP methods, and mobilize private capital and large multinational enterprises to participate in regional infrastructure construction investment, including the use of standardized contracts and setting up a list of basic investment projects.

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