LOGISTICS EFFICIENCY EVALUATION FOR ASEAN BASED ON DEA MODEL

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Abstract: *This paper takes the investment of the logistics industry in fixed assets, logistics network mileage and the number of employees in logistics as input indicator; and quantily of shipments, turnover of freight traffic and logistics production as output indicators to build an efficient evaluation index system of ASEAN regional logistics. 2010-2014 logistics industry to ASEAN economies of scale and technology analysis and evaluation of benefits, the results show 2010 ASEAN logistics efficiency has not reached the best of input-output ratio, logistics inefficiency and waste logistics resources, ASEAN 2011-2014 input and overall effectiveness of the logistics industry, the logistics industry has development potential. According to the analysis of the present situation of logistics industry in ASEAN and the DEA results, recommendations for improvement, and to promote the sustainable development of ASEAN regional logistics industry.*

Keywords: *Asean; logistics; efficiency evaluation; DEA*

INTRODUCTION

Since 2002, the leaders of China and ASEAN countries have signed the Framework Agreement on Comprehensive Economic Cooperation between China and ASEAN. By 2010, the China-ASEAN Free Trade Area will be officially launched. Since the establishment of the China-ASEAN Free Trade Area in 2010, the economic and trade cooperation has entered a new stage of development. The economic cooperation between CAFTA and China-ASEAN Free Trade Area has been continuously strengthened, with rapid trade growth and increasing trade volume (figure 1).

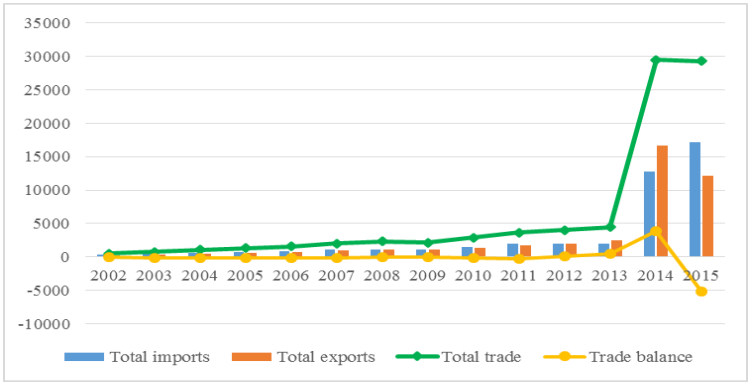

Figure 1. *2002-2015, China-ASEAN trade volume and balance (unit: billion)*

Source: China Bureau of Statistics website (www.stats.gov.cn)

At present, as the world's third-largest free trade market, the China-ASEAN free trade area plays an important role in the world economy development. ASEAN has become China's largest trading partner and main source of foreign investment. ASEAN and China have benefited from the deepening of regional economic integration. In order to deepen cooperation between China and ASEAN, the two sides need to strengthen regional trade facilitation, improve logistics efficiency, this is also the basis for bilateral trade development.

China - ASEAN regional economic and trade cooperation, speed up the construction and development of logistics, promote China - ASEAN regional economic and trade cooperation and development. At present, there are few areas of ASEAN regional logistics research, therefore, the ASEAN regional logistics efficiency evaluation research, logistics resources investment, rational allocation, in order to improve the efficiency of logistics operation of the ASEAN regional economic development help.

From the domestic and foreign scholar's documents, there are various methods of logistics system efficiency evaluation. The evaluation methods used by domestic and foreign scholars mainly include comprehensive index analysis method, input-output method, fuzzy comprehensive evaluation method, analytic hierarchy process, frontier efficiency analysis method and data envelopment analysis (DEA). DEA method in the evaluation of the efficiency of logistics services is very effective.

Schinnar used data envelopment analysis to evaluate the efficiency of third-party logistics[1]. Weber based on Schinnar, carried out reforms of three inputs to the DEA model: the use of price, return rate, delay arrival rate of the logistics service efficiency evaluation of the analysis[2]. Lea Friedman and Zilla Sinuary-Stem through all data in canonical correlation analysis and discriminant analysis to construct a rational evaluation index system[3]。 Sinuany combines two-stage DEA / AHP complete ordering model with data envelopment analysis and analytic hierarchy process[4]. Rabinovic used the DEA model to evaluate the efficiency of US logistics companies and analyzed the impact of logistics service performance and service breadth on production efficiency[5]. Domestic scholars in the study of efficiency evaluation using DEA method. The earliest, Zhi Cai use of DEA model for road transport enterprise technical efficiency and scale effectiveness analysis[6]. Liu Yuan discussed the feasibility and superiority of the DEA method in the evaluation of the economic benefit of enterprise logistics system, and pointed out that the premise and foundation of using DEA model is to establish scientific evaluation index system[7]. Shuai Bin, Du Wen Based on the analysis of DEA and PCA methods, it is proposed that the combination of the two will be more reasonable for the comprehensive analysis and evaluation of the logistics industry[8]. Guo Xiao-ping, Zhang Qi-shan using the fixed assets investment in the logistics industry and the number of employees in the logistics industry as the input targets, the total output of the logistics industry and the total wages of the employees in the logistics industry are taken as the output targets, using improved DEA model analysis of the efficiency of regional logistics in China [9]. Lin Tan and Ning Jun fei used the DEA model to evaluate the allocation efficiency of EU carbon emission rights in 2009[10].

The efficiency of the logistics industry has made some progress on the study of the use of data envelopment (DEA) theory of the efficiency of the logistics industry evaluation methods and other efficiency evaluation methods has its unique advantages. For ASEAN regional logistics system

efficiency is less studied in the research documents, applying DEA method to evaluate the efficiency of ASEAN regional logistics system plays an important role in coordinating regional economic development, and for the development of China-ASEAN trade, it also provides strong logistic support.

I. ASEAN REGIONAL LOGISTICS INDUSTRY'S DEVELOPMENT SITUATION

1.1. ASEAN economic development status

ASEAN is a member of the Association of South-East Asian Nations (ASEAN). Since its founding in Bangkok in 1967, it has 10 member states of Indonesia, Malaysia, the Philippines, Singapore, Thailand, Brunei, Vietnam, Myanmar, Laos and Cambodia. ASEAN is located in South-East Asia, North of the Mainland, South Australia, East of the Pacific Ocean, West of India Ocean and Bangladesh, India border, connecting Sanya (Asia, Africa, Pacific), two oceans at a "crossroads" position. The region consists of Indochina and Malay Islands. ASEAN countries have a total area of 4.5 million square kilometers, a population of about 576 million. ASEAN countries, the level of economic development (figure 2).

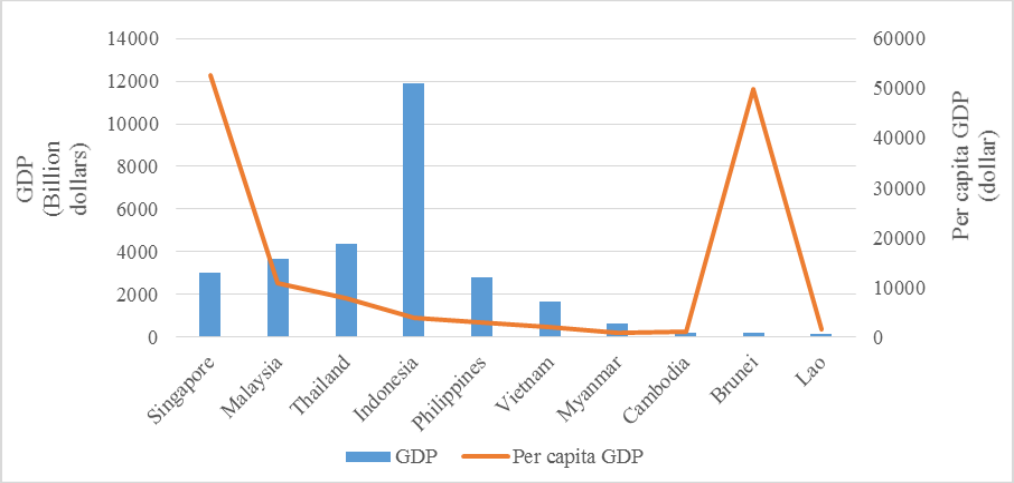

***Figure 2**. 2014 ASEAN Economic development level*
Source: Statistics on United Nations Conference on trade and development (UNCTAD) and the national statistical office data consolidation.

Data shows that ASEAN regional economic development from an overall perspective of development faster economic development gap between countries, seen from the total GDP, Indonesia and Thailand's GDP is highest, following is Malaysia, the Philippines and Singapore, Viet Nam is at the middle, Laos, Myanmar, Cambodia and Brunei is the lowest, but judging from the per capita GDP, Singapore and Brunei are among the number 1, followed by Malaysia, and Thailand, and Indonesia, and the Philippines, Viet Nam and Laos, the last ones are Cambodia and Myanmar.

1.2. ASEAN logistics infrastructure status

In ASEAN countries, Singapore's infrastructure is the most complete, Malaysia, Thailand's infrastructure is more developed, while other countries' infrastructure is still lagging behind.

Among the ten ASEAN countries, Malaysia, and Thailand, Indonesia, the Philippines and Viet Nam are marine State and located in major shipping lanes-the Malacca Straits and its surrounding, and has a long maritime history, in these countries, therefore, shipping plays an extremely important role. Among them, the Singapore Strait of Malacca and Malaysia's Port Klang are the world's most famous goods transfer hub. ASEAN route mode of the various modes of transport as shown in figure 3.

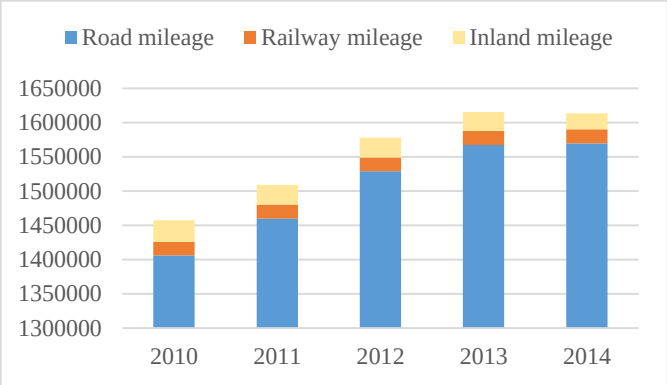

Figure 3. *2010-2014 Route of ASEAN modes of transport (unit: km)*
Source: Asean Statistics 2014

As can be seen from figure 3, in recent years, in the transportation, ASEAN has been vigorously building transport lines, road mileage has continuously increased, from 1569698 km in 2010 to 1405986 km in 2014, an increased by 163712 Km. The railway mileage is also steadily growing, from 197,773.5 km in 2014 to 20,635.5 km in 2014, increased by 862 km. the construction of China – ASEAN Interconnection infrastructure has benefited ASEAN economy and trade development, promotes the fundamental development of ASEAN the logistics industry.

1.3. ASEAN logistics development

At present ASEAN countries attach great importance to logistic development, and invested heavily in logistics infrastructure, can be seen from figure 4, ASEAN logistics industry in GDP increased from 85.145 billion dollars to 109.318 billion dollars, and still growing.

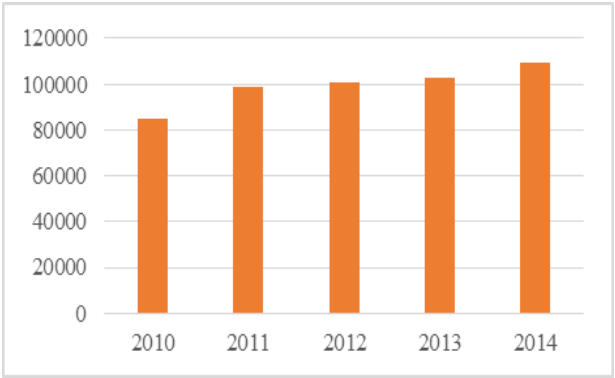

Figure 4*. ASEAN's logistics industry (unit: millions of dollars)*
Source: Statistics on United Nations Conference on trade and development (UNCTAD) and the national statistical office data consolidation.

The Economy of China-ASEAN Free Trade Area. The background of trade cooperation brings the efficiency to ASEAN logistics analysis, the comprehensive relativity of ASEAN logistics integrated input-output, technology, and scale, and also important to the efficiency of analysis and evaluation.

II. DEA MODEL OF ASEAN LOGISTICS EFFICIENCY AND EVALUATION METHOD

Data Envelopment Analysis (DEA) is an evaluation method that uses a mathematical programming model to determine the relative efficiency between decision units with multiple inputs and multiple outputs. The DEA model includes: The C^2Rmodel is mainly used to evaluate the relative validity of decision-making units. The C^2GS^2model is mainly used to evaluate the technical effectiveness of decision-making units.

2.1. C^2R Model

The DEA method was first established by A.Charnes, W.Rhodes and E.Cooper by CCR model[11]. Zhu J on the CCR model for two element analysis of changes, input oriented efficiency evaluation model can be obtained, that is C^2R efficiency evaluation model [12]. The mathematical expression of C^2R model is:

$$\min\theta-\varepsilon(\hat{e}S^{-}+eS^{+})$$

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

Form: θ is investigating unit efficiency value; $\hat{e}=(1,1,1...1)^T\in E^m$, $e=(1,1,1...)\in E^s$, E is the unit matrix; X_0 is a model of input indicators; Y_0 is output index; $X_j=(X_{1j}, X_{2j},..., X_{mj})^T$; $Y_j=(Y_{1j}, Y_{2j},..., Y_{mj})^T$, use (Xj,Yj)for j decision marking unit, $S^{-}=(S^{-}_1, S^{-}_2,...,S^{-}_m)$ is m input of slack variables; $S^{+}=(S^{+}_1, S^{+}_2,...,S^{+}_s)$ is output of slack variables; λ_j is a weight; ε is a very small (generally 10^{-10}integer) [3].

The implication of the C^2R model is as follows:

(1) When $\theta=1$, $S^{+}=S^{-}=0$, the decision making unit is DEA effective, in the economic system which is composed of n decision making units, the combination of production factors of the decision making unit has reached the optimal state, the optimal allocation of resources is achieved, and the optimal combination and maximum output is achieved;

(2) When $\theta=1$, $S^{+}\neq 0$, $S^{-}\neq 0$, the decision making unit is effective for weak DEA, and the decision making unit is not the best technology efficiency at this time;

(3) When $\theta<1$, the decision unit for the DEA is invalid, the technology is invalid.

2.2. C^2GS^2Model

The mathematical expression of C^2GS^2 model is:

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

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

Form: X_i is input index, Y_i is output index, λ_j is a weight, S^+ is a vector consisting of the slack variables corresponding to the output, S^- is a vector consisting of the remaining variables corresponding to the inputs. When θ=1, the decision making unit is effective in technology, otherwise it is not effective.

Table 1. *ASEAN logistics system input-output index system*

Index type	Index name	Unit	Index description
Input index	Fixed asset investment in transportation, storage and postal industry（X_1）	Million dollar	Response logistics industry capital investment
	Logistics network mileage（X_2）	Kilometre (km)	Response logistics infrastructure investment
	Transportation, warehousing and postal service personnel（X_3）	Ten thousand people	Response logistics personnel and human resources input
Output index	Freight volume（Y_1）	Million tons	Response to transport production results, reflecting the number of transport services for the economy
	Freight turnover（Y_2）	Million ton kilometers	The reaction results of logistics transportation
	Transportation, storage and postal industry output（Y_3）	Million dollar	Response logistics development scale

In this paper, the ASEAN region 2010-2014 years of data, the 2010-2014 years of logistics input and output data as a decision making unit (DMU), as shown in table 2:

Table 2. *2010-2014 years of ASEAN logistics industry input and output raw data*

	Particular year	2010	2011	2012	2013	2014
Input index	Fixed asset investment in transportation, storage and postal industry（X_1）Million dollar	201	208	268.8	311.5	418.4
	Line network mileage（X_2）Kilometre	1457623	1508800	1577861	1615538	1613332
	Transportation, warehousing and postal service personnel（X_3）Ten thousand people	11587	11716	11643	11694	11745
Output index	Freight volume（Y_1）Million tons	237438.3	246925.1	256635.1	243534.8	211992
	Freight turnover（Y_2）Million ton kilometers	2785565	3428119	4414050	4811636	4967851
	Transportation, storage and postal industry output（Y_3）Million dollar	85145	98627	100865	102715	109318

III. MODEL AND SOLUTION

Application of DEA model in MATLAB software for solving, results are shown in table 3, table 4.

3.1. DEA scale effectiveness analysis of logistics efficiency

Table 3. *C2R model results*

Variable	2010	2011	2012	2013	2014
θ	1.0016	1	1	1	1
λ_1	0.0516	0	0	0	0
λ_2	0.8927	1	0	0	0
λ_3	0.0164	0	1	0	0
λ_4	0.0018	0	0	1	0
λ_5	0.0007	0	0	0	1
S_1^-	0.0018	0	0	0	0
S_2^-	7956.1301	0	0	0	0
S_3^-	328.8951	0	0	0	0
S_1^+	40.0297	0	0	0	0
S_2^+	503122.6920	0	0	0	0
S_3^+	9210.2827	0	0	0	0
Scale efficiency	Decline	Effective	Effective	Effective	Effective

According to the evaluation results table 3 can be seen in 2011, 2012, 2013, 2014, the four decision - making units in the optimal value of $\theta=1$, 且$S^-=S^+=0$, which shows that in 2011, 2012, 2013, 2014, the four decision making units for DEA. In 2010, the optimal value of the decision making unit is $\theta>1$, which indicates that the decision making unit is non DEA effective in 2010. Therefore, for the DEA invalid unit can be adjusted by input and output, and ultimately to achieve DEA effective[13].

For non DEA effective decision making units to further improve, that is, in the C2R model in 2010 $\theta>1$ projection analysis:

$X_{11}=201\times0.0516-0.0018=10.36$, Transportation, warehousing and postal industry fixed assets investment decreased 10.36 million dollar;

$X_{12}=1457.623\times1.0016-0.7956.1301=145.19$, That is the length of the line is reduced to 145.19km;

$X_{13}=11587\times1.0016-328.8951=11276$, Transportation, warehousing and postal employees reduced to 112 million 760 thousand people;

Through the adjustment can increase the income for:

X_{14}＝237438.3＋40.0297＝237478.32, That cargo volume increased to 237478.32 million ton;

X_{15}＝2785565＋503122.6920＝3288687.69, The freight turnover increased to 3288687.69 million ton kilometers;

X_{16}＝85145＋9210.2827＝1047355.28, Transportation, warehousing and postal services increased to 1047355.28 million dollar.

3.2. Efficiency Analysis of DEA Technology for Logistics Efficiency

Table 4. *C^2GS^2model results*

Year	θ	S_1^-	S_2^-	S_3^-	S_1^+	S_2^+	S_3^+	Technical efficiency
2010	1	0	0	0	0	0	0	Effective
2011	1	0	0.0001	0	0	0.0002	0	Effective
2012	1	0	0.0069	0.0001	0	0	0	Effective
2013	1	0	0.0001	0	0	0	0	Effective
2014	1	0	0	0	0	0	0	Effective

The results from the C^2GS^2model analysis, in 2010, 2011, 2012, 2013, 2014, the five decision - making units are effective technology.

IV. CONCLUSION

This paper selects the DEA efficiency evaluation model from 2010-2014 ASEAN logistics input and output data, takes fixed assets investment in transportation, warehousing and postal services, logistics network mileage, transportation and storage postal employees as input variables, The paper analyzes the logistics efficiency of ASEAN, and analyzes the technical efficiency and scale effectiveness of the input and output of ASEAN logistics system, get to the following conclusions:

(1) By C^2R model analysis, the ASEAN with the evaluation result of 4 units (2011, 2012, 2013, 2014) out of total 5 from 2010-2014 shows efficiency to DEA, meaning the inputs and outputs of logistic reaches the best achievement, its benefit scale is efficient. Just only the year of 2010 did not achieve economies of scale, and in a State of decreasing income, and did not meet the best of input-output ratio.

(2) Through the C^2GS^2model analysis, the ASEAN region from 2010-2014 are technically effective.

Therefore, from the data dimensions the DEA C^2R and the C^2 GS^2 models have efficiency to economic development and resources, consequently make it better for improvement direction. In the ASEAN regional logistics industry evelopment, the rational allocation of existing logistics resources has improved the quality of employees, continued developing the logistics industry policy-driven, improved the logistics industry output, play an important role.

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