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Efficiency Evaluation Between Port Logistics and Economic Growth by DEA: A Case Study of Zhejiang Province

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Abstract: This study shows that the development of modern logistics industry can promote the development of economy. Meanwhile, vigorously develop the port logistics is an important approach for Zhejiang province to seek new economic growth point. In this study, Grey correlation analysis was used to study the correlation between regional logistics and economic growth, concluded that there is a large degree of correlation between logistics industry and economic growth. Next, with the application of Data Envelopment Method, the efficiency between port logistics and economic growth of Zhejiang province was calculated, results showed that the overall influence efficiency is not satisfactory, coordination needs to be strengthened. Finally, logistics industry development countermeasures were put forward based on Marine economy perspective. The results can provide reference to Marine economic development of Zhejiang province.

Key words: Efficiency evaluation, port logistics industry, regional economy, data envelopment analysis, grey correlation analysis

INTRODUCTION

About the relationship between modern logistics and economic growth, a common saying is generally accepted by theorists that the development of modern logistics can promote the development of economy, that is to say modern logistics is “the accelerator” of the economic development. When the economy is developing speedily, it will also produce huge demand for logistics industry, thus promote the development of logistics related industry such as transportation, postal and telecommunication services industry, etc. All of these theories suggested that there is a certain relationship between logistics industry and economic development. So study the internal relationship between regional logistics and economic growth is of great significance.

Liu and Li (2007) analyzed the mutual relationship between the modern logistics development and economic growth from supply and demand aspects, verified the interact relationship between these two aspects by using the method of Granger Causality Test. They found that the modern logistics development and economic growth were in reciprocal causation, mutual promotion and joint development. Relative to the overall development of economy in Zhejiang province, the logistics industry development level and speed still lags behind the social and economic development. Thus, enhance the

supply capacity of social logistics service, turn huge potential logistics service requirements into effective logistics service demand were the core content of future study. Jiang (2005) proposed a view that the capacity of the regional logistics level was closely related to the regional economic competitiveness. Regional logistics and regional economic competitiveness has interdependence, mutual promotion relationship. Regional logistics was the basis of the regional economic activities, the efficiency, cost and service level of regional logistics were direct factors that would influence the regional economic competitiveness. Shao (2009) taken the provincial data as investigation object, studied how the logistics industry development impact on in China's economic growth. By using the method of input-output quantitative, the “relevance and spread effect” among China's logistics industry and other industries in the economy was estimated. Meanwhile, he studied the relationship between regional economic growth and logistics market scale by using FMOLS method. The empirical results showed that there existed a significant positive correlation. Liu and Yu (2010) analyzed China's logistics industry efficiency and its influencing factors among different areas, by using both DEA model and Tobit model with the provincial panel data. He obtained the conclusion that the overall efficiency of the regional logistics industry in China was not high and also

proposed that we should strengthen the logistics marketization degree in provinces, cities and autonomous regions, construct an all-round, open and unified market system. Regional logistics technology, application efficiency, logistics information technology application level and resource utilization need to be improved. Government should emphasis on accelerating the development of port logistics, etc.

Haralambides *et al.* (2011), taken East Africa for example, using logistic models analyzed the port logistics impact on the local economy according to the trend of port capacity requirements. Robinson (2006) taken Australia's ports as the core, built a port logistics oriented strategy framework, analyzed the importance of port logistics development for the economy. Woo *et al.* (2011), using the Performance Measurement and Confirmatory Factor Analysis, taken supply chain management, global network as the core, studied the influences of port evolution on the logistics environment, analyzed its satisfaction to customer needs and then studied its impact on economic development. Wang (2011) studied the market of port logistics under supply chain environment, analyzed the competition situation of port logistics and supply chain case by case, concluded its correlation degree with the condition of the local economy. Finally put forward a strategic plan for the market of port logistics.

Zhejiang province is one of the largest Marine resources provinces which has an important position in the national strategy of coastal development. Zhejiang has huge potential to accelerate the development of Marine economy with unique geographical conditions, rich Marine resources, prominent characteristic industry and flexible systems and mechanisms (Sun *et al.*, 2010). At the same time, the port logistics industry in recent years occupies a more and more important position in the province. According to expert estimation, 1% increase in port of shipping means 11% increase in Economic Value Added (EVA) for society. From view of energy consumption, water transportation will cause less energy consumption compare with other modes of transportation, in line with the development request of constructing a resource-conserving and environment-friendly modern society. Therefore, strive to develop high yield, good prospects, environmentally friendly port logistics industry, will become the preferred strategy to promote the development of economy in Zhejiang. In early 2011, the state council formally approved "Zhejiang Marine economy development demonstration area plan". It became an important milestone in the process of the development of Marine economy in Zhejiang province. As the international trade situation is getting better and

shipping price is getting higher, Marine transportation industry rapidly get warm again (Chen, 2011). Since port logistics is the main carrier of import and export logistics, so to study port logistics and its influence on economy is of strategic importance.

With the rapid development of marine economy, especially port logistics industry, it is worthwhile to look deep into the relationship between port logistics industry and Zhejiang's economic growth. Firstly, by using Grey Correlation Analysis, the relevance between the logistics industry and economy was calculated. Then, Data Envelopment Analysis (DEA) was applied to evaluate the influence efficiency of the logistics industry on economic growth. Finally, some strategic suggestions are put forward to enhance the development of logistics industry especially port logistics in Zhejiang province.

GREY CORRELATION ANALYSIS OF THE LOGISTICS INDUSTRY AND ECONOMIC GROWTH

Basic principle of grey correlation analysis: Grey System Theory is a kind of system-scientific theory firstly founded by the famous scholar Deng Julong. Grey correlation analysis is used to determine the degree of correlation between various factors based on the similarity degree of the geometry curve. Grey Correlation Analysis method is a multifactor statistical analysis method, if two factors of a sample data reflect the same change trend (direction, size and speed, etc.), then the correlation between them is big, on the other hand, the correlation is small. Grey Correlation Analysis method requires less sample size which is also applied to irregular data. Because of its low requirements for original data and there are many factors which will influence regional economic development, so this study uses Grey correlation analysis method to study the link between logistics industry and economic development, further more indicates that which factor has a large effect to economic development.

Firstly, determine the reference sequence which can reflect the system's behavior and the compare sequence which can influence the behavior of the system. Secondly, make the index data column into dimensionless variables. Thirdly, calculate grey correlation coefficient $\xi(X_i)$ between the reference sequence and compare sequence. In fact, the so-called correlation coefficient is the degree of difference between geometric curves. It can be used as a measurement of correlation degree. For reference sequence X_0 , there are several compare numbers as X_1, X_2, \dots, X_m , the Grey correlation coefficient $\xi(X_i)$ between compare sequence and reference sequence at every point of time can be calculated by using the following equation:

$$\xi(X_i) = \frac{\Delta \min + \Delta \max}{\Delta oi(k) + \xi \Delta \max}$$

where, ξ is the distinguish coefficient and $0 < \xi < 1$.

There are many correlation coefficients, it is inconvenient to make integrated comparison. So it is necessary to integrate these correlation coefficients in each moment into one number. That is to calculate the mean value r_i , by the following equation:

$$r_i = \frac{1}{N} \sum_{k=1}^N \xi(k)$$

The greater the value of correlation, the greater the correlation between the comparative sequence and reference sequence.

Selection of the logistics industry and economic growth indicators: In previous studies, the Freight volume is used as a measurement of the logistics industry. Besides, considering the situation of Marine logistics industry, logistics industry gross output value and the coastal port throughput are selected as logistics related indicators. Due to no logistics industry output value found in the statistical year book and transportation industry constitutes the main part of the logistics industry, so we use transportation, warehousing and postal service production as logistics industry output value. In the mean time, industry, building industry, financial industry, real estate industry, wholesale and retail and other related industrial production indexes are selected to study the comparative degree between these indexes and GDP in Zhejiang province.

Data collection and analysis: This article selects GDP figures in Zhejiang province from 2007-2011. Indexes include transportation warehousing and postal service, industry, building industry, finance industry, real estate industry, wholesale and retail, coastal port cargo handling capacity, as shown in Table 1. Indexes which related to prices are made prices standardization according to year 2007's price.

After calculation of the grey correlation degree between related industries and GDP, results are shown in the Table 2.

Form Table 2 we can know that, all the indexes has relationship with Zhejiang economy. Here we sort them from big to small according to the correlation degree: Industry, Building industry, Real estate industry, Transportation warehousing and postal service output, Finance industry, Sales and retail, Coastal port cargo handling capacity. Except the last index, others have high correlation degree (all above 0.9),

Table 1: Data of related industries and Zhejiang's GDP value

Indexes	Year				
	2007	2008	2009	2010	2011
GDP	18754	21463	22990	27722	32319
Transportation warehousing and post service	749	843	888	1077	1207
Coastal port cargo handling capacity	88661	95638	103744	112787	122373
Industry	9091	10329	10518	12658	14683
Building industry	1064	1239	1390	1640	1873
Sales and retail industry	1650	1899	2119	2646	3289
Finance industry	1251	1653	1899	2327	2730
Real estate industry	981	1052	1317	1618	1677

Table 2: Grey correlation degree between related industries and GDP

Related indexes	Correlation degree
Industry	0.953
Construction industry	0.950
Real estate industry	0.936
Transportation warehousing and post service	0.907
Finance industry	0.891
Sales and retail	0.781
Coastal port cargo handling capacity	0.501

Distinguish coefficient ζ is 0.5

that means the sec industry and third industry play a prominent position in economic development.

The correlation degree between logistics industry and economic development is 0.907, they have a strong correlation. The reason is that Zhejiang is a province with little land resources, more specifically, the abundance of natural resources is counted third from bottom throughout the country. Traditional manufacturing mainly rely on export advantage, therefore the development of transportation industry is fast. Meanwhile, in recent years, the state council issued "The logistics industry adjust and revitalization planning", it means that the province is seizing this opportunity to overcome the impact of the international financial crisis. Recent years, logistics volume has been expanded which effectively promotes and supports the economic stabilization and recovery in Zhejiang. The position and role of logistics industry has become increasingly apparent.

The correlation degree between coastal port throughput and economic development is 0.501, shows that there is a certain correlation. However, the role of the port logistics on the province's economic development is not prominent enough. According to statistics, since 2007, the average growth rate of Zhejiang province's GDP, turnover volume of freight transport and coastal port throughput is 15.86, 17.03 and 15.86%, respectively. In recent years, the development speed of port logistics is relatively slow, lagging behind the pace of economic development.

To sum up, the connection degree of the logistics industry and economic growth is very high, there exists a

certain correlation between the coastal port throughput and economic growth. In order to in-depth analysis the coordination degree between logistics industry and economic development, DEA method, was used to further study the efficiency between logistics industry and economic growth.

EFFICIENCY EVALUATION BETWEEN PORT LOGISTICS AND ECONOMIC GROWTH BY DEA

An introduction of DEA: DEA method was proposed by Charnes *et al.* (1978), three famous American operation researchers. Their first model was named the C2R model. The DEA model is used to assess the effectiveness of Decision Making Unit (DMU), the most obvious advantage of DEA is: Linear programming techniques is used to determine the effective frontier with the sample data, then we can get the relative efficiency of decision making units and other relevant information.

Here a C2R model of DEA is introduced. Suppose there are n same type decision units (DMU), for each decision-making unit there are m types of “input” and p types of “output”. Each decision making unit efficiency evaluation index is defined as:

$$h_j = \frac{\sum_{i=1}^p u_i y_{ij}}{\sum_{i=1}^m v_i x_{ij}} \quad j = 1, 2, \dots, n$$

And the relative efficiency optimization evaluation model of number j_0 decision making units is:

$$\max h_{j_0} = \frac{\sum_{i=1}^p u_i y_{ij_0}}{\sum_{i=1}^m v_i x_{ij_0}}$$

$$\text{s.t.} \begin{cases} \frac{\sum_{i=1}^p u_i y_{ij}}{\sum_{i=1}^m v_i x_{ij}} \leq 1, & j = 1, 2, \dots, n \\ v_i, u_r \geq 0, & i = 1, 2, \dots, m \quad r = 1, 2, \dots, p \end{cases}$$

where, x_{ij} , y_{ij} are known numbers (can be obtained by historical data or prediction data), v_i , u_r are variables. The implications of the model are based on weight coefficient v_i , u_r as variables, with all decision making units’ efficiency h_j as constraint, taken the efficiency index of decision making unit j_0 as the objective. It is a fractional programming model, we need to transfer it into a linear programming model to solve it. Therefore, we suppose:

$$t = \frac{1}{\sum_{i=1}^m v_i x_{ij_0}} \quad \mu_r = tu_r, w_i = tv_i$$

Turn this model into vector form:

$$\begin{cases} \max h_{j_0} = \mu^T y_0 \\ \mu^T Y_j - \omega^T X_j \leq 0 \\ \omega^T X_0 = 1 \quad j = 1, 2, \dots, n \\ \omega \geq 0, \mu \geq 0 \end{cases}$$

Then use its’ antithesis problem to solve:

$$\min V_D = \theta \quad \text{s.t.} \begin{cases} \sum_{j=1}^n \lambda_j x_j + s^- = \theta x_0 \\ \sum_{j=1}^n \lambda_j y_j - s^+ = y_0 \\ s^- \geq 0, s^+ \geq 0, \lambda_j \geq 0, \theta \text{ unrestraint} \end{cases}$$

Defination:

- If $\theta^* = 1$, then DMU_{j_0} is weak DEA effectiveness
- If $\theta^* = 1$ and $S^{*-} = 0, S^{*+} = 0$, then DMU_{j_0} is DEA effectiveness (overall), vice versa

Selection of input index and output index: Input indexes are logistics indexes include: Production of transport warehousing and postal industry, turnover volume of freight transport and Port cargo throughput. Port cargo throughput is one of the important statistical indexes to measure function and level of port logistics, it shows the quantity of the goods loading and unloading by sea into and out of the port within the scope in a certain period of time. Therefore, port cargo throughput index is selected to represent port logistics development level, Wang (2008). Output indexes are economic growth indicators include: Gross regional product, Total import and export of foreign trade.

Data collection and analysis: Data from 2000-2011 was being used to study the effect efficiency of the logistics industry on economic growth in Zhejiang province, as shown in Table 3. Indexes which involve price are made price standardization according to year 2000’s price.

After data standardization, the final results are shown in Table 4. According to Table 4, average comprehensive DEA efficiency reached 97.3%, indicates high efficiency of the logistics industry and economic development in Zhejiang province. There are 5 years during which the comprehensive efficiency is 1 which means they reached DEA effective. In these years, logistics industry input and economic output achieved the best proportion. The

Table 3: Data and indexes of logistics and economic development

Year	Transportation warehousing/post service	Freight turnover	Main port cargo throughput	Foreign trade import/export production	GDP
2000	428	1120	19638	2783265	6141
2001	504	1372	21827	3279969	6898
2002	602	1617	25503	4195650	8004
2003	701	2048	32216	6141083	9705
2004	445	2702	40810	8521312	11649
2005	513	3417	70871	10739123	13418
2006	631	4364	82186	13914686	15718
2007	749	4962	88661	17685633	18754
2008	843	5476	95638	21110927	21463
2009	888	5659	103744	18773488	22993
2010	1077	7117	112787	25353311	27722
2011	1207	8635	122373	30937777	32319

Table 4: Efficiency evaluation results between port logistics and economic growth

Year	CRSTE	VRSTE	SCALE	Return to scale
2000	1.000	1.000	1.000	-
2001	1.000	1.000	1.000	-
2002	1.000	1.000	1.000	-
2003	1.000	1.000	1.000	-
2004	1.000	1.000	1.000	-
2005	0.987	0.993	0.987	irs
2006	0.930	0.967	0.962	irs
2007	0.966	0.980	0.986	irs
2008	1.000	1.000	1.000	-
2009	0.987	1.000	0.987	drs
2010	0.988	1.000	0.988	drs
2011	1.000	1.000	1.000	-

irs: Means return to scale increase, drs: Means return to scale decrease

comprehensive efficiencies of other years are less than 1, so they are non-effective DEA unit. The detail situations are divided into the following stages.

The first stage is 2000-2004. Over the past several years, the government has paid a lot of attention on the development of logistics industry in Zhejiang province. And the develop speed is accord with the development of economy. So these years reached DEA effective.

The second stage is 2005-2007. The added value of the logistics industry showed a trend of steady growth but the year-on-year growth of GDP has slowed. Comprehensive efficiency did not achieve effective, technical efficiency and scale efficiency didn't reach 1 either. During this period, scale return is increasing, suggesting that output should increase. Macroeconomic development lags behind the pace of development of logistics.

The third stage is the 2008-2010. As we all know, finance crisis began in 2008 in China. Influenced by the international financial crisis and the contraction of international market demand, Zhejiang's export economy and product exports fell sharply. So the scale efficiency didn't reached 1 in these years. Severe crisis also led to less foreign orders, less demand of port logistics. Thus, the logistics industry scale is too large which reduces the production efficiency. Logistics total cost in 2009 was 406.4 billion CNY, equivalent to 17.8% of GDP, although,

slightly lower than the national average but still higher than 10% in developed countries. It suggests that the overall logistics efficiency is low in Zhejiang province. So when enlarging the scale of the logistics industry, we should strengthen the integration and utilization of logistics resources at the same time, avoid the low efficiency use of logistics resources.

CONCLUSION

Firstly, Grey correlation analysis was used to indicate that the logistics industry in Zhejiang province is one of the important factors influencing economic development. Increase investment in the logistics industry helps to promote the development of the economy. At the same time, the port logistics industry and economic development also has a certain degree of correlation. Secondly, by using the DEA method we got a conclusion that the influence efficiency of the logistics industry on economic growth needs to be improved. How to grab the opportunity, to give full play to port resources to speed up the regional harmonious development is a major issue for Zhejiang Province. In the end, based on the above analysis, we put forward some advices to better coordinate the development of logistics industry and economy in Zhejiang province.

Perfect the policy support system of port logistics, construct International comprehensive logistics hub. By 2012, the gross output value of Marine economy was 700 billion CNY and the added value was 270 billion CNY, accounting 9% of GDP in the province. Well organized and perfect the functions of port and transportation system can basically meet the demand of economic and social development in our province. In early 2011, the state council approved "The development of Zhejiang Marine economy demonstration area plan" which became an important milestone in the process of the development of Marine economy. The plan stated the "one center" definition which means Zhejiang will become China's important commodity international logistics center.

Therefore, we have to grasp this opportunity to transform coastal ports and island areas into China's largest bulk cargo and strategic resources center which include the below functions: Transit and storage, bonded processing, distribution of logistics. A port logistics system consist of bulk throughput, trading and financial services should also come into being. Large attention should also be paid to the creation of "International logistics hub island" which can drive the rapid development of regional economy, Wang (2008). We should actively strive for national and provincial policies and financial support on port logistics, so as to reduce the cost, highlight the important role of port logistics.

Perfect the construction of port transportation system. Under the background of financial crisis, Zhejiang must expand exports to further improve comprehensive efficiency of port. Zhejiang is an economically developed province which relies on port to turn over many goods. Good transport condition of port logistics can push forward economic development. With multiple cross-sea bridge opened to traffic, the international logistics relationships between Zhejiang and coastal areas, surrounding cities are much more closely. Meanwhile, resource advantages and location advantages are more apparent. These provide a solid foundation for the further development of port logistics industry. Currently Zhoushan has initially formed a collection and distribution network that combines sea, land, air and tube together. However, this kind of construction is far behind some developed cities such as Rotterdam, Hong Kong, Singapore and so on. Problems mainly lie in the lack of a completed port-road network to connect every port and the lack of direct access to hinterland. Weak infrastructure of warehouse and yard can't be neglected either. Fast and efficient "seamless" transportation management system has not been set up, Sun *et al.* (2010). At the same time, we must actively expand hinterland markets and give a strong push to the construction of international container logistics system.

Promote "Wisdom logistics" and raise the services level of port logistics. Currently, the Internet of things, cloud computing, mobile Internet and other information technologies are booming. A port logistics public information platform blending "Cloud computing" technology should be established. It can enhance the efficiency of information transmission, lower social costs, improve the efficiency of port operations and the comprehensive competitiveness of port. Since 2004, port of Rotterdam has started to use information sharing system, especially the application of EDI technology. Literally, it is the largest and most efficient port in Europe. As a global maritime center, approximately one ship will

enter or leave the port every 2-3 min, 42 container ships will be handled every day. Monthly container throughput is over one million TEU. Zhejiang can draw lessons from excellent foreign ports like Singapore, develop corresponding information system and enhance the level of port services. On the other hand, development of port logistics and e-commerce can be combined to accelerate the formation of electronic port logistics center, promote the development of offshore trade and remote logistics. We suggest that relevant governments actively put forward the policy of promoting the development of port informatization as soon as possible. In addition, increase capital investment to the port information construction, etc.

Cultivate and introduce ports logistics talents. Talent is the key to the development of ports logistics. There is a severe shortage of senior talents who not only possess logistics theory and skills but can also be engaged in design, management and decision-making. Colleges and universities should focus on the cultivation of talents who know well about logistics in order to meet the need of the high-end logistics development. Logistics enterprises should increase the intensity to cultivate professionals, practitioners should not only be familiar with international freight business but also the condition of the industry she/he serves. After all, theory should be closely combined with practice. In the end, enterprises should speed up to introduce high-end talents with international perspective, who can provide practical and effective international logistics services, solutions to the enterprise.

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