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The Evaluation of Soft Power Investment Effect on Shanghai Port Competitiveness Using DEA method

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ABSTRACT

With the economy development, the competition among ports becomes increasingly intense. In order to improve the overall competitiveness of Shanghai, this paper proposes a systematic evaluation model for the competitiveness of Shanghai Port with 25 input indicators (e.g. port infrastructure and port soft power) and 6 output indicators (e.g. Port service level and port development potential). The proposed evaluation model reduces the dimensions of the indices by Factor Analysis, and uses the data envelopment analysis (DEA) to validate the analysis of Shanghai Port from 2008 to 2013. By implementing the cross-evaluation mechanism after analyzing the factor deviation, this paper is capable to recognize the pros and cons of each decision-making unit (DMU), and point out the improvement direction for each DMU, so as to enhance the competitiveness of Shanghai Port.

1. Introduction

As the economy continues to develop, the status and role of the port are also becoming more and more important. Port is not only the center of the transport network, but also an important component of the economic system. The study of how to improve the comprehensive competitiveness of Shanghai Port, not only has great significance of Shanghai's economic development, but also has great impact on the construction of other ports nationwide.

There are many scholars on the analysis of port competitiveness. James (1968, 1971) first proposed study on port which named "Port, that is Anyport model". Meyer (1970) extended the port competitive analysis to several areas, including labor costs, the level of rail transport link and other factors. Kenyon (1970) proposed that port competitive analysis included the factor of port accessibility. Haynes et al. (1997) figured out efficiency is the most important factor that affects port competitiveness through a comprehensive study of Hong Kong and Kaohsiung Ports. Fleming (1997) validated that the first-class service and facility of port can attract many liner shipping companies and strengthen the competitive power of the port, and the influence of hinterland will also be increased. Ha (2003) analyzed the factors that influenced the service quality and information availability, transit time, and facility availability in Northeast Asia container ports. Liu and Lu (2013) built a port competitiveness evaluation model according to the characteristics of Chernooff Faces, and then used the model to evaluate port competitiveness of ten coastal ports in China. He mapped out all the ports in image, through which the relative strengths of port competitiveness can be figured out clearly.

Among the methods used to analyze the port competitiveness, DEA is a popular one. Roll and Hayuth (1993) applied the DEA in the constant scale model to evaluate the relative efficiency of the port, and elaborated how to calculate the relative efficiency of the ports. By using DEA model for assessing four Australia ports and analyzing the efficiency of twelve international container ports, Jose (2001) pointed out that port efficiency is an important factor affecting the competitiveness of the port. Valentine and Gray (2001) proposed a DEA model by selecting 31 samples of the world's top 100 container ports. Their work was implemented from the perspective of cluster to analyze the reasons that impact the port efficiency.

The above literature review laid the foundation for the study

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of the competitiveness of Shanghai Port. However, there are some shortcomings in the past studies. Researchers usually select large numbers of evaluation index in order to consummate a comprehensive evaluation on port competitiveness. Too many indicators make the evaluation complicated, and there is interdependence among the indicators. There is few scholars focus on a particular port as the majority of the study concentrated on geographical ports. Moreover, few studies are laid on the comparison in time sequence on the development of the port itself. In order to reduce the indicator redundancy, and decrease the correlations among indicators, this paper will firstly decrease the dimensions of the indicators by using factor analysis method, and evaluate the port competitiveness of Shanghai port in time sequence by DEA. Finally, crossover evaluation mechanism is executed to assess the superiority of each decision-making unit.

2. The Research Method

Factor analysis (FA) was proposed by Thurstone, Louis Leon (1935) in the early twentieth century. The main idea of Factor analysis is to assort the original observed variables into groups according to the correlations among the sizes. It is a statistical method used to describe the social science, market analysis, product management, logistics planning and other applied sciences with large amounts of data. The main idea of FA is to assort the original observed variables into groups according to the correlations among the sizes. Its goal is to use a small amount of random variables called unobserved factors to explain changes in some observable random variable.

Data envelopment analysis (DEA), named by Charnes, Cooper and Rhodes (1978) was first proposed in 1978. DEA is a linear programming model, which expressed as the ratio of the outputs of inputs. The method utilizes the objective reality data to evaluate and rank the DMUs which have the same nature. Therefore, the port can be regarded as an input-output system. The effectiveness evaluation of the economic benefit is to distinguish all the relative factors that influence the port competitiveness. The greater the relative effectiveness of the port is, the more competitive the port is. Therefore, the relative effectiveness of DEA method can be used to evaluate the port relative input-output efficiency.

Charnes, Cooper and Rhodes named their proposed model as CCR model. The CCR model evaluated the scale effectiveness and individual DMUs simultaneously, and judged whether the investment of each DMU was appropriate. CCR model is capable of assessing the factor effectiveness with simple input. Therefore, CCR model enjoys a unique advantage in port competitiveness evaluation.

3. The Construction of Indicator System

The Established Indicators of Input and Output Ports Competitiveness

It is important to select appropriate and reasonable indicator system when evaluating the performance of port. Taking the advantages of DEA in the port evaluation from the existing literature, DEA will be adopted in this paper. Moreover, the port innovation ability, informatization and other soft power evaluation indexes are added. To be specifically, the free port policy for international cargo transit, simplified domestic transit and policy environment development are the main concerns for the soft power indexes. The introduction of soft power indicators helps managers to identify the internal differences and to guide the development of the port. The detail of the evaluation indicator system is shown in Table 1.

Table 2: The inputs and outputs of CCR model

Input indicators	A_{11};A_{12};A_{13};A_{14};A_{15}; A_{16};A_{17};A_{18}; A_{22};A_{23}; A_{32}; A_{41}; A_{42}; A_{51};A_{52};A_{53};A_{54};A_{55};A_{56};A_{57};A_{58}; A_{61};A_{62};A_{63};A_{64}	Output indicators	A_{21}; A_{31};A_{33}; A_{71};A_{72}; A_{73}

Source: Authors

The inputs and outputs of the CCR model are listed in Table 2.

4. DEA Analysis of Input and Output Indicators

Since the selected indicators are referred in different dimensions, it is necessary to deal with the initial data by changing them into non-dimensional indicators. Set the port in the i year of the j value for x_{ij}, then

$$x'_{ij} = (x_{ij} - \bar{x}_j)/s_j \tag{1}$$

$$\bar{x}_j = \frac{1}{n}\sum_{j=1}^{n} x_{ij} \tag{2}$$

$$s_j = \sqrt{\frac{\sum_{j=1}^{n}(x_{ij} - \bar{x}_j)^2}{n-1}} \tag{3}$$

Where i is the year, j is the value, n is sample size. x_{ij} is the i years of the j value, x'_{ij} is the data after dimensionless.

The reason for selecting the data from 2008 to 2013 is that the financial crisis of 2008 marked a turning point for the maritime industry. Since then, the development of transportation and port has changed to deflation. Therefore, the analysis of the soft power investment effect on the port competitiveness sounds to be essential since then.

There are many indicators in the evaluation system. Therefore, this paper will use factor analysis method to reduce dimensionality. SPSS software is used to proceed 25 input indicators. By calculating eigenvalue, variance contribution rate and the cumulative variance contribution rate, three factors are recognized as the common input factors as their cumulative variance

Table 1: Port evaluation indicator system

Level 1	Level 2	Level 3
Port competitiveness evaluation	Port infrastructure (A_1)	Coastal berth length (A_{11})
		The number of berths (A_{12})
		Fairway depth (A_{13})
		Warehouse area (A_{14})
		Yard area (A_{15})
		The number of domestic routes (A_{16})
		The number of international routes (A_{17})
		The number of handling equipment (A_{18})
	Operating conditions (A_2)	Container throughput (A_{21})
		Manpower resource (A_{22})
		The number of days in work every year (A_{23})
	Service Level (A_3)	The average waiting time of ships in harbor (A_{31})
		Pilot times (A_{32})
		Average number of tons of ship loading and unloading cargo (A_{33})
	Port investment and development (A_4)	Port total investment (A_{41})
		Number of berths in building process(A_{42})
	Soft power of port (A_5)	Innovation capability (A_{51})
		Research investment (A_{52})
		Information degree (A_{53})
		The degree of marketization and internationalization (A_{54})
		Capacity of environmental protection (A_{55})
		Adaptability to the market (A_{56})
		Advanced degree of logistics equipment (A_{57})
		Logistics developing ability (A_{58})
	Port policy environment (A_6)	Freeport policy of international transit cargo (A_{61})
		Domestic transit facilitation (A_{62})
		Industry development policies (A_{63})
		Shipping Development Index (A_{64})
	Port logistics development potential (A_7)	Annual growth of container cargo throughput (A_{71})
		GDP growth of hinterland (A_{72})
		Import and export volume growth rate (A_{73})

Source: Authors

Table 3: Dimensionless data

	Indicator	2008	2009	2010	2011	2012	2013
Input indicators	A_{11}	-1.3728	-0.8058	-0.0895	0.0597	1.0147	1.1937
	A_{12}	-0.3010	-1.8192	0.0916	0.3010	0.7984	0.9292
	A_{13}	-1.7003	-0.7513	0.4349	0.6722	0.6722	0.6722
	A_{14}	-1.6715	-0.5789	0.0220	0.4006	0.7734	1.0545
	A_{15}	-1.2827	-0.6399	-0.3699	0.0432	0.7523	1.4969
	A_{16}	-1.2549	0.5073	-0.6141	-0.6141	0.5073	1.4685
	A_{17}	-1.6044	-1.1269	-0.2292	0.3247	0.9741	1.6617
	A_{18}	-1.0838	-1.0696	-0.2630	0.2182	0.8267	1.3715
	A_{22}	-1.7928	-0.5976	0.5976	0.5976	0.5976	0.5976
	A_{23}	1.1047	0.5485	0.9404	-0.4025	-0.9687	-1.222
	A_{32}	-1.3916	-1.0186	0.1229	0.8518	0.3606	1.0748
	A_{41}	-1.1095	-0.7483	-0.3870	0.0774	0.4903	16772
	A_{42}	1.9155	-0.2642	0.1321	-0.8587	-0.2642	-0.661
	A_{51}	0.2147	-0.4294	0.4723	0.8588	1.2452	1.5028
	A_{52}	-0.4236	-1.401	-0.4236	0.1629	0.5539	1.5314
	A_{53}	-0.0696	-0.1392	-0.0278	0.0278	0.0696	0.1392
	A_{54}	-0.6556	-1.3580	-0.2341	0.0468	0.7493	1.4517
	A_{55}	-0.6556	-1.3580	-0.2341	0.0468	0.7493	1.4517
	A_{56}	-0.6556	-1.3580	-0.2341	0.0468	0.7493	1.4517
	A_{57}	-0.6270	-1.5674	-0.0627	0.3135	0.6897	1.2539
	A_{58}	-0.6059	-1.5147	-0.2424	0.3029	0.8483	1.2118
	A_{61}	-0.6556	-1.3580	-0.2341	0.0468	0.7493	1.4517
	A_{62}	-0.6273	-1.3244	-0.3485	0.0070	0.7667	1.4638
	A_{63}	-0.6556	-1.3580	-0.2341	0.0468	0.7493	1.4517
	A_{64}	-0.6556	-1.3580	-0.2341	0.0468	0.7493	1.4517
Output indicators	A_{21}	-0.6144	-1.5430	-0.2858	0.5395	0.7837	1.1201
	A_{31}	-0.4726	-1.1027	0.0788	-0.6301	0.3938	1.7328
	A_{33}	-1.1973	-0.9160	-0.3253	0.3245	0.6818	1.4323
	A_{71}	0.2588	-1.7043	1.2791	0.5582	-0.2403	-0.152
	A_{72}	-0.1379	-1.2016	0.3743	-0.7682	0.0591	1.6743
	A_{73}	0.2777	-1.4320	1.4547	0.5751	-0.5833	-0.292

Source: Chinese ports Statistical Yearbook 2008-2013, and Shanghai Statistical Yearbook 2008-2013.

contribution rate achieved 94.432%. Factor 1 is port infrastructure factor, Factor 2 is Port operations and investment factor, Factor 3issoft power and policy factor. In the same meaning, two factors are recognized as output factors as their cumulative variance contribution rate achieved 93.923%. Factor 1 is Service level and factor 2 is port logistics development potential. The detail factor scores that calculated by SPSS is shown in Table 4.

Because DEA model requires the input and output data are nonnegative, the date was processed according to the equation (4) (Song, 2010).

$$z'_{ij} = 0.1 + \frac{Z_{ij} - b_j}{a_j - b_j} \times 0.9 \quad (4)$$

Where Z_{ij} is indicator values without processing, and z'_{ij} is the processed indicator values. a_j is the maximum indicator of j, and b_j is the minimum indicator of j, and i represents the year, and j represents the indicator, then $Z'_{ij} \in [0.1, 1]$. The processed data are shown in Table 5.

5. Analysis of the Port Competitiveness Evaluation Based on DEA

Established Port Competitiveness Evaluation Model

Suppose there are n DMUs, and each DUM has m kinds of input and s kinds of output. $x_j = (x_1, x_2, ..., x_{mi})^T$, $j = 1, 2$ and $y_j = (y_{1j}, y_{2j}, ..., y_{sj})^T$, $j = 1, 2, ...n$ represent the amount of inputs and outputs respectively. Define h_j is the ratio between the j^{th} DMU weighted total input and weighted total output, and it is the efficiency rating indicator:

$$h_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} \nu_i x_{ij}} \quad (5)$$

DEA-CCR model is set up to evaluate the efficiency of j_0 DMU, and the CCR model is translated into linear programming problem.

$$min f_{j_0} = \theta - \varepsilon(\hat{e}^T s^- + e^T s^+)$$

$$s.t. \begin{cases} \sum_{j=1}^{n} x_j \lambda_j + s^- = \theta x_{j_0} \\ \sum_{j=1}^{n} y_j \lambda_j - s^+ = y_{j_0} \\ \lambda \geq 0 \\ s^- \geq 0 \\ s^+ \geq 0 \end{cases} \quad (6)$$

h_j: The comprehensive evaluation indicator of port competitiveness
j: The index of year
θ: Technical efficiency value of the port
x_{ij}: The invested volume of the j^{th} DMU in terms of the ith input, $x_{ij} > 0$
y_{rj}: The invested volume of the j^{th} DMU in terms of the ith output, $y_{rj} > 0$
ν_i: The weighting of the i^{th} input
u_r: The weighting of the r^{th} output

Table 6: The result of DEA model

DMU	Year	Combined efficiency	Pure technical efficiency	Scale efficiency	Returns to scale
1	2008	1.000	1.000	1.000	Unchanged
2	2009	1.000	1.000	1.000	Unchanged
3	2010	1.000	1.000	1.000	Unchanged
4	2011	0.810	0.813	0.997	Decreasing
5	2012	0.797	1.850	0.937	Increasing
6	2013	1.000	1.000	1.000	Unchanged

Source: Authors

s^+: Slack variable
s^-: Surplus variables
ε: Non-Archimedean infinitesimal

The Data Processing of DEA Input and Output Indicators

DEAP 2.1 software is used to deal with the data, and the results are shown in Table 6.

From Table 6, it is found that the values of scale efficiency are 1 for Year 2008, 2009, 2010, and 2013, which mean that the DMUs are efficient. It also illustrated that the returns to scale of these four years are unchanged. For those values of scale efficiency which are less than 1 such as Year 2011and 2012, it means that the DMUs are non-effective. Therefore, we know that the arrangement of these two years' resources was not appropriate, and the port operators should strengthen the rational distribution of resources in the port.

Cross-Evaluation Mechanism

Though the DEA-CCR model can figure out the effective and non-effective units, when DMUs are relatively effective, it is hard to distinguish the advantages and disadvantages of these DMUs. Therefore, this paper will implement the cross-evaluation mechanism to distinguish the advantages and disadvantages of these DMUs. Though the optimal solution of liner programming problem is not unique, then the cross-evaluation value is uncertainty, therefore this paper will implement the confrontational cross-evaluation mechanism to solve this problem. The basic principle of confrontational cross-evaluation mechanism is to find the self-evaluation value E_{jj} of every decision unit under the premise of maximum DMU_j, so that the other DMUs can get the possible smallest cross-evaluation value. Steps of establishing a confrontational cross-evaluation model are illustrated as follows:

(1) Use CCR model to calculate the value of self-evaluation E_{jj};

$$max\, h_{j_0} = \mu^T Y_0$$

Table 4: Factor scores

Year		2008	2009	2010	2011	2012	2013
Input	Factor 1	0.174805	-1.81624	-0.14139	0.026627	0.645808	1.110386
	Factor 2	-1.867	-0.04787	0.441547	1.108827	0.285027	0.079472
	Factor 3	-0.69003	0.925923	-0.98501	-0.91078	0.335414	1.324483
Output	Factor 1	-0.71734	-1.12399	-0.21123	-0.20636	0.589328	1.669596
	Factor 2	0.412467	-1.47357	1.399574	0.549006	-0.49085	-0.39663

Source: Authors

Table 5: Nonnegative date after processing

Year		2008	2009	2010	2011	2012	2013
Input	Factor 1	0.7123	0.1000	0.6151	0.6667	0.8571	1.0000
	Factor 2	0.1000	0.6502	0.7982	1.0000	0.7509	0.6887
	Factor 3	0.2150	0.8445	0.1000	0.1289	0.6146	1.0000
Output	Factor 1	0.2310	0.1000	0.3941	0.3956	0.6520	1.0000
	Factor 2	0.0908	0.1000	1.0000	0.7336	0.4078	0.4373

Source: Authors

$$s.t. \begin{cases} \omega^T X_j - \mu^T Y_j \geq 0 \\ \omega^T X_0 = 1 \\ \omega, \mu \geq 0 \end{cases} \tag{7}$$

(2) Solve linear programming by the given j;

$$min\ Y_k^Y u$$

$$s.t. \begin{cases} Y_j^T u \leq X_j^T v \\ Y_j^T u = E_{jj} X_j^T v \\ X_k^T = 1 \\ u, v \geq 0 \end{cases} \tag{8}$$

(3) Use linear programming optimal solution (v_{jk}^*, u_{jk}^*) to calculate the crossover evaluation value;

$$E_{jk} = \frac{Y_k^T u_j^*}{X_k^T v_j^*} \tag{9}$$

(4) Construct the cross-evaluation matrix by cross-evaluation value.

$$E = \begin{bmatrix} E_{11} & E_{12} & ... & E_{1n} \\ E_{21} & E_{22} & ... & E_{2n} \\ ... & ... & ... & ... \\ E_{n1} & E_{n2} & ... & E_{nn} \end{bmatrix} \tag{10}$$

Where u and v are the weight vectors of input and output; ω and μ are the weights of input and output; E_{jj} is self-evaluation value; Off-diagonal element E_{jk} ($k \neq 0$) is cross-evaluation value, j^{th} column is DMU_j evaluation value of each decision-making unit. The higher the evaluation value is, the more excellent DMU_j is. By executing the above steps and input the date into the Matlab software, the results of cross matrix evaluation are shown in Matrix (11).

$$E = \begin{bmatrix} 1.0000 & 0.0666 & 0.2137 & 0.1713 & 0.3759 & 0.6286 \\ 0.2525 & 1.0000 & 0.6407 & 0.5934 & 0.6568 & 0.7948 \\ 0.0422 & 0.0118 & 1.0000 & 0.5691 & 0.0664 & 0.0437 \\ 0.4630 & 0.2384 & 1.0000 & 0.9074 & 0.8658 & 1.0000 \\ 1.0000 & 0.1220 & 1.0000 & 0.8085 & 0.8723 & 1.0000 \\ 0.3243 & 0.1220 & 0.3660 & 0.2967 & 0.6180 & 1.0000 \end{bmatrix} \tag{11}$$

It is observed that $E_{11} = 1.0000$, $E_{22} = 1.0000$, $E_{33} = 1.0000$, $E_{44} = 0.9074$, $E_{55} = 0.8723$, $E_{66} = 1.0000$ in Matrix (11). The results are consistent with those efficiencies that calculated by CCR model. There are four self-evaluation values equal to 1 in Table 6. It is difficult to distinguish the pros and cons of each decision unit. Therefore the cross-evaluation value needs to be determined. The calculated evaluation value and the ranking are shown in Table 7.

Table 7 illustrates that the competitiveness efficiency of Shanghai Port ranked first in 2013. It means that the resources were

Table 7: Cross-evaluation value and ranking

Year	2008	2009	2010	2011	2012	2013
Cross-evaluation value	0.5137	0.2620	0.7034	0.5577	0.5759	0.7445
Ranking	5	6	2	4	3	1

Source: Authors

optimal allocated that year. Port operators can refer to the development patterns of 2013 in the future port development. In 2010 and 2012, the competitiveness efficiency of Shanghai Port ranked second and third, which mean that the resources of these two years were rationally planned and the operating conditions are greatly improved. However, the competitiveness efficiency of Shanghai Port was not good in 2008 and 2009. This illustrated that there are wastes of resources, or the resources are not rationally allocated. The reasons for this phenomenon may be explained by the financial crisis in 2008 and too much port infrastructure in 2009. Port operators need to optimize the allocation of resources, such as improving the operating environment, and strengthening the information technology, and implementing integrated strategy, in order to enhance human resources advantages.

6. Conclusions

In order to analyze the evaluation of soft power investment effect on Shanghai port competitiveness, this paper used factor analysis combined with DEA method. 31 quantifiable indicators are selected, and three input and two output factors are extracted from these 31 indicators. These indicators are executed by SPSS software to analyze the influence competitiveness indicators in Shanghai Port. Through the establishment of DEA model, this paper used DEAP2.1 and Matlab software to obtain the efficiency values for each year and make the corresponding analysis. By using cross assessment mechanism, we obtained competitiveness ranking of the Shanghai Port from 2008 to 2013. The results illustrated that the competitiveness efficiency of Shanghai Port ranked first in 2013, Port operators can refer to the development patterns of 2013 in the future port strategy. The efficiency analysis of the operations in Shanghai Port can help port operators sum up experience in port development, and recognize the strengths and weaknesses, in order to improve the competitiveness of the port.

This paper provides a basic model to assess the competitiveness of the port, which is easily to be implemented. However, the application is only applied from the 2008-2013 data. More data in time sequences can be included. Furthermore, this paper aims to analyze the soft power impact on the port competitiveness. In the future, the correlations between the soft power and hard power can be added in the model.

References

Bird JH. (1968) *Seaport Gateways of Australia*. London: Oxford University Press.

Bird JH. (1971) *Seaports and Seaport Terminals*. London: Hutchinson.

Mayer, H.M. (1973) *Some geographic aspects of technological change in maritime transportation*. Economic Geography 49(1), 145-151.

Kenvon, J. (1970) *Elements in inter port competition in the United States*. Economic Geography 46(1), 1-24.

Haynes, K.E., Hsing, Y.M. and Stough, R.R. (1997) *Regional Port dynamics in the global economy: The case of Kaohsiung*. Taiwan. Maritime Policy & Management 24(1), 93-113.

Fleming, D.K. (1997) *World Container Port Ranking*. Maritime Policy & Management 24(1), 175-181.

Ha, M.S.A. (2003) *A comparison of service quality at major container ports: implications for Korean ports*. Journal of Transport Geography 11(1), 131-137.

Yao Liu, Shengrong Lu. (2013) *Port Competitiveness Evaluation Research based on Chernooff Faces Model*. Procedia-Social and Behavioral Sciences 96(1), 1961-1966.

Roll, Y. and Hayuth, Y. (1993) *Port performance comparison applying data envelopment analysis*. Maritime Policy & Management 20(1), 153-161.

Jose Tongzon. (2001) *Efficiency measurement of selected Australia and other international ports using data envelopment analysis*. Transportation Research Part A 35(1), 107-122.

Valentine, V.F. and Gray, R. (2001) *The Measurement of Port Efficiency using Data Envelopment Analysis*. Proceedings of the 9th World Conference on Trans Port Research. Seoul: South Korea, pp 22-27.

Thurstone L L. (1935) *The Vectors of the Mind*. Literary Licensing, LLC.

Charnes A, Cooper WW, Rhode E. (1978) *Measuring the efficiency of decision making units*. European Journal of Operational Research 2(1), 429-444.

Song QQ. (2010) *Port competitiveness evaluation research used DEA method Thesis (PhD)*. Dalian Maritime University.