

# *Research and analysis on the value-added efficiency of listed port companies in China*

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**Abstract:** In order to solve the problem of value-added inefficiency of Chinese port listed companies, this paper aims to investigate whether port integration and strengthening port infrastructure can be a solution to the problem of value-added inefficiency of listed port companies, then put forward some suggestions. This study uses data of Chinese listed port companies, then uses DEA analysis and Tobit regression to investigate the role of state-owned equity in listed port companies played by port integration on the value-added efficiency. The results show that listed port companies with port integration have higher value-added efficiency; the richer the port infrastructure, the higher the value-added efficiency; and the higher the proportion of state-owned shares held, the more effective the impact of port integration on the value-added efficiency of listed port companies.

## 1. Introduction

Since the 21st century, the degree of opening up of various countries to the outside world has been increasing, and the demand for imports and exports is also increasing, thus the speed of port development has also accelerated, among which the development of Chinese ports is the most rapid, and the scale of ports steadily ranked the first in the world.

From only two Chinese ports in the top ten global ports in terms of container throughput in 2000, it has developed to seven of the top ten global port container throughput in 2012. However, compared to throughput, Chinese ports have been under performing among the top 10 global ports by annual revenue, with only one port entering the top 10 global port revenue ranking in 2017. The value-added efficiency of listed port companies is a crucial part of company development, so listed Chinese port companies need to think about and review their own value-added efficiency.

With the rapid development of the port industry, many ports choose the path of integration, port integration can achieve the purpose of avoiding competition and expanding resources, of which a total of four Chinese ports have completed consolidation between 2000 and 2010. Whether the advantages created by port integration can be an effective way to address the value-added inefficiencies of Chinese port listed companies remains to be studied.

In the process of continuous development of the port industry, the scale of port infrastructure is

also increasing, and port infrastructure is the most basic element of the port. At the same time, the port's investment in infrastructure has increased. Although the period of port infrastructure construction is long, the benefits brought by the improvement of port facilities are more considerable. There are already several studies on port integration and port infrastructure by scholars, most of the studies used case analysis, instead of empirical methods. Based on this, this study conducts empirical analysis on whether port integration and port infrastructure can be used to solve the problem of value-added inefficiency of listed port companies in China.

In the process of port development, China has gradually completed the reform of mixed ownership system, the company gradually introduced various types of heterogeneous shareholders, the state-owned equity has been diluted, but the state-owned shares still have an irreplaceable role based on their own particularity. State-owned equity symbolizes the investment of the state, and plays a better role when big changes occur in the company, and it is of great significance to explore the role played by state-owned equity in major project changes. Therefore, this study addresses the role of state-owned equity in the impact of port consolidation on listed port companies in China.

## 2. Literature review and Research hypotheses

### 2.1. Research of port integration

Port integration is strictly different from port alliances and port cooperation, which is the merging of two separate ports into a single port under the unified management of the government or a particular enterprise. Port alliances and port cooperation are long-term and stable partnerships established through contractual relationships. The researches on port integration are relatively poor.

Port integration occurs in many countries,<sup>[1]</sup>Stamatovic et al. used semi-structured expert interviews and data analysis to analyze the development of North Adriatic ports after integration.<sup>[2]</sup>Huo et al. used the multi-case analysis method to study in detail the changes that have occurred in Chinese ports in recent years, and systematically researched the evolution of integration and cooperation between Chinese and international ports.

Scholars have different opinions about whether port integration can play a role<sup>[3-5]</sup>. Most scholars believe that port integration can bring advantages,<sup>[6]</sup>Dong et al. applied game theory method to study the changes of ports under different port integration strength, and found that the greater the port integration, the smaller the decoration cost and the greater the container throughput.<sup>[7]</sup>Song & Panayides measured the impact of port integration on competitiveness. However, some scholars have pointed out the problems of port integration.<sup>[8]</sup>Saeed & Larsen used a two-stage game to study integration strategy of Pakistani port, and found that the port integration may incur more costs.

Most of the existing literature is studied by multi-case analysis and game theory method, instead of empirical analysis, this study uses empirical analysis to study port integration. Analysis of existing studies shows that port integration can enhance the competitiveness of ports, but it may cause problems at the management level. For Chinese ports, port integration is generally supported by the state or local government, and the problems that may arise at the management level can be minimized under the supervision of the government. And port integration can effectively enhance the competitiveness of listed port companies, and the value-added efficiency of listed port companies will also be affected. Therefore, this study proposes the following hypotheses:

**H<sub>1</sub>: Port integration positively promotes value-added efficiency of listed port companies.**

### 2.2. Research of Port infrastructure

In the face of increasing port competition, many listed port companies have begun to turn their attention to port infrastructure in order to enhance their competitiveness. Many studies have found

that port infrastructure can promote GDP, employment, investment and economic growth in port locations. <sup>[9-14]</sup>Some studies also show that port infrastructure affects the local economy by influencing the port economy by empirical methods.

The development of port infrastructure is an important matter for the future development of the ports, and many scholars have begun to study the development of port infrastructure for the ports themselves. <sup>[15]</sup>Fabing et al. simulated the adoption of new infrastructure and found that the adoption of new infrastructure can alleviate the capacity constraints and expand the shipping options. <sup>[16]</sup>Vega et al. studied the impact of port infrastructure on port selection decisions and found that significant port infrastructure can influence port choice through its impact on perceived costs. Ara-Diaz et al. used a cost function to study the impact of port infrastructure on ports and found that there is an incremental effect of rewards of scale in ports, whereby the port economy increased with the increase in infrastructure. Ara-Diaz et al. used a cost function to study the impact of port infrastructure and find that port economy increased with the increase of infrastructure.

Based on the existing literature, it can be judged that port infrastructure can affect the port economy by increasing port options, expanding port capacity and the scale effect of the ports, where the most common port infrastructure is the number of berths and the length of berths in the ports. The value-added efficiency of listed port companies can be used as one of the indicators to measure the port economy. Therefore, this study proposes the following hypotheses:

**H<sub>2a</sub>: Port berths in port infrastructure can positively promote the value-added efficiency of port listed companies.**

**H<sub>2b</sub>: Port berth length in port infrastructure can positively promote the value-added efficiency of port listed companies.**

### 2.3. Research of the proportion of state-owned shareholding

The reform of the mixed-ownership economy plays a major role in the implementation of economic system reform. Important elements in the development of a mixed-ownership economy include the participation of State-owned capital in the non-public economy. Therefore, research related to the proportion of state-owned shareholding is a popular topic at home and abroad.

First, the most classic paper on the research of equity structure and corporate performance is Jensen & Meckling developed the theory of enterprise ownership by synthesizing the elements of agency theory, property rights theory and financial theory<sup>[17]</sup>. As research continues, scholars have studied the ownership structure more thoroughly. <sup>[18]</sup>Coles et al. used models to demonstrate the association between equity structure and firm performance. <sup>[19]</sup>Chen Deping and Chen Yongsheng have studied the impact of enterprise performance from the aspects of equity concentration and equity balance in equity structure.<sup>[20]</sup>Lin Jingjuan explores the impact of equity structure on corporate performance from the perspective of state-owned shares.

Secondly, there is a skewing effect on the resources of state-owned capital. In the mixed ownership reform, state-owned and non-state-owned capital play different roles, and they integrate with each other and complement each other's strengths. Among them, state-owned capital plays a tilting effect in the company's resource allocation. <sup>[21]</sup>Fan et al. have studied CEOs with political backgrounds and found that the government holds the power to allocate resources. <sup>[22]</sup>Firth et al. found that the government tends to allocate resources to government-related companies by studying the investment behavior of firms and financing channels.

Ports are the infrastructure of the country and an important node connecting land and sea. The development of ports has always been emphasized by the local government and the state. The act of port integration is accomplished with the support of the state and the local government, the negative problems caused by port integration can be controlled with the support of the local government and

the state, and the more the proportion of state-owned shareholding, the greater the association between the company and the government. Therefore, this study proposes the following hypotheses:

**H<sub>3</sub>: The proportion of state-owned shareholding plays a positive moderating role in the impact of port integration on the value-added efficiency of listed port companies.**

### 3. Research methods

#### 3.1. DEA analysis

The DEA model was firstly used in efficiency studies in 1978 by Charnes et al<sup>[23]</sup>. The method which determines whether the efficiency is effective or not by observing whether each decision unit falls on the production frontier, which can avoid the interference of subjective factors and simplify the algorithm and reduce the error to a certain extent compared with other methods<sup>[24]</sup>. This paper is based on constructing a BCC-DEA model for listed port companies with variable scale remuneration, and the expression is:

$$\left\{ \begin{array}{l} \min[\theta - \varepsilon(\sum_{i=1}^m si^- + \sum_{i=1}^n sr^+)] \\ \sum_{j=1}^I x_{ij}\lambda_j + si^- = \theta x_{ik} \\ \sum_{j=1}^I y_{rj}\lambda_j - sr^+ = y_{rk} \\ \sum_{j=1}^I \lambda_j = 1 \\ \lambda_j, si^-, sr^+ \geq 0, j = 1, 2, \dots, n \end{array} \right.$$

Among them,  $x_{ij}$  and  $y_{ij}$  are the  $i$ -th input of decision unit  $j$  and the  $i$ -th output of decision unit  $j$ ,  $x_{ij}, y_{ij} \geq 0$ ,  $\theta$  is the target planning value,  $\varepsilon$  is non-Archimedean infinitesimal,  $si^-, sr^+$  are relaxation variables. If  $\theta=1, s^-=0, s^+=0$ , DEA is in a valid state; If  $0 < \theta < 1$ , DEA is in an invalid state; If  $\theta=1, s^- \neq 0, s^+ \neq 0$ , DEA is in a weakly valid state.

#### 3.2. Tobit regression

Tobit model is also known as restricted dependent variable model, the dependent variable of Tobit model is restricted variable and independent variable is actual value. Since the efficiency calculated by DEA takes values in the interval  $[0,1]$  and is a discrete value, it matches the Tobit model. Compared with the conventional least squares method, using the Tobit model to regress the DEA efficiency can avoid biased and inconsistent parameter estimates. Therefore, this paper adopts the Tobit model to analyze the factors affecting the value-added efficiency of listed port companies. There are many literature on the use of Tobit model for regression in DEA models, of which Coelli was the first to propose and use them<sup>[25]</sup>. The basic model of Tobit is:

$$Y = \begin{cases} Y^* = \alpha + \beta X + \varepsilon, & Y^* > 0 \\ 0, & Y^* \leq 0 \end{cases}$$

Where  $Y$  is the dependent variable vector,  $Y^*$  is the latent dependent variable vector, and  $X$  is

the vector of independent variables;  $\alpha$  is the intercept term, which is constant;  $\beta$  is the regression coefficient; and  $\varepsilon$  is the error term.

## 4. Methods and data

### 4.1. Selection of variables

(1) Dependent variable: value-added efficiency (Y). In this paper, the efficiency of value-added process of listed port companies is taken as the dependent variable and measured by the DEA-BCC model. The DEA model requires that the number of DMUs is three to five times of the number of indicators. In order to ensure the effectiveness of the DEA model, this paper selects one input variable and two output variables, 12 listed port companies are also selected in this paper<sup>[26]</sup>. This study refers to a large number of literature and improves on this basis<sup>[27-30]</sup>, and selects gross operating income and long-term capital return as output variables. The total operating income can be used as the overall output level of the operating activities of listed ports companies, and long-term capital return can effectively reflect the economic efficiency of listed port companies. Therefore, the evaluation index system of port value-added efficiency is shown in Table 1.

Considering the different input scales of listed port companies, in order to avoid efficiency changes caused by different scales, this paper discards the scale efficiency value and the total technical efficiency value, selects the pure technical efficiency value as the final dependent variable.

Table 1: Port value-added efficiency evaluation index system.

| The type of variable | Variable                            | Per unit |
|----------------------|-------------------------------------|----------|
| Input variables      | Total cost of operations            | Yuan     |
| Output variables     | Total operating income              | Yuan     |
|                      | Long-term rate of return on capital | /        |

(2) Independent variable: Port Integration (INT). Port integration is a dummy variable, if the main operating port is originally formed by the merger of two or more different ports, then the port integration takes the value of 1, otherwise it is 0. Number of berths in the port (BER)- It refers to the location where ships can dock in the port area, and a berth is a basic unit of port loading and unloading operations. Length of berths in the Port (BL)-The length of the berth generally includes the sum of the length of the ship and the necessary safety intervals between the ship and the sum.

(3) Moderator variable: Proportion of state-owned shareholdings (PSSH). Proportion of state-owned shareholdings = total number of state-owned shares of the company / total number of shares of the company. It can reflect the degree of connection with the government.

(4) Control variable: Board size (BS)-the total number of people who served on the board of directors of listed port companies in different years. The largest shareholding ratio (S1) - the largest shareholding ratio = total number of shares held by the largest shareholder in the listed port company/total number of shares in the company. Total Import and Export (TIE) -the total amount of import and export of the province where the port managed by the listed port company is located. Number of employees in the company (EM)-The number of employees in this company.

### 4.2. Data object selection and source

Considering the different listing times of listed port companies, this paper selects Chinese listed port companies as the research object, the sample period from 2013 to 2020, and removes companies that were not listed before 2013, the missing part of data and non-coastal listed port companies, and retains 12 listed port companies. The selected listed port companies are shown in Table 3. The data types are shown in Table 1 and Table 2. The data comes was obtained from the

2013-2020 China Port Yearbook, China Urban Statistical Yearbook, Ministry of Transportation and Communications statistics, Cathay Pacific database, and Municipal statistical yearbooks.

Table 2: Selected listed port companies.

| The type of ports  | Port included   |
|--------------------|---|
| Integrate ports    | Ningbo-Zhoushan Port, Beibu Gulf Port, Xiamen-Zhangzhou Port  |
| Unintegrated ports | Dalian Port, Yingkou Port, Tianjin Port, Shanghai Port, Lianyungang Port, Rizhao Port, Zhuhai Port, Jinzhou Port, Tangshan Port |

### 4.3. Model building

In order to verify hypothesis H<sub>1</sub>, this paper takes the value-added efficiency calculated by DEA as the dependent variable, port integration as the independent variable, then adds the control variables, the Tobit model is used to study the impact of port integration, and construct the following model:

$$Y_{it} = \alpha + \beta_1 INT_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$

In order to verify hypothesis H<sub>2a</sub> and H<sub>2b</sub>, replace the independent variables on the basis of (1), take the number of port berths and port berth length as the independent variables, use the Tobit model to study the impact on the value-added efficiency, and construct the following model:

$$Y_{it} = \alpha + \beta_1 BER_{it} + \beta_2 BL_{it} + \beta_3 X_{it} + \varepsilon_{it} \quad (2)$$

In order to verify hypothesis H<sub>3</sub>, the modulating variables and interaction terms are added on the basis of (1), the Tobit model is used to study the role state-owned shareholdings played in the impact of port integration on the value-added efficiency, and construct the following model:

$$Y_{it} = \alpha + \beta_1 INT_{it} + \beta_2 PSSH_{it} + \beta_3 INT * PSSH_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (3)$$

Where  $\alpha$  is a constant term;  $\varepsilon$  is the error term;  $\beta$  is the regression parameter of each influencing factor;  $i$  is the number of each listed port company,  $i=1, 2, \dots, n$ , and  $n=12$ ;  $t$  represents the year, specifically 2013-2020, and in order to eliminate the influence of heteroscedasticity on the regression model, this study logarithmizes the variables with larger values.

## 5. Analysis of the results

### 5.1. DEA model results

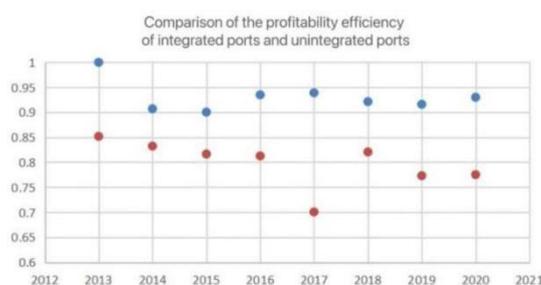


Figure 1: Comparison of profitability efficiency of integrated and non-integrated ports.

From the comparison between the profitability efficiency of integrated ports and unintegrated ports, as shown in Figure 1. The profitability efficiency of port integration is obviously higher than that of non-integrated ports from 2013 to 2020, the profitability efficiency of port integration

fluctuates between 0.9-1, and the profitability efficiency of unintegrated ports fluctuates between 0.75-0.85 except for the year of 2017, and both of them have little fluctuation overall.

## 5.2. Tobit regression results

In order to make the regression results of this study more objective and robust, it is assumed that the disturbance terms of listed port companies in the port are regressed independently of each other among different companies, but the disturbance terms of the same listed port company in different years are related with each other, and the regression results are shown in Table 3.

As can be seen from the results of the regression of model(1): port integration (INT). The coefficient of port integration is 0.240577 and is positively significant at the level of 1%, which is confirmed by H<sub>1</sub> of this study. It indicates that the existence of port integration can enhance the value-added capacity of listed port companies through resource integration.

As can be seen from the results of model(2): Port Integration (INT). The coefficient of integration is 0.206341, which is positively significant at the level of 5%; the inclusion of the moderating variable only affects the size of the coefficient of port consolidation, but does not change the direction of the effect of port consolidation. Interaction between port integration and the percentage of state-owned shareholdings (INT\*PSSH). The coefficient of the interaction term is 0.645233, which is positively significant at the level of 10%, which is confirmed by H<sub>3</sub> in this study. It indicates that the proportion of state-owned shareholdings can bring resources and motivation for listed port companies in port integration. Therefore, the proportion of state-owned shareholdings plays a positive moderating role in the effect of port integration on the value-added efficiency.

Table 3: Panel Tobit model regression results.

| VARIABLES | Model(1)                 | Model(2)                 | Model(3)                   |
|-----------|--------------------------|--------------------------|----------------------------|
| INT       | 0.240577***<br>(0.08082) | 0.206341**<br>(0.103165) |                            |
| PSSH      |                          | -0.553843*<br>(0.293338) |                            |
| INT*PSSH  |                          | 0.645233*<br>(0.362623)  |                            |
| BER       |                          |                          | 0.513701***<br>(0.132982)  |
| BL        |                          |                          | -0.379228***<br>(0.125745) |
| BS        | 0.032825*<br>(0.017594)  | 0.037016<br>(0.017604)   | 0.029402<br>(.014906)      |
| S1        | 0.050262<br>(0.150894)   | 0.074672<br>(0.14594)    | 0.028623<br>(0.142797)     |
| TIE       | -0.026842<br>(0.127565)  | -0.003152<br>(0.138258)  | -0.143504<br>(0.09592)     |
| EM        | -0.0061<br>(0.073747)    | -0.001777<br>(0.071424)  | 0.04534<br>(0.05351)       |
| Cons      | 0.687174<br>(0.935777)   | 0.461106<br>(1.018174)   | 2.04738**<br>(0.904202)    |
| Obs       | 96                       | 96                       | 96                         |

Note: (1) \*\*\* means significant at the 1% level, \*\* means significant at the 5% level, \* means significant at the 10% level; (2) Standard deviation in parentheses.

As can be seen from the results of model(3): Number of port berths (BER). The coefficient of the number of port berths is 0.513701, which is positively significant at the level of 1%, which is confirmed by H<sub>2a</sub> of this study. It indicates that the number of port berths enhances the value-added efficiency of listed port companies by expanding port containers and expanding port options, and it also indicates that port infrastructure is still in the stage of increasing returns to scale.

### 5.3. Robustness test

In this paper, the method of adjusting the sample period is adopted to test the robustness of the regression results of different models. Due to the new pandemic in the late year of 2019 and the valuation of data already existed in 2020, the sample period is shortened to 2013-2018 with no change in variables, and the original regression results are tested, as shown in Table 4.

Table 4: Robustness test results.

| VARIABLES | Model(1)                  | Model(2)                 | Model(3)                   |
|-----------|---------------------------|--------------------------|----------------------------|
| INT       | 0.241563***<br>(0.066923) | 0.203833**<br>(0.09001)  |                            |
| PSSH      |                           | -0.539722*<br>(0.279032) |                            |
| INT*PSSH  |                           | 0.6423831*<br>(0.324232) |                            |
| BER       |                           |                          | 0.538265***(0.125295)      |
| BL        |                           |                          | -0.389607***<br>(0.142116) |
| BS        | 0.029578<br>(0.020545)    | 0.034743<br>(0.020906)   | 0.025203<br>(0.016903)     |
| S1        | 0.170967<br>(0.19521)     | 0.2016<br>(0.193441)     | 0.100166<br>(0.172878)     |
| TIE       | 0.022091<br>(0.158947)    | -0.044696<br>(0.177286)  | -0.09111<br>(0.108354)     |
| EM        | -0.020693<br>(0.07445)    | -0.01773<br>(0.070119)   | 0.023799<br>(0.04027)      |
| Cons      | 0.373268<br>(1.113221)    | 0.149206<br>(1.23122)    | 1.762*<br>(0.927467)       |
| Obs       | 72                        | 72                       | 72                         |

Note: (1) \*\*\* means significant at the 1% level, \*\* means significant at the 5% level, \* means significant at the 10% level; (2) Standard deviation in parentheses.

From the robustness test results of model (1), model (2) and model (3), the significant level and direction of regression coefficients of each variable did not change in terms of port integration, percentage of state-owned shareholdings, interaction term, number of port berths and length of port berths. Only the regression coefficients and the size of the standard deviation changed slightly, which was consistent with the regression results of the benchmark model, which indicated that the regression results of the benchmark model had better robustness.

## 6. Conclusions and perspectives

Based on the environment of port development in recent years, this study uses the DEA

evaluation model to construct the value-added efficiency of listed port companies. And it also provides new ideas and countermeasures for the future development of ports. The main research conclusions and recommendations of this paper are as follows:

Firstly, the value-added efficiency of listed port companies with port integration is higher. Therefore, if there exists the rationality as well as the necessity of port integration among ports, port integration projects can be carried out to enhance the competitiveness of ports, expand the scale of ports, and improve the value-added efficiency of listed port companies according to the competition avoidance and resource richness brought by port integration.

Secondly, the richer the port infrastructure, the higher the value-added efficiency of listed port companies, which indicates that the development of port infrastructure is still in the stage of increasing scale returns. Therefore, increasing port infrastructure within a reasonable range can improve port conditions by increasing the abundance of port options and reducing port congestion, thereby enhancing the value-added efficiency of listed port companies.

Thirdly, the more the proportion of state-owned shareholding, the more effective the impact of port integration on the value-added efficiency of listed port companies. Therefore, listed port companies that need port integration can introduce state-owned equity before integration to enhance the resources and power for subsequent development of the port, solve the management problems arising after port integration, and then increase the value-added efficiency of listed port companies.

This research is based on the example of Chinese ports, which is representative but also has limitations. In future studies, the study will be expanded to make it more generalized and to explore more characteristics and commonalities in the environment in which ports are located.

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