THE COMPARISON OF ECONOMIC EFFICIENCY AMONG THE COMMERCIAL PORTS IN TAIWAN

Kee-Kuo CHEN
Associate Professor
National Taiwan Ocean University
No.2, Pei-Ning Road, Keelung,
Taiwan R. O. C.
TEL: +886-2-2462-2192-3437
FAX: +886-2-2462-0724
E-mail: kkchen@mail.ntou.edu.tw

Madeleine HUANG
Staff officer
Keelung Harbor Authority
No.1, Chung-Cheng Road, Keelung,
Taiwan, R.O.C.
Tel: + 886-2-24208576
FAX: +886-2-2424-2495
E-mail: maymayih@klhb.gov.tw

Abstract: This paper aims at comparing the differences of economic efficiency among the commercial ports in Taiwan by using a stochastic frontier cost function through a balanced panel dataset. The sample is made of cost data of five commercial ports through the period of 1983-1999. By estimating a fixed stochastic frontier cost model, the differences of economic efficiency among the five ports do exist, and that reveals that economic efficiencies of the smaller ports are superior to the larger ones. The proportions of employee cost to total cost in large ports are higher than those in smaller ones. As a result, the larger ports have more of the over-hiring problem and higher economic inefficiency than smaller ports. Furthermore, the progress of technology over time and economies of scale are detected in this paper.

Key Words : economic efficiency, stochastic frontier cost function, fixed effect model random effect model.

1. Introduction

The purpose of this study is to analyze the economic efficiencies of the commercial ports in Taiwan over the period of 1983-1999. In the end of the paper, a frontier cost function has been estimated which separates the commercial ports into different classification according to their economic efficiency.

There are totally five commercial ports operating in Taiwan, which include port of Keelung, port of Taichuang, port of Kaohsiung, port of Suao and port of Hualien. Among these ports listed above, port of Suao is the auxiliary port belonging to port of Keelung. Nevertheless, when estimating the model, we take them as two different ports because these two ports basically operate independently, possessing their own accounting department, port business department, engineering department, shipping and navigation department, as well as electronic data processing center.

These five commercial ports are almost public-owned and commanded under the MOTC (Ministry of transportation and communication). As a result of the framework of the shipping policy under the Taiwan Government, the Government seems to emphasize too much on investing specific ports so that there are big differences in the scale among the five ports. The Taiwan government puts plenty of resources into port of Kaohsiung to turn it into a world-class container port. By taking a look at the volume of incoming and outing cargo of ports in Taiwan, the volume of port of Kaohsiung is 20 times higher than port of Suao. Therefore, the purpose of this study is to provide further investigation of whether the investments from Taiwan government instilled into these ports have reached the maximum utility. In other words, we intend to assess the economic efficiencies of these ports.

When it comes to efficiencies, in general, it can be distinguished into technical efficiency, allocative efficiency and economic efficiency. Technical efficiency refers to how well a unit of physical inputs can produce a unit of outputs. Allocative efficiency is regarding to the departure of the observed factor ratios from the optimal ratios, given the prices of the factors fixed. The economic efficiency focuses on the degree to which costs are being minimized by defining an efficiency frontier and calculating the deviation from it. In this study, we will emphasize on economic efficiency.

2.The econometric model

In this paper, a panel dataset with times series and cross sections will be dealt with. From the panel dataset, not only can we acquire the economies of scale but also the technological change. A study by Pablo Coto-Millan [7] examined the costs of 27 Spanish ports from 1985 to 1989 by using a stochastic frontier cost function. A frontier cost function represents the minimum cost at which a particular level of output is produced given the technology and the prices of the input factors used. The basic model, for the ith firm in year t is

$$C_{it} = C(Y_{it}, W_{it}, t; \beta)\exp(\mu i) \qquad \mu i \geq 0 \tag{1}$$

Where C is the total cost of the i-th firm in the year of t, Y is the output vector, W is the price vector of the inputs. $C(Y,W,t;\beta)$ represents the minimum cost. Besides, μi's will be equal or greater than 0 because they are the deviations of the cost of each firm from the minimum cost.

The total C is made of the following elements: employee costs, depreciation and intermediate consumption. In addition, in order to reduce the loss of degree of freedom, the model only contains a single production variable, which is the total volume of incoming and outgoing cargos. There are three inputs variable included in the model: labor (L), capital (K), and intermediate consumption (E).

The prices of each elements are defined as follows: the price of labor (W_L) is the ratio of total employee costs (measured NT$) to the total number of workers employed by the port authorities; the price of capital (W_K) is the ratio of depreciation (measured NT$) to the total length of operational wharf of each port; the price of intermediate consumption (W_E) is the ratio of the intermediate consumption to the total volume of incoming and outgoing cargos (measured in thousands of Metric tons). The port operation has become more and more capital-intensive because of the progress of technology so that the ports put much investment to improve their facilities to strengthen the competitive edge. That is why this paper takes depreciation as an important input to the port operation. Besides, as it's mentioned above, the commercial ports in Taiwan are almost public-owned, so there seems to be a problem of over-hiring. That's an interesting issue we intend to examine.

In general, a cost frontier model can be estimated through either fixed effect model or random effect model. The former assume the deviations from the frontier are owing to the economic inefficiency, whereas the later entails the random and uncontrolled factors, which affect the performances and costs of the ports. These may be out of the environmental and geographical conditions, the shipping policy from government emphasized on upgrading some specific international ports, or measurement errors [2]. Consequently, the error term will be separated into two parts:

$$C_{it} = C(Y_{it}, W_{it}, t; \beta)\exp(\varepsilon_i) \qquad \varepsilon_i = \mu_i + \upsilon_i \tag{2}$$

Where ν i accounts for the random effect, and μi for the economic inefficiency.
In order to compare the economic efficiency of the five commercial ports in Taiwan, we define the economic efficiency as

$$EE_i = C(Y_i, W_i; \beta) / C_i = 1 / \exp(\mu_i) \tag{3}$$

3. Data description

Since1987, the gaps of total costs among the five commercial ports in Taiwan are more and more larger as shown in Figure 1. Port of Suao and port of Hualien have been maintaining the same level of total cost over the period of time, which means besides of offering the payment of employees and the depreciation of the existing facilities, both of them seem to stop investing to improve their operation facilities. On the other hand, port of Kaohsiung, since 1987, has been continued to grow up, as well as port of Keelung and port of Taichuang. Thus it can be seen, there are big differences in the scale among the commercial ports in Taiwan compared with total cost.

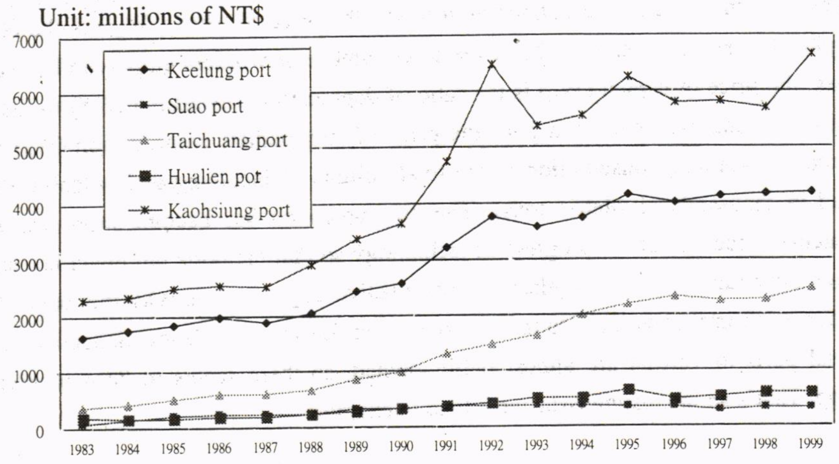

Figure 1. The total cost of commercial ports in Taiwan over 1983-1999

There is a significant escalation of the volume of cargo handled in port of Kaohsiung, the trend, as shown in Figure 2, is just similar with Figure 1. On the contrary, since 1985, the volume of cargo of port of Keelung went downward. Except that, the volumes of cargo of the other ports have the same pattern with the total cost.

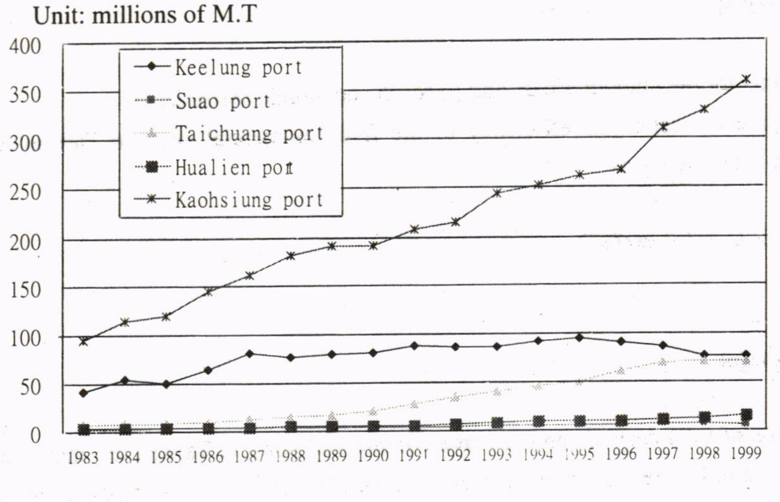

Figure 2. The volume of cargo handled of commercial ports in Taiwan over 1983-1999

From figure 3, the depreciation of port of Kaohsiung is far lager than the other ports in Taiwan during the period of 1983-1999. In 1992, the depreciation of port of Kaohsing went up extraordinarily because the Kaohsiung port authority conducted a project to build the third container terminal. In addition, the depreciation of port of Taichuang, since 1994, has been climbing up far more than port of Keelung. Contrary to the trend of the ports mentioned above, there seems to be less investments instilled to port of Suao and port of Hualien since 1992.

Unit : millions of NT$

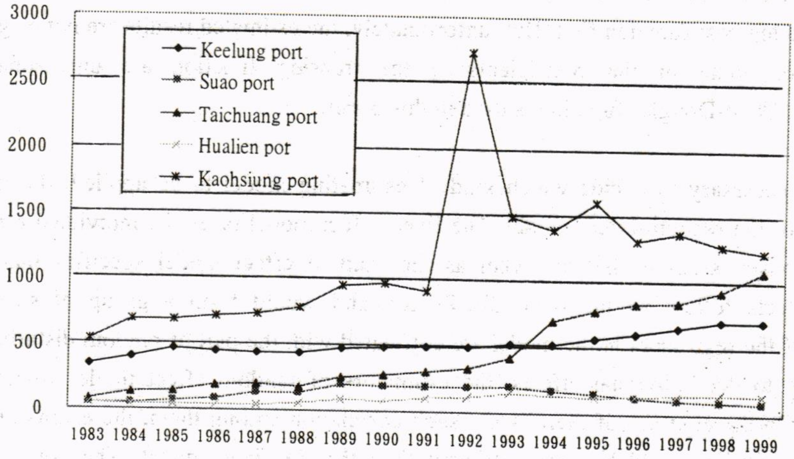

Figure 3. The depreciation of commercial ports in Taiwan over 1983-1999

The total employee costs of port of Kaohsiung and port of Keelung are higher than the other commercial ports. That's because the numbers of employee hired in these two ports are very huge.

Unit : million of NT$

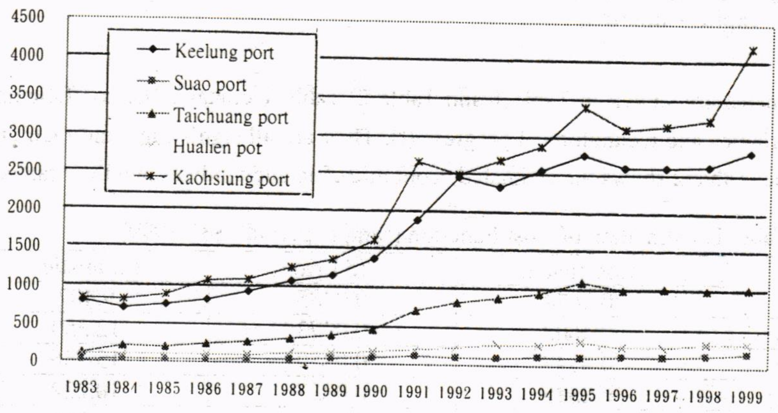

Figure 4. The employee costs of commercial ports in Taiwan over 1983-1999

4. Estimation of economic model

A "balanced panel", that includes 85 observations consisted of five commercial ports and 17 years' cost data for each port, will be used to estimate a frontier cost function. In order to choose an appropriate and useful model, some problems should be considered. First, what form of cost function will be fitted? As Brown et al. [2] have brought up, some cost functions such as Cobb-Douglas have an advantage of estimating fewer parameters, but they are not as flexible as functions such as translog function. For the sake of having more flexibility, we estimated translog cost function first. But, unfortunately, the estimated results are not as good as anticipated. Some of the coefficients in the translog function are unreasonable. Consequently, Cobb-Douglas function is used in this paper.

Second, it is necessary to decide which kind of estimating model to be applied: the fixed effect model or the random effect model. The fixed effect model takes the individual effects as specific constants for each firm, whereas the random effect model specifies that the individual effects follow an unknown distribution and would form a group of specific disturbance. If the regressors in the model are correlated with the part of random disturbance corresponding to the individual effects, the estimators of random effect model would be inconsistent. On the contrary, if there is not such correlation among them, the estimators of random effect model would be more efficient than that of fixed model. The correlation relationship is tested by the Hausman's test [5], the value of Hausman statistics is 40.49, which is significantly at 5% level. From the result of the test, it indicates that the fixed effect model is suitable for our following analysis. To account for the individual effect, we set up dummy variables to represent each port (αi), and the indices of economic efficiency are derived as

$$EE_i = \frac{1}{\exp(\mu_i)} = \frac{1}{\exp[\alpha_i - \min(\alpha_i)]} \tag{4}$$

The model estimates are shown in Table 1 and Table 2. Table 1 contains the coefficients of output, input variables and technological progress (t). They are all significant, and their signs are all reasonable. Table 2 shows the estimated economic efficiency indices and their ranks.

Table 1. Estimation of Cost Function (sample period 1883-1999)

Variable	Coefficient	Std.Error	t-Statistics
Log(Y)	0.2674	0.0285	9.407
Log(W_L)	0.4602	0.0373	12.350
Log(W_K)	0.3547	0.0250	15.766
Log(W_E)	0.2325	0.0227	10.222
t	-0.008523	0.0045	-1.882

Adjust R-square=0.99829, F=5434.45

Table 2. Individual Effects and Economic Efficiency Indices

Port	Coefficient	t-Statistics	Efficiency index	Ranking
Port of Suao	6.81109	0.39912	1	1
Port of Hualien	7.17019	0.40836	0.698	2
Port of Taichuang	7.62644	0.42155	0.442	3
Port of Keelung	7.89365	0.4377	0.338	4
Port of Kaohsiung	8.16552	0.44778	0.258	5

5. Empirical results

According to table 1, the cost function could be demonstrated as

$$\ln C_{it} = \alpha_i + 0.2676 \times \ln Y + 0.4601 \times \ln W_L + 0.3547 \times \ln W_K + 0.2325 \times \ln W_E - 0.0085 \times t \quad (5)$$

The rate of technological change and economies of scale [4] could be estimated as

$$\delta_t = \frac{-d \ln C}{dt} = 0.0085 \quad (6)$$

$$e.s._{it} = \frac{1}{(\frac{d \ln C_{it}}{d \ln Y_{it}})} - 1 = 2.7369 \quad (7)$$

From the result of the estimation, the technology change of the port operation in Taiwan is significant over the period of 1983-1999. The coefficient of economy of scale is 2.7369, which means that the ports operations have the property of economic of scale in Taiwan. In an economic sense, the economic of scale means the long-term average cost of commercial ports in Taiwan is still at the downward stage. As the production goes up the average cost per unit will go down.

Table 2 shows the economic efficiency indices as well as the efficiency rank for each port. The economic efficiency of port of Suao is superior to the others. We intend to further compare the efficiency differences among these five ports. Bonferroni test is used to establish the joint confident intervals for the differences of efficient coefficients. After the comparison, their economic efficiency ranks are listed: port of Suao $\succ$ port of Hualien $\succ$ port of Taichuang $\succ$ port of Keelung $\succ$ port of Kaohsing, where $A \succ B$ represents A is superior to B. It is noted that port of Suao is relatively smaller than the other ports. In the other words, the raking of economic efficiency has an adverse trend toward the scale of these ports measured on the total costs or the total volumes of cargo. The coefficient of correlation between EEi and total cost is –0.88, and –0.70 between EEi and total volume of cargos.

According to the coefficient of correlation mentioned above, there is a negative relationship between the economic efficiency and the scale of ports. In order to figure out the reason, we review the cost structure in each port. The proportions of employee costs to total costs in the five commercial ports are listed below.

Table 3. The proportions of employee costs to total costs

Port	Keelung	Suao	Taichung	Hualien	Kaoshiung
Proportion	59%	30%	47%	53%	49%

The relatively larger ports have the higher proportions of employee costs than those of the relatively smaller ones. If we further divide the employee costs by wharf lengths in each port (hereafter regarded as **employee cost per unit**), we could find out that in each meter of operation wharf, the lager ports spend more employee costs than smaller ports. The coefficient of correlation between EEi and **employee cost per unit** is –0.7664. It can explain why larger ports have higher economic inefficiency. The average employee costs in larger ports is higher than those of smaller ports. The result is concerned with the public-owned institution. As the ports develop, they hire more and more civil servants. Once the government employees worked there, it's not easy to dismiss them. This is a reason why the larger ports have the over-hiring phenomenon.

6. Conclusion

In order to compare the differences of economic efficiency among five commercial ports in Taiwan over the period of 1983-1999, a fixed stochastic frontier cost function is estimated in the paper. It is fund that the economic efficiency of these five ports is ranked as follow: port of Suao $\succ$ port of Hualien $\succ$ port of Taichuang $\succ$ port of Keelung $\succ$ port of Kaohsing, and the differences are significantly. The result shows that the larger the scale of a port is, the lower the economic efficiency of this port is. The finding is the same with Pablo Boto-Millan et al. [7]. Our model also reveals that there exists a technology progress and economy of scale in these ports over the time period. The existence of economies of scale in the five commercial ports in Taiwan means the port industry in Taiwan stays at the stage when the long-term average cost is downward. Furthermore, the finding that the economic efficiencies of larger ports are lower then smaller ones is relative to the over-hiring under the public-owned institution.

REFERENCES

1.Neter, J., Kutner, M.H., Nachtsheim, C.J., Wasserman, W. (1996) **Applied Linear Regression Models 3rd.**

2.Brown, R.S. Caves, D.W. and Christensen, L.R. (1979), Formulation and estimation of stochatic frontier production function models. **Journal of Econometrics, Vol. 46, 256-273.**

3.Econometric Software (1994) **LIMDEP.** Econometric Software Inc., New York and Sydney.

4.Green, W.H.(2000) **Econometric Analysis.** MacMillan, New York

5.Hausman, J. (1978) Specification tests in econometrics. **Econometrica, Vol. 46, 1251-1272.**

6.Kenkel J.L. (1996) **Introduction Statistics for Management and Economics**,4th. University of Pittsburgh.

7.Pablo, C.M., Jose, B.P., Ana R.A. (2000) Economic efficiency in Spanish port: some empirical evidence, **Maritime Policy & Management., Vol. 27, No.2, 169-174.**