# STUDY ON TRANSPORTATION EFFICIENCY OF INTERNATIONAL CARGO FOR TAIWAN TRADE AREAS

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## ABSTRACT

This study attempts to propose the development and reflect the transportation economic efficiency for international marine-air cargo of trade countries. The method of traditional evaluation is always absolutely efficiency and can not reflect how to improve this efficiency. Therefore, this study uses the data envelopment analysis to measure the competition potentiality for international marine-air cargo of input-output trade countries, also applies industry trade concentration index and area trade concentration index to analyse economic efficiency of trade amounts and rate and transportation cost for trade countries. This study uses the quantified envelopment data analysis for each import-export trade country such as cargo transportation amount, transportation fare and transportation cost as a suitable input and output variables. The survey data are 2011-2012. The results show the higher efficiency performance for air cargo of trade countries than marine cargo of trade countries. The efficiency performance of export trade countries is much better than the efficiency performances of import trade countries. The outcome also shows the European countries are the highest degree of industry trade concentration and best return to scale. Meanwhile, the aggregate economic effects of export industries by air better than the aggregate economic effects of export industries by marine, and the aggregate economic effects of import industries by marine better than the aggregate economic effects of import industries by air.

*Keywords: transportation efficiency, international cargos, Taiwan trade areas, DEA, regression*

## INTRODUCTION

Taiwan is an island country and is located the important geographic status of the east Asia region, which the trade depends on the carrier by international maritime and air transport. The Taiwan international logistics services are more important and competitive for the international manufacturing supply chain management and Taiwan regional economic development. The logistics industries not only develop intermodal transportation of air and sea, customs clearance, warehousing, dispatching, the whole process of service delivery to final customers, but also require precise control of the international terms of trade and transportation prices, to operate the globalizing logistics management and get revenues.

Domestic scholar Cai (2008) point out four dimensions of Taiwan's international logistics, customs, logistics policies, incentives and logistics infrastructure environment are improving. The past 20 years of the new economic geography scholars Fujita (1988) and Krugman (1991) began to focus on the emphasis on transportation costs for the aggregate impact of international trade and industry. In particular, Krugman combined Dixit and Stiglitz (1977) monopolistic competition model and Samuelson (1952 ) international trade market of the iceberg transportation costs to construct monopolistic competition, which assumes that a fixed proportion of the product will melt or evaporate in the course of transportation to discuss the economy increasing returns to scale and transportation costs. Krugman proves that the transportation costs of impact factor for international trade and industries aggregation effects. Recent China economists (Liang Qi 2005) and geographers (Duan Jun 2010) also starting to focus on the Fujita and Krugman exposition, to have an impact on the innovation and development of the mainland's economic geography and regional science. Transport prices and transportation costs of the changes will not only affect the international logistics industries and international trade industries of aggregation economic effects, however, in practice which routes of goods' high value, trade conditions, logistics location, airport and port conditions and other microeconomic factors will affect the conditions of competition in the international logistics industries. Therefore, this study will continue to develop and expand Krugman assumptions, increase the regional impact of the new elements to strengthen the international logistics industry regional development, transport prices and transportation costs.

In Taiwan's air markets, air transport freights are mostly high-tech and perishable goods and machine goods takes the second place in overall transport volume. Taiwan's top three imports and exports countries in freight volume are Hong Kong, Japan, and the United States December 2008 ago. Taiwan international logistics industries should know which trade counties and transport characteristic of international cargo and find their competing abilities. Owing to supplying the market knowledge or information to support industries, this study applies the theory of New Economic Geography, and considers the cargo characteristics, location factor, transportation and free trade zone for international cargo trade. This study combines the theory and data of Taiwan Ministry of Transportation and Communication Department of statistics and survey data of International air/marine cargo goods. This study first pay to study for international cargo carriers concerned with international spatial aspects of freight transportation in these important issues. This study attempts to propose the development and reflect the transportation economic efficiency for international marine-air cargo of trade countries. This study uses the DEA and regression model to measure the competition potentiality for carrier routes. The merits of this method can reflect the relative competitive degrees of air transportation to improve the weakness of import or export cargos of different trade countries.

This paper first reviews the competition characteristic of international trade in order to determine suitable value of transportation amount and fares for different cargo trade. Second, the paper proposes data envelopment analysis model to measure and analyze the efficiency performance of airline's routes. This study uses the quantified competitive indexes of each trade country such as cargo amount and transportation revenue. Third,This study intends to be applied envelopment analysis and regression analysis of the 2010-2011 years, Taiwan maritime and air transport of international cargo characteristics, location factors of import and export routes, transport costs and transport prices as the prediction and assessment of Taiwan's import and export country trade commodity inputs and production the relevance of different trade Area of the terms of trade, and also allocate the reference of future investment in the region as the international logistics industries. The use of the trade data of the Statistics Department of the Ministry of Communications announced and shipped freight survey report, combined with the theoretical basis of new economic geography, location factors to expand international trade and transportation costs, free trade, import and export of goods characteristics and other factors discussed not only theoretical framework but also applied practice the empirical data, to be contribute to the Government's transport policy formulation and effectiveness analysis. Fourthly, air/marine cargo freight cost, freight amount model are estimated by regression model. This study not only considers important variables of transportation amount, transportation rate, and transportation mileage, also employs dummy variables such cargo type, flight routes, and cross-strait relation to discuss the effect of transportation revenue of air/marine cargo. Thus, this study attempts to test above social-economic factors and compare the strength of international cargos of trade countries in order to measure and evaluate which transportation efficiency of trade countries is competitive. Finally, the paper sums up the empirical study including the elastic of transportation amount, transportation rate between transportation efficiency for Taiwan export/import countries in air cargo transportation.

# THE FACTORS AND MODEL OF TRANSPORTATION EFFICIENCY OF INTERNATIONAL AIR/MARINE CARGO

There are many methods for a general measurement of efficiency performance. The efficiency of airline efficiency influenced the completion of airline market. This study proposed data envelopment analysis model to construct efficiency. Its efficiency measurement is not only relative value and no in advance setting the weight value, but also using single ratio value to represent multi-input and output situation. The evaluating outcome can be known the resources input and output situation and improving the direction of improvement and no more standardized to deal with. Data Envelopment Analysis (Chang, 1991) is a well known technique to estimate the relative efficiencies of decision making unit with common inputs and outputs. It was applied with linear programming planning to get the optimal efficiency of decision-making unit, and then applying the dual problems approach to get the inefficiency decision-making unit to improve the input and output direction and range. In practice the linear programming version of the fractional program is used as it can easily be solved using a linear programming software package. This study is by means of factors between input and output relation and mathematics programming to construct models.

Data Envelopment Analysis (DEA) is an operation research-based method for measuring the performance efficiency of decision units that are characterized by multiple inputs and outputs. DEA converts multiple inputs and outputs of a decision unit into a single measure of performance, generally referred to as relative efficiency. While traditional approaches are more appropriate for macro-level analysis, DEA is a micro-level measurement tool that may have more managerial relevance. Charnes, Cooper, and Rhodes (1978) were the first to propose the DEA methodology as an evaluation tool for decision units. Since then, DEA has been applied successfully as a performance evaluation tool in may fields including manufacturing, schools, banks, pharmacies, hospitals, and airline business. DEA is a well known technique in many fields to estimate the relative efficiencies of decision making unit with common inputs and outputs. However, it has not applied in international air/marine cargo. DEA uses linear programming planning to get the optimal efficiency of decision-making unit-an air/marine import or export country, and then applies the dual problems approach to display the less efficient decision-making unit and to improve the input and output direction and range. It can be easily be solved using a linear programming software package. Therefore, this study proposes data envelopment analysis model to construct and measure the efficiency for each international air/marine of cargo transportation. This study also can sum up the efficiency performance including the total efficiency, the pure efficiency, the scale efficiency and return to scale for Taiwan export/import countries in air/marine cargo transportation.

Performance is considered to be a kind of examination for organization to measure the level they achieve their objectives. Moreover, some studies hold an opinion that performance means the same as objectives. Also, the performance is considered to be included two phases of meaning, which are as efficiency and effectiveness. Efficiency is measured with the ratio of output and input since to raise efficiency means to gain more amount of output with an identical amount of input. Meanwhile, the fundamental goal of good service operations is punctuality, accuracy, and quality. In order to increasing levels of international and opening of new markets, there are significant issues through focusing attention on the efficient flight management for airlines. There are some competition characteristics and factors to be considered including carrier choice, frequency levels, aircraft size and transportation rate. The airline strategies are to increase flight frequencies between the city pairs, and depend on the demand to modify the aircraft size used between city pairs, reconstructing the air route structures and influencing route operating costs and market share on routes. However, most airlines are constant returns to scale (e.g. (1)). High traffic density has been found to bring significant economies to airlines. Li(e.g. (1)) considers geo-economic factors (income-related variables), location factor (travel time), service-related factors, air route structure, airlines' costs, and market share of airlines are to be taken into consideration and effectively evaluated for strategies for a competing air route planning.

Most air transport-related researches study on the related fields of air passenger, only a small portion of the air cargo sector explore research, especially for international air cargo revenue or transportation rate is one of the few. Hereby review the aviation and transportation industry, air cargo transportation rates and pricing literature, whether passenger or cargo rate structure, begin with the distance length as a measure of the basic factors of air cargo. Any of the means of transport, cargo traffic or passenger traffic is important decision variables to measure the basic air cargo rate. The factors show to affect the transportation revenue for international air cargo, flight mileage length, flight transport amount, and flight transportation rate are the most important decision variables of air cargo revenues.

Therefore, this study selected independent variables in the air cargo revenue considerations in addition to mileage and time of flight, in order to effectively reflect the differences of the different types of goods on the freight revenue. This study employed the dummy variables to discuss the industry competition, such as whether high-tech goods or not, whether perishable goods or not, whether regional Asia routes or not, to be concluded as cargo goods. Much emphasis is placed on air route development variables such that social-economic variables and carrier operating variables, however, little focuses are on the routes of efficiency performance and market share competition. Most of the past research air cargo revenues use dollars to reflect the amount of profit, which can not reflect the relationship between input costs and output gains of the different goods or different routes as it lacks to show operating indicators such as operational cost threshold, market growth, production and revenue for each import/export route, or improving direction, such as modify which route's transportation rate to expand the catchment area are neglected. Therefore, this study propose and introduce air transportation revenue model to measure the ton-kilometer and extended ton-hour the way to evaluate each route's operational cost threshold to provide more operational indicators or statistics for Taiwan aviation logistic markets.

# THE MODEL FORMUATION OF TRANSPORT EFFICENCY FOR TAIWAN TRADE AREA

## Model Assumption and Formulation

This section first studies the related variables of efficiency performance for air/marine cargo in main area. Second, chooses the suitable input/output variables of efficiency performance. Third, constructs the data envelopment analysis of mathematic model.

## Primary Model

The mathematic model of data envelopment analysis can formulate as function (1) to (4). Function (1) represents the maximum rate to be equal to the rate of total outputs and inputs. Function (2) represents the rate of total outputs and inputs must smaller than 1. Function (3) represents the dummy variable of each output item must larger than 0. Function (4) represents the dummy variable of each input item must larger than 0.

$$Max \quad h_k = \frac{\sum_{r=1}^{s} U_r Y_{rk}}{\sum_{i=1}^{m} V_i X_{ik}} \tag{1}$$

$$S.T. \quad \frac{\sum_{r=1}^{s} U_r Y_{rk}}{\sum_{i=1}^{m} V_i X_{ik}} \leq 1 \ , k = 1,......,\text{n} \tag{2}$$

$$U_r \geq \varepsilon > 0 \, ; r = 1,..., s \tag{3}$$

$$V_r \geq \varepsilon > 0 \, ; i = 1,..., m \tag{4}$$

where,

$h_k$ : Represent the efficiency for the international air/marine cargo in import/export trade area k.

$X_{ik}$: Represent the input value for the trade area k of the $i$ cargo transportation amount.

$Y_{rk}$: Represent the output value for the trade area k of the r transportation fares.

$V_i$: Represent the dummy variable of the $i$ input item of cargo transportation amount.

$U_r$: Represent the dummy variable of the r output item of transportation fares. Thus, the scale efficiency of per decision making unit will as follows

## Charnes, Cooper and Rhodes Model (CCR Model)

The fraction mathematic model can transform the formulations to function (5) to (9) by Charnes, Cooper and Rhodes. Function (5) represents the maximum performance of total outputs. Function (6) represents the performance of total inputs must equal to 1. Function (7) represents the maximum performance of total outputs subtracts the performance of total inputs must smaller equal to 1. Function (8) represents the dummy variable of each output item must larger than 0 Function (9) represents the dummy variable of each input item must larger than 0.

$$Max \quad \sum_{r=1}^{s} U_r Y_{rk} \tag{5}$$

$$S.T. \quad .\sum_{i=1}^{m} V_i X_{ik} = 1 \tag{6}$$

$$\sum_{r=1}^{s} U_r Y_{rk} - \sum_{i=1}^{m} V_i X_{IK} \leq 0, k = 1,..., n \tag{7}$$

$$U_r \geq \varepsilon > 0 ; r = 1,..., s \tag{8}$$

$$V_r \geq \varepsilon > 0 ; i = 1,..., m \tag{9}$$

## Dual Model of CCR

The primary mathematic model can transform the formulations of dual model as function (10) to (13). Function (10) represents the minimum of difference between input and output values of total slacks variable. Function (11) represents the relation between input item variable and input slack variable. Function (12) represents relation between output item variable and output slack variable. Function (13) represents the slack variables of each input/output item must larger than 0.

$$Min \quad \theta - \varepsilon\left(\sum_{r=1}^{s} S_r^+ + \sum_{i=1}^{m} S_i^-\right) \tag{10}$$

$$S.T. \quad \sum_{k=1}^{n} \lambda_k X_{ik} + S_i^- = \theta X_{ik}, i = 1..., m \tag{11}$$

$$\sum_{k=1}^{n} \lambda_k Y_{rk} - S_r^+ = Y_{rk}, r = 1..., s \tag{12}$$

$$\lambda_k, S_i^-, S_r^+ \geq 0, \forall i, r, k \tag{13}$$

$S_i^{-*}$ : Represent the slack variable of the $i$ item input variable.

$S_r^{+*}$ : Represent the slack variable of the $i$ item output variable.

$\lambda_k$ : Represent the dual price of slack variable

**Banker,Chames and Cooper (BCC) Model**

Eq.(14)- (19) is the Banker, Chames and Cooper (BCC) Model.

$$Max \quad \sum_{r=1}^{s} U_r Y_{rk} - U_k \tag{14}$$

$$S.T. \quad \sum_{i=1}^{m} V_i X_{ik} = 1 \tag{15}$$

$$\sum_{r=1}^{s} U_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} - U_k \le 0, k = 1,..., n \tag{16}$$

$$U_r \ge \varepsilon > 0 ; r = 1,..., s \tag{17}$$

$$V_r \ge \varepsilon > 0 ; i = 1,..., m \tag{18}$$

$U_k$ no constraints; $j = 1,..., n$ (19)

**Dual Model of BCC**

Eq.(20)- (24) is the dual model of BCC.

$$Min \quad \theta_k - \varepsilon \left( \sum_{r=1}^{s} S_r^{+} + \sum_{i=1}^{m} S_i^{-} \right) \tag{20}$$

$$S.T. \quad \sum_{k=1}^{n} \lambda_k X_{ik} + S_i^{-} \le \theta_k X_{ik}, i = 1..., m \tag{21}$$

$$\sum_{k=1}^{n} \lambda_k Y_{rk} - S_r^{+} \ge Y_{rk}, r = 1..., s \tag{22}$$

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{23}$$

$$\lambda_k, S_i^{-}, S_r^{+} \ge 0, \forall i, r, k \tag{24}$$

**Scale Efficiency Model**

The total technical efficiency model is above mention Eq.(5)-(9) is the Charnes, Cooper and Rhodes Banker (CCR) Model. Meanwhile, the pure technical efficiency model is above mention Eq.(14)-(19) is the Banker, Chames and Cooper (BCC) Model. Thus, the scale efficiency of per decision making unit as follows Eq. (25) If the value of Eq(5) is equal Eq.(14) represent the scale efficiency is optimal. If the value of Eq(25) is equal 1 that represent the scale efficiency of per making decision unit is optimal.

$$SE_k = \frac{CCR_k}{BCC_k} \tag{25}$$

### Return to Scale

The This study also computes the value of $\sum_{j=1}^{n}\lambda_j$ to get the value of return to scale for each decision-making unit. If the value of $\sum_{j=1}^{n}\lambda_j > 1$, this figure represents deceasing of return to scale for each decision-making unit. If the value of $\sum_{j=1}^{n}\lambda_j < 1$, the figure represents increasing of return to scale for each decision-making unit. If the value of $\sum_{j=1}^{n}\lambda_j = 1$, the figure represents constant of return to scale for each decision making unit. That is to say Eq. (25) to create the scale efficiency of air/marine cargo transportation for each trade area. Thus, the value of the scale efficiency for each trade area k is equal 1 that represent the scale efficiency of every trade area k is optimal. This study also computes the value of $\sum_{j=1}^{n}\lambda_j$ to get the value of return to scale for each trade area. If the value of $\sum_{j=1}^{n}\lambda_j > 1$, this figure represents deceasing of return to scale for each trade area. If the value of $\sum_{j=1}^{n}\lambda_j < 1$, the figure represents increasing of return to scale for each trade area. If the value of $\sum_{j=1}^{n}\lambda_j = 1$, the figure represents constant of return to scale for each trade area.

## THE MODEL APPLICATION

This section will separate three parts as follows: import/export transportation amount for main air/marine cargo areas, DEA model for import/export main air/marine cargo areas, and result analysis. This study applied above mentioned CCR model ( Eq.(5)-(9) )and BCC model (Eq.(14) -(19) ) to create the total technical efficiency of air/marine cargo transportation and the pure technical efficiency of air/marine cargo transportation.

### Import/export Transportation Amount for Main Air/marine Cargo Areas

Because of data are difficult to collect, this study collects the data of three important variables from the statistics and survey data of the Ministry of Transportation and Communication on 2010-2011. These there variables of input items, one is the transportation amount for each export/import country of air/marine, the other is the transportation rate for each export/import country of air/marine transportation. The output variable is transportation cost. This study takes as two input variables which one is transportation amount of three bigger important air/marine import/export trade area, another variable which is transportation rate of three bigger important air/marine import/export trade area. The total trade areas are 240 nations in 2010-2011 statistic data as 240 decision marking units.

Table 1-2 shows the higher cargo transportation amount rate of trade countries by marine than by air, and the higher cargo transportation rate of trade countries by air than by marine. Meanwhile, the air/ marine transportation amount of export trade countries are lower than the transportation amount of import trade countries. Another trend is air/marine transportation fare of export trade countries is higher than the transportation amount of import trade countries. This shows the sensitivity of transportation fares for air transportation is more than marine transportation. Meanwhile, the transportation rate of America and Europe export/important national areas are larger than Asia national areas.

Table 1 Transportation amount of import/export industries for air/marine transportation (Tons)

| Classify | Trade area | Year | Marine | | Aviation | |
|---|---|---|---|---|---|---|
| | | | 2010 | 2011 | 2010 | 2011 |
| Import | Middle East | Average | 9791133.50 | 8306336.00 | - | - |
| | | Standard error | 11854643.07 | 9766037.02 | - | - |
| | | Sample number | 2 | 2 | - | - |
| | Asia | Average | 4576131.71 | 4304014.00 | 7022.10 | 6441.05 |
| | | Standard error | 8188319.02 | 8337240.52 | 6867.84 | 6950.92 |
| | | Sample number | 14 | 15 | 19 | 17 |
| | Americas | Average | 1677190.20 | 2083385.38 | 3914.01 | 3556.58 |
| | | Standard error | 1745074.49 | 1946834.17 | 5113.86 | 4474.85 |
| | | Sample number | 10 | 8 | 10 | 10 |
| | Europe | Average | | | 5794.48 | 3010.02 |
| | | Standard error | | | - | 4018.71 |
| | | Sample number | | | 1 | 3 |
| | Australia | Average | 11717146.75 | 9180972.20 | | |
| | | Standard error | 13552211.08 | 12101708.41 | | |
| | | Sample number | 4 | 5 | | |
| Export | Asia | Average | 888640.92 | 901007.59 | 6811.08 | 6159.08 |
| | | Standard error | 1528727.70 | 1497546.83 | 10470.83 | 10153.83 |
| | | Sample number | 24 | 22 | 22 | 21 |
| | Africa | Average | | 425282.00 | | |
| | | Standard error | | - | | |
| | | Sample number | | 1 | | |
| | Americas | Average | 411229.28 | 354346.80 | 9338.97 | 7560.11 |
| | | Standard error | 257143.57 | 270945.03 | 12473.82 | 10387.73 |
| | | Sample number | 4 | 5 | 6 | 7 |
| | Europe | Average | 121901.36 | 161555.00 | 509.39 | 592.65 |
| | | Standard error | - | - | 339.95 | 230.60 |
| | | Sample number | 1 | 1 | 2 | 2 |
| | Australia | Average | 813261.40 | 761283.00 | - | - |
| | | Standard error | - | - | - | - |
| | | Sample number | 1 | 1 | - | - |

Table 2 Transportation rate of import/export industries for Air/Marine transportation (NT dollars/ton)

| Classify | Trade Area | Year | Marine | | Aviation | |
|---|---|---|---|---|---|---|
| | | | 2010 | 2011 | 2010 | 2011 |
| Import | Middle East | Average | 836 | 790 | - | - |
| | | Variance | 287282.000 | 243602.000 | - | - |
| | | Sample number | 2 | 2 | - | - |
| | Asia | Average | 594 | 524 | 44421 | 49294 |
| | | Variance | 94401.654 | 55637.124 | 163712865.497 | 144845588.235 |
| | | Sample number | 14 | 15 | 19 | 17 |
| | Americas | Average | 960 | 976 | 61090 | 70300 |
| | | Variance | 178791.333 | 154905.929 | 196838777.778 | 217566666.667 |
| | | Sample number | 10 | 8 | 10 | 10 |
| | Europe | Average | - | - | 87100 | 84333 |
| | | Variance | - | - | - | 9333333.333 |
| | | Sample number | - | - | 1 | 3 |
| | Australia | Average | 464 | 467 | - | - |
| | | Variance | 44881.583 | 48490.700 | - | - |
| | | Sample number | 4 | 5 | - | - |
| Export | Asia | Average | 1218 | 1196 | 35750 | 40143 |
| | | Variance | 524189.311 | 644342.346 | 212388333.333 | 225728571.429 |
| | | Sample number | 24 | 22 | 22 | 21 |
| | Africa | Average | | 41 | | |
| | | Variance | | - | | |
| | | Sample number | | 1 | | |
| | Americas | Average | 5084 | 5494 | 67650 | 72000 |
| | | Variance | 9541700.080 | 8099027.500 | 32123000.000 | 116333333.333 |
| | | Sample number | 4 | 5 | 6 | 7 |
| | Europe | Average | 3856 | 3450 | 94600 | 104500 |
| | | Variance | - | - | 375380000.000 | 40500000.000 |
| | | Sample number | 1 | 1 | 2 | 2 |
| | Australia | Average | 260 | 201 | - | - |
| | | Variance | - | - | - | - |
| | | Sample number | 1 | 1 | - | - |

# THE RESULTS AND DISCUSSION

## The Analysis of Transportation Efficiency Performance for Each Trade Areas

We take both input and output data into DEA model (BCC and CCR), which is operating by LINDO software. Table 3 shows the efficiency performances of 240 trade area decision-making units. It can separate four groups to analysis the efficiency performance between air/marine and import/export nations. From the DEA figures of efficiency performances such as total technical efficiency, pure technical efficiency, return to scale, and scale efficiency for evaluated 240 units to analyze which units are better condition. The result shows the higher efficiency performance for air cargo of trade areas than marine cargo of trade areas. The total technical efficiency and pure technical efficiency of for air cargo of trade areas are more efficient than marine cargo of trade areas. Meanwhile, we can see the value of scale efficiency for almost export trade areas are still higher than the value of scale efficiency for import cargo of trade areas. These tends means the efficiency performance of export trade areas is higher than the efficiency performances of import trade countries. The outcome also shows the scale efficiency of import/export America and Europe trade areas are better than import/export Asia and Austria trade areas.

Table 3 Scale efficiency of import/export industries for air/maritime transportation

| Classify | Trade Area | Year | Marine | | | Aviation | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2010 | 2011 | Total | 2010 | 2011 | Total |
| Import | Middle East | Average | 0.473 | 0.611 | 0.542 | - | - | - |
| | | Variance | 0.315 | 0.599 | 0.311 | - | - | - |
| | | Sample number | 2 | 2 | 4 | - | - | - |
| | Asia | Average | 0.595 | 0.603 | 0.599 | 0.693 | 0.651 | 0.673 |
| | | Variance | 0.123 | 0.083 | 0.098 | 0.045 | 0.052 | 0.047 |
| | | Sample number | 14 | 15 | 29 | 19 | 17 | 36 |
| | Americas | Average | 0.657 | 0.793 | 0.718 | 0.819 | 0.815 | 0.817 |
| | | Variance | 0.074 | 0.039 | 0.060 | 0.049 | 0.046 | 0.045 |
| | | Sample number | 10 | 8 | 18 | 10 | 10 | 20 |
| | Europe | Average | - | - | - | 1.000 | 0.976 | 0.982 |
| | | Variance | - | - | - | - | 0.002 | 0.001 |
| | | Sample number | - | - | - | 1 | 3 | 4 |
| | Australia | Average | 0.600 | 0.583 | 0.591 | - | - | - |
| | | Variance | 0.179 | 0.125 | 0.130 | - | - | - |
| | | Sample number | 4 | 5 | 9 | - | - | - |
| Export | Asia | Average | 0.506 | 0.578 | 0.541 | 0.646 | 0.594 | 0.620 |
| | | Variance | 0.070 | 0.042 | 0.057 | 0.069 | 0.056 | 0.062 |
| | | Sample number | 24 | 22 | 46 | 22 | 21 | 43 |
| | Africa | Average | - | 0.062 | 0.062 | - | - | - |
| | | Variance | - | - | - | - | - | - |
| | | Sample number | - | 1 | 1 | - | - | - |
| | Americas | Average | 0.863 | 0.908 | 0.888 | 0.976 | 0.986 | 0.981 |
| | | Variance | 0.075 | 0.039 | 0.048 | 0.017 | 0.001 | 0.008 |
| | | Sample number | 4 | 5 | 9 | 6 | 7 | 13 |
| | Europe | Average | 0.609 | 0.766 | 0.687 | 0.981 | 1.000 | 0.990 |
| | | Variance | - | - | 0.012 | 0.001 | 0.000 | 0.000 |
| | | Sample number | 1 | 1 | 2 | 2 | 2 | 4 |
| | Australia | Average | 0.239 | 0.317 | 0.278 | - | - | - |
| | | Variance | - | - | 0.003 | - | - | - |
| | | Sample number | 1 | 1 | 2 | - | - | - |
| Total | | Average | 0.578 | 0.632 | 0.605 | 0.740 | 0.725 | 0.732 |
| | | Variance | 0.095 | 0.080 | 0.087 | 0.061 | 0.063 | 0.062 |
| | | Sample number | 60 | 60 | 120 | 60 | 60 | 120 |

From the figures as Table 4 of the return to scale of 240 trade areas, shows there are 22 units of fixed the return to scale, 207 units of increasing the return to scale, and 11 units of is decreasing of return to scale. There are there are 13 units by marine of fixed the return to scale, 103 units by marine of increasing the return to scale, and 4 units by marine of is decreasing of return to scale. There are there are 9 units by air of fixed the return to scale, 104 units by air of increasing the return to scale, and 7 units by air of is decreasing of return to scale. We can see the optimal industry trade areas of 2011-2012 are marine export industries of articles of iron or steel,machanical appliances and parts, and marine import industries are salt, sulphur, earths and stone,ores, slag and ash and mineral fuels, mineral oils and products of their distillation. The marine import industry units of increasing return to scale are higher than marine export industry units of increasing return to scale. Meanwhile, the optimal trade areas of 2011-2012 are air export industries of electrical machinery and equipment and parts thereof, live trees and other plants, and air import industries are fish and other acquatic invertebrates. The export industry units of increasing return to scale by air are higher than import industry units of increasing return to scale by air. These figures show the turn to scale of export industries by air better than the turn to scale of export industries by marine and the turn to scale of import industries by marine better than the turn to scale of import industries by air. This means the aggregate economic effects of export industries by air better than the aggregate economic effects of export industries by marine, and the aggregate economic effects of import industries by marine better than the aggregate economic effects of import industries by air.

Table 4 Return to scale of Import/export industries for marine/aviation transportation

| Transportation | Marine | | | | | | Aviation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2010 | | | 2011 | | | 2010 | | | 2011 | | |
| Industries(import/export) | $\sum\lambda=1$ | $\sum\lambda>1$ | $\sum\lambda<1$ | $\sum\lambda=1$ | $\sum\lambda>1$ | $\sum\lambda<1$ | $\sum\lambda=1$ | $\sum\lambda>1$ | $\sum\lambda<1$ | $\sum\lambda=1$ | $\sum\lambda>1$ | $\sum\lambda<1$ |
| Fish and other acquatic invertebrates | | | | | | | 1/0 | | 2/3 | 1/0 | | 2/3 |
| Live trees and other plants | | | | | | | 0/1 | | 0/2 | 0/1 | | 0/2 |
| Edible vegetables | | | | | | | | | 3/0 | | | 3/0 |
| Edible fruit and nuts | | | | | | | | | 3/0 | | | 3/0 |
| Cereals | | | 3/0 | 1/0 | | 2/0 | | | | | | |
| Oil seeds, oleaginous fruits and fodder | | | 3/0 | | | 3/0 | | | | | | |
| Salt, sulphur, earths and stone; | 1/0 | | 2/3 | 1/0 | | 2/3 | | | | | | |
| Ores, slag and ash | 1/0 | | 2/0 | 1/0 | | 2/0 | | | | | | |
| Mineral fuels, mineral oils and products of their distilation | 1/0 | 2/0 | | 1/0 | 2/0 | | | | | | | |
| Inorganic chemicals prectous metals | | | 3/3 | | | 3/3 | | | | | | |
| Organic chemicals | | | 6/0 | | | 6/0 | | | | | | |
| Pharmaceutical products | | | | | | | | | | | | 3/0 |
| Miscellaneous chemical products | | | | | | | | | 3/0 | | | 3/0 |
| Plastics and articles thereof | | | 3/3 | | | 3/3 | | | 3/3 | | | 3/3 |
| Rubber and articles thereof | | | | 0/1 | | 0/2 | | | | | | |
| Wood and articles of wood | | | 3/0 | | | 3/0 | | | | | | |
| Paper or of paperboard | | | 0/3 | | | 0/3 | | | | | | |
| Man-made filaments | | | 0/3 | | | | | | | | | |
| Knitted or crocheted fabrics | | | | | | | | | 0/3 | | | 0/3 |
| Articles of apparel and clothing accessories, knitted or crocheted | | | | | | | | | 3/0 | | | |
| Glass and glassware | | | | | | | | | 3/3 | | | 3/3 |
| Iron and steel | | | 3/3 | | | 3/3 | | | | | | |
| Articles of iron or steel | 0/1 | | 0/2 | 0/1 | | 0/2 | | | 0/3 | | | 0/3 |
| Machanical appliances and parts | 0/1 | | 0/2 | 0/1 | | 0/2 | | 2/0 | 1/3 | | 1/0 | 2/3 |
| Electrical machinery and equipment and parts thereof | 0/1 | | 0/2 | | | 0/3 | 0/2 | 2/0 | 1/1 | 0/2 | 2/0 | 1/1 |
| Vehicles other than railway or tramway rolling-stock, and parts and accessories | | | | | | | | | 0/3 | 0/1 | | 0/2 |
| Optical, photographic, medical or surgical instruments and apparatus | | | | | | | | | 3/3 | | | 3/3 |
| Total | 3/3 | 2/0 | 28/24 | 4/3 | 2/0 | 27/24 | 1/3 | 4/0 | 25/27 | 1/4 | 3/0 | 26/26 |

This study find the 22 optimal units by air/marine of fixed the return to scale(scale efficiency=1), we pick up these 22 optimal units to compute each unit of the degree of industries trade concentration and the degree of area trade concentration to analyze the relation between the degree of industries trade concentration, the degree of area trade concentration and scale efficiency. The function of the degree of industries trade concentration and the degree of area trade concentration as follows:

The export commodities concentration (XCC) defined formula (26) the commodity exports accounted for each region the proportion of total merchandise exports of the classification to be square find the square root of the sum and then that was. If the commodity in the regions distributed more evenly over the convenient lower the concentration. The imported goods concentration (MCC) is defined formulas (27) Imports of various commodities regional share of total imports of the commodities are square find the square root of the sum and then that was the proportion of them. If the commodity in the regions distributed more evenly over the convenient lower the concentration. The export areas concentration (XRC) were defined formulas (28) various commodities regional export share of total exports of each commodity, be square find the square root of the sum and then that was, GC value means that the higher the concentration of the degree of the higher ratio. Importer region concentration (MRC) the imports defined formula (29) for each commodity imports for each region share of total imports of each commodity, be square find the square root of the sum and then that was, GC value means that the higher the concentration of the degree of the higher ratio.

$$CC_{Xj} = \sqrt{\sum_{i=1}^{n}\left(\frac{X_{ij}}{X_{.j}}\right)^2} \qquad (26)$$

$$CC_{Mj} = \sqrt{\sum_{i=1}^{n}\left(\frac{M_{ij}}{M_{.j}}\right)^2} \qquad (27)$$

$$GC_{Xi} = \sqrt{\sum_{j=1}^{m}\left(\frac{X_{ij}}{X_{i.}}\right)^2} \qquad (28)$$

$$GC_{Mii} = \sqrt{\sum_{j=1}^{m}\left(\frac{M_{ij}}{M_{i.}}\right)^2} \qquad (29)$$

We can find the Table 5,6 show the figure of the degree of industries trade concentration and the degree of area trade concentration for 22 optimal units. We find that the degree of industries trade concentration of aviation transportation units are higher than the degree of industries trade concentration of marine transportation units. The degree of industries trade concentration in Europe trade areas are closed to 1, this means that the degree of industries trade concentration in Europe trade areas are very industries trade concentrated. Meanwhile, the degree of area trade concentration of marine transportation units are higher than the degree of industries trade concentration of aviation transportation units. The degree of areas trade concentration in Asia and America by marine are bigger than the others areas. the figures show that the degree of industry trade concerned for optimal efficiency of Taiwan international trade transportation is air transportation better than marine transportation, and

Table 5 The degree of industries trade concentration of 22 optimal unit (Scale efficiency=1)

| Classify | Trade area | Year | Marine 2010 | Marine 2011 | Marine Total | Aviation 2010 | Aviation 2011 | Aviation Total |
|---|---|---|---|---|---|---|---|---|
| Import | Asia | Average | 0.676 | 0.744 | 0.721 | | | |
| | | Variance | - | 0.132 | 0.067 | | | |
| | | Sample number | 1 | 2 | 3 | | | |
| | Americas | Average | 0.470 | 0.526 | 0.507 | | | |
| | | Variance | - | 0.006 | 0.004 | | | |
| | | Sample number | 1 | 2 | 3 | | | |
| | Europe | Average | | | | 1.000 | 1.000 | 1.000 |
| | | Variance | | | | - | - | 0 |
| | | Sample number | | | | 1 | 1 | 2 |
| | Australia | Average | 0.538 | | 0.538 | | | |
| | | Variance | - | | - | | | |
| | | Sample number | 1 | | 1 | | | |
| Export | Asia | Average | | | | 0.384 | 0.385 | 0.384 |
| | | Variance | | | | - | - | 0 |
| | | Sample number | | | | 1 | 1 | 2 |
| | Americas | Average | 0.565 | 0.493 | 0.529 | 0.409 | 0.382 | 0.396 |
| | | Variance | 0 | 0 | 0.002 | - | - | 0.000 |
| | | Sample number | 3 | 3 | 6 | 1 | 1 | 2 |
| | Europe | Average | | | | 1.000 | 1.000 | 1.000 |
| | | Variance | | | | - | 0 | 0 |
| | | Sample number | | | | 1 | 2 | 3 |

Table 6 The degree of trade area concentration for 22 optimal units (Scale efficiency=1)

| Classify | Trade area | Year | Marine 2010 | Marine 2011 | Marine Total | Aviation 2010 | Aviation 2011 | Aviation Total |
|---|---|---|---|---|---|---|---|---|
| Import | Middle East | Average | | | | - | - | - |
| | | Variance | | | | - | - | - |
| | | Sample number | | | | - | - | - |
| | Asia | Average | 0.818 | 0.694 | 0.735 | | | |
| | | Variance | | 0.018 | 0.014 | | | |
| | | Sample number | 1 | 2 | 3 | | | |
| | Americas | Average | 0.677 | 0.715 | 0.702 | | | |
| | | Variance | | 0.004 | 0.002 | | | |
| | | Sample Number | 1 | 2 | 3 | | | |
| | Europe | Average | | | | 0.580 | 0.602 | 0.591 |
| | | Variance | | | | | | 0 |
| | | Sample number | | | | 1 | 1 | 2 |
| | Australia | Average | 0.589 | | 0.589 | | | |
| | | Variance | | | | | | |
| | | Sample number | 1 | | 1 | | | |
| Export | Asia | Average | | | | 0.578 | 0.581 | 0.580 |
| | | Variance | | | | | | 0.000 |
| | | Sample number | | | | 1 | 1 | 2 |
| | Americas | Average | 0.693 | 0.662 | 0.678 | 0.578 | 0.581 | 0.580 |
| | | Variance | 0.004 | 0.006 | 0.004 | | | 0.000 |
| | | Sample number | 3 | 3 | 6 | 1 | 1 | 2 |
| | Europe | Average | | | | 0.794 | 0.738 | 0.757 |
| | | Variance | | | | | 0.008 | 0.005 |
| | | Sample number | | | | 1 | 2 | 3 |

the degree of trade area concerned for optimal efficiency of Taiwan international trade transportation is marine transportation better than air transportation.

## Regression Analysis

This study expects to estimate the difference transportation amount and fare of international trade area, therefore, this study applied 22 optimal data and design the dummy of the export/import areas is from/to Asia countries or not, if belong to Asia country, the value of dummy variable is 1, otherwise is 0. We also employ the dummy variable of import/export areas, if the value of export cargos is 1, otherwise the value of import cargos is 0. We also use the dummy variable of marine/air transportation, if the value of marine cargo transportation is 1, otherwise the value of air cargo transportation is 0. We sum up above mentioned t variables of total technical efficiency, pure technical efficiency, return to scale, scale efficiency, cargo transportation amount and fare, transportation cost to compute these 16 variables. In this study, selection of the dependent variable and independent variables are presented as follows:

$T_{cost}$ : Represent freight transportation costs of each type cargo on/for the various routes

$T_{amount}$ : Represent types of cargo transportation amount on/for the various routes (Unit: tons)

$T_{rate}$ : Represent Types of cargo transportation rate on/for the various routes.

$Exp$ : Represent Dummy variables for various types of import or export of goods belonging to the various routes, where $Exp = 1$ represent export, otherwise, represent import.

$Air$ : Represent Dummy variables for various types of air or maritime of goods belonging to the various routes, where $Air = 1$ represent air cargo, otherwise, represent maritime cargo.

$Asia$ : Represent all kinds of goods in the various routes and dummy variables of Asian regional routes, where $Asia = 1$, represent Asian regional routes, otherwise, $Asia = 0$ represent nonAsian regional routes.

$ENAsia$ : Represent all kinds of goods in the various routes and dummy variables of east-north Asian regional routes, where $ENAsia = 1$, represent east-north Asian regional routes, otherwise, $ENAsia = 0$ represent non east-north Asian regional routes.

$ESAsia$ : Represent all kinds of goods in the various routes and dummy variables of east-south Asian regional routes, where $ESAsia = 1$, represent east-south Asian regional routes, otherwise, $ESAsia = 0$ represent non east-south Asian regional routes.

$EU$ : Represent all kinds of goods in the various routes and dummy variables of European regional routes, where $EU = 1$, represent European regional routes, otherwise, $EU = 0$ represent non-European regional routes.

$America$ : Represent all kinds of goods in the various routes and dummy variables of America regional routes, where $America = 1$, represent America regional routes, otherwise, $America = 0$ represent nonAsian regional routes.

$Austria$ : Represent all kinds of goods in the various routes and dummy variables of Austrian regional routes, where $Austria = 1$, represent Austrian regional routes, otherwise, $Austria = 0$ represent non-Austrian regional routes.

$Tech$: Represent all types of cargo at the various routes for the dummy variable of high technology goods, where $Tech = 1$ represent high tech goods, otherwise, represent non high technology goods.

$Perish$ : Represent all types of cargo at the various routes for perishable goods, the dummy variable, where $Perish = 1$ represent perishable goods, otherwise, represent non-perishable goods

$Dis\tan ce$ : Represent all types of cargo in the actual distance mileage (kilometers ) of each route. .

$CC_{XM}$ : Represent the degree of industries trade concentration for import/export by air/marine.

$GC_{XM}$ : Represent the degree of area trade concentration for import/export by air/marine.

**Estimation Models**

From the correlation coefficient figures of 16 variables as Table 7, show the variables of transportation amount, transportation fare, total costs, distance, the degree of industries trade concentration for import/export by air/marine,. the degree of area trade concentration for import/export by air/marine and 10 dummy variables of 40 trade area. The outcomes show that the transportation cost estimation are mainly influence with transportation amount, regional variance as function (30). The European countries can decrease the transportation cost about 1,927 million NT dollars, but Austrian countries will increase 8604 million NT dollars. The relation between transportation cost and transportation distance are not significant. We also find transportation amount are mainly influence with export type, by air, regional areas difference such as function (31). Although transportation distance and transportation amount are not significant relationship, we can see the transportation amount of Austrian, south-eastern and Asian are increasing. The aviation transportation amount will decrease 4045 thousand ton than marine transportation amount. The export transportation amount will decrease 5220 thousand ton. The transportation rate is mainly influence with by air, regional area difference, perishable cargo, and the degree of industries trade concentration for import/export by air/marine such function (32)-(34). From function (30) to (34) provide the next step to estimate the transportation cost, transportation amount and transportation rate for Taiwan international trade areas.

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$T_{\cos t} = 2188.01 + 0.163 T_{amount} + 8603.704 Australia - 1927.226 EU$ (Million NT dollars)

(t=5.501) (4.211) (5.029) (-2.648) (30)

$R^2 = 0.875, F = 41.914, n = 22$

$T_{amount} = 6415.837 - 5219.785 Exp + 24025.904 Austria + 15774.191 SEAsia + 7675.593 Asia - 4044.738 Air$

(t=4.750) (-3.368) (6.996) (4.323) (4.276) (-2.753)

$R^2 = 0.920, F = 36.995, n = 22$ (Thousand ton) (31)

$T_{rate} = 3.290 + 51.91 Air + 42.68 EU$ (Thousand NT dollars/ton)

(t=1.244) (9.524) (6.675)

$R^2 = 0.952, F = 189.633, n = 22$ (32)

$T_{rate} = 64.160 Air + 33.190 Persih$ (Thousand NT dollars/ton)

(t=10.896) (3.758)

$R^2 = 0.944, F = 168.703, n = 22$ (33)

$$T_{rate} = 67.762 Air + 15.297 CC_{XM} \quad \text{(Thousand NT dollars/ton)} \qquad (34)$$

(t=9.626) (2.297)

$R^2 = 0.924, F = 102.385, n = 22$

# CONCLUSION

This paper employed the DEA method to measure the scale efficiency of air/ marine transportation in Import/ export trade areas. Meanwhile, this paper proposes new strategies to improve current efficiency. The major findings from this study are summarized in the following:

First, the outcomes of the scale efficiency for main import/export Taiwan national areas show that the average efficiency by air is better than by marine. These outcomes can identify those main import/export national areas of Taiwan that are not scale efficiency and propose advance strategies or tactics to improve no efficiency national areas to be more efficient. The other hand, these 240 unit figures show the turn to scale of export industries by air better than the turn to scale of export industries by marine and the turn to scale of import industries by marine better than the turn to scale of import industries by air. This means the aggregate economic effects of export industries by air better than the aggregate economic effects of export industries by marine, and the aggregate economic effects of import industries by marine better than the aggregate economic effects of import industries by air.

Second, the result shows the scale efficiency performances of export trade countries are much better than the efficiency performances of import trade countries, no matter in air or marine cargo transportation. The outcome also shows the European countries not only the bigger coefficient of scale efficiency than other region, but also the highest degree of industry trade concentration and best economic performance by aviation. Therefore, The regression estimation predict the scale efficiency of European countries can decrease the transportation cost estimation of European countries can decrease transportation cost, but Austrian must increase transportation cost.

Third, although transportation distance and transportation amount are not significant relationship, we can see the transportation amount of Austrian, south-eastern and Asian are larger increasing in optimal 22 trade areas.

Fourth, the transportation rate is mainly influence with by air, regional area difference, perishable cargo, and the degree of industries trade concentration for import/export by air/marine correlation coefficient between dummy variable of Asia country and the other variables shows that no matter air or marine international air/marine cargo transportation,

Fifth, the cargo transportation rate of marine are cheaper than air the cargo transportation fares for 22 main trade areas.

Finally, this DEA and regression model can be employed to study air/marine transportation strategies, and can be used as references and tools to compare efficiency differences between air and marine. In the next steps, we can deeply study the transport efficiency of export/import trade areas and international air/marine transportation for different trade industries.

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