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# Integrating the Additive Seasonal Model and Super-SBM Model to Compute the Efficiency of Port Logistics Companies in Vietnam

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**Abstract:** The growing trade process is pushing the importing and exporting ratio of products at ports in Vietnam. The total amount of goods is determined by analyzing the effectiveness of products that are delivered at ports. Thus, this research presents a whole performance picture of the port logistics operation process at two airports and six seaport logistics companies in Vietnam to describe exchanging products by utilizing additive trend methods to formulate the efficiency and rank them from previous periods to future terms. Based on the prediction analysis, the best accuracy result is calculated by the additive Holt Winters method when the mean absolute percentage error (MAPE) indicators remain at the standard level, and its average qualification is also the lowest. Combining the actual and prediction values, the ranking of all ports accordingly by year during the past, current, and future time periods from 2011–2022 is obtained after calculating the final efficiency via the super-SBM model. The empirical result of the current and estimated efficiency denotes that Da Nang port logistics is always selected as the best port logistics company and maintained the first ranking with consistently high scores on the basis of the performance qualification. The empirical analysis result proposes the status quo of port logistics companies in Vietnam from the past to future to describe the amount of exchanging goods.

**Keywords:** port logistics; Vietnam; additive trend method; additive Holt-Winters method; MAPE; super-SBM model; efficiency

## 1. Introduction

Growing international trade requires a larger amount of products to be delivered to places all over the world. Further, the affected globalization and competitive economics are a supported foundation [1], which leads to establishing and expanding logistics servers all over the world. Professional transportation ensures that a high-quality service is provided with the criteria of safety, cost reduction, and speed [2]. In the transportation process, the port logistics company is defined as a key element to smoothly implement and control transferring goods and information at the ports in question [3]. The main services of port logistics such as environmental technologies, processes and quality improvement, monitoring and upgrading, communication and cooperation, and active participation [4], are necessary to execute the successful delivery of goods. The activities of importing and exporting products are controlled by port information systems [5]. As shown in Figure 1, the operation process is managed by the port logistics company. When a shipping container is transferred from the supplier to the warehouse at the port, customs will begin to execute their procedures step-by-step. After receiving a container, the clearance process starts by establishing a profile and then checks the image of the container and materials. It is delivered to the customer if it has been cleared; it is held and sent back to the supplier if customs detects errors.

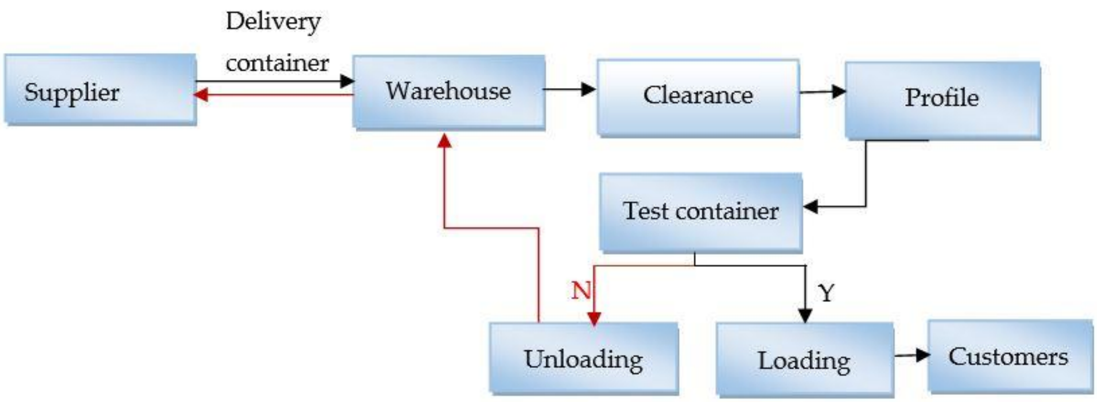


**Figure 1.** Port logistics operation process [6].

Vietnam is a developing country with a high speed of exchanging products; after joining the World Trade Organization (WTO), Vietnam was given new opportunities to take part in the global market [7]. Table 1 shows the past logistics status quo in Vietnam over the period of 2007–2016 [8]. The World Bank revealed Vietnam's position among 160 countries by employing the logistics performance index (LPI); Vietnam ranked 53rd from 2007 to 2012 and increased to 48th in 2014, but decreased to 64th in 2016. The database of the international shipments showed a continuous increase from 3.00 to 3.22 during the 2007–2014 period; however, this figure decreased to 3.12 in 2016.

**Table 1.** Vietnam's Logistics Performance Index.

| Year | LPI Rank | LPI Score | Customs | Infrastructure | International Shipments | Logistics Quality/Competence |
|---|---|---|---|---|---|---|
| 2016 | 64 | 2.98 | 2.75 | 2.7 | 3.12 | 2.88 |
| 2014 | 48 | 3.15 | 2.81 | 3.11 | 3.22 | 3.09 |
| 2012 | 53 | 3 | 2.65 | 2.68 | 3.14 | 2.68 |
| 2010 | 53 | 2.96 | 2.68 | 2.56 | 3.04 | 2.89 |
| 2007 | 53 | 2.89 | 2.89 | 2.5 | 3 | 2.8 |

Source: The World Bank [8].

For that reason, with the purpose of evaluating the operation performance and ranking of port logistics companies from past to future terms, this research project proposes recognizing the efficiency of the exchanged process of products in Vietnam's airport and seaport logistics companies by combining additive trend methods and the super-SBM model. The study applies additive trend methods for predicting the future time of airport and seaport logistics companies in Vietnam during the 2018–2022 term because Tableau integrates a prediction tool with time-series and formulating indicators such as gamma, beta, MAPE, and so on, in order to obtain accurate results. Then, for calculating their performance and determining their ranking, super-SBM in DEA helps to determine the probability of reaching the maximum efficiency [9] and ranking methodology for different performances [10]. Hence, super-SBM is utilized to escalate the efficiency of each year separately in order to seek out their position every year. The empirical analysis process provides full particular acknowledgment of airport and seaport logistics companies in Vietnam.

The paper is organised as follows: Section 1 introduces common transportation and the current status logistics in Vietnam, in addition to major characteristics of the additive trend method and super-SBM model; Section 2 is a literature review of port logistics and common background application of Tableau and its additive trend model and super-SBM model; Section 3 provides the research approach and the study's methodology; Section 4 analyzes the empirical results; and Section 5 summarizes the empirical results and makes suggestions for future research.

## 2. Literature Review

Port Logistics is terminology used to point out an enterprise that specializes in checking and approving customs clearance procedures, as well as managing loading and unloading containers at importing and exporting points [11,12]. With the central activity roles of information transmission and the physical movement of products to support economic development [13], these enterprises have a crucial task of maintaining the quantity of commodity circulation. In recent years, delivering goods at the port of Vietnam has been exhibiting a higher trend with respect to economic development, even in the future, with a prediction of Danang port in Vietnam by the decomposition method based on long-term change in the time series data to give the status of the port operation in Danang port presenting an increased trend [14]. Besides, an assessment of the dry port in the Vinhphuc province of Vietnam by the multi-criterial decision-making analysis method [15] and an analysis of the Vietnamese port system [16] have also been conducted. Hence, there are many methods, such as the penal fixed affect model, stochastic frontier model [13], multi-criterial decision-making analysis method [15], and so on, which can be used for evaluating the performance and forecasting the status of port logistics, but this study applies the additive seasonal model in Tableau for predicting the future development of ports logistics in Vietnam and the super-SBM model for formulating and ranking port logistics companies.

Tableau is useful statistics analysis software for linear and branching time point-based temporal logics [17] in various application domains such as economics, science, and so on. For example, Tableau Workbench, with the function of "cut and paste", gives various hooks for implementing blocking techniques using histories and variables, as well as hooks for defining optimization techniques [18]. Additionally, the temporalized belief logic provides the proposed labelled tableau calculus for the analysis, design, and verification of agent-based systems operating in dynamic environments [19], in addition to utilizing exponential smoothing to forecast the future when it is based on historical time series [20] and prediction data for the testing of quality metrics and smoothing coefficients. Conversely, additive trend methods use general exponential smoothing and the winters method for prediction [21]. The additive trend method in Tableau is an accurate prediction tool that measures full parameters, performance [20], and a large amount of data [22]. It comprises the additive trend and seasonality level, such as none, additive, and multiplicative, to quantify cumulative renormalization correction factors. The Holt-Winters method mentions double exponential smoothing, where the extension of exponential smoothing sets up trend and seasonal time series, and the forecasting business data obtains seasonality, changing trends and seasonal correlation [23]. As it has a high accuracy and is an inexpensive technique, exponential smoothing is an excellent forecast tool in a wide variety applications [24]. With regards to these characteristics, this study will use the additive trend method in Tableau to forecast the future values.

After obtaining all data for the past, current, and future scenarios, the super-SBM model is an analysis tool with a super-efficiency measure in DEA that can solve directly with slacks in inputs/outputs and compare values with the super-efficiency measures using the radial expansion or reduction of input/output directly. The rationality for the measure reduces the sort of weighted $\iota_1$ istance from an efficient DMU to production possibility [25]. The slack-based model denotes that the scalar measure deals directly with the input excesses and output shortfalls of the decision-making unit. In the traditional model, Charnes-Cooper-Rhodes (CCR) and Banker-Charnes-Cooper (BCC) also directly solve the input excesses and output shortfalls, but they do not have a scalar measure and do not take account of the existence of slacks. In addition, the score of an inefficiency unit is smaller than 1 [26]. With these characteristics, the super-SBM is applied in various researches.

Estimating the super efficiency by the weights and the desirability of inputs and outputs determines the rank of each DMU [27]. Li demanded an improved super-SBM model for solving under a weak disposability assumption of undesirable outputs to conduct an energy efficiency analysis of Chinese industrial sectors [28]. Zhang and Zeng proposed the super-SBM model with undesirable outputs to measure the LCEE and dynamic low-carbon economy efficiency (ELCEE) of 30 provinces in mainland China from 2005 to 2012 [29]. Zhou and Zhu also used the super-SBM model with undesirable outputs for determining the efficiency of Chinese commercial banks [30]. Tessa and Liem defined the efficiency of the Indonesian manufacturing industry during the period of 2010–2014 when utilizing the none-parametric oriented super-SBM model [31]. These empirical analysis results suggest that the super-SBM model is the best measuring model for a comparison of the efficiency and ranking of each DMU because the DEA model can conduct the efficiency comparison. For most DEA models, the highest score is 1. But, too many DMUs will have a score of 1. For the same score, DEA models can distinguish which one is better, but the distinguish rate is not good. However, Super SBM can overcome this issue without a limitation for the highest score. So, the research can really distinguish the performances. No DMU will have the same score and the study can really distinguish the ranks.

Based on the theory of additive seasonal models and the super-SBM model, the study integrates two models to predict and then count the efficiency of port logistics in Vietnam. The rank of each port during the period of 2011–2022 is determined by the performance results of the rationality of inputs/outputs after analysis is completed by the super-SBM model.

## 3. Methodology

### 3.1. Proposal Research Framework

Figure 2 shows the four basic steps in forecasting and estimating the efficiency of airport and seaport logistics companies in Vietnam:

- Stage 1: Determine the theme and collect data on the input and output variables. The input and output factors must be reselected in another theme when they are unsuitable. The data of port logistics companies in Vietnam are posted on Vietstock [32]; the researcher chose two airport and six seaport logistics companies. Next, introduce the status of transportation in Vietnam and provide an overview of the additive trend methods and super-SBM model.
- Stage 2: When obtaining historical data, the additive trend method in Tableau is employed to analyze and compute the forecasting values. The additive trend method distinguishes three methods, i.e., Holt's linear method, the additive Holt–Winters method, and the multiplicative Holt–Winters method, which are selected to predict future times for airport and seaport logistics companies in Vietnam. Their mean absolute percentage error (MAPE) indicators measure the accuracy level of the estimated data and propound the best result. The appreciate values are used for the next step in measuring efficiency. If no method is suitable, the input and output must be reelected.
- Stage 3: DEA is a type of statistics analysis is always "isotonic," so the Pearson correlation must be tested before utilizing any model to formulate the performance. The Pearson correlation is suitable between −1 and +1, and the factors must be re-selected to exclude values from −1 to +1. The pertinent data are applied to calculating the efficiency of two airport and six seaport logistics companies in Vietnam by the super-SBM model in DEA. The performance index proposes the ranking of port logistics companies over each term.
- Stage 4: Comment on the empirical data, analyze the data via selecting the best estimated method, and present the performance and ranking of the airport and seaport logistics companies in Vietnam at the previous, current, and future time points.

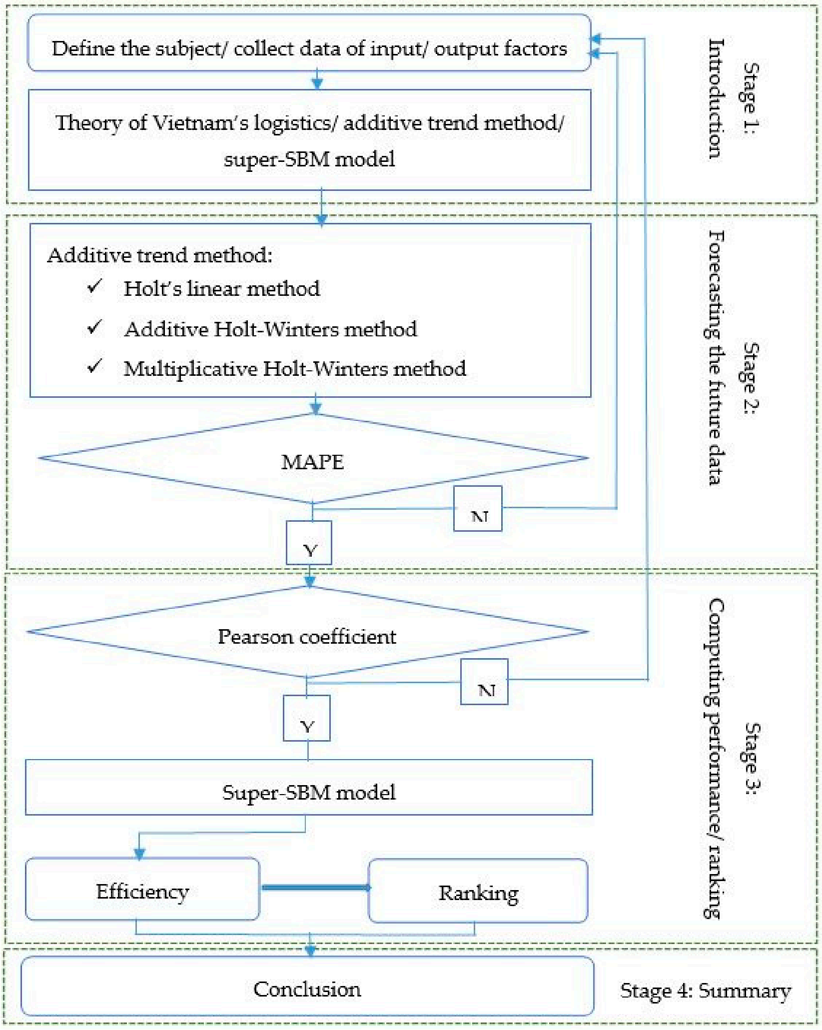


**Figure 2.** Research framework.

### 3.2. Data Collection

The term "logistics" indicates the general transportation process, including all aspects of products, machines, and people, that the research will demand to transfer the goods at the ports in Vietnam. The study collects the input and output data of two airports and six seaports logistics companies in Vietnam from 2011 to 2017 that are listed on Vietstock [32]; the names of two airport and six seaport logistics companies are given in Table 2.

**Table 2.** Names of airport and seaport logistics companies in Vietnam.

| No | Code | Name | Type of Port |
|---|---|---|---|
| 1 | CDN | Danang Port Joint Stock Company | air |
| 2 | CLL | Cat Lai Port Joint Stock Company | sea |
| 3 | CMP | Chanmay Port Joint Stock Company | sea |
| 4 | DNL | Dang Nang Port Logistics JSC | sea |
| 5 | NCT | Noi Bai Cargo Terminal Service Joint Stock Company | air |
| 6 | PDN | Dongnai Port Joint Stock Company | sea |
| 7 | PHP | Port of Hai Phong Joint Stock Company | sea |
| 8 | QNN | Quangninh Port Joint Stock Company | sea |

Source: Viet.stock [32].

Input and output variables describe the detail of circumstance in any sector; the investment sources include human resources, raw materials, information, technologies, and so on, and are identified as the inputs. After the performing process, investors will obtain their products under the classification "output". Forecasting the future of enterprises and then evaluating a common efficiency based on their financial index is posted on Vietstock [32]. Thus, the research also chooses appreciative factors in economics to predict and define the ability operation of port logistics companies in Vietnam as follows:

(a) Total assets (input): Totalizing the tangible and intangible assets of an enterprise.
(b) Owner's equity (input): Totalizing the tangible and intangible assets minus liabilities.
(c) Net revenue (output): Income of an enterprise when they perform their business.
(d) Gross profit (output): Profit valuation appraises a company's efficiency.

These factors are key in finance to help illustrate a business; their values are used to help expose the efficient economics in previous time periods and also to predict future situations.

### 3.3. Additive Trend Method

Exponential smoothing is a forecasting future value tool which is based on the regular time series. Tableau is an analysist software that applies exponential smoothing to prediction values by selecting good optimal smoothing parameters when it gives an aggregative prediction by calculating from a closed form equation. Simple exponential smoothing measures forecast values from the weighted average of the last actual value and the last level. Besides, the visualization provides components such as trend and seasonality to compute an effective prediction values.

Setting up $DMU_0$ like the units of port logistics companies in Vietnam is conducted by using the primal time series ($P_t$, $P_{t+1}$, ..., $P_{t+n}$ "$t$ = 0, 1, 2, ... ") and then estimating the forecasting values ($F_t$, $F_{t+1}$, $F_{t+2}$, ... , $F_{t+n}$ "$t$ = 0, 1, 2, ..."). The sequence of observation for both primal time series and prediction values at the first period, $t$, also starts at a time point equaling 0, and the original mathematical procedure of exponential smoothing is formulated by the specific formula as follows:

$$\begin{gathered} F_0 = P_0 \\ F_t = \alpha \times P_t + (1-\alpha) \times F_{t-1} \\ 0 \leq \alpha \leq 1 \end{gathered} \tag{1}$$

Holt (1957) [33] established standard exponential smoothing methods. From these methods, this study selects some formulae to apply to inferring the future of port logistics companies in Vietnam through three cases. The additive trend is used for all three instances and is combined with the seasonality; alternatively, no seasonality, additive seasonality, and multiplicative seasonality are applied. Single exponential smoothing is a simple model that is utilized to forecast a short time range in the future without a trend. Thus, Holt (1957) extended single exponential smoothing with a trend to predict the data of time series.

#### 3.3.1. Holt's Linear Method

($A$, $N$) has one level and one trend, so Holt's linear method is given as below:

$$\begin{gathered} F_t = \alpha P_t + (1-\alpha)(F_t + A_{t-1}) \\ A_t = \beta(F_t - F_{t-1}) + (1-\beta)A_{t-1} \\ \hat{P}_t(n) = F_t + nA_t \end{gathered} \tag{2}$$

The parameter $\beta$ changes slowly in each term.

Holt-Winters was proposed by combining the work of Holt (1957) [33] and Winters (1960) [34] to catch up with seasonality. The Holt-Winters seasonality method not only captures the forecast equation, but also three smoothing equations such as the level, trend, and seasonal component, with parameters $\alpha$, $\beta$, and $\gamma$. Two variations are displayed with the variations in the nature of the seasonal component, the seasonal variations in the additive method are constant through the series, and the seasonal component appears in all terms in the scale of the observed series. Additionally, the subtracting the seasonal component adjusts the series in the level equation. In contrast, in the multiplicative method, the seasonal variations are changed proportional to the level of the series, and the relative terms and the series in the seasonal component are adjusted by distinguishing them by the seasonal component. As a result, the seasonal component in the additive method is approximately zero and the seasonal component in the multiplicative method is up to approximately $n$.

### 3.3.2. Additive Holt-Winters Method

Overviewing the forecasting of the time series is denoted as follows:

$$\begin{aligned} F_t &= \alpha(P_t - I_{t-q}) + (1-\alpha)(F_{t-1} + A_{t-1}) \\ A_t &= \beta(F_t - F_{t-1}) + (1-\beta)A_{t-1} \\ I_t &= \gamma(P_t - F_{t-1} - A_{t-1}) + (1-\gamma)I_{t-1} \end{aligned} \tag{3}$$

The seasonal component is given by:

$$I_t = \delta(P_t - F_t) + (1-\delta)I_{t-q} \tag{4}$$

The smoothing equation for the level of the component is expressed as:

$$\begin{aligned} I_t &= \delta(1-\alpha)(P_t - F_t - A_{t-1}) + (1-\delta)I_{t-q} \\ \hat{P}_t(n) &= F_t + nA_t + I_{t-q+n} \end{aligned} \tag{5}$$

### 3.3.3. Multiplicative Holt-Winters Method

The multiplicative Holt-Winters method is calculated as below:

$$\begin{aligned} F_t &= \alpha\left(\frac{P_t}{I_{t-q}}\right) + (1-\alpha)(F_{t-1} + A_{t-1}) \\ A_t &= \beta(F_t - F_{t-1}) + (1-\beta)A_{t-1} \\ I_t &= \gamma\left(\frac{P_t}{F_{t-1}+A_{t-1}}\right) + (1-\gamma)I_{t-q} \\ \hat{P}_t(n) &= F_t + nA_t + I_{t-q+n} \end{aligned} \tag{6}$$

Table 3 expresses all notations for the additive trend method which are used in Section 3.3.

**Table 3.** Notation for additive trend method.

| Signal | Remark |
|---|---|
| $\alpha$ | Smoothing coefficients for the level of series $(0 \le \alpha \le 1)$ |
| $\beta$ | Smoothing coefficients for discount factors $(0 \le \beta \le 1)$ |
| $\delta$ | Smoothing parameter for seasonal indication $(0 \le \delta \le 1)$ |
| $\gamma$ | Smoothing coefficients for the trend $(0 \le \gamma \le 1)$ |
| $P_t$ | The consequence of actual value in the historical period time $t$ |
| $F_t$ | The consequence of computing the prediction value at the time $t$ |
| $A_t$ | Smoothed additive trend at the end of period $t$ |
| $I_t$ | Smoothed seasonal index at the end of period $t$ |
| $n$ | Number of periods in the prediction lead time |
| $q$ | Number of periods in the seasonal cycle |
| $t$ | The length of time |
| $\hat{P}_t$ | Forecast value with n period from the original time t |

Forecasting values are calculated by the additive trend and three seasonal values in the exponential smoothing, and they must be tested accurately by the MAPE indicator, which is escalated as below:

$$\text{MAPE} = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{P_t - F_t}{P_t}\right| \quad (7)$$

Measuring MAPE conduces the exact qualification of forecasting values [35,36]. The interpretation of MAPE results shows the accuracy of the forecast: when MAPE is smaller than 10%, the prediction value is excellent; 10% to 20% indicates good forecasting data; the prediction value is reasonable when it ranges from 20% to 50%; and more than 50% is an unacceptable prediction [37,38] and the research must retest with another model.

*3.4. Super SBM Model*

Super-SBM expresses the principles of super efficiency and non-radial measurement which Tone [25] wrote after collecting and analyzing information of previous researchers including technical efficiency [39], relative efficiency [10], the non-parametric linear programming method [40,41], dealing multiple inputs to produce multiple outputs [42], the non-radial model [43], and so on. The Super-SBM model deals n DMUs with the input and output, setting input ($A = a_{hk}$) and output ($B = b_{hk}$). $A$ and $B$ must be positive and $R^+$, hence the production possibility is denoted as follows:

$$P = (A, B) \quad (8)$$

Subject to

$$a \geq A\lambda,\ b \leq B\lambda,\ \lambda \geq 0$$

Here, $\lambda$ is a non-negative vector in $R^+$.

$$\begin{array}{c} a_0 = A\lambda + s^-; \\ b_0 = B\lambda - s^+ \\ \{\lambda, s^-, s^+ \geq 0\} \end{array} \quad (9)$$

The vectors $s^+$ and $s^-$ belong to $R^+$ in order to define input excess and output shortfall with the condition $A \geq 0,\ \lambda \geq 0$, which satisfies $a_0 \geq s^-$.

Following $s^+$ and $s^-$, $\rho$ is formulated as below:

$$\begin{array}{c} \rho = \frac{1-\frac{1}{m}\sum_{h=1}^{m} s_h^-/a_{h0}}{1-\frac{1}{s}\sum_{h=1}^{s} s_h^+/b_{h0}} \\ (0 < \rho \leq 1) \end{array} \quad (10)$$

The efficiency of ($a_0$, $b_0$) is calculated following:

$$Min\ \rho = \frac{1-\frac{1}{m}\sum_{h=1}^{m} s_h^-/a_{h0}}{1-\frac{1}{s}\sum_{h=1}^{s} s_h^+/b_{h0}} \quad (11)$$

Subject to

$$\begin{array}{c} a_0 = A\lambda + s^-;\ b_0 = B\lambda + s^+ \\ \{\lambda, s^-, s^+ \geq 0\} \end{array}$$

Setting up an optimal solution for the SBM model is $\rho^*,\ \lambda^*,\ s^{-*},\ s^{+*}$. X DMU is defined as the SBM model efficiency when it is based on the optimal solution under the condition $\rho^* = 1,\ s^{-*} = 0,\ s^{+*} = 0$ and no input excess, and there is no output shortfall in any optimal solution.

$$\min\delta = \frac{\frac{1}{m}\sum_{h=1}^{m} \overline{a_h}/a_{h0}}{\frac{1}{s}\sum_{h=1}^{s} \overline{b_h}/b_{h0}} \quad (12)$$

Subject to

$$\overline{a} \geq \sum_{k=1,\neq 0}^{n} \lambda_k a_k,\ \overline{b} \leq \sum_{k=1,\neq 0}^{n} \lambda_k b_k$$
$$\overline{a} \geq a_0,\ \overline{b} \leq b_0,\ \overline{b} \geq 0,\ \lambda \geq 0$$

When the output $r$ has no position, it is denoted as $\overline{b_r^+} = b_r^+ = 1$. Tone (2002) described the super-SBM model as follows:

$$\min\delta = \frac{1}{\frac{1}{s}\sum_{r=1}^{s} \overline{\overline{b_r}/b_{r0}}} \quad (13)$$

Whereas

$$\overline{a} \geq \sum_{k=1,\neq 0}^{n} \lambda_k a_k,\ \overline{b} \geq \sum_{k=1,\neq 0}^{n} \lambda_k b_k$$
$$\left\{\overline{a} = a_0; 0 \leq \overline{b} \leq b_0;\ \lambda \geq 0\right\} \quad (14)$$

## 4. Results

### 4.1. Estimated Valuation

A forecasting process in preceding and preparing must test the feasibility of original actual data that has time-series and trends. Each method is applied to reveal predictions under controlling parameter space and the measurement of performance within the case of time-series [44–46]; these parameters will be formulated to define the accuracy level of forecasting values. The additive trend method in Tableau displayed a clarification of parameter classification when the historical time-series data were used for estimating the future of two airport and six seaport logistics companies in Vietnam, as shown in Section 3.2.

#### 4.1.1. Smoothing Coefficients

Based on the space condition, the alpha, beta, and gamma parameters are 0 to 1; the parameters of three models in exponential smoothing are utilized to formulate the future operation of port logistics companies. Tables A1–A3 indicate that all the parameters are appreciated, particularly with their empirical scopes of 0 to 0.5.

#### 4.1.2. Accuracy Indication

The results will be retested by smoothing constants as a MAPE index to seek out the best estimated results. Tables 4–6 indicate the classification of three methods in the additive trend method; most of them obtained a standard qualification under 50% and the average percentages of Holt's linear method, the additive Holt–Winter method, and the multiplicative Holt–Winter method are 24.37%, 16.22%, and 18.43%, respectively.

**Table 4.** MAPE calculation results of Holt's linear method.

| Code | TAS | OEY | NRE | GRP |
|---|---|---|---|---|
| CDN | 23.00% | 39.20% | 20.80% | 40.60% |
| CLL | 8.70% | 13.40% | 13.20% | 3.90% |
| CMP | 13.70% | 12.80% | 24.50% | 30.10% |
| DNL | 16.40% | 10.70% | 15.50% | 19.40% |
| NCT | 20.10% | 18.90% | 20.70% | 21.90% |
| PDN | 22.40% | 9.10% | 32.50% | 18.40% |
| PHP | 28.70% | 47.70% | 14.20% | 37.70% |
| QNN | 44.40% | 12.00% | 80.70% | 44.60% |
| Average | 24.37% | | | |

Note: TAS: Total assets; OEY: Owner's equity; NRE: Net revenue; GRP: Gross profit.

**Table 5.** MAPE calculation results of the additive Holt-Winter method.

| Code | TAS | OEY | NRE | GRP |
|---|---|---|---|---|
| CDN | 11.00% | 22.90% | 22.10% | 36.90% |
| CLL | 12.10% | 11.60% | 10.70% | 3.10% |
| CMP | 12.70% | 11.90% | 13.40% | 20.40% |
| DNL | 12.40% | 5.90% | 12.40% | 13.30% |
| NCT | 12.90% | 12.90% | 14.40% | 15.70% |
| PDN | 11.60% | 4.00% | 13.80% | 7.60% |
| PHP | 20.10% | 34.70% | 12.80% | 28.80% |
| QNN | 16.70% | 10.10% | 29.60% | 40.40% |
| Average | 16.22% | | | |

**Table 6.** MAPE calculation results of the multiplicative Holt-Winter method.

| Code | TAS | OEY | NRE | GRP |
|---|---|---|---|---|
| CDN | 12.60% | 35.90% | 25.20% | 54.00% |
| CLL | 12.80% | 13.90% | 11.30% | 3.20% |
| CMP | 14.50% | 13.20% | 13.30% | 21.50% |
| DNL | 12.60% | 5.90% | 12.60% | 13.40% |
| NCT | 13.50% | 13.50% | 13.90% | 15.50% |
| PDN | 12.90% | 4.30% | 13.90% | 8.00% |
| PHP | 21.60% | 48.20% | 13.50% | 31.00% |
| QNN | 17.20% | 10.30% | 29.50% | 46.90% |
| Average | 18.43% | | | |

From Equation (7) and the principle of MAPE [37,38], the net revenue of QNN in Holt's linear method is 80.70%, so the forecasted value proposition is absolutely inaccurate. Therefore, it affects a final test of Holt's linear method directly; it does not get put through its paces. In the multiplicative Holt–Winter method, the gross profit of CND is higher than the benchmark at 54.00%; consequently, it excludes criteria and cannot move to the next step. All MAPE of ports in the additive Holt–Winter method obtained quality under 50%, as their percentages are 3.10% to 40.40%. For the reason that the additive Holt–Winter method is an exact forecasting tool of future Vietnam ports, the predicted values are authentic and utilized to monitor the efficiency in the period of 2018–2022 in the next stage. The best accurate forecasting data by the additive Holt–Winter method are shown in Table A4.

### *4.2. Performance Index and Ranking*

In data envelopment analysis, the relationship between input variables and output variables must be isotonic so the input quantity rises; the output quantity could not be deducted under the same condition. The correlation coefficient is from −1 to +1. The Pearson correlation has a perfect linear relationship when it is closer to ±1. The empirical result of the research, as shown in Table A5, demonstrates that it displays a strong positive correlation when these correlation values are between 0.6074 and +1, with the result that the input factors and output factors are absolutely qualified.

Although many DEA models are used for calculating the performance, the ranking of some cases over each year cannot be distinguished. This research defines the efficiency of each port logistics company and their clear distinction ranking; thus, a super-SBM model is utilized to compute the performance. The rank of each DMU is determined by the weights and the desirability of inputs and outputs.

Figure 3 and Tables 7 and 8 denote the efficiency change of port logistics companies over the time period of 2011–2022. Most of the port logistics companies exhibit fluctuating values, with stable scores as one number in whole terms, excluding PHP, which received a stable efficiency. CLL and PDN have a particular efficiency change, i.e., one-year increases and one-year decreases smoothly with previous time and future time, respectively. CMP indicates value change as CLL and PDN during the time period of 2011–2016 and 2018–2022, and CMP rises softly from 2016 to 2018. DNL and QNN also present a dramatic efficiency rise and then drop slightly according to each year during the time period 2011–2022. DNL has an up-efficiency within two consecutive time periods from 2011–2013 and is down to two continual time periods from 2015–2017. CDN and NCT exhibit the action of deduction and accretion of performance during the time period of 2011–2022, respectively. Notably, the empirical experienced result shows that DNL always mantains the highest performance over the time period of 2011–2022, and its smallest value is 6.89607, with its largest value at 10.36043. Although CLL, CMP, and PDN express the "soft fluctuation" trend, they still have a low efficiency under 1.

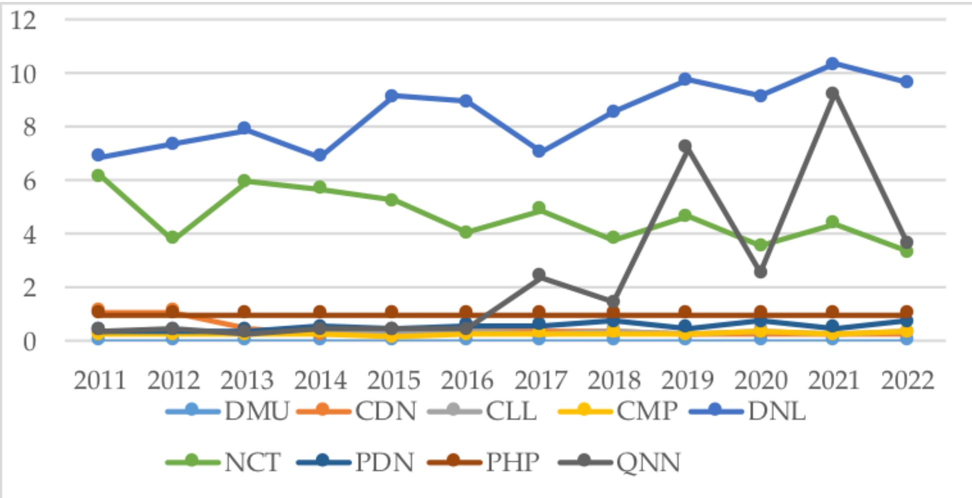


**Figure 3.** Productivity Efficiency of port logistics companies.

**Table 7.** Score of port logistics companies over the historical term.

| DMU | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| CDN | 1.10308 | 1.06952 | 0.42256 | 0.2269 | 0.38878 | 0.40679 |
| CLL | 0.32825 | 0.33977 | 0.27022 | 0.39477 | 0.28778 | 0.33058 |
| CMP | 0.24352 | 0.24457 | 0.21705 | 0.29977 | 0.16503 | 0.24013 |
| DNL | 6.89607 | 7.36205 | 7.9072 | 6.90754 | 9.12671 | 8.92694 |
| NCT | 6.16017 | 3.78382 | 5.95239 | 5.6909 | 5.23455 | 4.05713 |
| PDN | 0.36727 | 0.41517 | 0.37382 | 0.52197 | 0.46475 | 0.58014 |
| PHP | 1 | 1 | 1 | 1 | 1 | 1 |
| QNN | 0.39691 | 0.42146 | 0.28561 | 0.42124 | 0.45036 | 0.46161 |

**Table 8.** Score of port logistics companies over the future term.

| DMU | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|
| CDN | 0.38048 | 0.33888 | 0.29794 | 0.30289 | 0.28764 | 0.29065 |
| CLL | 0.30926 | 0.39296 | 0.26503 | 0.36733 | 0.25538 | 0.35123 |
| CMP | 0.27401 | 0.29396 | 0.2239 | 0.32964 | 0.24192 | 0.35998 |
| DNL | 7.05042 | 8.55567 | 9.73181 | 9.1439 | 10.3604 | 9.67142 |
| NCT | 4.91851 | 3.79334 | 4.64783 | 3.55591 | 4.40863 | 3.36177 |
| PDN | 0.61006 | 0.76097 | 0.50165 | 0.72984 | 0.50524 | 0.71933 |
| PHP | 1 | 1 | 1 | 1 | 1 | 1 |
| QNN | 2.41737 | 1.42161 | 7.19477 | 2.55652 | 9.2276 | 3.65386 |

The ranking of airport and seaport logistics companies is shown in Figure 4. Based on the performance indication, DNL always maintains a dominant position. NCT ranks in second position according to alternative years 2011–2018 and 2020; it is in third position for the years 2019, 2021, and 2022. PHP reaches the third classification from 2013 to 2016 and fourth position according to the years 2011, 2012, and 2017–2022. CLL obtains a sixth ranking in 2014, 2018, and 2020, respectively, and seventh ranking in other terms. CMP seems to be the worst port, as it is usually at the lowest point during the time periods of 2011–2013, 2015–2019, and 2021; it only went up one level in 2014 and 2020. However, the forecasting data indicates that CMP can reach sixth position in 2022. PDN will rank as the fifth class in the future time terms of 2017–2022 and go up from sixth to fourth position during the periods of 2011–2012, 2013, and 2014–2016, respectively. Besides, CDN and QNN are the two port logistics companies that have a sharp change consecutively; CDN remains at the third ranking in 2011–2012 and then it falls to the bottom position in the years 2014, 2020, and 2022. The actual values and prediction values show that CDN remains at the bottom; QNN remains in a high position when it obtains a high forecasting efficiency.

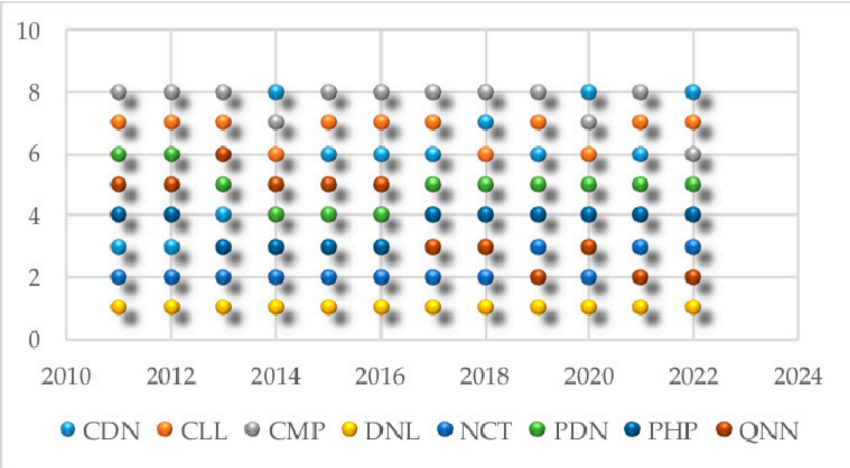


**Figure 4.** Ranking of port logistics companies.

The empirical results of previous and future time periods in port logistics companies denote the actual efficiency and estimated performance by using the super-SBM for figuring out their values and the follow-up final mark indicates their ranking. By way of consequence, CDN always gets the highest efficiency with the first rank in all terms. NCT has a large performance ratio and stays in second position, but its ratio can be reduced and directly affects its ranking. PHP in the middle term 2013–2016 upgrades the point and rises one position, maintaining the classification within these four years. As a consequence, CDN, NCT, and PHP are the best port logistics companies, with a high efficiency above 1. On the other hand, CMP and CLL are ineffective ports, with a low performance of under 1. Per the analysed results, the number of efficient and inefficient port logistics companies in each term is shown in Table 9. The number of efficient companies is four, and number of inefficient ones is four in 2011–2012 and 2017–2022. The number of companies becoming efficient is three, and five companies are inefficient over the period of 2012–2016. For the improvement of inefficient companies, they must increase their output variables such as revenue and gross profit. This denotes that they exist in an inefficient operating process.

**Table 9.** The efficient and inefficient index of port logistics companies.

| Indicators | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Efficient | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |
| Inefficient | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 |

## 5. Conclusions

In short, this valuable study presents an overview of port logistics companies in Vietnam from the past to the future, while combining the additive trend method and the super-SBM model. The application of the additive trend method in Tableau is used to predict the future, and the super-SBM is employed for calculating the efficiency. In general, most port logistics in Vietnam are experiencing a robust growth rate when based on real and forecast performance indicators. Both airport logistics companies and seaport logistics companies exhibit a development trend. Hence, these values express that the trade of Vietnam is experiencing a large demand to expand the products exchanged with foreign markets. The empirical results are analysed by integrating the additive trend method and super-SBM model.

The accuracy forecasting data in the period of 2018–2022 is employed by the additive Holt-Winters method when formulating results based on the historical data during the term of 2011–2017. Four variables, i.e., total assets, owner's equity, net revenue, and gross profit, are key financial indicators that determine an enterprise's operating status. The prediction results exhibit the future operation status of port logistics companies.

Furthermore, with the best function of the super-SBM model in measuring comparisons of efficiency and ranking of each port logistics company, the empirical analysis result computes the performance of port logistics companies in Vietnam through the super-SBM model. Further, their efficiency scores also define the ranking and capable operation of each port logistics company for every year. Consequently, port logistics companies can know about their position and their operation.

This research discusses the effectiveness of port logistics companies, but it still has limitations. First, indicators such as containers and labor forces of ports logistics companies are non-listed; thus, it is difficult to attain depth and specification overviews via port logistics companies. Therefore, more input and output factors are necessary in order to analyze the efficiency of port logistics companies in Vietnam. Second, information on many port logistics companies is not posted, which creates a lack of comparison; thus, future research should aim to reveal more relative inputs and outputs of other logistics companies.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

## Appendix A

**Table A1.** Forecasting parameters of port logistics companies in Vietnam by Season of none over the period of 2018–2022.

| Code | TAS | | | OEY | | | NRE | | | GRP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ |
| QNN | 0.5 | 0 | 0 | 0.343 | 0 | 0 | 0.5 | 0 | 0 | 0.116 | 0 | 0 |
| PHP | 0.455 | 0 | 0 | 0.5 | 0 | 0 | 0.134 | 0.5 | 0 | 0.297 | 0 | 0 |
| PDN | 0.5 | 0.037 | 0 | 0.5 | 0.084 | 0 | 0.5 | 0.064 | 0 | 0.5 | 0.089 | 0 |
| NCT | 0.298 | 0.104 | 0 | 0.489 | 0.009 | 0 | 0.5 | 0.023 | 0 | 0.144 | 0.336 | 0 |
| DNL | 0.5 | 0 | 0 | 0.5 | 0.015 | 0 | 0.497 | 0 | 0 | 0.5 | 0 | 0 |
| CMP | 0.431 | 0 | 0 | 0.5 | 0 | 0 | 0.5 | 0 | 0 | 0.5 | 0 | 0 |
| CLL | 0 | 0.044 | 0 | 0.5 | 0 | 0 | 0.5 | 0 | 0 | 0.5 | 0.002 | 0 |
| CDN | 0.5 | 0.076 | 0 | 0.5 | 0.014 | 0 | 0.1 | 0.427 | 0 | 0.106 | 0 | 0 |

**Table A2.** Forecasting parameters of port logistics companies in Vietnam by season of additive over the period of 2018–2022.

| Code | TAS | | | OEY | | | NRE | | | GRP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ |
| QNN | 0 | 0.045 | 0 | 0.072 | 0.467 | 0 | 0 | 0.045 | 0 | 0.5 | 0.064 | 0 |
| PHP | 0.163 | 0.5 | 0 | 0.175 | 0.5 | 0 | 0.215 | 0.5 | 0 | 0.243 | 0.5 | 0 |
| PDN | 0.5 | 0 | 0.5 | 0.5 | 0 | 0.252 | 0.5 | 0 | 0.5 | 0.5 | 0 | 0.5 |
| NCT | 0.128 | 0.5 | 0 | 0.148 | 0.5 | 0 | 0.197 | 0.5 | 0 | 0.5 | 0.167 | 0 |
| DNL | 0 | 0.044 | 0 | 0.5 | 0 | 0.5 | 0.234 | 0.5 | 0 | 0.183 | 0.5 | 0 |
| CMP | 0.5 | 0.017 | 0 | 0.5 | 0.006 | 0 | 0 | 0.046 | 0 | 0.5 | 0 | 0.5 |
| CLL | 0.211 | 0.5 | 0 | 0.5 | 0.106 | 0.023 | 0.248 | 0.5 | 0 | 0.203 | 0.5 | 0 |
| CDN | 0.106 | 0.5 | 0 | 0.218 | 0.5 | 0 | 0.135 | 0.5 | 0 | 0.5 | 0 | 0 |

**Table A3.** Forecasting parameters of port logistics companies in Vietnam by season of multiplicative over the period of 2018–2022.

| Code | TAS | | | OEY | | | NRE | | | GRP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ | $\alpha$ | $\beta$ | $\gamma$ |
| QNN | 0 | 0.045 | 0 | 0.08 | 0.5 | 0 | 0.444 | 0.5 | 0.5 | 0.5 | 0.174 | 0.044 |
| PHP | 0.214 | 0.5 | 0 | 0.292 | 0.5 | 0.181 | 0.227 | 0.5 | 0 | 0.345 | 0.5 | 0.017 |
| PDN | 0.5 | 0 | 0.458 | 0.5 | 0 | 0.148 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| NCT | 0.152 | 0.5 | 0 | 0.179 | 0.5 | 0 | 0.5 | 0.283 | 0 | 0.5 | 0.365 | 0 |
| DNL | 0 | 0.044 | 0 | 0.5 | 0 | 0.5 | 0.225 | 0.5 | 0 | 0.178 | 0.5 | 0 |
| CMP | 0.445 | 0.107 | 0 | 0.5 | 0.032 | 0.12 | 0 | 0.046 | 0 | 0.5 | 0.5 | 0.5 |
| CLL | 0.224 | 0.5 | 0 | 0.355 | 0.195 | 0.248 | 0.248 | 0.5 | 0.174 | 0.217 | 0.5 | 0 |
| CDN | 0.197 | 0.5 | 0 | 0.233 | 0.499 | 0.5 | 0.136 | 0.5 | 0.098 | 0.049 | 0.5 | 0.499 |

**Table A4.** Estimated values of port logistics companies over the period 2018–2022 (VND in Millions).

| Name of Ports | Year | (I) Total Assets | (I) Owner's Equity | (O) Net Revenue | (O) Gross Profit |
|---|---|---|---|---|---|
| CDN | 2018 | 504,669 | 196,323 | 1,304,010 | 1,024,266 |
| CLL | | 312,502 | 117,620 | 650,418 | 628,270 |
| CMP | | 99,134 | 65,839 | 475,675 | 357,562 |
| DNL | | 35,902 | 13,118 | 48,392 | 49,104 |
| NCT | | 827,101 | 437,209 | 677,610 | 579,552 |
| PDN | | 606,204 | 177,454 | 929,363 | 439,431 |
| PHP | | 2,771,517 | 998,564 | 7,316,593 | 4,973,681 |
| QNN | | 980,608 | 147,488 | 808,823 | 682,506 |
| CDN | 2019 | 720,145 | 276,448 | 1,566,220 | 1,143,554 |
| CLL | | 327,468 | 122,802 | 768,568 | 735,696 |
| CMP | | 91,300 | 65,355 | 594,325 | 423,029 |
| DNL | | 31,899 | 12,683 | 49,633 | 56,485 |
| NCT | | 900,475 | 496,545 | 626,312 | 542,816 |
| PDN | | 685,394 | 190,603 | 1,044,150 | 469,048 |
| PHP | | 2,586,004 | 1,045,432 | 6,943,971 | 5,615,173 |
| QNN | | 2,260,845 | 155,620 | 821,121 | 625,130 |
| CDN | 2020 | 554,062 | 233,754 | 1,521,173 | 1,222,758 |
| CLL | | 348,509 | 122,442 | 690,509 | 726,776 |
| CMP | | 104,408 | 85,842 | 542,282 | 412,394 |
| DNL | | 37,261 | 13,860 | 50,487 | 54,645 |
| NCT | | 931,716 | 476,841 | 768,371 | 659,034 |
| PDN | | 772,962 | 216,502 | 1,125,091 | 497,863 |
| PHP | | 3,015,200 | 1,154,983 | 8,425,751 | 5,858,369 |
| QNN | | 1,379,383 | 181,118 | 879,931 | 749,442 |

**Table A4.** *Cont.*

| Name of Ports | Year | (I) Total Assets | (I) Owner's Equity | (O) Net Revenue | (O) Gross Profit |
|---|---|---|---|---|---|
| CDN | 2021 | 787,338 | 324,569 | 1,807,001 | 1,345,587 |
| CLL | | 363,143 | 127,735 | 814,525 | 842,660 |
| CMP | | 96,031 | 82,593 | 672,101 | 483,281 |
| DNL | | 33,084 | 13,381 | 51,737 | 62,519 |
| NCT | | 1,007,596 | 539,604 | 704,936 | 612,483 |
| PDN | | 851,139 | 228,388 | 1,243,103 | 527,530 |
| PHP | | 2,803,800 | 1,197,299 | 7,922,473 | 6,532,391 |
| QNN | | 3,024,890 | 187,473 | 890,271 | 683,573 |
| CDN | 2022 | 603,454 | 271,185 | 1,738,336 | 1,421,251 |
| CLL | | 384,515 | 127,264 | 730,600 | 825,282 |
| CMP | | 109,681 | 105,846 | 608,888 | 467,227 |
| DNL | | 38,620 | 14,601 | 52,582 | 60,186 |
| NCT | | 1,036,330 | 516,473 | 859,131 | 738,516 |
| PDN | | 939,720 | 255,551 | 1,320,819 | 556,295 |
| PHP | | 3,258,882 | 1,311,403 | 9,534,908 | 6,743,056 |
| QNN | | 1,778,157 | 214,749 | 951,040 | 816,378 |

## Appendix B

**Table A5.** Pearson's correlation.

| Factors | TAS | OEY | NRE | GRP | TAS | OEY | NRE | GRP |
|---|---|---|---|---|---|---|---|---|
| Year | 2011 | | | | 2012 | | | |
| TAS | 1 | 0.9846 | 0.9606 | 0.6245 | 1 | 0.9903 | 0.9814 | 0.8591 |
| OEY | 0.9846 | 1 | 0.9381 | 0.6211 | 0.9903 | 1 | 0.9663 | 0.8646 |
| NRE | 0.9606 | 0.9381 | 1 | 0.7621 | 0.9814 | 0.9663 | 1 | 0.9187 |
| GRP | 0.6245 | 0.6211 | 0.7621 | 1 | 0.8591 | 0.8646 | 0.9187 | 1 |
| | 2013 | | | | 2014 | | | |
| TAS | 1 | 0.9941 | 0.9684 | 0.7008 | 1 | 0.9984 | 0.96 | 0.8225 |
| OEY | 0.9941 | 1 | 0.9631 | 0.7123 | 0.9984 | 1 | 0.9653 | 0.8303 |
| NRE | 0.9684 | 0.9631 | 1 | 0.8436 | 0.96 | 0.9653 | 1 | 0.9443 |
| GRP | 0.7008 | 0.7123 | 0.8436 | 1 | 0.8225 | 0.8303 | 0.9443 | 1 |
| | 2015 | | | | 2016 | | | |
| TAS | 1 | 0.9987 | 0.9581 | 0.887 | 1 | 0.9979 | 0.9754 | 0.926 |
| OEY | 0.9987 | 1 | 0.9629 | 0.8938 | 0.9979 | 1 | 0.9763 | 0.9319 |
| NRE | 0.9581 | 0.9629 | 1 | 0.9766 | 0.9754 | 0.9763 | 1 | 0.9837 |
| GRP | 0.887 | 0.8938 | 0.9766 | 1 | 0.926 | 0.9319 | 0.9837 | 1 |
| Year | 2017 | | | | 2018 | | | |
| TAS | 1 | 0.9828 | 0.9204 | 0.8503 | 1 | 0.9973 | 0.9484 | 0.9349 |
| OEY | 0.9828 | 1 | 0.8564 | 0.8859 | 0.9973 | 1 | 0.9487 | 0.9364 |
| NRE | 0.9204 | 0.8564 | 1 | 0.8272 | 0.9484 | 0.9487 | 1 | 0.9547 |
| GRP | 0.8503 | 0.8859 | 0.8272 | 1 | 0.9349 | 0.9364 | 0.9547 | 1 |
| | 2019 | | | | 2020 | | | |
| TAS | 1 | 0.9967 | 0.7171 | 0.9142 | 1 | 0.9964 | 0.9128 | 0.9446 |
| OEY | 0.9967 | 1 | 0.7146 | 0.9173 | 0.9964 | 1 | 0.9106 | 0.9438 |
| NRE | 0.7171 | 0.7146 | 1 | 0.7172 | 0.9128 | 0.9106 | 1 | 0.9285 |
| GRP | 0.9142 | 0.9173 | 0.7172 | 1 | 0.9446 | 0.9438 | 0.9285 | 1 |
| | 2021 | | | | 2022 | | | |
| TAS | 1 | 0.9957 | 0.6122 | 0.9249 | 1 | 0.9957 | 0.8744 | 0.9512 |
| OEY | 0.9957 | 1 | 0.6074 | 0.9255 | 0.9957 | 1 | 0.8695 | 0.9486 |
| NRE | 0.6122 | 0.6074 | 1 | 0.6234 | 0.8744 | 0.8695 | 1 | 0.8986 |
| GRP | 0.9249 | 0.9255 | 0.6234 | 1 | 0.9512 | 0.9486 | 0.8986 | 1 |

## References

1. Martí, L.; Martín, J.C.; Puertas, R. A Dea-logistics performance index. *J. Appl. Econ.* **2017**, *20*, 169–192. [CrossRef]
2. Park, H.G.; Lee, Y.J. The Efficiency and Productivity Analysis of Large Logistics Providers Services in Korea. *Asian J. Shipp. Logist.* **2015**, *31*, 469–476. [CrossRef]
3. Roh, H.-S.; Lalwani, C.S.; Naim, M.M. Modelling a port logistics process using the structured analysis and design technique. *Int. J. Logist. Res. Appl.* **2007**, *10*, 283–302. [CrossRef]
4. Kang, D.; Kim, S. Conceptual Model Development of Sustainability Practices: The Case of Port Operations for Collaboration and Governance. *Sustainability* **2017**, *9*. [CrossRef]
5. Sutrisnowati, R.A.; Bae, H.; Song, M. Bayesian network construction from event log for lateness analysis in port logistics. *Comput. Ind. Eng.* **2014**, *89*, 53–66. [CrossRef]
6. Về việc ban hành quy định về kiểm tra hang hóa xuất kh]ẩu, nhập khẩu bằng máy soi container. Available online: https://thuvienphapluat.vn (accessed on 20 July 2018).
7. Limbourg, S.; Giang, H.T.Q.; Cools, M. Logistics Service Quality: The Case of Da Nang City. *Procedia Eng.* **2016**, *142*, 123–129. [CrossRef]
8. *Global Rankings 2016: Logistics Performance Index*; The World Bank: Washington, DC, USA, 2017; Available online: https://lpi.worldbank.org (accessed on 15 June 2018).
9. Fang, H.-H.; Lee, H.-S.; Hwang, S.-N.; Chung, C.-C. A slacks-based measure of super-efficiency in data envelopment analysis: An alternative approach. *Omega* **2013**, *41*, 731–734. [CrossRef]
10. Andersen, P.; Petersen, N.C. A Procedure for Ranking Efficient Units in Data Envelopment Analysis. *Manag. Sci.* **1993**, *39*, 1261–1264. [CrossRef]
11. Bae, H.-S. The Effect of Market Orientation on Relationship Commitment and Relationship Effectiveness of Port Logistics Firms. *Asian J. Shipp. Logist.* **2012**, *28*, 105–134. [CrossRef]
12. Ji, M.-J.; Chu, Y.-L. Optimization for Hub-and-Spoke Port Logistics Network of Dynamic Hinterland. *Phys. Procedia* **2012**, *33*, 827–832. [CrossRef]
13. Wang, G.; Gao, C. Technical Efficiency and Port Competition: Revisiting the Bohai Economic Rim, China. *J. Risk Financ. Manag.* **2012**, *5*, 115–130. [CrossRef]
14. Nguyen, T.D.H.; Cools, M. An Analysis of the Development of Port Operation in Danang Port, Vietnam. *IOP Conf. Ser. Earth Environ. Sci.* **2018**. [CrossRef]
15. Nguyen, L.C.; Notteboom, T. A Multi-Criteria Approach to Dry Port Location in Developing Economies with Application to Vietnam. *Asian J. Shipp. Logist.* **2016**, *32*, 23–32. [CrossRef]
16. van Thai, V.; Grewal, D. An Analysis of the Efficiency and Competitiveness of Vietnamese Port System. *Asia Pac. J. Mark. Logist.* **2005**, *17*, 3–31. [CrossRef]
17. Goranko, V.; Montanari, A.; Sala, P.; Sciavico, G. A general tableau method for propositional interval temporal logics: Theory and implementation. *J. Appl. Logic* **2016**, *4*, 305–330. [CrossRef]
18. Abate, P.; Gore, R. The Tableau Workbench. *Electron. Notes Theor. Comput. Sci.* **2009**, *231*, 55–67. [CrossRef]
19. Ma, J.; Orgun, M.A.; Adi, K. An analytic tableau calculus for a temporalised belief logic. *J. Appl. Logic* **2011**, *9*, 289–304. [CrossRef]
20. Harsoor, A.S.; Patil, A. Forecast of sale of Walmart store using big data applications. *Int. J. Res. Eng. Technol.* **2015**, *4*, 51–59.
21. Bartolomei, S.M.; Sweet, A.L. A note on a comparison of exponential smoothing methods for forecasting seasonal series. *Int. J. Forecast.* **1989**, *5*, 111–116. [CrossRef]
22. Ting, D. Towards Optimal Cardinality Estimation of Unions and Intersections with Sketches. In Proceedings of the Conference of KDD '16, San Francisco, CA, USA, 13–17 August 2016.
23. Gelper, S.; Fried, R.; Croux, C. Robust Forecasting with Exponential and Holt-Winters Smoothing. *J. Forecast.* **2010**, *29*, 285–300.
24. Ostertagov, E.; Ostertag, O. Forecasting using simple exponential smoothing method. *Acta Electrotech. Inform.* **2012**, *12*, 62–66. [CrossRef]
25. Tone, K. A slacks-based measure of super-efficiency in data envelopment analysis. *Eur. J. Oper. Res.* **2002**, *143*, 32–41. [CrossRef]
26. Tone, K. A slack-based measure of efficiency in data envelopment analysis. *Eur. J. Oper. Res.* **2001**, *130*, 498–509. [CrossRef]

27. ANoura, A.; Lotfi, F.H.; Jahanshahloo, G.R.; Rashidi, S.F. Super-efficiency in DEA by effectiveness of each unit in society. *Appl. Math. Lett.* **2011**, *24*, 623–626. [CrossRef]
28. Li, H.; Shi, J.-F. Energy efficiency analysis on Chinese industrial sectors: An improved Super-SBM model with undesirable outputs. *J. Clean. Prod.* **2014**, *65*, 97–107. [CrossRef]
29. Zhang, J.; Zzzeng, W.; Wang, J.; Yang, F.; Jiang, H. Regional low-carbon economy efficiency in China: Analysis based on the Super-SBM model with $CO_2$ emissions. *J. Clean. Prod.* **2015**, *163*, 202–211. [CrossRef]
30. Zhou, L.; Zhu, S. Research on the Efficiency of Chinese Commercial Banks Based on Undesirable Output and Super-SBM DEA Model. *J. Math. Financ.* **2017**, *7*, 102–120. [CrossRef]
31. Soetanto, T.V.; Fu, L.P. Super Slack-Based Model efficiency and Stock Performance of Manufacturing Industry Listed in Indonesian Stock Exchange. *Procedia Soc. Behav. Sci.* **2015**, *211*, 1231–1239. [CrossRef]
32. Vietstock. Available online: http://en.vietstock.vn/ (accessed on 2 May 2018).
33. Beverton, R.J.H.; Sidney, J.H. *On the Dynamics of Exploited Fish Populations*; Great Britain Fishery Investment: London, UK, 1957.
34. Winter, P.R. Forecasting Sale by Exponentially Weighted Moving Averages. *Manag. Sci.* **1960**, *6*, 324–342. [CrossRef]
35. Wong, K.K.F. The relevance of business cycles in forecasting international tourist arrivals. *Tour. Manag.* **1997**, *18*, 581–586. [CrossRef]
36. Martin, C.A.; Witt, S.F. Accuracy of econometric forecasts of tourism. *Ann. Tour. Res.* **1989**, *16*, 407–430. [CrossRef]
37. Khair, U.; Fahmi, H.; al Hakim, S.; Rahim, R. Forecasting Error Calculation with Mean Absolute Deviation and Mean Absolute Percentage Error. *J. Phys. Conf. Ser.* **2017**, *930*. [CrossRef]
38. Lewis, C.D. *Industrial and Business Forecasting Methods: A Practical Guide to Exponential Smoothing and Curve Fitting*; Butterworth Scientific: London, UK, 1982.
39. Farrell, M.J. The Measurement of Productive Efficiency. *J. R. Stat. Soc.* **1957**, *120*, 253–290. [CrossRef]
40. Charnes, A.; Cooper, W.W.; Rhodes, E. Measuring the Efficiency of Decision Making Units. *Eur. J. Oper. Res.* **1978**, *2*, 429–444. [CrossRef]
41. Charnes, A.; Cooper, W.W.; Golany, B.; Seiford, L.; Stutz, J. Foundations of Data Envelopment Analysis for Pareto-Koopmans Efficient Empirical Production Functions. *J. Econ.* **1985**, *30*, 91–107. [CrossRef]
42. Färe, R.; Lovell, C.A.K. Measuring the Technical Efficiency of product. *J. Econ. Theory* **1978**, *19*, 150–162. [CrossRef]
43. Thrall, R.M. Duality, classification and Slacks in DEA. *Ann. Oper. Res.* **1996**, *66*, 109–138. [CrossRef]
44. Aldrin, M.; Damsleth, E. Forecasting Non-seasonal Time Series with Missing Observations. *J. Forecast.* **1989**, *8*, 97–116. [CrossRef]
45. Archibald, B.C. Parameter space of the Holt-Winters' model. *Int. J. Forecast.* **1990**, *6*, 199–209. [CrossRef]
46. Gardner, E.S., Jr. Exponential Smoothing: The State of the Art. *J. Forecast.* **1985**, *4*, 1–28. [CrossRef]