EFFICIENCY ANALYSIS OF CONTAINER TERMINALS IN HAI PHONG, VIET NAM BY WINDOW AND SUPER-EFFICIENCY DEA

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CONTENTS

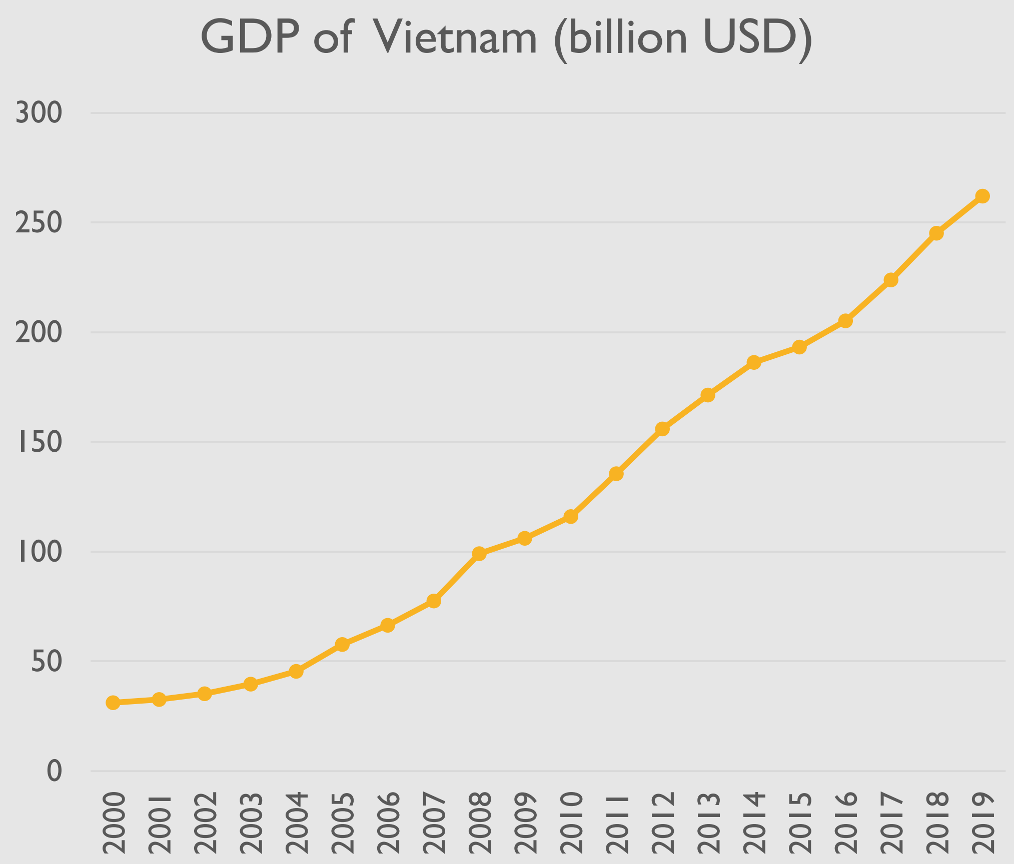
1. INTRODUCTION

1. INTRODUCTION

- Vietnam has an outstandingly developing economy.

- GDP increases from US$31.173 billion in 2000 to US$261.921 billion in 2019.

- Vietnam's seaport industry has been strongly developing and playing a crucial role in the country's international trade while 90% of nation's import and export cargo are handled by this factor. (Vietnam Maritime Administration)



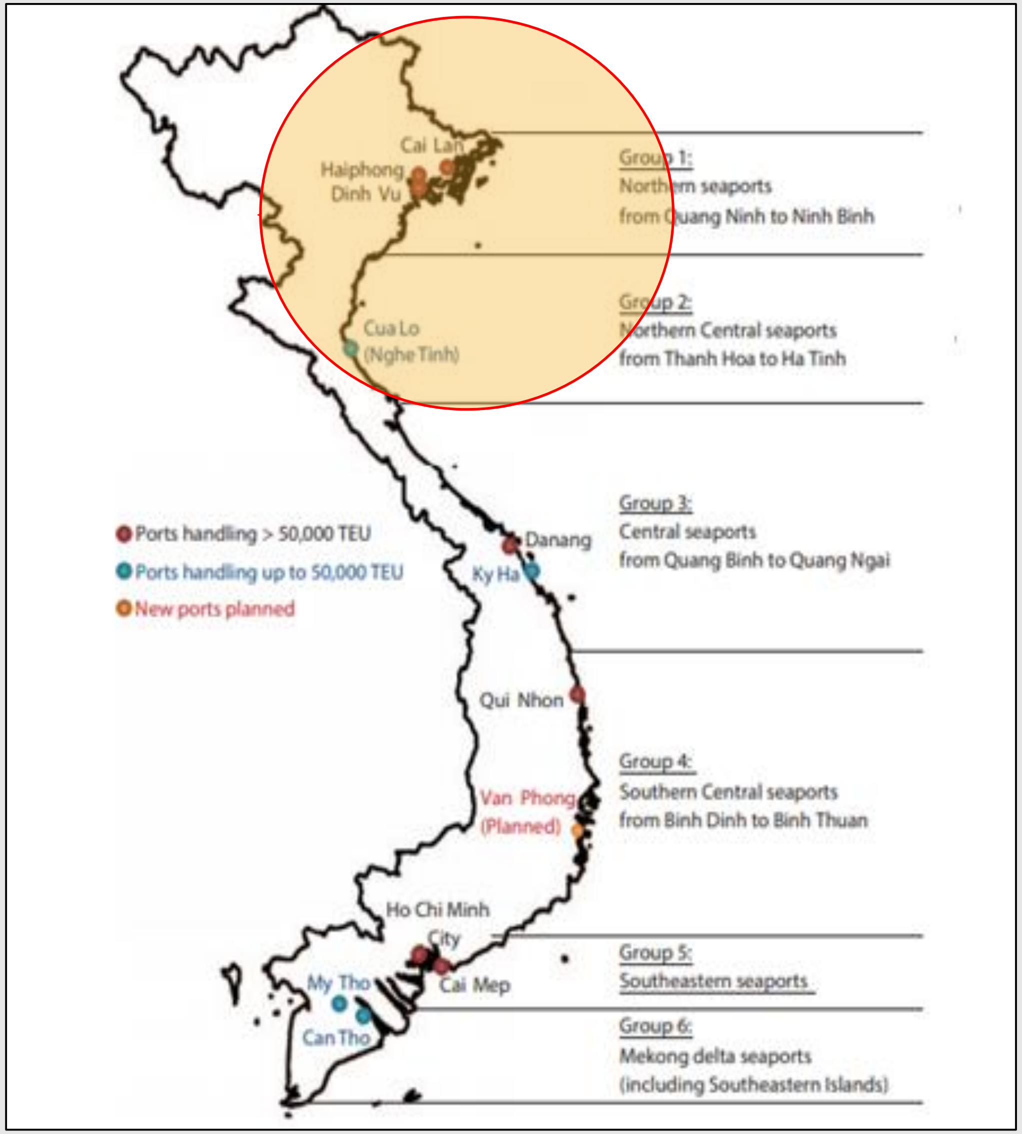
Source: World Bank (2020)

1. INTRODUCTION

- There are 40 seaports with 166 terminals deviding into three regions of Vietnam

- The period from 1999 to 2019 has witnessed a significant increase (from nearly 98 thousands TEUS to more than 15 millions TEUs) in the total container throughput of Vietnam's port system. (Vietnam Maritime Administration)

- The volume of containerized cargo throughput mainly concentrated on the Southeastern (Ho Chi Minh area) and the Northern (Hai Phong area). (Vietnam Maritime Administration)



1. INTRODUCTION

- Modern and efficient container terminals have become a central issue in keeping pace with the rapidly increasing demand for import and export container cargo services

- Research object: gain an understanding of container terminal efficiency in the Hai Phong area at the northern region of Vietnam. This research determined the latest efficiency levels of the 15 container terminals operating in the study site and the 10-year efficiency trend exhibited by these facilities

- Research method: window DEA, DEA CCR, DEA BCC, and a slacks-based measure of super efficiency in DEA (DEA SBM).

2. LITERATURE REVIEW

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Authors	Model	Time of data	Sample
Seo et al. (2012)	DEA CCR	2010	32 main ports in nine ASEAN countries
Kutin et al. (2017)	DEA BCC DEA CCR	2014	50 container ports and terminals in ASEAN region
Nguyen and Kim (2015)	DEA CCR	2012 - 2014	11 container terminals in Northern Vietnam
Ly et al. (2018)	HHI Shift Share Analysis DEA CCR DEA BCC	2016	7 Korean and 21 Vietnamese container ports
Nguyen et al. (2019)	DEA CCR DEA BCC Malmquist Productivity Index	2013-2017	26 Vietnam container terminals
Nguyen et al. (2020)	HHI Shift share analysis Gini coeddicient Super efficiency DEA	2007-2017	28 largest container ports in Southeast Asia

2. LITERATURE REVIEW

Previous study

- Some scholars have studied the performance of ports in ASEAN region
- Some scholars have studied the relative efficiencies of ports in Vietnam with single-year statistics

Research Gap

- Recent studies only slightly derived comprehensive results with reference to port efficiency trend
- No study has focused on container terminal performance in Hai Phong, one of the two largest ports in Vietnam
- This study filled this gap to analyze the relative efficiency of Hai Phong container terminals from 2020 to 2019

3. OVERVIEW OF CONTAINER TERMINALS IN HAI PHONG

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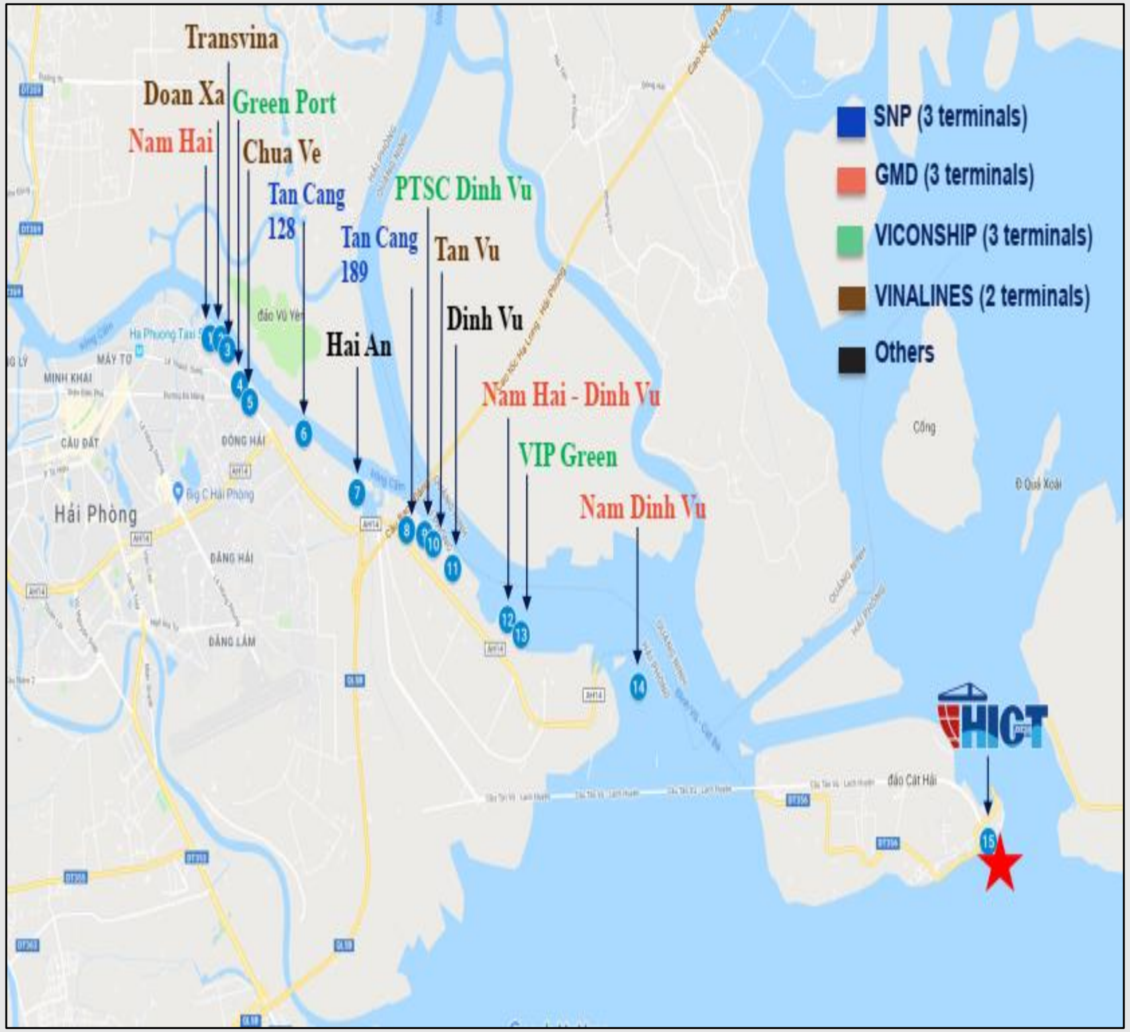
- Hai Phong, a natural habour, is located on the southern side of the River Cam 100 kilometers southeast of Ha Noi capital.
- The Hai Phong port system lies in the Ha Noi – Hai Phong – Quang Ninh economic triangle an area characterized by developed economic and infrastructure conditions.
- With regard to transportation networks, Hai Phong is the only region in Vietnam that connects to all four traffic systems, that is, roads, railways, inland waterways, and air.
- There are 15 container terminals in this area



3. OVERVIEW OF CONTAINER TERMINALS IN HAI PHONG

No	Area	Terminal	Starting Year	DWT	Capacity (1000TEU)
1	Lach Huyen	HICT	2018	132,000	1,100
2	Dinh Vu	PTSC Dinh Vu	2011	20,000	300
3		Tan Cang 189	2012	15,000	200
4		Tan Vu	2008	55,000	550
5		Nam Hai Dinh Vu	2014	30,000	500
6		Vip Green	2016	30,000	500
7		Nam Dinh Vu	2018	40,000	500
8		Dinh Vu	2007	40,000	450
9	Cam river	Green port	2003	20,000	350
10		Nam Hai	2009	10,000	200
11		Chua Ve	2000	20,000	550
12		Doan Xa	2002	40,000	200
13		Transvina	2005	13,000	150
14		Tan Cang 128	2013	15,000	250
15		Hai An	2011	20,000	250

4. METHODOLOGY

4. METHODOLOGY

DEA-Window

Dynamic change of Efficiency

DEA-CCR, DEA-BCC

Comparing of scale effect of DMU for latest year(2019)

Super SBM efficiency DEA

Detailed raking comparison for latest year(2019)

Hai Phong area efficiency evaluation

4. METHODOLOGY

WINDOW DEA

$$X_n^t \begin{bmatrix} x_n^{1t} \\ \vdots \\ x_n^{mt} \end{bmatrix}, \; Y_n^t \begin{bmatrix} y_n^{1t} \\ \vdots \\ y_n^{st} \end{bmatrix},$$

$$X_{kw} = \begin{bmatrix} x_1^k & x_2^k & \cdots & x_N^k \\ x_1^{k+1} & x_2^{k+1} & & x_N^{k+1} \\ \vdots & \vdots & \ddots & \vdots \\ x_1^{k+w} & x_2^{k+w} & \cdots & x_N^{k+w} \end{bmatrix}, \quad Y_{kw} = \begin{bmatrix} y_1^k & y_2^k & \cdots & y_N^k \\ y_1^{k+1} & y_2^{k+1} & & y_N^{k+1} \\ \vdots & \vdots & \ddots & \vdots \\ y_1^{k+w} & y_2^{k+w} & \cdots & y_N^{k+w} \end{bmatrix}$$

4. METHODOLOGY

DEA CCR

$$max\, h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i\, x_{i0}}$$

$$\text{subject to: } \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_{ij}} \leq 1; \quad \text{j} = 1, \ldots, \text{n},$$

$$v_r, u_i \geq 0; \quad \text{r} = 1, \ldots, \text{s}; \quad \text{i} = 1, \ldots, \text{m}.$$

DEA BCC

$$max\, h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i\, x_{i0}}$$

$$\text{subject to: } \frac{\sum_{r=1}^{s} u_r y_{rj} + u_0}{\sum_{i=1}^{m} v_{ij}} \leq 1; \quad \text{j} = 1, \ldots, \text{n},$$

$$v_r, u_i \geq 0; \quad \text{r} = 1, \ldots, \text{s}; \quad \text{i} = 1, \ldots, \text{m}.$$

4. METHODOLOGY

SUPER SBM EFFICIENCY DEA

$$\delta^k = \min \frac{\left[\frac{1}{m}\sum_{m=1}^{M} \bar{x}/x_m^k\right]}{\left[\frac{1}{n}\sum_{n=1}^{N} \bar{y}/y_m^k\right]}$$

s.t $\overline{x_m} \geq \sum_{j=1,j\neq k}^{j} x_m^j \lambda^j$ (m=1,2,…,M)

$\overline{y_n} \leq \sum_{j=1,j\neq k}^{j} y_n^j \lambda^j$ (n=1,2,…,n)

$\bar{x} \geq x_m^k, \bar{y} \leq y_n^k$

$\lambda \geq 0, (j = 1,2, \dots, j \neq k)$

4. METHODOLOGY

- Data Envelopment Analysis (DEA) is a non-parametric mathematical programming approach for measuring relative efficiencies of decision-making units (DMUs) with respect to multiple inputs and outputs, developed by Charnes et al. (1978). They created the DEA method with constant return to scale (CRS) or the so-called DEA-CCR. This method is extended by Banker et al. (1984) to include variable returns to scale (VRS) and it is also known as DEA-BCC.
- Each DMU selects input and output weights that maximize its efficiency score. Generally, a DMU is considered to be efficient if it obtains a score of 1. In contrast, a DMU is inefficient if its score is less than 1. The CCR efficiency scores measure the overall technical efficiency while the BCC model estimates the pure technical efficiency of a DMU at a given scale of operation.
- The conventional DEA-CCR and DEA-BCC analyses have the limitation that detailed ranking cannot be applied because the efficiency of DMUs across the limit curve is the same. The Super SBM efficiency DEA can differentiate the ranks by comparing the ranks of DMUs that have the highest efficiency
- If the data exist in a time series, dynamic analysis using the DEA window analysis is possible. This study conducted an analysis for eight periods in total with a window span of three years.

4. METHODOLOGY

- As noted by Culliane and Wang (2006), container throughput is the most important indicator of port or terminal output and widely accepted in numerous studies. Moreover, container throughput is considered as the most compatible and analytically tractable indicator of port or terminal efficiency.
- In addition, the efficient use of land, equipment and labor are crucial indicator affecting container terminal performance.

Input		Output	
I_1	Container yard (㎡)	O_1	Throughput (TEU)
I_2	Number of quay crane		
I_3	Berth draft (m)		
I_4	Berth length (m)		
I_5	Numer of labor		

	I_1	I_2	I_3	I_4	I_5	O_1
Min	40,000	2	7.8	150	52	8
Max	562,50	15	14	980	925	985
Aver.	12389	4	7	311	209	243
S.D	13492	4	4	285	212	225

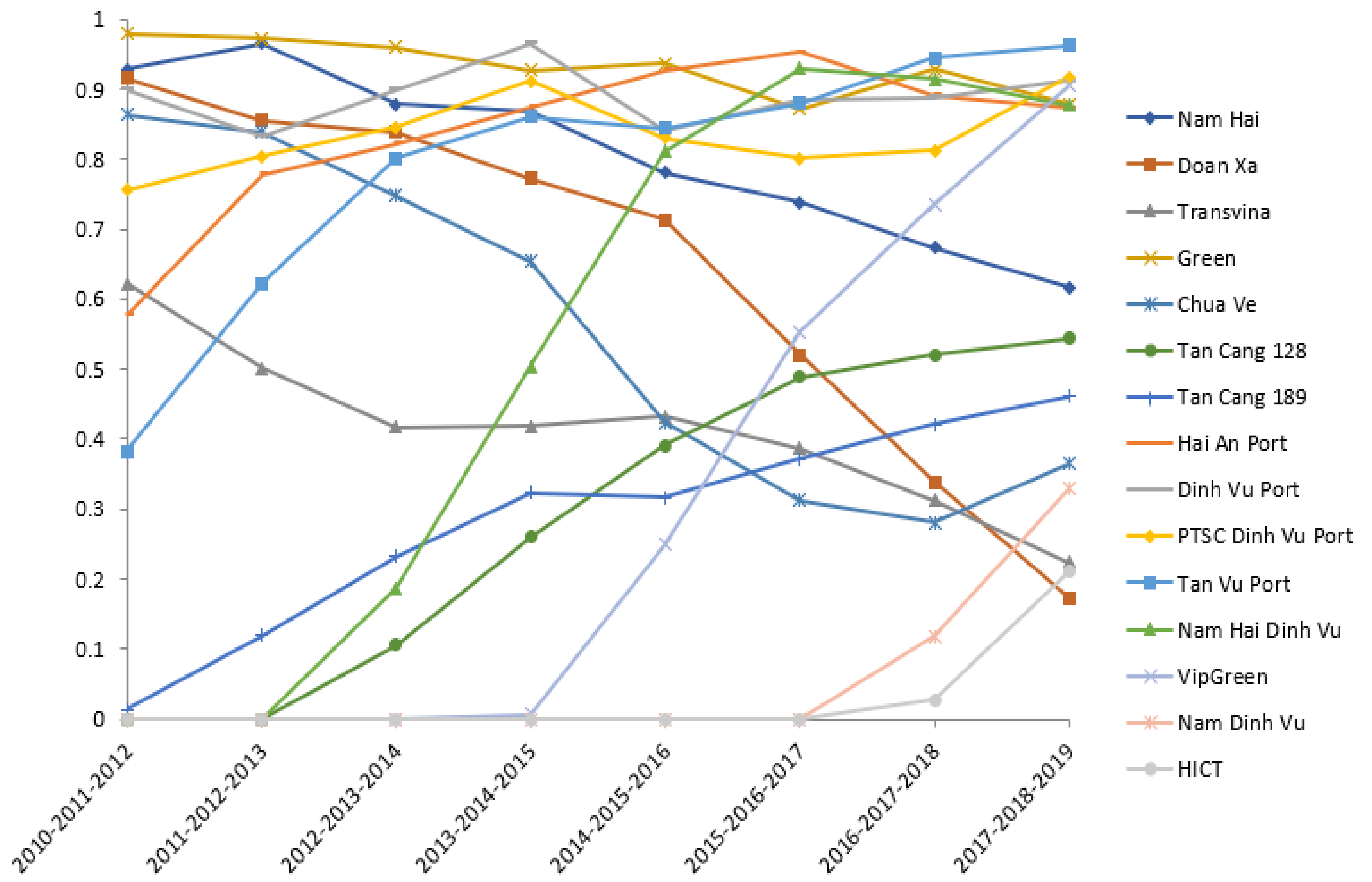
5. CASE STUDY

5-1. DEA WINDOW ANALYSIS

Container terminal (DMUs)	2010-2012	2011-2013	2012-2014	2013-2015	2014-2016	2015-2017	2016-2018	2017-2019	Avg.	
Nam Hai	0.928	0.965	0.879	0.867	0.781	0.738	0.673	0.616	0.806	
Doan Xa	0.915	0.855	0.839	0.773	0.713	0.520	0.338	0.174	0.641	
Transvina	0.623	0.501	0.418	0.419	0.432	0.386	0.313	0.225	0.415	
Green	0.979	0.972	0.959	0.926	0.936	0.871	0.929	0.879	0.931	1
Chua Ve	0.863	0.839	0.748	0.654	0.424	0.312	0.281	0.365	0.561	
Tan Cang 128	0	0	0.106	0.260	0.391	0.489	0.521	0.543	0.289	
Tan Cang 189	0.013	0.120	0.232	0.324	0.316	0.371	0.421	0.461	0.282	
Hai An	0.748	0.778	0.822	0.874	0.927	0.953	0.891	0.873	0.858	3
Dinh Vu	0.899	0.833	0.898	0.965	0.840	0.884	0.889	0.911	0.890	2
PTSC Dinh Vu	0.756	0.804	0.846	0.912	0.831	0.801	0.812	0.917	0.835	
Tan Vu	0.383	0.623	0.801	0.860	0.844	0.880	0.945	0.962	0.787	
Nam Hai Dinh Vu	0	0	0.187	0.503	0.811	0.929	0.914	0.877	0.528	
Vip Green	0	0	0	0.007	0.249	0.554	0.735	0.905	0.306	
Nam Dinh Vu	0	0	0	0	0	0	0.119	0.329	0.056	
HICT	0	0	0	0	0	0	0.027	0.210	0.030	

5-1. DEA WINDOW ANALYSIS

- Nam Hai, Doan Xa, Transvina, Chua Ve: downward trend
- Others: upward trend



5-1. DEA WINDOW ANALYSIS

- Green, which showed the highest efficiency for the total period, had four quay cranes and a bearth lengh of 320 m, indicating efficient operation with smaller number of cranes than other terminals of similar scales.

- Dinh Vu Port, which showed the second highest efficiency for the total period, recorded the highest efficiency during the 2013-2015 window span including 2015. This is because the labour of Dinh Vu Port in this period decreased compared to the previous year, and the throughput increased from 575,000 TEU to 630,000 TEU

- Hai An Port showed the third highest efficiency for the total period, and its input and throughput have increased together since 2010.

5-2. DEA-CCR, DEA-BCC ANALYSIS OF 2019

DMUs	CCR-O	BCC-O	RTS	SE
Nam Hai	0.574	1.000	Increasing	0.574
Doan Xa	0.160	0.886	Increasing	0.181
Transvina	0.073	1.000	Increasing	0.073
Green	1.000	1.000	Constant	1.000
Chua Ve	0.465	0.943	Increasing	0.492
Tan Cang 128	0.426	0.951	Constant	0.448
Tan Cang 189	0.420	1.000	Increasing	0.420
Hai An Port	1.000	1.000	Constant	1.000
Dinh Vu Port	0.886	0.945	Increasing	0.938
PTSC Dinh Vu Port	1.000	1.000	Constant	1.000
Tan Vu Port	1.000	1.000	Constant	1.000
Nam Hai Dinh Vu	0.743	0.919	Increasing	0.808
VipGreen	1.000	1.000	Constant	1.000
Nam Dinh Vu	0.652	1.000	Increasing	0.652
HICT	0.567	0.698	Increasing	0.812
Average	0.664	0.956		0.693

5-2. DEA-CCR, DEA-BCC ANALYSIS OF 2019

- The terminals that showed the efficiency of 1 in the CCR analysis for 2019 are Green, Hai An Port, PTSC Dinh Vu Port, Tan Vu Port, and Vip Green.

- The CCR analysis result showed that the average was 0.664 and there were eight DMUs that were lower than the average.

- The terminals whose efficiency was not 1 in the DEA-CCR analysis, but was 1 in the DEA-BCC analysis are Nam Hai, Transvina, Tan Cang 189, and Nam Dinh vu.

- The terminals which are operating efficiently and having optimal scale include Green, Hai An Port, PTSC Dinh Vu Port, Tan Vu Port, and VipGreen.

- The terminals with a large loss due to scale in terms of the SE value include Transvina (0.073), Doan Xa (0.181), Tan Cang 189 (0.420),Tan Cang 128 (0.448), Chua Ve (0.492), and Nam Hai (0.574).

5-3. SUPER SBM EFFICIENCY OF 2019

DMUS	SUPER SBM DEA	SUPER SBM DEA RANK
Nam Hai	0.573	9
Doan Xa	0.160	15
Transvina	0.073	14
Green	1	5
Chua Ve	0.464	12
Tan Cang 128	0.425	13
Tan Cang 189	0.420	10
Hai An Port	1.318	3
Dinh Vu Port	0.886	6
PTSC Dinh Vu Port	1.088	4
Tan Vu Port	1.359	2
Nam Hai Dinh Vu	0.742	8
VipGreen	1.382	1
Nam Dinh Vu	0.652	7
HICT	0.566	11

5-3. SUPER SBM EFFICIENCY OF 2019

- It seems that VipGreen achieved the highest efficiency even though the input levels of quay crane and berth length, the other input variables besides the container yard, are the same or larger than those of other terminals because of the smaller container yard and the larger throughput.

- Tan Vu, the second highest efficiency, have larger inputs than other terminals in every input variable. Nevertheless, it recorded a high efficiency because its throughput was 985,000 TEU. As shown by the SE result, the Tan Vu Port do not have differences in efficiencies between CCR and BCC. Hence, it is a terminal that had no loss for scale and performed excellent operation.

- The Hai An Port, which ranked third, is not a large terminal in terms of absolute throughput. However, it is evaluated as an efficient terminal due to the low input variables.

6. CONCLUSION

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- The DEA Window analysis result showed that over the last decade, the DMU with the highest efficiency is the Green terminal, followed by Dinh Vu Port, Hai An Port and PTSC Dinh Vu Port. The factor that enabled these highly efficient terminals maintain high efficiency is the steady increase in throughput.

- As a result of the DEA-CCR for 2019, the terminal that showed a large loss due to scale were Transvina (0.073), Doan Xa (0.181), Tan Cang 189 (0.420), Tan Cang 128 (0.448), Chua Ve (0.492), and Nam Hai (0.574).

- Meanwhile, the Super SBM efficiency analysis for 2019 showed that VipGreen had the highest efficiency, followed by Tan Vu Port, Hai An Port, and PTSC Dinh Vu Port.

- The academic significance of this study is that it provides in-depth analysis results for the Hai Phong ports in the northern Vietnam, which has been less researched. This study is particularly meaningful in that it provided changes in efficiency over the recent decade and presented the rankings of DMUs that have the same efficiency using the Super SBM efficiency DEA

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