A Study on the Development of Vietnamese Container Ports and Their Relative Efficiency

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Abstract

Currently, there are very few studies about container ports in Vietnam. Of those that have, several of them evaluate the efficiency of container ports located in the North of Vietnam; others focus on comparing all types of ports in Vietnam with regard to the differences in efficiency scores when applying different methods to evaluate efficiency. There are few studies specifically analyze the whole Vietnamese container ports system or compare Vietnamese container ports with those of other countries in terms of efficiency.

To draw an overall picture about Vietnamese container ports in respect of their development process and their efficiency, firstly HI (Herfindahl-Hirschman Index) and SSA (shift-share analysis) applied to analyze the concentration trend and shifting in the container ports' market share; then, 21 major Vietnamese container ports and 7 major Korean container ports are selected to examine their level of efficiency in 2016 using Data Envelopment Analysis (DEA). This paper applies both constant return to scale (CRS) and variable return to scale (VRS) to explore the differences among overall technical efficiency, pure technical efficiency and scale efficiency of container ports under evaluation, also indicate slacks and set the projection for inefficiency ports.

Keywords: HHI, SSA, container port system analysis, port efficiency, Korean container ports, DEA, overall efficiency, pure technical efficiency, scale efficiency.

Chapter 1 Introduction

Since the first container terminal opened in 1962 and the first container port system established in the USA, the whole world has witnessed a speedy, extensive and robust containerization. While developed countries and advanced maritime countries are the earliest countries exposed to this evolution, Vietnam appeared to be rather late in approaching this new unitization. The first container ships operated in Vietnam was started from 1989, which carried containers from Ho Chi Minh to Singapore weekly but the containerization process in Vietnam just start to be rapid after 2000 and demands for container ports thereby also increase. Seeing the benefit from this industry, in the period of 2005-2007, there were many investors including big foreign shipping lines and port operators invested to build container terminals in Vung Tau and Ho Chi Minh, Southern Vietnam where handle about 70% container cargoes volume of the whole country; meanwhile, in North, there were also a series of container terminals established along Cam River, Hai Phong province.

Recent years, when the volume of import and export container cargoes increases rapidly, the port system in Vietnam appears to be backward and unable to catch up with demands and requirements of container shipping lines. That is due to most of the container ports in

Vietnam are facing with problems such as being located at narrow channels and limited drafts, not equipped with specialized container handling equipment, inland transportation infrastructure has not been developed, lack of technology application. These limitations in Vietnam container port system are strongly affecting to ports' performance and would lead to less competitiveness, or the lag of Vietnamese container ports comparing to other container ports in other countries.

To have an insight container port system in Vietnam, this study firstly employs Herfindahl-Hirschman Index (HHI) and shift-share analysis (SSA) to analyze the development process of the system and provide basic information to explain the results in the second part which applies Data Envelopment Analysis (DEA) to evaluate the efficiency of 21 major container ports in Vietnam. For an easy evaluation, this study picks 7 majors container ports of Korea into the group of decision-making units. Hopefully, selecting container ports of Korea which are known as an advance maritime country will bring more accurate result and interesting information about container ports in Vietnam.

However, the problems may vary according to different regions in Vietnam where container ports located. So that, to see how different in level of efficiency among different regions in Vietnam, Vietnamese container ports are divided into 3 groups corresponding to 3 regions in Vietnam, namely the North, the South and the Central and their average efficiency score is compared to each other.

After all, the purposes of this study is to provide to investors, port operators and policymakers useful information and importance implications about Vietnamese container ports; from that help avoiding repetition of inappropriate investment and wasting resources, especially, when the trends in the world container ports such as the deployment of mega-ships, the alliances or consolidation of shipping lines are imposing great pressures on container ports and force them to continue improving their level of performance.

The rest of this study is organized as follows: Chapter 2 provides information about container port in Vietnam in respect of categorizing of port groups, parameters and infrastructure of major container ports and their hinterland connectivity; Chapter 3 is about earlier studies and researches relating to container port system analysis and port efficiency; Chapter introduces the methodologies applied to this study, they are HHI and SSA for container port system analysis and DEA for container port efficiency; Chapter 5 shows the empirical results and discussion; and finally Chapter 6 Summarize the results, convey implications.

Chapter 2 Container Ports in Vietnam

2.1 The Potential of Seaports Development in Vietnam

One decade after joining WTO in November 2006 and signing 16 free trade agreements, Vietnam economy has recorded a big step in integrating into the world economy and achieved a great development. Annual GDP, FDI and import, export value has increased rapidly and consistently.

Table 1 below describes these values during a period of 2000-2016. On average, GDP growth rate of Vietnam was 6.39% while this of the world was 3.88% (World Bank). FDI also increased quickly from 391 projects with the value of registration is 2,763 million USD in 2000 to 2,613 projects and the value of 26,891 million USD in 2016.

The foreign investment activities in Vietnam formed the flow of materials transport into Vietnam and the flow of finished products or semi-finished products exported to other countries; created many jobs and raised the personal income for employees boosting the consumption demand for both domestic and imported commodities. Consequently, import and export cargoes increased significantly with the average rate of 17.9% in the period of 2000-2016.

Because of the limitation in transportation infrastructure and the advantages in the location with a long coastline, shipping becomes the most important means of transport in Vietnam which carrying about 90% of import and export cargoes.

These facts together with the rapid increase in cargoes import and export boost the need to have a modern container port system that is able to handle the demand of national cargoes and take advantages on favourable maritime conditions.

Table 1. Annual GDP, FDI and import, export value in Vietnam in the period of 2000-2016

Year	GDP growth rate	FDI		Import, export value			Import, export growth rate
	(%)	No. of FDI projects	Registered value (million USD)	Total import, export (million USD)	Export (million USD)	Import (million USD)	(%)
2000	6.79	391	2,763	30,084	14,449	15,635	29.9
2001	6.19	555	3,266	31,190	15,027	16,163	3.7
2002	6.32	808	2,993	36,439	16,706	19,733	16.8
2003	6.90	791	3,173	45,403	20,176	25,227	24.6
2004	7.54	811	4,534	58,458	26,504	31,954	28.8
2005	7.55	970	6,840	69,420	32,442	36,978	18.8
2006	6.98	987	12,005	84,717	39,826	44,891	22.0
2007	7.13	1,544	21,349	111,244	48,561	62,683	31.3

2008	5.66	1,171	71,727	143,399	62,685	80,714	28.9
2009	5.40	1,208	23,108	127,045	57,096	69,949	(11.4)
2010	6.42	1,237	19,887	157,075	72,237	84,838	23.6
2011	6.24	1,186	15,598	203,656	96,906	106,750	29.7
2012	5.25	1,287	16,348	228,310	114,529	113,781	12.1
2013	5.42	1,530	22,352	264,066	132,033	132,033	15.7
2014	5.98	1,843	21,922	298,068	150,217	147,851	12.9
2015	6.68	2,120	24,115	327,587	162,017	165,570	9.9
2016	6.21	2,613	26,891	350,743	176,632	174,111	7.1
Average	**6.39**						**17.9**

(Data was released by General Statistic office of Vietnam and World Bank)

2.2 Introduction to Seaport System in Vietnam

Vietnam is a maritime country of which the East, the South and the Southwest lying toward the South China Sea make up a coastal line of 3,264km. The continental shelf of Vietnam is over 1 million square kilometers (determined by the United Nations Convention on the Law of the Sea – UNCLOS in 1982) and located on major shipping routes connecting the Indian Ocean with North Pacific Ocean, the Middle East and Europe with China, Korea and Japan.

According to Decision No.70/2013/QĐ-TTg on November 19, 2013, approved by the Prime Minister, Vietnam has 219 terminals located along the coastal line, which consist of 373 berths with the total length of about 44,000m. These terminals belong to 44 ports and divided into 3 groups as follow

- *Type I*: Type of international gateway ports and national hub ports (14 ports), comprising Quang Ninh, Hai Phong, Nghi Son (Thanh Hoa), Nghe An, Ha Tinh, Hue, Da Nang, Dung Quat, Quy Nhon (Binh Dinh), Khanh Hoa, Ho Chi Minh, Vung Tau, Dong Nai and Can Tho.
- *Type II*: Type of local ports (17 ports), including Hai Thinh (Nam Dinh), Thai Binh, Quang Binh, Quang Tri, Ky Ha (Quang Nam), Vung Ro (Phu Yen), Ca Na (Ninh Thuan), Binh Thuan, Binh Duong, Tien Giang, Ben Tre, Dong Thap, An Giang, Vinh Long, Nam Can (Ca Mau), Kien Giang and Tra Vinh.
- *Type III*: Type of offshore oil and gas ports, including 9 ports in Ba Ria - Vung Tau namely Rong Doi, Rang Dong, Lan Tay, Dai

Hung, Chi Linh, Ba Vi, Vietsopetro 01, Chim Sao and Te Giac Trang; 3 ports in Binh Thuan namely Hong Ngoc, Su Tu Den and Su Tu Vang; and Song Doc port in Ca Mau.

These groups above are classified depending on some criteria with their different weights (score). These weights of such criteria correspond to their level of importance as table 2 below.

Table 2. Criteria to classify Vietnamese seaports by decision No.70/2013/QĐ-TTg

No.	**Criteria**	**Maximum score**
A	**ATTRACTIVE CHARACTERISTIC OF PORT'S LOCATION**	30
I	**Local's area, population**	10
1	**Area (km2)**	5
	Below 2.000	1
	From 2.000 to 5.000	3
	Above 5.000	5
2	**Population (person)**	5
	Below 5.000.000	1
	From 5.000.000 to 10.000.000	3
	Above 10.000.000	5

II	**Urban area, industrial zone, maritime services**	10
1	**Urban area**	4
	There is urban area(s) in Port's local:	
	Urban type I	4
	Urban-type II	2
	Urban-type III	1
2	**Industrial zone**	4
	There is an industrial zone(s) in Port's local	
	Very important industrial zone	4
	Important industrial zone	2
3	**Maritime services**	2
	Complete and convenient maritime services	2
	Incomplete maritime services	0
III	**Transportation condition**	10
	There is an international airport in Port's local	2
	There is railway connecting to the Port	2
	Distance from Port to the highway is under 10km	2

	There is inland waterway transporting to the Port	2
	Distance from Port to international shipping route is under 100 nautical miles	2
B	**ROLE OF PORT**	40
1	Serving for socio-economic development of national or inter-regional scope	30
	Serving for socio-economic development of the region where port located	20
	Serving for socio-economic development of the local where port located	10
2	To be able to become an international transhipment port	10
3	To be able to become an international gateway port	10
C	**SIZE OF PORT**	30
I	**Current size**	15
1	**Cargoes throughput**	7
	Below 1 million MT per year	3
	From 1 million MT to 3 million MT per year	5
	Above 3 million MT per year	7
2	**Type of port, length of the berth, capacity**	8

	There is general terminal for ship capacity above 10.000 DWT	2
	There is container terminal for ship capacity above 10.000 DWT	2
	There is specified terminal for ship capacity above 15.000 DWT	1
	The total length of berths is above 1000m	1
	Total number of the berths is above 5 berths	2
II	**Size as planning**	15
1	**Cargoes throughput**	7
	From 3 million MT to below 5 million MT per year	3
	From 5 million MT to 10 million MT per year	5
	Above 10 million MT per year	7
2	**Type of port, length of the berth, Capacity**	8
	There is general terminal for ship capacity above 20.000 DWT	2
	There is container terminal for ship capacity above 20.000 DWT	2
	There is specified terminal for ship capacity above 30.000 DWT	1
	The total length of berths is above 2000m	1
	Total number of the berths is above 10 berths	2
	Total score	**100**

Ports have a total score of 50 points and above are categorized Type I, whereas ports have a score of below 50 points categorized as Type II. Ports mainly serve for business activities of enterprises care categorized Type III.

In terms of their location regions, the seaport system is divided into 6 groups:

Group 1: the group of Northern seaports which located from Quang Ninh to Ninh Binh. In which, ports in Thai Binh, Nam Dinh and Ninh Binh play the roles of serving for local economics' development. Terminals in Hai Phong are located deep inside the river with the distance of 36km from buoy number 0 and the channels are quickly accrued by alluvial leading to limiting the depth of channels. However, nowadays, new terminals in Hai Phong tend to locate closer to the river mouth. In contrast to that, terminals in Quang Ninh have favorable conditions such as a deeper channel, being able to be located near the river's mouth. Due to the better transportation system, ports' infrastructure and a larger cargoes market, Hai Phong become the most active terminals group in the North.

Group 2: is the group of Northern Central seaports positioning from Thanh Hoa to Ha Tinh. Due to the limitations in natural geography such as having cyclones and sandstorms regularly, terminals in this group are located deep inside the upstream with a shallow draft but near the rail and road systems.

Group 3: is the group of Middle Central seaports lying from Quang Binh to Quang Ngai. Similar to group 2, seaports in this group has shallow draft and function as transitional ports or to serve the need for boosting local economies. Except for Da Nang port, others terminals in this group have a small size and fewer cargoes handling equipment.

Group 4: The group of Southern Central seaport from distributed from Binh Dinh to Binh Thuan. This region has advantages in building the large ports such as large and deep gulfs along the coastal, short channels and near international shipping routes. However, this region is far from the key economic zone and the cargoes market here is not large that leading to this region does not have any important terminal excluding Quy Nhon.

Group 5: is the group of South East seaports, including Ho Chi Minh City, Binh Duong, Dong Nai, Ba Ria – Vung Tau and along Soai Rap River in Long An and Tien Giang province. This group is located in the key economic zone of Vietnam with many industrial centers, and active trading and services market. The terminals in Ho Chi Minh are positioned deeply inside inland about 49 nautical miles from where they are less affected by the strong waves, storms or strong wind and the channel is less affected by alluvial. However, due to the speedy urbanization, these terminals are not able to be expanded so that the Government has planned to move such terminals to Ba Ria – Vung Tau. Meanwhile, terminals in Ba Ria – Vung Tau are located close to river's mouth so that they have a deep draft but favorable geography conditions such as less alluvial, deep channel, less strong wind or storms and having inland waterway to connect to Mekong Delta and South West area.

Group 6: The group of seaports in Mekong Delta area and South West islands, comprising ports located in Tien River and Hau River, Ca Mau peninsula and coastal of Thailand Gulf. Ports in this group are local ports and very small in size.

Figure 1 shows groups of Vietnam seaports with their locations and the percentage of container cargoes volume that each group handled in 2016. Among these above groups, in 2016, group 5 handles about 45% total cargo throughput and about 64% container cargo throughput; group 1 handles about 30% total cargo throughput and about 32% container cargo throughput; group 3 (mainly Da Nang) handle about 2.4% container cargoes throughput; groups 2, 4, 6 handle very small volume of cargoes (under 1%).

Container ports in group 1 include container ports located in Hai Phong and Quang Ninh. In Hai Phong, these are Hai Phong terminal (Chua Ve and Tan Vu terminal), Dinh Vu, Hai An, Green Port, Doan Xa, Transvina, Nam Hai, Nam Hai Dinh Vu, PTSC Dinh Vu, Vip Green Port, TC – 128 Hai Phong and TC – 189 Hai Phong. In Quang Ninh, these are CICT (Cai Lan International Container terminal) and Quang Ninh. There is only Nghe Tinh which handles container cargoes in group 2. In group 3, Ky Ha and Da Nang are two ports that are able to handle container cargoes. Nevertheless, container cargoes throughput in Ky Ha port is very small and recently, only Da Nang port handles container cargoes. There is only Quy Nhon port in group 4 which is able to handle container cargoes. Container ports in group 5 include Ho Chi Minh port, Dong Nai port, Binh Duong port and Vung Tau port. In Ho Chi Minh, container terminals comprise Cai Lai, Bong Sen, Ben Nghe, Sai Gon, Hiep Phuoc New Port, SPCT and VICT. Container terminals in Vung Tau include SITV, SP-PSA, TCIT, CMIT, TCTT, SSIT and TCCT. There are only Can Tho port and Cai Cui New Port in group 6. In which, Cai Cui New Port just started their business in December 2016. Besides that, there is a group of barge terminals in group 6. These are Sa Dec, Cao Lanh, My Thoi, Tra Noc, Thot Not and Giao Long.

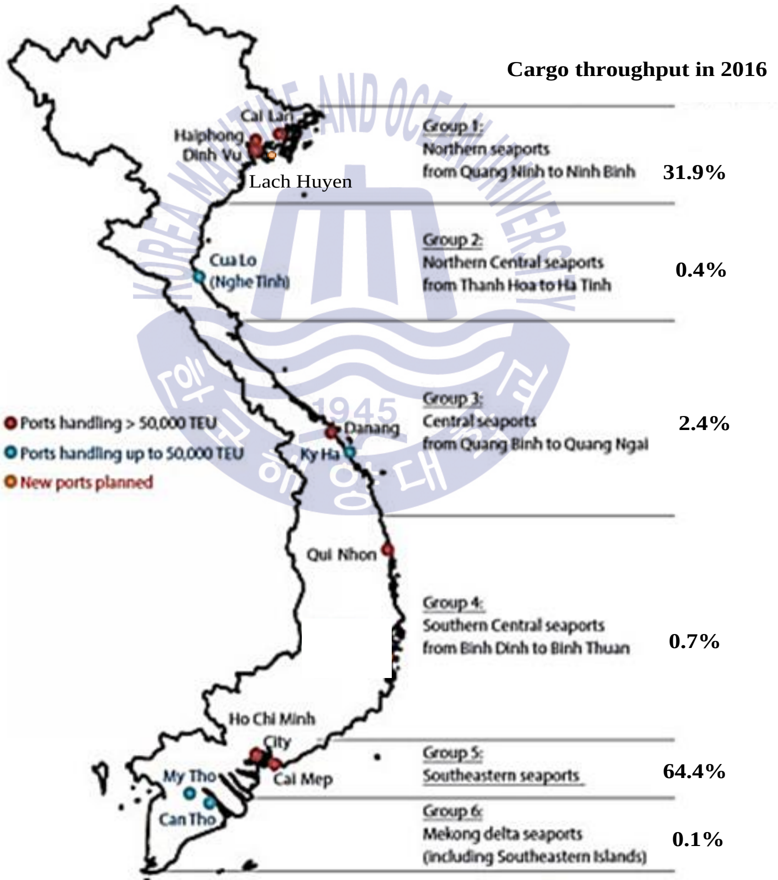

Figure 1. Vietnamese seaports system and their percentage of cargoes throughput in 2016

2.3 Infrastructure of Vietnamese Container Ports System

According to the Global Competitiveness index, 2017-2018 reported by World Economic Forum, Vietnam ranks 82th among 137 economies in the world in term of quality of port infrastructure. This ranking base on the data in 2016 about extensiveness and condition of seaports, for landlocked countries, this ranking assesses the ability to access to seaports.

Table 3. Quality of port infrastructure ranking in 2016

No.	Country/economies	Score	Rank/137
1	Singapore	6.7	2
2	Hong Kong SAR	6.5	3
3	Malaysia	5.4	20
4	Japan	5.3	21
5	Korea, Rep.	5.2	23
6	Taiwan, China	5.2	24
7	China	4.6	49
8	Sri Lanka	4.5	57
9	Thailand	4.3	63
10	Indonesia	4	72
11	Cambodia	3.7	81
12	Viet Nam	3.7	82

(*Note: score of 1 = extremely poor, 7 = extremely good*)

Table 3 above describes score and ranking of the quality of port infrastructure of Asia countries among 137 countries and economies. One can see that the quality of Vietnam's port infrastructure is very low (ranks 82th, score: 3.7) comparing to other countries in Asia or even among South East Asia countries such as Malaysia (ranks 20th, score: 5.4), Thailand (ranks 63th, score: 4.3) or Indonesia (ranks 72th, score: 4).

2.3.1 Channels of Vietnamese Seaports

As Vietnam Maritime Administration, currently, there are 38 channels in Vietnam. In which, group 1 has 6 channels, group 2 has 5 channels, group 3 has 10 channels, group 4 has 5 channels, group 5 has 7 channels and lastly group 6 has 5 channels. Table 4 demonstrates these 38 channels with their parameters.

Table 4. Channels parameters

No.	**Channels**	**Parameters**		
		Length	Width	Depth
		km	m	m
1	**Hai Phong channel**			
	Nam Trieu segment	19	100	-4.5
	Lach Huyen segment	17	100	-7.2
	Ha Nam segment	7	80	-7
	Bach Dang segment	8	80	-7
	Cam River segment	10	80	-5.5
	Vat Cach segment	9	60	-3.7
2	**Vạn Gia channel (Quang Ninh province)**			

	From Buoy 0 to Buoy 11	9.2	120	-5.7
3	**Hon Gai channel (Cai Lan, Quang Ninh province)**			
	Hon Bai - Cai Lan segement	31	130	-10
4	**Pha Rung channel (Hai Phong city)**			
	The segment from Dinh Vu intersection to floating dock	1.9	80	-4.2
	Segment from floating dock to The mouth of Gia River	9.7	60	-2
	Gia River segment	2.1	50	-2
5	**Diem Dien channel (Thai Binh province)**			
	(From Buoy 0 to Berth 1 Diem Dien port)	10.6	45	-3.3
6	**Hai Thinh channel (Thai Binh province)**			
	(From Buoy 0 to 200 meters far from upstream of Hai Thinh port)	9.3	60	-1
7	**Le Mon channel (Thanh Hoa province)**			
	(From Buoy 0 to 200 meters far from upstream of Le Mon terminal)	17.5	50	-1
8	**Nghi Son channel (Thanh Hoa province)**			

	(From Buoy 0 to Berth 1 of Nghi Son port)	3.6	80	-8.5
9	**Cua Lo channel (Nghe An province)**			
	(From Buoy 0 to Berth 3 of Cua Lo port)	3.8	80	-5.5
10	**Cua Hoi channel (Ben Thuy, Nghe An province)**			
	(From Buoy 0 to 200 meters far away from Ben Thuy terminal)	23	60	-3
11	**Vung Ang channel (Ha Tinh province)**			
	(From Buoy 0 to Vung Ang terminal)	2	150	-12
12	**Hon La channel (Quang Binh Province)**	3	100	-8.2
13	**Cua Gianh channel (Quang Binh province)**			
	(From Buoy 0 to 200 meter far from upstream of Gianh terminal)	4.1	60	-3.3
14	**Nhat Le channel (Quang Binh province)**			
	(From Buoy 0 to 200 meter far from upstream of Nhat Le terminal)	2.8	50	-1.2
15	**Cua Viet channel (Quang Tri province)**			

	(From Buoy 0 to 200 meter far from upstream of Cua Viet terminal)	2.6	60	-4.5
16	**Thuan An channel (Hue province)**			
	(From Buoy 0 to Thuan An terminal)	5	60	-4.5
17	**Chan May channel (Hue province)**			
	(From Buoy 0 to Chan May port)	3	150	-12.1
18	**Da Nang channel**			
	Tien Sa segment (From Buoy 0 to Berth 3 of Tien Sa port)	6.3	110	-11
	Han River segment (Segment from Berth 3 of Tien Sa port to the end of Berth 6 of Han-River port)	4.7	60	-6.2
	Segment 234 (Segment from Berth 6 of Han-River port to Nguyen Van Troi berth)	2.9	44	-3.7
19	**Ky Ha channel (Quang Nam province)**			
	(From Buoy 0 to Ky Ha port)	11	80	-6.5
20	**Sa Ky channel (Quang Nam)**			
	(From Buoy 0 to Sa Ky port)	2.1	50	-3.5
21	**Dung Quat channel (Quang Ngai province)**	5.4	300	-14.5

22	**Quy Nhon channel**	9	110	-10.5
23	**Vung Ro channel (Phu Yen province)**	3	300	-10
24	**Nha Trang port channel (Khanh Hoa province)**	11,1	130	-11
25	**Dam Mon channel (Khanh Hoa province)**	16,5	200	-16
26	**Ba Ngoi port channel (Khanh Hoa province)**	13	200	-10.2
27	**Sai Gon - Vung Tau channel**	94	150	-8.5
28	**Dua River channel (Ho Chi Minh city)**	10	60	-7
29	**Dong Nai channel (Dong Nai province)**	5	150	-8.5
30	**Thi Vai channel (Ba Ria - Vung Tau province)**			
	Segment 1: From Sai Gon - Vung Tau channel to Phu My	36,5	150	-10
	Segment 2: From Phu My to Go Dau	-	90	-7.2
31	**Soai Rap channel (Hiep Phuoc, Ho Chi Minh)**			
	Soai Rap segment	65,9	200	-9.2
	Hiep Phuoc segment	-	150	-8.5
32	**Dinh River channel (Ba Ria - Vung Tau)**			

	Segment from Buoy 5 of Sai Gon - Vung Tau channel to turning basin of Vietsovpetro port	15,2	150	-7
	Segment from turning basin of Vietsovpetro port to 200 meters far from upstream of Vinaoffshore	-	100	-5.8
	A segment of 200 meters far from upstream of Vietsovpetro port to Buoy 15 and 20	-	100	-4.7
33	**Tien River channel**	74	80	-4.8
34	**Dinh An channel (Can Tho province)**	120	100	-3.2
35	**Con Son channel (Con Do island, Ba Ria - Vung Tau)**	14	200	-2
36	**Ha Tien channel (Kien Giang province)**	10,5	60	-1.5
37	**Nam Can channel (Ca Mau province)**	45,5	60	-2
38	**Sa Dec channel (Dong Thap province)**	0,65	-	-

Almost of channels in Vietnam are one-way channels due to the limitation in the width. Majority of the channels of ports located in the key economic areas are shallow with the draft of fewer than 10 meters. In the South, only Soai Rap (Ho Chi Minh) and Thi Vai (Vung Tau) are good channels but they are also limited in width (Soai Rap: 200 meter;

Thi Vai: 150 meters) and depth (Soai Rạp: 9.2 meter; Thi Vai: 10 meters). In the North, Hon Gai channel in Cai Lan (Quang Ninh province) has the deepest draft of 10 meters, other channels are very shallow with a draft of fewer than 5 meters, even Hai Phong where many container ports are locating also has a shallow channel with the draft of 7 meters.

2.3.2 Terminal Parameters and Storage Area of Major Container Ports

Table 5 below describes basic parameters and facilities in majors Vietnamese container terminals and container ports. Data was collected from website and brochures of these terminals. These data demonstrate that majority of Vietnamese container terminals are small terminals with shallow drafts, small capacity and narrow container yard area.

Table 5. Terminal parameters of majors container ports in 2016

STT	Ports/Terminals	Length of container berth (meter)	Number of container berth	Capacity /year	Maximum ships capacity call at the port	Maximum draft alongside (meter)	Container yard area (m2)
1	Hai Phong port						
	- Chua Ve Container Terminal	848	5	500,000 TEUs	20,000 DWT	-8.0	202,110
	- Tan Vu Container Terminal	981	5	1,000,000 TEUs	55,000 DWT	-9.4	510,000
	- Doan Xa container terminal	220	1	4,400,000 MT	20,000 DWT	-8.4	65,000
	- Transvina container terminal	168	1	2,500,000 MT	7,000 DWT	-7.1	50,000
	- New Port 128 – Hai Phong	480	3	240,000 TEUs	15,000 DWT	-8.2	107,000
	- Dinh Vu New Port	425	2	500,000 TEUs	40,000 DWT	-10.2	200,000
	- New Port 189 – Hai Phong	430	2	200,000 TEUs	15,000 TEUs/ 20,000 DWT	-8.5	197,400

	- Nam Hai Dinh Vu terminal	450	2	500,000 TEUs	2,000 TEUs/ 30,000 DWT	-12.0	150,000
2	Quang Ninh port - CICT	594	3	1,200,000 TEUs	75,000 DWT	-13.0	181,000
3	Nghe Tinh port	656	4	-	15,000 DWT	-9.5	17,930
4	Tien Sa Terminal - Da Nang port	1,192	7	8,000,000 MT	2,500 TEUs/ 50,000 DWT	-11.5	82,400
5	Quy Nhon port	779	7	-	30,000 DWT	-12.5	48,000
6	Dong Nai port - Long Binh Tan terminal	124	2	200,000 TEUs	5,000 DWT	-7.5	88,000
7	Binh Duong port	100	1	-	5,000 DWT	-7.5	60,000
8	Ho Chi Minh port						
	- Ben Nghe terminal	783	4	-	45,000 DWT	-11.0	220,000
	- Cat Lai terminal	1,500	8	4,600,000 TEUs	3,800 TEUs/ 45,000 DWT	-12.5	1,050,0 00
	- Bong Sen (lotus) terminal	300	2	-	50,000 DWT	-11.0	100,000
	- Hiep Phuoc New Port terminal	420	2	650,000 TEUs	50,000 DWT	-13.4	90,000

	- VICT	678	4	500,000 TEUs	25,000 DWT	-11.0	99,840
	- SPCT	950	4	1,500,000 TEUs	50,000 DWT	-10.5	31,516
12	Vung Tau port						
	- CMIT	600	2	1,115,000 TEUs	18,000 TEUs/ 200,000 DWT	-16.5	300,000
	- TCIT and TCCT	890	3	1,800,000 TEUs	110,000 DWT	-14.0	540,000
	- TCTT (ODA)	600	2	1,000,000 TEUs	110,000 DWT	-15.0	473,600

2.3.3 Handling Equipment at Major Container Ports

Table 6 shows handling equipment at major container terminals and container ports in 2017. The table illustrates that there are several large terminals equipped enough specialized container handling equipment such as Cat Lai, Tan Vu, VICT, TCIT; majority of container terminals are equipped very few container equipment such as Dinh Vu New Port, Nam Hai Dinh Vu, TC – 128 New Port, Ben Nghe, Bong Sen, CICT; and some of them without any container quay gantry crane and container yard crane, instead of that, they are using portal slewing cranes or mobile harbor cranes or other multi-function cranes such as Doan Xa, Quy Nhon, Dong Nai, Nghe Tinh.

Table 6. Handling equipment at major container terminals in 2017

STT	Ports/Terminals	Quay gantry crane	Multi-function Ship - to - shore crane	Container yard crane (RMG/RTG)	Reach-stacker/ Forklift/ straddle carrier	Trailer/ container truck
1	Hai Phong port					
	- Chua Ve Container Terminal	4	5	8	11	23
	- Tan Vu Container Terminal	8	7	26	18	35
	- Doan Xa container terminal	0	3	0	6	12
	- Transvina container terminal	1	1	0	11	20
	- TC 128 - Hai Phong	5	2	5	12	30
	- Dinh Vu New Port	2	5	4	15	18
	- Nam Hai Dinh Vu terminal	2	3	0	15	60
2	Quang Ninh port - CICT	4	0	12	7	28
3	Nghe Tinh port	0	3	0	2	9
4	Tien Sa terminal – Da Nang port	2	2	2	34	28

5	Quy Nhon port	0	2	0	7	25
6	Dong Nai port – Long Binh Tan terminal	0	2	0	6	-
7	Binh Duong port	2	1	0	7	10
8	Ho Chi Minh port					
	- Ben Nghe terminal	2	4	6	28	16
	- Cat Lai terminal	20	6	57	58	457
	- Bong Sen (lotus) terminal	2	3	3	9	18
	- Hiep Phuoc New Port terminal	2	7	6	5	18
	- VICT	7	0	10	28	56
	- SPCT	5	0	13	5	20
12	Vung Tau port					
	- CMIT	5	0	15	4	55
	- TCIT	6	0	20	4	61
	- TCTT (ODA)	4	0	15	2	20

2.4. Inland Transportation and Hinterland Connectivity

2.4.1 Inland Transportation and Hinterland Connectivity in Northern Vietnam

- *Domestic shipping routes:*

Hai Phong – Ho Chi Minh – Hai Phong; Hai Phong - Quy Nhon – Cai Mep; Cua Lo – Ho Chi Minh – Hai Phong.

- *International shipping routes:*

Busan New Port – Shanghai – Hai Phong – Busan New Port; Hai Phong – Hong Kong – Shenzhen; Hai Phong – Ho Chi Minh – Bangkok – Laemchabang; Hai Phong - Ho Chi Minh - Tanjung Pelepas (Malaysia); Hai Phong - HongKong – Busan; Singapore - Davao (Philipines) – Hai Phong; Kaohsiung – Hai Phong; Hai Phong – HongKong – Kaohsiung; Thailand – Vietnam – Singapore; Tokyo-Yokohama - Nagoya - Osaka - Keelung- Kaohsiung- Shekou- Hong Kong- Hai Phong- Zhangjiang - Hong Kong - Shekou and Tokyo; Hai Phong – HongKong – Yiantan – Xiemen – Osaka – Kobe – Hakata – Busan – Keelung - HongKong - Hai Phong - Tanjung Palapas – Singapore – Da Nang and Ho chi Minh – Hai Phong – HongKong.

Although Hai Phong is the biggest container port in the South, the shallow channels and alluvial effect to shipping routes here, reduce the number and the size of container ships calling at Hai Phong port.

- *Road routes:*

Highway 5A: connects terminals in Hai Phong to Ha Noi capital. Highway 5A is also a part of Asian Highway 14 (AH14) with 106 kilometers length of route Ha Noi – Hai Duong – Hai Phong. The ending point of this route is Chua Ve terminal, Hai Phong port.

Highway 10: is an inter-provincial road running along the northern coast through 6 provinces and cities: Quang Ninh, Hai Phong, Thai Binh, Nam Dinh, Ninh Binh and Thanh Hoa with the total length of 212 kilometers.

Highway 37: is an interprovincial road connecting 7 provinces, namely Thai Binh, Hai Phong, Hai Duong, Bac Giang, Thai Nguyen, Tuyen Quang, Yen Bai and Son La. In which, the section from Vinh Bao (Hai Phong) to Gia Loc (Hai Duong) connects to Highway 5, 10, 18 and Ha Noi - Hai Phong, Noi Bai - Ha Long. There is a great demand for transportation between Hai Duong, Hai Phong and other provinces in the northern key economic area.

Hanoi - Hai Phong Expressway: This is a 105.5 kilometers long highway from Hanoi capital through Hung Yen, Hai Duong to Hai Phong port. It connects Ha Long - Hai Phong Expressway to Ha Noi - Hai Phong Expressway completing the Northern Economic Corridor connecting Hanoi - Hai Phong - Quang Ninh. Ninh.

Quang Ninh - Hai Phong - Ninh Binh expressway: is a project to develop a 160 kilometers long highway linking economic centers in the northern coastal region of Northern Vietnam from Ninh Binh to Ha Long. This is a highway located at the bottom of the Red River delta triangle; the project is also included in the program "two corridors, one economic belt".

In spite of the fact that there are many road routes in Hai Phong, cargoes are mainly transported to Hai Phong port by road but roads connected with terminals have poor quality and narrow, causing serious traffic jams and congestion at the port area.

- *Inland waterway:*

Hai Phong has 16 national inland waterway routes with a total length of 326 kilometers and a high density of inland waterway vehicles. Therefore, Hai Phong has advantages in the diversification of the waterway system in the north, contributing an important part in the exchange, transportation and socio-economic development of the city and the coastal provinces of the North. However, river channels are shallow and narrow, only low-value commodities such as rice, fertilizer, coal and ore, not container cargoes are transported

- *Railways:*

Haiphong has the Hanoi - Hai Phong railway, which is used to transport passengers and cargoes. This railway is 102 km long, parallel to Highway 5A, passing through Hai Phong, Hai Duong, Hung Yen and Ha Noi. This railway connects Ha Noi to Hai Phong port (Chua Ve and Tan Vu terminals) and carries a small part of cargoes volume (less than 6% of total cargoes volume) but low efficiency.

2.4.2 Inland Transportation and Hinterland Connectivity in Southern Vietnam

- *Ho Chi Minh port:* Terminals in Ho Chi Minh have no connection with railway but all of them are linkable to Mekong Delta and Cambodia through waterway network. The South of Vietnam has a dense rivers and canals network, this is an advantage to develop a waterway transport system. Therefore, in recent years the trend of container shipping by inland waterways is increasing and the advantages of inland waterway transport have been manifested in comparison with other modes of transport such as road, rail and air. The barges are using waterway network to carry container cargoes from terminals in Ho Chi Minh, Vung Tau to depots, ICDs within Ho Chi Minh or to neighbor provinces such as Dong Nai, Binh Duong and provinces in Mekong Delta area and vice versa, container cargoes are carried from Mekong Delta provinces, ICDs and neighbor provinces of Ho Chi Minh to Ho Chi Minh terminals for exporting. Besides that, recently, there is a new mode of transport named river-sea vessels which allows the vessels to access both to the coastal area and rivers inside the hinterland. However, such these vessels need to comply with strict safety regulations when they are operated in the sea area.

Due to the density of the road vehicles in Ho Chi Minh, cargoes transported to destinations by roadway takes a long time and frequently face the congestion in not only terminals area but also in the city. These limitations have impacted a lot to Ho Chi Minh port especially to terminals located deep inside the city.

- *Vung Tau port:* Currently, there are 7 container terminals in Cai Mep – Thi Vai (Vung Tau) namely SITV, SP-PSA, TCCT, TCIT, CMIT, TCTT và SSIT with a total capacity of more than 7 million TEU per years. However, these terminals currently handle about 30% of total capacity partly because of poor infrastructure and lacking connectivity to the hinterland. There is only Highway 51 connects these above terminals to Ho Chi Minh city and other neighbour provinces where many industrial zones are located such as Binh Duong and Dong Nai but congestion and traffic jams regularly occur so that the exporters have to use barges on the waterway. This takes a long time so it can affect the business activities of the exporters. In consequence, it needs to connect the road from the provinces of the South West region and surrounding areas of Cai Mep such as Bien Hoa, Long Thanh, Nhon Trach (Dong Nai) to Cai Mep - Thi Vai, upgrade of inland waterways to increase the capacity and capacity of transporting barges and inland waterways to Ho Chi Minh City, Cua Long River Delta and Cambodia.

2.5 The Management System of Vietnamese Vietnam

In recent years, to maximize investment funds and encourage to increase ports quantity, the Government policy in construction, exploitation and management of ports is quite open, they have allowed for private enterprises or foreign capital enterprises to take part in management ports so that the port management system in Viet Nam is very complex and overlapping; it comprises 3 management bodies: state-owned corporations, local government and joint – venture corporations. The management system of Vietnam ports is shown in table 7 below

Table 7. Port management system in Vietnam

Port Management bodies	**Administrative government bodies**	**Example of ports**
Viet Nam Maritime Administration	Ministry of Transport	Nghe Tinh, Quy Nhon

(VINAMARINE)		
Viet Nam National Shipping Lines (VINALINES)	Ministry of Transport	Hai Phong, Quang Ninh, Da Nang, Sai Gon, Can Tho
Local Government Departments	Cities or provinces	Ben Nghe Port
State-owned corporations	Various ministries such as the Ministry of Industry, Ministry of Defense, or cities or provinces, etc.	Sai Gon New Port
Joint – venture corporations	Ministry of Planning and Investment, Ministry of Transport	VICT

This policy consequently increases the number of ports however it caused a lot of waste and adequacy. Due to the multi-component of port administration government bodies aforesaid, there was no consistency in direction of ports development, the investment resources are unbalanced among ports leading to the situation where some strategic ports face lacking investment and others are almost deserted. This policy also has resulted in some others problems such as improper port dispersion, lack of coordination in handling large vessels.

The Government not only allows private companies to take part in port management but also encourage the investment in construction new ports by applying the corporate income tax at the rate of 10% in 15 years if they are determined as the strategic ports.

In 2016, The Parliament voting conducted for approval of the new maritime law including the new State's policy of maritime development and the law is effective from July 2017. As the new policy, the Government will establish an organization called "the Department of Port Management and exploitation, this department will be the only body has the right to be in charge of planning the ports investment and construction in detail to avoid the unequal investment and the unfair competition from the joint – venture corporation bodies.

Besides that, due to the situation of ports in Viet Nam, the new policy focuses on upgrading the container terminal, equipping modern devices and facility at ports to serve large vessels so that the exporters can save the cost of carriage to transhipment ports in other countries. The new policy has got approval but there still have many arguments relating to the effects of new policy in connection with the existing Viet Nam's ports management system.

Chapter 3 Literature Review

3.1 Literature Review of Container Ports System Analysis

There are numerous studies regarding containerization and container port systems of various maritime countries have been conducted. Taaffe et al (1963) pointed out six phases in port system in Ghana and Nigeria comprising (1) scattered ports, (2) penetration lines and concentration, (3) development feeders, (4) the beginnings of interconnection, (5) complete interconnection and (6) the emergence of high priority main streets .

In 1981, Hayuth proposed a model with five phases of the evolution in container port system and applied to the North American container ports. Five phases in Hayuth (1981) includes (1) precondition for change: ports face difficulties to perform its function and interest parties need the changes; (2) initial container port development: several large ports which are more exposed to outside information initially adopt containerization; (3) diffusion, consolidated and port concentration: More ports enter to containerization, few large and strong financial container ports have dominant position and rapidly extend the transport network to hinterland leading to the concentration; (4) the load center: technological improvement and rapid containerization strongly effect to the system of terminals, inland carriers and ships leading to the form of load center or the concentration trend; (5) the challenge of the periphery: at this stage, load centers face problems such as lack of space for extension, congestion, diseconomies of scale and other problems leading to the entering of smaller ports and the concentration in the previous stage would be altered by de-concentration trend.

However, Wang (1998) with the case study of Hong Kong container port argued that the evolution of container port system may vary with different regions and it depends on the regional circumstances so that one can't apply a general model for all container port systems.

Other researches were interested in comparing container system evolution of two or three countries such as Li et al (2012) compared China and the USA container port systems, Le and Ieda (2010) compared Japan, China and Korea container port systems. Some others employed HHI, the Gini coefficient, Lorenz curve or shift-share analysis to analyze container port systems namely Notteboom (1997), Hayuth (1988).

3.2 Literature Review Relating to Ports' Relative Efficiency

Since the first academic journal paper of Roll and Hayuth (1993) which applied DEA to analyze the efficiency of 20 ports, there have been a large number of researches interested in port efficiency using various DEA models or combining DEA with other methods.

Martinez- Budria (1999) applied DEA-BCC model to analyze the efficiency of 26 Spanish ports using panel data from 1993 to 1997 and he chose depreciation cost, labour cost, other expenditures as input factors and cargo throughput, rental income from leasing port facilities as outputs.

Tongzon (2001) employed DEA-CCR and DEA-Additive to 16 container ports comprising 4 Australia ports and other 12 international ports. This study selected 6 input factors namely number of cranes, number of the berths, number of tugs, terminal area, vessel waiting time and number of port employees and 2 output factors selected are container throughput and the number of the container moved per working hour.

Furthermore, Cullinane et al (2005) employed DEA to analyze the relationship between efficiency and organizational structures using panel data from 1992 to 1999 of 30 container ports around the world. Cullinane et al (2006) applied both DEA and SFA in examining the efficiency of 57 ports and terminals of the top 30 world's biggest container ports in 2001 and compared the results obtained. Some other previous studies on DEA and port efficiency are summarized in table 8.

Table 8. Summary of previous studies

Authors (year)	Model	Sample	Inputs	Outputs
Itoh (2002)	DEA-CCR DEA-BCC	8 Japanese port	- Number of berths - Terminal area - Number of cranes - Number of employees	Container throughput
Ryoo (2006)	DEA-CCR DEA-BCC	26 container terminals from China, Korea and Singapore	- Number of berths - Berth length - Terminal area - Number of quay	Container throughput

			cranes	
Seo et al. (2012)	DEA-CCR	32 container ports in ASEAN	- Number of berths - Berth length - Container yard area - Number of cranes	Container throughput
Bichou (2013)	DEA-CCR DEA-BCC	420 container terminals	- Quay length - Maximum draft - Terminal area - Quay crane index - Yard stacking index - Gates	Container throughput
Almawsheki et al. (2015)	DEA-CCR	19 container terminals in the Middle Eastern Region	- Quay length - Maximum draft - Terminal area - Number of quay cranes - Number of yard equipment	Container throughput

Chapter 4 Methodology

4.1 Container Port System Analysis

In the exploitation of container port system, this study employs Herfindahl-Hirschman Index (HHI) and shift-share analysis (SSA). HHI is used to measure the concentration index of container ports and how the concentration index changed since the very early container ports established in Vietnam until now. On the other hand, SSA is used to analyze the "share" effect and the "shift" effect in the change of volume of each individual container port. In another word, the absolute growth of each container port will be composited into 2 components: share effect and shift effect.

In addition to that, simple indicators those are container throughput volume and growth rate, the growth of a number of container terminals are also used to provide a general look about the development of this system. By applying such analysis to the empirical data, this study hopes that it can reveal a general picture of the container port system and how the container market power distributed over time in Vietnam.

4.1.1 The Herfindahl-Hirschman Index (HHI)

HHI is the common measure of market concentration reflected in the size of each firm in relation to that industry. HHI is calculated by summing up all squares of market share corresponding to each firm in that system. In applying HHI to container port system, the formula is as follows

$$H = \frac{\sum_{i=1}^{n} X_i^2}{\left(\sum_{i=1}^{n} X_i\right)^2} = \sum_{i=1}^{n} S_i^2 \qquad (1)$$

$$\frac{1}{n} \leq H \leq 1$$

In which:

- H is the concentration index of the container port system

- n is the number of container terminals in the system

- X_i is the container throughput of container terminals i

H reaches the maximum value of 1 where there is only 1 container terminal dominating the market. In this case, the system is a full concentration or the market is monopolized and lowest competitive. The minimum value of *H* occurs where all the container terminals own the same market shares; as close to 0 of H value, as close to the perfect competition of the market.

Among several tools used to analyze the concentration of port system, HHI is one of the most preferred since it takes into account all individual ports in that system rather than only considers the largest port.

4.1.2 Shift-Share Analysis (SSA)

Initially, SSA is a regional analysis method to determine how much of the regional economic growth can be attributed to national trends and how much is due to regional factors.

In a similar way, SSA is applied to the development of container port system at a country to disclose the change in the actual growth of a container terminal. This change can be decomposed into 2 components; one is from national container throughput growth (share) and another one is from the container port's competitiveness (shift). In other words, it can reveal how much the throughput volume of each container terminal should be increased or decrease to maintain its market share and how much the throughput volume that container terminal won or lose to its rivals.

Since the shifts indicate the cargo volume shift among container ports in a system, the sum of them should equal to zero. SSA formula applying to ports was provided by Notteboom (1997) as follows

$$ABSGR_i = TEU_{it_1} - TEU_{it_0} = SHARE_i + SHIFT_i \quad (2)$$

$$SHARE_i = \left(\frac{\sum_{i=1}^{n} TEU_{it_1}}{\sum_{i=1}^{n} TEU_{it_0}} - 1 \right) . TEU_{it_0} \quad (3)$$

$$SHIFT_i = TEU_{it_1} - \frac{\sum_{i=1}^{n} TEU_{it_1}}{\sum_{i=1}^{n} TEU_{it_0}} . TEU_{it_0} \quad (4)$$

In which:

- $ABSGR_i$ is the absolute growth of container port i for the period $t_0 - t_1$, in TEU

- $SHARE_i$ is the share effect of container port i for the period $t_0 - t_1$, in TEU

- $SHIFT_i$ is the total shift of container port i for the period $t_0 - t_1$, in TEU

- TEU_s is the container throughput volume of container i for the period $t_0 - t_1$

- n *is* the total number of container ports in the system.

4.2. Container Port Relative Efficiency

Data envelopment analysis (DEA) is a method for evaluating the relative efficiency of the performances between homogeneous organizations such as business firms, hospitals, government agencies, etc.; such units are called decision-making units (DMUs). The level of efficiency is determined by comparison each DMU to the single reference DMU or a convex combination of the DMUs located on the frontier.

One of the advantages of DEA comparing to the traditional ratio which is commonly used a measure of efficiency that is the former can take into account many outputs and inputs at the same time while the latter only uses single output and input. Another advantage is a specific functional form relating inputs to outputs doesn't need to be imposed in the model so that we can apply it to multiple production processes.

4.2.1 DEA CCR Model

CCR model was proposed by Charnes, Cooper and Rhoders (1978) and categorized to input – oriented (CCR-I) and output-oriented (CCR-O) models.

The CCR-I linear programming is:

$$\begin{aligned} &\underset{\mu,v}{Max}\ \omega_o = \sum_{r=1}^{s} \mu_r y_{ro} \\ &S.t.\quad \sum_{r=1}^{s} \mu_r y_{r_j} - \sum_{i=1}^{m} v_r x_{ij} \le 0\ ,\quad j = 1,2,\ldots,n \\ &\qquad \sum_{i=1}^{m} v_i x_{io} = 1 \\ &\qquad \mu_r, v_i \ge \varepsilon,\quad \forall r,i \end{aligned} \tag{5}$$

Where, ω_o is the efficiency score of the $o-th$ DMU, x_{ij} is the amount of input $i-th$ for the $j-th$ DMU, y_{r_j} is the amount of output $r-th$ for the

$j-th$ DMU, v_i is the weight of input $i-th$, μ_r is the weight of output $r-th$, ε is an infinitesimal value, m is the number of inputs, s is the number of outputs and n is the number of DMUs being evaluated.

Equation (5) can be transformed to a linear dual problem as:

$$\begin{aligned}
&\underset{\theta,\lambda,S_r^+,S_i^-}{Min} \quad Z_o = \theta - \varepsilon\left(\sum_{r=1}^{s} S_r^+ + \sum_{i=1}^{m} S_i^+\right) \\
&S.t. \quad \sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ = y_{ro}, \quad \begin{matrix} j = 1,2,\ldots,n \\ r = 1,2,\ldots,s \end{matrix} \\
&\qquad \sum_{j=1}^{n} \lambda_j x_{ij} + S_i^- = \theta x_{io}, \quad i = 1,2,\ldots,m \\
&\qquad \lambda_j, S_r^+, S_i^- \geq 0, \quad \forall j, r, i
\end{aligned} \tag{6}$$

In which, λ_j is the weight of the entity in the reference set used to evaluate DMU_o, slack variables S_r^+, S_i^- represent the input excesses and output shortfalls.

The CCR-O linear programming as follows:

$$\underset{\theta,\lambda,S_r^+,S_i^-}{Max}\ Z_o = \theta - \varepsilon\left(\sum_{r=1}^{s} S_r^+ + \sum_{i=1}^{m} S_i^-\right)$$

$$S.t.\quad \sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ = \theta y_{ro}, \quad \begin{matrix} j = 1,2,...,n \\ r = 1,2,...,s \end{matrix} \tag{7}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^- = x_{io}, \quad i = 1,2,...,m$$

$$\lambda_j, S_r^+, S_i^- \geq 0, \quad \forall j, r, i$$

DMU_o is defined as CCR efficiency (or overall technical efficiency) if $\theta^* = 1$, $S_r^{+*} = 0$ and $S_i^{-*} = 0$ simultaneously. In case DMU_o have $\theta^* = 1$ but slacks are non-zero, then DMU_o is called radial efficiency.

4.2.2 DEA BCC Model

BCC input-oriented model and BCC output-oriented model introduced by Banker, Charnes and Cooper (1984) are respectively similar to CCR input-oriented model and CCR output-oriented model but added an additional constraint that is the sum of Lambdas is equal to 1.

Decomposition of overall technical efficiency

While the CCR model assumes the constant-returns-to-scale production possibility set, the BCC model takes into account the disadvantageous conditions of scale under which the DMUs are operating. Then, the relationship between CCR scores (Overall Technical efficiency) and BCC scores (Pure technical efficiency) as follow:

Overall Technical efficiency (OTE) = Pure technical efficiency (PTE) * Scale efficiency (SE)

Decomposing PTE and SE to OTE can reveal whether the source of inefficiency is caused by inefficient operation or by disadvantageous conditions or by both. DMUs obtain SE scores of 1 means they are operating at the most productive scale.

4.2.3. Data Explanation

DMUs selected include 7 Korean container ports and 21 Vietnamese container ports. In which, Vietnam container ports comprise ports from three different regions; they are from the South, the Central and the North. Although it is better to analyze each container terminal in a port, this study treats the whole container port rather than a terminal as a DMU due to limitations in collecting data.

Banker et al. (1989) suggested the sample size should follow as (8), that is, if the number of DMUs is n, the number of inputs is m and the number of outputs is s, then

$$n \geq \max\{m \times s, 3(m+s)\} \tag{8}$$

Input factors chose in this paper as a proxy of capital, land and labors are container berth length (m), container yard area (m2) and the number of ship-to-shore cranes. Container cargo throughput volume (TEUs) is used as the only output factor. Data collected is in 2016 through websites of ports, Google Earth, related Organizations websites such as VPA (Vietnam Seaports Association), KOSIS (Korean Statistical Information

Service) and directly contacted by phone. The data is statistically described in Table 9.

Table 9. A Descriptive statistic of data

Group	Number of DMUs	Statistic	Container berth length (m)	Container yard area (m2)	Number of cranes	Cargo throughput (TEUs))
Korea	7	Mean	2,980	1,004,517	22	3,269,990
		SD	3,056	1,022,506	26	4,710,190
		Max	8,350	2,640,000	62	12,835,000
		Min	480	96,000	2	56,564
North - VN	6	Mean	595	212,852	5	443,829
		SD	618	250,275	5	159,235
		Max	1,829	712,110	16	1,086,630
		Min	168	50,000	2	70,761
Central-VN	3	Mean	876	49,443	3	158,467
		SD	281	32,259	2	139,956
		Max	1,192	82,400	5	318,654
		Min	656	17,930	2	475,402
South - VN	12	Mean	690	255,366	8	724,013
		SD	405	288,308	6	1,109,646
		Max	1,500	1,050,000	23	4,037,257
		Min	100	31,516	2	58,406

Among several types of DEA models, the constant return to scale base output oriented (CCR-O) and variables return to scale base output oriented (BCC-O) are selected to analysis container port efficiency in this study due to the fact that it is not practical to reduce the berth length and equipment quantity. Although port authorities can transfer equipment between ports, it is also really hard and needs the collaboration between port operators because of the variety of port operators. Furthermore, this paper attempt to set a reference target output for the operators of inefficient ports.

Chapter 5 Results and Discussion

5.1 Container Port System Analysis

5.1.1 Overview of Container Cargoes Throughput and Container Port System in Vietnam

Container ports in this study include container ports which handle only container cargoes and multipurpose ports which have container terminal(s) to handle container cargoes. Besides that, there are also other types of ports or container barge terminals those also handle a minority of container cargoes but excluded in this study. Table 10 and figure 2 below show the container cargoes handled by the container port system and its growth rate during the period of 1998 to 2016. Data was collected from port authority websites and Vietnam Port Authority Association (www.vpa.org.vn).

Table 10. Container cargoes throughput the in TEUs and its growth rate in the period of 1998 -2016

Year	Container cargo throughput (TEUs)	Growth rate (%)
1998	815,781	11.7
1999	963,774	18.1
2000	1,149,791	19.3
2001	1,291,890	25.8
2002	1,516,432	17.4

2003	1,798,599	18.6
2004	2,268,901	26.1
2005	2,654,797	17.0
2006	3,368,884	26.6
2007	4,438,244	31.7
2008	5,152,210	16.1
2009	5,948,786	15.5
2010	7,087,516	19.1
2011	7,501,612	5.8
2012	8,379,814	11.7
2013	8,987,875	7.3
2014	10,790,738	20.1
2015	12,153,429	12.6
2016	13,490,875	11.0

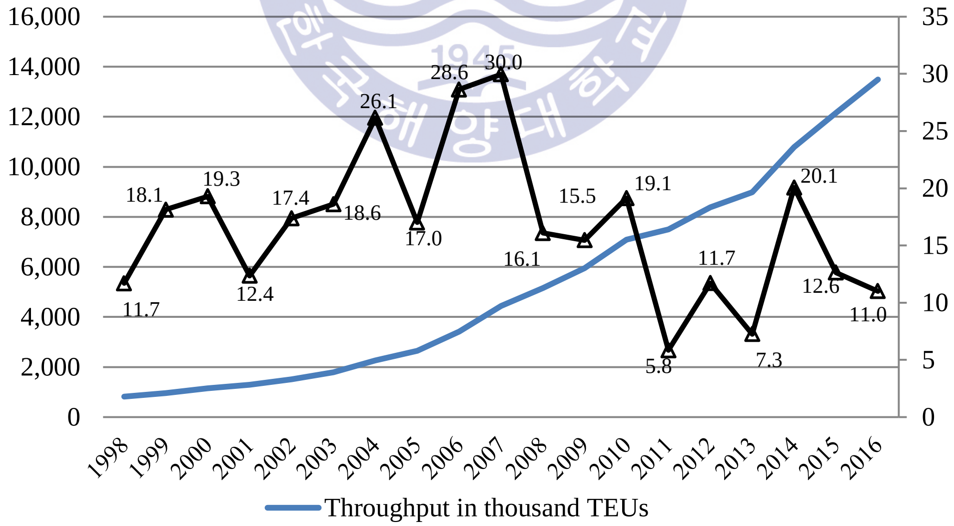

Figure 2. Container cargoes throughput and the growth rate of the container system in the period of 1998-2016

Generally, container throughputs in Vietnam recorded a period of steady and consistent growth from 1998 to 2016 with a compound annual growth rate (CAGR) of 16.9% even under the impacts of the global financial crisis in 2008. On average, container throughput in the period of 1998-2016 increased 671,605 TEUs corresponding with a growth rate of 16.8% per year. In 1998, there were only 7 container ports in the system handling about over 800,000 TEUs, until 2016, the number of container terminals increased to 35 units and the system handled about 13.5 million TEUs.

Figure 2 shows 4 different short periods of growth in Vietnam container system. The first is the period before 2001. In this period, cargoes throughput highly increased with the average growth rate of 16.4% and dropped to 12.4% in 2001 because of the effect from the world economy. In 2001, the world seaborne trade annual growth rate was negative 1% while the world merchandise exports decreased by 1.5% compared 2000 which was increased by 11.9% (UNCTAD, Review of Maritime Transport, 2002) leading to a rapid decrease in growth rate of container port traffic from 18.7% in 2000 to 2.2% in 2001 (UNCTAD, Review of Maritime Transport, 2003).

The second period is between 2001 and 2007 with a sharper growth rate of 21.4% on average; especially reach the peak of 30.0% in 2007 before falling to 16.1% in 2008 and 15.5% in 2009. The prosperity of container ports in Vietnam in this period followed the trend in the world economy. From 2001 to 2006, the world merchandise exports and world seaborne trade grew rapidly. Typically, in 2006, the volume of world merchandise trade recorded a quick growth rate of 8% resulting from deepening economic integration of worldwide economies and strong containerized trade leading to an increase of 13.4% of the world container throughput (UNCTAD, Review of Maritime Transport, 2007).

In the third period of 2008 - 2013, the growth rate of container throughput in Vietnam sharply decreased due to the effect of the global financial crisis in 2008. In these depression years, the average growth rate slumped to 12.6% and, except for that of 2010. There was a sign of recovery in 2010 with the increased growth rate of 19.1% but that expected recovery of growth rate as before didn't happen due to the drop again right after that which is from 2011 to 2013, especially growth rate dropped to the bottom of 5.8% in 2011.

The last period is between 2014 and 2016. Under the slow recovery of the world economy and the expansion of developing economies' share of the world container port throughput, growth rate of container throughput in Vietnam gradually boosted up with an average of 14.6% and expected to continue growing up in next years.

In the period of 1998 – 2016, the container port system in Vietnam recorded a remarkable rise in the number of ports over years proving by the figure 3 below.

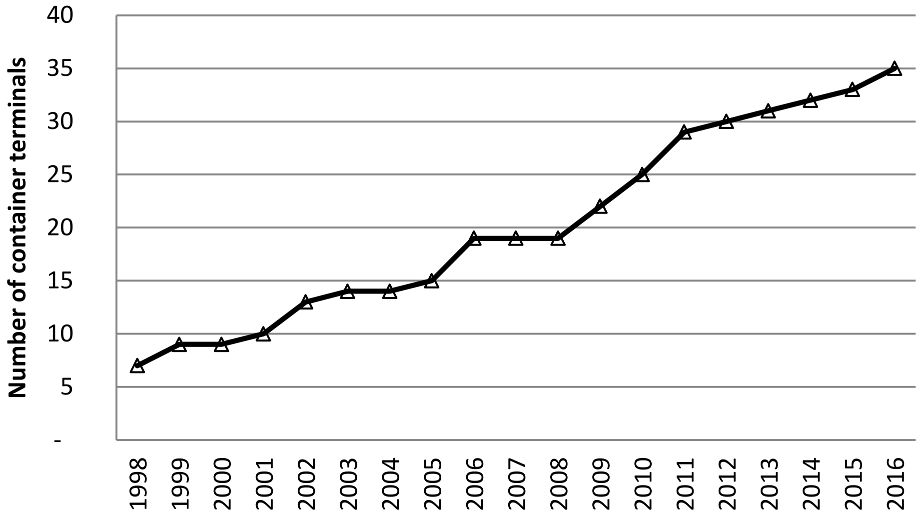

Figure 3. Number of container terminals in Vietnam over years

From this figure, we can see a substantially expand of the number of container terminals in the period of 2008 to 2011. That is because there were many container ports projects completed in 2009 and started their operation in 2010 both in the South and the North of Vietnam. These container terminals were built to be modern container terminals and equipped specialized container handling equipment.

The period of 2001 – 2006 recorded a noticeable increase in container ports due to the converting from bulk ports to adapt to the demand of container cargoes trading in Vietnam. This is also a premise of launching a series of projects on the construction of new specialized container terminals in 2005 and 2006.

5.1.2 HHI Results of Vietnam Container Port System in the Period of 1998-2016

Market concentration index of the container port system is calculated by the equation (1) and the results are as figure 4

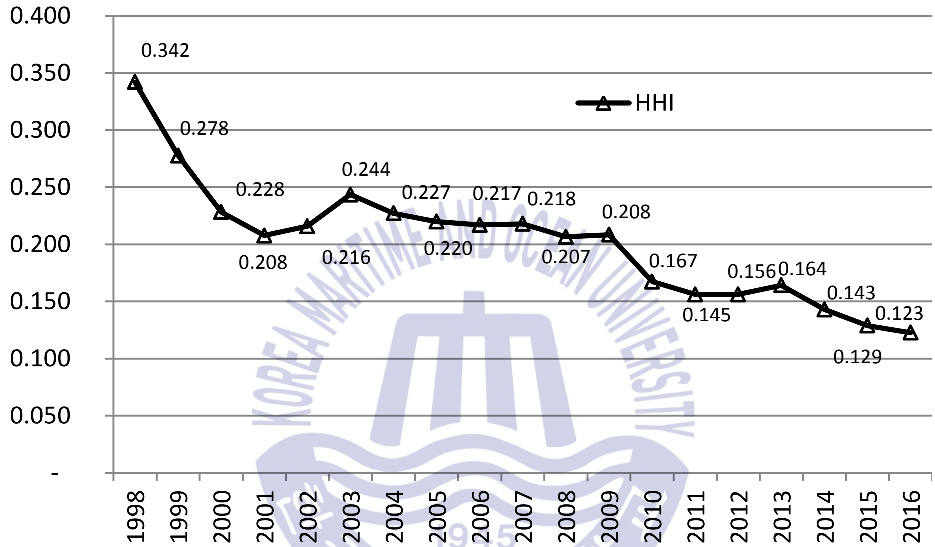

Figure 4. HHI of Vietnam container port system in the period of 1998-2016

In general, HHI of container port system in Vietnam was decreased from 0.342 in 1998 to 0.123 in 2016. These results demonstrate that the system experienced a high de-concentration during this period with different phases.

The first phase is from 1998 to 2001, which witnessed a quick de-concentration trend. In this phase, the index fell from 0.342 to 0.208

because of not only the appearing of 3 new container ports but also the strong reducing disparities between existing container ports at that time.

In the second phase which is from 2001 to 2003, the index noticeably increased from 0.208 to 0.244 indicating the concentration trend in container port system. This was due to the emerging as a load center in the system of certain container ports which are the large terminals such as Cat Lai, VICT and Hai Phong.

The third phase is the period of 2003 – 2009, which experienced a slow de-concentration. In this phase, there was an apparent extension of the number of container ports. Some of them are the new-built which specialized in handling container cargoes and many of them were converted from old bulk ports to container ports or building a container terminal in the old bulk ports with a limit of container cargoes handling equipment. This extension made major container ports such as Hai Phong and VICT slowly lose their market share to newcomers and the container system gradually deconcentrate in this phase.

The last phase of 2009 - 2016 exposed a second quick de-concentration trend. In this period, there were a significant number of new specialized container terminals from many projects in previous years completing and successfully getting involved in the market by gaining a certain market share, such as CMIT, TCIT, SPCT in the South or PTSC Dinh Vu, Nam Hai Dinh Vu, Hai Phong New Port 189 in the South. Besides that, there were also some projects launched in Vung Tau have failed in attracting container cargoes. Some container terminals in this group remained a small market share namely terminals group of Cai Mep

– Thi Vai (TCCT, TCTT) and SP - PSA, some terminals changed to handle other types of cargoes to maintain the business such as SITV, SP – PSA or even temporarily stopped operating such as SSIT.

5.1.3 SSA Results of Vietnam Container Port System in the Period of 2005-2016

Table 11 and figure 5 describe the results of SSA analysis of container port system in Vietnam between 2005 and 2016. From the absolute growth column (ABSGR), one can see that container cargoes throughput increased in almost all container ports except for Quang Ninh and Sai Gon where the cargoes volume in 2016 declined 117,043 TEUs and 11,262 TEUs compared to 2005.

The shift effect results indicate the flow of market share distribution in the North that is from Quang Ninh container terminal (Quang Ninh port), Hai Phong terminal to Doan Xa, Transvina, Green Port, Nam Hai, Dinh Vu, PTSC Dinh Vu in the first period (2005 - 2010) and from all above container ports to Nam Hai Dinh Vu, TC 189 – Hai Phong, TC 128 – Hai Phong, Hai An and VIP Green Port in the next period (2011 - 2016). In other word, at the first stage, the trend in the market share is shifting from the multi-purpose ports to specialized container terminals, after that, at the second stage the trend is shifting from the container terminals and multi-purpose ports located in upstream with shallow draft to container terminals located at downstream with deeper draft except for TC128 – Hai Phong. TC 128 – Hai Phong is located nearby upstream of Cam River but still maintain its market share since TC 128 belongs to Sai Gon New Port operator, it has a certain domestic container cargo transporting from Cat Lai terminal (Sai Gon New Port) in Ho Chi Minh to Hai Phong.

In Central Vietnam, there are only three small container ports and primarily handle domestic cargoes. Nghe Tinh Port and Da Nang Port experienced a positive shift effect of 49,693 TEUs and 154,297 TEUs between 2005 and 2016 whereas Quy Nhon Port recorded a negative shift effect of 116,372 TEUs in the same period.

In Southern Vietnam, market share in the period of 2005 - 2016 mainly shifts from older ports located in Ho Chi Minh, namely Sai Gon, Ben Nghe, Cat Lai and VICT to specified newer container terminals located in Vung Tau, namely CMIT (1,217,610 TEUs), TCIT (1,112,279 TEUs) and mall parts to other newer container terminals located in Ho Chi Minh, namely SPCT (152,073 TEUs), Hiep Phuoc New Port (218,969 TEUs) and ports located in neighboring provinces of Ho Chi Minh where have largest industrial zones namely Binh Duong (201,387 TEUs) and Dong Nai (374,000 TEUs).

The last case includes SP-PSA, TCCT, SSIT and SITV (Vung Tau – the South). These terminals have no container throughput. It happens due to the Government approved for a series of new-built container port construction projects at Vung Tau in years of 2005 – 2007 but the container ports' relocation plan which intends to move container ports located in center of Ho Chi Minh to Cai Mep – Thi Vai (Vung Tau) was postponed leading to the oversupply of container terminals in Vung Tau and a huge resource waste since 2010 until now.

Table 11. Shift-share analysis for container terminals in Vietnam in the period of 2005-2016

No.	Container terminals	Share effects			Shift effect			ABSGR (2005-2016)
		2005-2010	2011-2016	2005-2016	2005-2010	2011-2016	2005-2016	
1	Quang Ninh	198,088	207,774	484,240	(112,596)	(466,419)	(601,283)	(117,043)
2	Hai Phong	665,042	813,402	1,625,740	(109,696)	(745,566)	(937,410)	688,330
3	Doan Xa	125,668	181,587	307,205	18,680	(288,265)	(261,708)	45,497
4	Transvina	92,567	101,445	226,285	11,786	(157,745)	(210,963)	15,322
5	Nghe Tinh	3,339	10,918	8,163	8,874	35,263	49,693	57,856
6	Da Nang	54,003	91,315	132,014	2,853	112,966	154,297	286,311
7	Quy Nhon	70,072	49,939	171,297	(39,815)	(15,596)	(116,372)	54,925
8	Ben Nghe	273,514	123,411	668,623	(226,775)	(93,272)	(647,721)	20,902
9	Sai Gon	475,040	246,654	1,161,267	(357,564)	(282,347)	(1,172,529)	(11,262)
10	Bong Sen(Lotus)	35,064	45,144	85,716	(51,566)	(43,281)	(48,310)	37,406

11	**Cat Lai-SGNP**	1,763,205	2,073,768	4,310,272	(260,795)	(633,926)	(1,329,015)	2,981,257
12	**VICT**	628,977	297,428	1,537,575	(687,710)	(36,345)	(1,280,660)	256,915
13	**Can Tho**	30,672	2,552	74,981	(44,217)	13,618	(73,985)	996
14	**Green Port**	-	297,802	-	335,000	(370,802)	300,000	300,000
15	**Dinh Vu**	-	351,014	-	399,647	(141,439)	649,224	649,224
16	**Nam Hai**	-	159,679	-	180,000	(137,515)	222,164	222,164
17	**PTSC Dinh Vu**	-	122,943	-	147,356	(46,930)	230,000	230,000
18	**Binh Duong**	-	49,646	-	96,538	89,559	201,387	201,387
19	**SP-PSA**	-	180,064	-	293,912	(405,533)	63	63
20	**SPCT**	-	111,594	-	95,934	(99,293)	152,073	152,073
21	**TCCT**	-	148,607	-	299,363	(334,525)	214	214
22	**TCIT**	-	219,733	-	-	617,328	1,112,279	1,112,279

23	**CMIT**	-	75,468	-	-	1,047,617	1,217,610	1,217,610
24	**Dong Nai**	-	2,548	-	-	368,261	374,000	374,000
25	**Ky Ha-QN**	-	22,388	-	24,774	(50,429)	-	-
26	**Nam Hai Dinh Vu**	-	-	-	-	526,202	526,202	526,202
27	**CICT(Cai Lan)**	-	-	-	-	17,332	17,332	17,332
28	**TC 189 – Hai Phong**	-	-	-	-	249,413	249,413	249,413
29	**TC128 - Hai Phong**	-	-	-	-	209,394	209,394	209,394
30	**Hai An**	-	-	-	-	323,343	323,343	323,343
31	**TCTT**	-	-	-	-	224,609	224,609	224,609
32	**Hiep Phuoc New Port**	-	-	-	-	218,969	218,969	218,969
33	**VIP Green Port**	-	-	-	-	300,000	300,000	300,000

Trends in the shift of market share period 2005- 2016

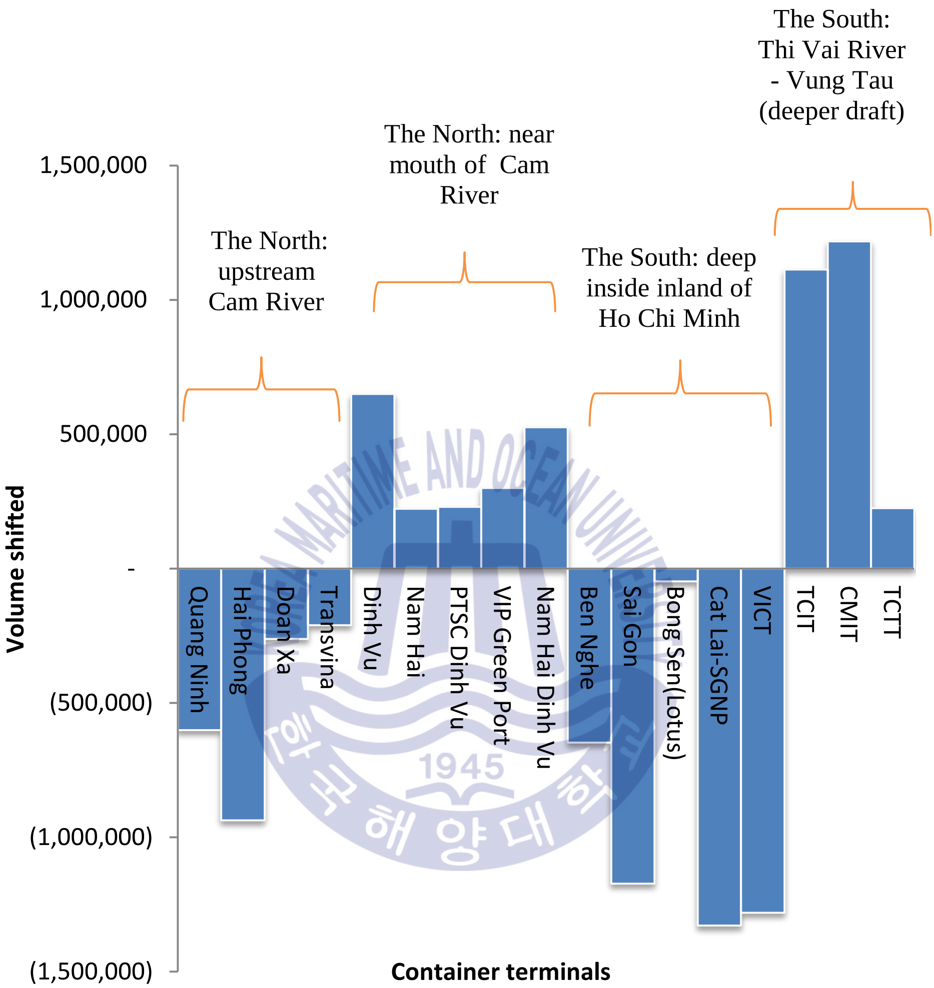

Figure 5. Trends of market share in the period of 2005-2016

5.2. Relative Efficiency of Container Ports

DEA-Solver software providing by Cooper, W.W., Seiford, L.M. and Tone, K. (2006) was employed to analyze the efficiency of 28 DMUs, results as follows.

5.2.1. Overall Technical Efficiency, Pure Technical Efficiency and Scale Efficiency

As shown in the results obtained from CCR-O model, there are only 3 efficient container ports, namely Busan New Port (Korea), Cat Lai-SGNP (Southern Vietnam) and CMIT (Southern Vietnam). While Gunsan (0.12) and Pohang (0.19) are the two most inefficient container ports in Korea, Bong Sen (0.11), Ben Nghe (0.11) and TCTT (0.16) are the three most inefficient container ports in Vietnam and they are all in Southern Vietnam.

There are some container ports with the relatively large production size but performed the relatively low efficiency such as Hai Phong (0.32; 1,086,630 TEUs) and Gwangyang (0.44; 2,249,585 TEUs). Then, the relationship between the efficiency and the size of production (represented by the cargo volume) was tested by using Spearman's rank order correlation coefficient. The coefficients obtained are 0.7108 and 0.3893 for CCR model and BCC model, respectively. The coefficient for the CCR model demonstrated that the size of production significantly impacts the efficiency of container ports. Notwithstanding, when the influence of operating scale is eliminated from BCC efficiency score, the coefficient is much smaller, means the size of production is no longer significantly effects to the efficiency of ports. This result strongly supports for economies of scale concept.

After Vietnamese and Korean container ports are compared, the results indicate that on average, overall technical efficiency score (CCR result) of Vietnamese container ports (0.52) and Korean container ports (0.50) is similar but, as shown in the BCC model results, the pure technical efficiency of Vietnamese container ports (0.66) appears to be higher than Korean container ports (0.53). This difference can be explained by the difference in scale efficiency between Korean container ports and Vietnamese container ports. While all Korean container ports in this analysis are operating at nearly optimal scale (average SE= 0.90), Vietnamese container ports are indicated that their overall technical efficiency is influenced by the improper scale (average SE =0.82).

Table 12. CCR output-oriented, BBC output-oriented and SE

Group		CCR Score	BCC Score	SE score
Korea		**0.50**	**0.53**	**0.90**
1	Busan North Port	0.59	0.65	0.91
2	BusanNew Port	1.00	1.00	1.00
3	Gunsan	0.12	0.15	0.81
4	Gwangyang	0.44	0.50	0.88
5	Incheon New Port	0.52	0.54	0.95
6	Incheon South Port	0.63	0.63	1.00
7	Pohang	0.19	0.24	0.77
Total Vietnam		**0.52**	**0.66**	**0.82**

North - VN		**0.47**	**0.66**	**0.76**
8	Dinh Vu	0.89	0.99	0.90
9	Doan Xa	0.31	0.47	0.67
10	Hai Phong	0.32	0.33	0.96
11	Nam Hai Dinh Vu	0.75	0.81	0.93
12	New Port 128-Hai Phong	0.32	0.37	0.88
13	Transvina	0.24	1.00	0.24
Central-VN		**0.40**	**0.68**	**0.63**
14	Da Nang	0.51	0.57	0.88
15	Nghe Tinh	0.44	1.00	0.44
16	Quy Nhon	0.26	0.47	0.57
South - VN		**0.57**	**0.65**	**0.89**
17	Ben Nghe	0.11	0.12	0.98
18	Binh Duong	0.82	1.00	0.82
19	Bong Sen (Lotus)	0.11	0.11	0.92
20	Cat Lai port-SGNP	1.00	1.00	1.00
21	CMIT	1.00	1.00	1.00
22	Đ ong Nai	0.84	1.00	0.84
23	Hiep Phuoc New Port	0.33	0.45	0.74
24	Sai Gon	0.37	0.41	0.90
25	SPCT	0.63	0.93	0.68
26	TCIT	0.64	0.66	0.97
27	TCTT	0.16	0.16	0.98
28	VICT	0.83	1.00	0.83

In the BCC results, the number of efficient DMUs substantially increases to eight ports, there are five more efficient container ports, namely Transvina (CCR: 0.24, BCC: 1), Nghe Tinh (CCR: 0.44, BCC: 1), Binh Duong (CCR: 0.82, BCC: 1), VICT (CCR: 0.83, BCC: 1) and Dong Nai (CCR: 0.84, BCC: 1). Transvina (SE: 0.24) and Nghe Tinh (SE: 0.44) are two container ports affected the most by the scale of economics.

Among three groups of Vietnamese container ports, the group of container ports in Central – VN is the most technically inefficient (CCR: 0.4) and also being affected the most by scale (SE: 0.63). This may due to the Central of Vietnam is the least developed economic region among the above three regions and container ports in this region function as transitional ports with small yard area and less container cargo handling equipment.

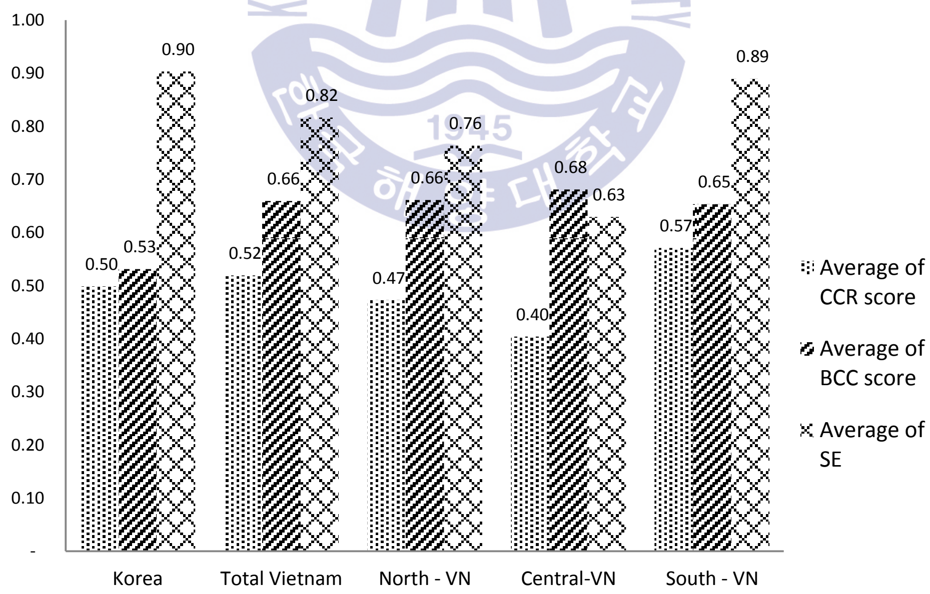

Figure 6. Summary CCR, BCC and SE score of different groups

5.2.2. Return to Scale

Table 13. Return to scale

Group	CRS	IRS	DRS
Korea	3 (43%)	4 (57%)	0
Total VN	3 (14%)	18 (86%)	0
- North - VN	1 (17%)	5 (83%)	0
- Central-VN	0 (0%)	3 (100%)	0
- South - VN	2 (17%)	10 (83%)	0

As described in table 13, the majority of Vietnamese container ports are operating under increasing return-to-scale (86%) which means that the output is increasing at the larger proportion than the input increases. However, as Matías Herrera Dappe and Ancor Suárez-Alemán (2016), ports are limited in their ability to affect the demand that means we can't increase significantly inputs in the hope that ports can increase output proportionally.

In addition to that, there are many other factors need to examine such as available land, the capacity of hinterland connectivity, congestion of existing facilities, etc. that the policy makers should thoughtfully consider before influencing the scale of operation.

5.2.3 Projection and Slacks

Table 14. CCR projection of container ports and their slacks

No.	DMU I/O	Score Data	Projection	Difference	%
1	BusanNew Port	1.00			
	container berth length (m)	8,350	8,350	-	-
	Container yard	1,684,000	1,684,000	-	-
	number of cranes	62	62	-	-
	TEUs	12,835,000	12,835,000	-	-
2	Busan North Port	0.59			
	container berth length (m)	5,673	5,673	-	-
	Container yard	1,816,204	1,816,204	-	-
	number of cranes	56	53	(3)	-0.06
	TEUs	6,065,000	10,277,034	4,212,034	0.69
3	Gwangyang	0.44			
	container berth length (m)	3,700	2,520	(1,180)	-0.32
	Container yard	2,640,000	1,260,000	(1,380,000)	-0.52
	number of cranes	21	21	-	-
	TEUs	2,249,585	5,113,962	2,864,377	1.27
4	Pohang	0.19			
	container berth length (m)	1,000	240	(760)	-0.76
	Container yard	249,472	120,000	(129,472)	-0.52
	number of cranes	2	2	-	-
	TEUs	90,926	487,044	396,118	4.36

5	Gunsan	0.12			
	container berth length (m)	480	250	(230)	-0.48
	Container yard	98,000	98,000	-	-
	number of cranes	2	2	-	-
	TEUs	56,564	462,587	406,023	7.18
6	Incheon South Port	0.63			
	container berth length (m)	859	859	-	-
	Container yard	350,309	350,309	-	-
	number of cranes	7	7	-	-
	TEUs	1,023,392	1,616,850	593,458	0.58
7	Incheon New Port	0.52			
	container berth length (m)	800	647	(153)	-0.19
	Container yard	195,637	195,637	-	-
	number of cranes	5	5	-	-
	TEUs	569,464	1,101,593	532,129	0.93
8	Hai Phong	0.32			
	container berth length (m)	1,829	1,829	-	-
	Container yard	712,110	712,110	-	-
	number of cranes	16	16	-	-
	TEUs	1,086,630	3,448,838	2,362,208	2.17
9	Dinh Vu	0.89			
	container berth length (m)	425	360	(65)	-0.15
	Container yard	193,000	180,000	(13,000)	-0.07

	number of cranes	3	3	-	-
	TEUs	649,224	730,566	81,342	0.13
10	Nam Hai Dinh Vu	0.75			
	container berth length (m)	450	373	(77)	- 0.17
	Container yard	150,000	150,000	-	-
	number of cranes	3	3	-	-
	TEUs	526,202	697,216	171,014	0.33
11	Doan Xa	0.31			
	container berth length (m)	220	220	-	-
	Container yard	65,000	65,000	-	-
	number of cranes	2	2	(0)	- 0.02
	TEUs	120,761	385,960	265,199	2.20
12	New Port 128-Hai Phong	0.32			
	container berth length (m)	480	393	(87)	- 0.18
	Container yard	107,000	107,000	-	-
	number of cranes	3	3	-	-
	TEUs	209,394	649,414	440,020	2.10
13	Transvina	0.24			
	container berth length (m)	168	168	-	-
	Container yard	50,000	50,000	-	-
	number of cranes	2	2	(0)	- 0.25
	TEUs	70,761	295,576	224,815	3.18
14	Da Nang	0.51			

	container berth length (m)	1,192	409	(783)	- 0.66
	Container yard	82,400	82,400	-	-
	number of cranes	5	3	(2)	- 0.39
	TEUs	318,654	628,031	309,377	0.97
15	Quy Nhon	0.26			
	container berth length (m)	779	238	(541)	- 0.69
	Container yard	48,000	48,000	-	-
	number of cranes	2	2	(0)	- 0.12
	TEUs	96,892	365,843	268,951	2.78
16	Nghe Tinh	0.44			
	container berth length (m)	656	89	(567)	- 0.86
	Container yard	17,930	17,930	-	-
	number of cranes	2	1	(1)	- 0.67
	TEUs	59,856	136,658	76,802	1.28
17	Cat Lai - SGNP	1.00			
	container berth length (m)	1,500	1,500	-	-
	Container yard	1,050,000	1,050,000	-	-
	number of cranes	23	23	-	-
	TEUs	4,037,257	4,037,257	-	-
18	TCIT	0.64			
	container berth length (m)	890	890	-	-
	Container yard	340,000	340,000	-	-
	number of cranes	9	9	-	-

	TEUs	1,112,279	1,731,777	619,498	0.56
19	CMIT	1.00			
	container berth length (m)	600	600	-	-
	Container yard	300,000	300,000	-	-
	number of cranes	5	5	-	-
	TEUs	1,217,610	1,217,610	-	-
20	VICT	0.83			
	container berth length (m)	678	495	(183)	-0.27
	Container yard	99,840	99,840	-	-
	number of cranes	7	4	(3)	-0.47
	TEUs	633,615	760,954	127,339	0.20
21	Đ ong Nai	0.84			
	container berth length (m)	262	257	(5)	-0.02
	Container yard	82,000	82,000	-	-
	number of cranes	2	2	-	-
	TEUs	374,000	444,800	70,800	0.19
22	Sai Gon	0.37			
	container berth length (m)	1,198	483	(715)	-0.60
	Container yard	97,430	97,430	-	-
	number of cranes	10	4	(6)	-0.64
	TEUs	273,244	742,586	469,342	1.72
23	SPCT	0.63			
	container berth length (m)	950	156	(794)	-0.84

	Container yard	31,516	31,516	-	-
	number of cranes	5	1	(4)	- 0.77
	TEUs	152,073	240,207	88,134	0.58
24	Ben Nghe	0.11			
	container berth length (m)	783	783	-	-
	Container yard	340,000	340,000	-	-
	number of cranes	9	9	(0)	- 0.03
	TEUs	184,712	1,625,379	1,440,667	7.80
25	Binh Duong	0.82			
	container berth length (m)	100	100	-	-
	Container yard	60,000	60,000	-	-
	number of cranes	2	1	(1)	- 0.31
	TEUs	201,387	245,985	44,598	0.22
26	Hiep Phuoc New Port	0.33			
	container berth length (m)	420	420	-	-
	Container yard	90,000	90,000	-	-
	number of cranes	6	3	(3)	- 0.47
	TEUs	218,969	657,861	438,892	2.00
27	Bong Sen (Lotus)	0.11			
	container berth length (m)	300	300	-	-
	Container yard	100,000	100,000	-	-
	number of cranes	5	3	(2)	- 0.43
	TEUs	58,406	552,634	494,228	8.46

28	TCTT	0.16			
	container berth length (m)	600	600	-	-
	Container yard	473,600	357,143	(116,457)	-0.25
	number of cranes	7	7	-	-
	TEUs	224,609	1,406,797	1,182,188	5.26

The projection results indicate that majority of inefficient container ports are mix-inefficiency, means they should increase their outputs to the projection and also reduce slacks in the inputs at the same time. For instance, Gwangyang port needs to increase cargo throughput 127% more and reduce slacks of 1,180 meters in container berth length and 1,380,000 square meters in container yard area to be efficiency. There are several container ports those are radial inefficient, namely TCIT, Hai Phong, Incheon South Port and Doan Xa (all slacks are zero) so that these container ports only need to increase the output without reducing their inputs to become efficient.

On average, Korea container ports need to increase 250% output, North-VN container ports need to increase 168% output, Central-VN container ports need to increase 168% output and South-VN container ports need to increase 270% output together with reducing slacks to achieved level of efficiency.

Chapter 6 Conclusion

At the first, this study applies HHI and SSA to analyze the container system in Vietnam from the early stage to recent years, in different regions of the country. Firstly, in overall, the results indicate that container ports system in Vietnam recorded a quick expansion in both numbers of container terminals and container cargoes throughput. Secondly, in term of the market share, the results illustrate that container ports system in Vietnam experienced a de-concentration trend. This means during the analyzing period, there were more and more container terminals getting involved in the market and gained their certain market share; the market was in a fierce competition.

However, the results also indicate that in different periods of time and in different regions, the container system in Vietnam experienced particular circumstances. If the period of 1998 – 2001 recorded a quick de-concentration trend and then between 2001 to 2003 is the emerging of several loading centers, the period of 2004 – 2009 showed a slower de-concentration with the expansion in the number of container ports which are both from modified bulk cargoes ports and new-built container terminals; and the last period between 2009 and 2016, Vietnam's container port system steadily de-concentrated with a series of new specialized container ports launched. If the market share of container ports in the North shifted from multi-purpose ports and container ports located in upstream to container ports located downstream of Cam River, the market share of container ports in the South mainly shift from container ports located in Ho Chi Minh to certain container terminals in Vung Tau; and Central of Vietnam is the region experienced at least expansion in both number of container ports and cargoes throughput volume.

At the present, Cat Lai port-loading center in the South are overloading and causing congestion. The Government are driving a part of container cargoes from Cat Lai to container terminals in Vung Tau where have a deeper draft and modern equipment but temporarily lack inland connection system. Meanwhile, in the North, container terminals with a better geographical location are improving their market share. These stages in the evolution of the system will lead to a continuous de-concentration trend in next years. From that, this study justified the driving factors of a de-concentration trend that Hayuth (1988) observed by proving a case study and verify Wang (1998) statement that the evolution of container port system may vary with different regions.

In the second part, this study evaluates the efficiency of 21 major container ports in three regions in Vietnam together with some major container ports in Korea. The results point out that on average, the overall technical efficiency of Korea container ports is similar to Vietnamese container ports. However, after decomposing the inefficiency into component parts, the results indicate that while Korean container ports are operating at nearly optimal scale and their inefficiency is caused substantially by managerial inefficiency, the inefficiency of Vietnam container ports is caused not only by managerial inefficiency but also by the disadvantageous conditions of scale.

Among the three different regional groups of container ports in Vietnam, container ports in the Central of Vietnam are the most technical inefficient group and being influenced the most by operating scale. Besides that, this study addresses that the majority of Vietnamese container ports is operating under increasing return-to scale. This conclusion is consistent with H. –O. Nguyen et al 2017 which analyzed 43 Vietnamese ports handling various types of cargo (container, general cargo or bulk cargo) even though this study only focuses on container ports and there are some major Korean container ports selected to evaluate the efficiency together with Vietnamese container ports.

Nevertheless, in this study, there are some different conclusions from H. –O. Nguyen et al 2017 when the container ports are analyzed separately and in more detail. As the results indicated from this study, container ports in Southern Vietnam are slightly more efficient than in the North because of their advantage in operating scale whereas container ports in the North appear to be more efficient than in the South in term of pure technical efficiency, while H. –O. Nguyen et al 2017 justified that ports in the North including container ports are more efficient than in the South. From these results, the study implies that in applying DEA to analyze efficiency, different types of ports should be analyzed separately to have more accurate results so that port authorizes can identify which part of their ports (container terminals, bulk cargo terminals or specialized cargo terminal) performs inefficiently.

In the meantime, this research has some limitations. Firstly, in analyzing the development of container port system, some more other criteria such as logistic services at ports and management regimes the government imposed on container ports should be discussed. Secondly, DMUs in Vietnam consist of ports and container terminals. It is better to compare the same status of DMUs. This research considered input factors such as container berth length, yard areas, number of crane and output factor of container throughput. In the future research, it is necessary to consider various inputs and output factors.

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