University of Antwerp
Institute of Transport and Maritime Management Antwerp

The future of small seaports: challenges from increasing ship-size

(Focus of Pyeongtaek port in South Korea)

This thesis is submitted in partial of the requirements

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Student: Lee Myoun Soo

Promoter: Prof. Dr. Willy Winkelmans
Supervisor: Mr. Bert Vernimmen

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Abstract

The size of newly generated vessels has exceeded the 8,000TEUs. The volume became larger and the speed get faster. The hub and feeder ports are becoming more and more important in the current booming shipping market. Especially, Asian shipping market is changing dramatically. There are changes in the ranking of world's busiest ports. Shanghai port has surpassed Hong Kong port and ranked the second among world's busiest ports. In addition, there is a fierce competition in the shipping market. Therefore, if a hub port fails in preparing and forecasting some critical points of the market, it may lose its market share, and its role.

This paper discusses on the basis of a case study of Pyeongtaek port, South Korea.

Recently, the role of feeder port has become more important as the feeder port network is getting dense. Many ports in Europe, such as the port of Rotterdam, Antwerp, Hamburg, Le Havre and so on have offered feeder services. Although Pyeongtaek port has invested in facilities and expanded hinterland, its influence is still low in Korea. One of reasons is that it can not compete with the Incheon port, nearby although the both have similar conditions such as hinterland.

This paper reviews how small ports can survive in the current shipping market. In addition, the competitiveness of Pyeongtaek port is compared to the other small ports such as, Incheon port. Three scenarios, which are Hong Kong-Pyeongtaek (or Incheon and Busan)-Long Beach, Hong Kong-Pyeongtaek (or Incheon and Busan) and Pyeongtaek –Long Beach (or Incheon and Busan) are considered.

The results of this paper is Pyeongtaek port can not compete with Inchoen port, but it still has its potentialities to be a feeder port.

Chapter 1. Introduction

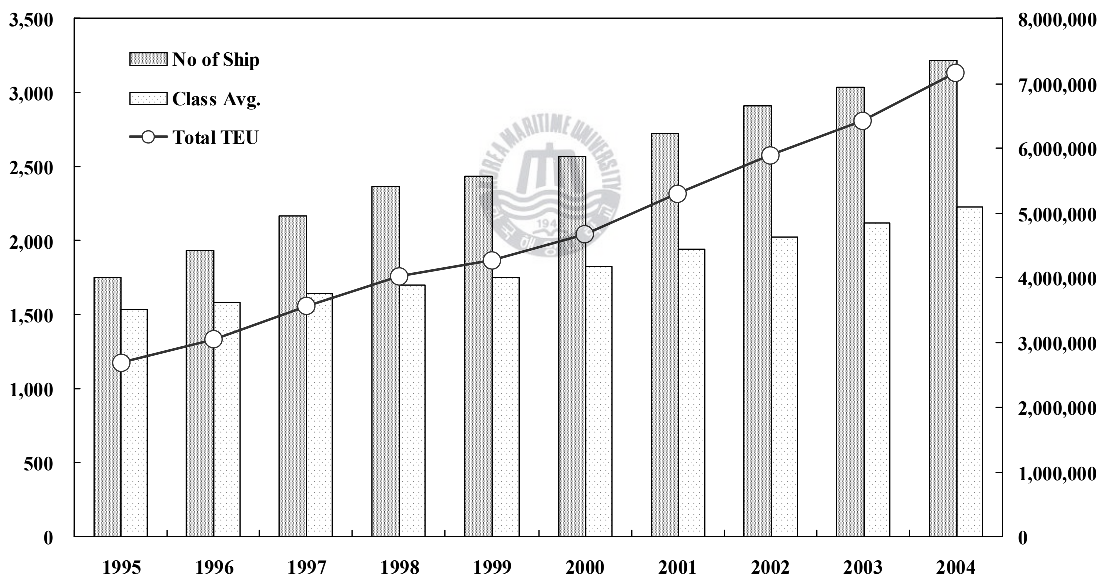
Shipping market has been changed dramatically with an increase of ship size and speed, so the number of port calls is decreased. However, container terminals still have to be operated in their full capacity at a critical level. More hub ports have emerged with the trend of booming shipping market. Hub ports in Singapore, Hong Kong, Shanghai and Busan have been ranked among the top busiest ones in the world.

Besides, small ports such as Tanjung Pelepas, Klang, Pyeongtaek, Osaka ports and so on appeared as well. South Korea is rich of such small feeder ports. They are Pyeongtaek, Incheon, Masan, Kwangyang and Pohang port. In this market environment, with many small ports, big ports such as Busan and Kaohsiung ports may lose their market shares. Hence, it is necessary for small ports to build proper strategies in order to survive. One of alternatives is that small ports adjust to feeder service market which provides subsequent transshipment to other ports. For example, Antwerp port has been strengthening its position as a European transshipment hub. Consequently, the growth rate of intra-European container traffic via sea-going vessels amounts from 15 to 20 percent per year. (http://www.beanr.com)

Chapter 2 displays the present conditions of Pyeongtaek and Incheon port. It presents the weaknesses and advantages of the two ports and current issues. Chapter 3 studies the case of European port such as Rotterdam, Antwerp, Hamburg and Bremerhaven port. These ports are good examples of feeder network service. Although they are hub ports in Europe, they also serve as feeders to the other regions. It can be applied to Korean ports. Thus, we can find some features of the feeder network of European cases and then apply to Pyeongtaek port. Chapter 4 shows competitiveness of Pyeongtaek port in trade some small ports of China. It will be compared with Incheon port through three mentioned scenarios. Finally, this paper will display the Strength, Weakness, Opportunity and Threat of Pyeongtaek port and how small ports have to be prepared to survive in the market and how they can make a feeder network.

Figure 1 shows Scale of container ship's size. The number of ship, class average of ship and throughputs were increasing until, now.

Figure 1. Scale of Container ship's size



Source: Institute of Shipping Economics and Logistics (2005)

Chapter 2. Prospect of Pyeongtaek port and Incheon port

This chapter will display the prospect of Pyeongtaek and Incheon port. First, it will show the present conditions of ports, such as handling volumes, facilities and so on. Pyeontaek port and Incheon port are located similarly. This chapter reviews what the weaknesses and opportunities of Pyeongtaek port are, in comparison with Incheon port.

Figure 2. Pyeongtaek port and Incheon port

2.1 Present conditions

Table 1 shows the handling volumes of Pyeongtaek and Incheon port in six years. Both of ports' volumes have been increasing. Occupancy rate is from whole handling volumes in South Korea and growth rate is from previous year.

Incheon port handled a cargo volume of 1,148,666TEUs in 2005 with an increasing rate of 7.6%. In contrast, Pyeongtaek port handled the cargo of 227,333TEUs in 2005 with an increasing rate of 1.5%, but growth speed is relatively slower than previous years. One of the reasons is that the capacity of port facilities and scale of Pyeongtaek port are smaller than those of Incheon port. Table 2 and Table 3 display the current status of the facilities of Pyeongtaek port and Incheon port, respectively. Pyeongtaek port has only one container terminal, while Incheon port has four in total. Besides, they have different berth ability. Pyeongtaek port's berth can serve five ships simultaneously. The detail figures are displayed in Table 2, such as, number of berths, berth length, handling capacity and type of cargo handled and so on.

Table 1. Volumes of Pyeongtaek port and Incheon port

Unit: TEUs

		2000	2001	2002	2003	2004	2005
Port	Total	9,116,448	9,990,111	11,889,798	13,185,871	14,523,138	15,141,530
Incheon port	Total (occupancy rate)	611,261 (6.7%)	663,042 (6.6%)	769,791 (6.5%)	821,071 (6.2%)	934,954 (6.4%)	1,148,666 (7.6%)
	growth rate	-	8.5%	16.1%	6.7%	13.9%	29.9%
Pyeongtaek port	Total (occupancy rate)	898 (0.0%)	21,111 (0.2%)	66,238 (0.6%)	152,259 (1.2%)	190,088 (1.3%)	227,333 (1.5%)
	growth rate	-	-	213.8%	129.9%	24.8%	19.6%

Source: Ministry of Maritime Affairs & Fisheries, PORT-MIS

Table 2 displays facilities of Pyeongtaek port. Pyeongtaek port is divided into two parts -- Posung and Dangjin areas with a total berth number of 13. Posung area includes 7 berths, six for general cargo and one for container. Dangjin area includes 1 berth for scrap metal and 3 berths for steel. Especially, handling volumes of car and general cargo are higher than other cargo, because car and general cargo are usually traded to other countries via Pyeongtaek port.

According to the development plan of Pyeongtaek port, additional 22 berths will be built until 2010, 6 berths for container, 3 berths for car, 2 berths for lumber and 2 berths for cement are planned in Posung area and 9 berths for scrap metal, steel and coal in Dangjin area.

Table 2. Facilities of Pyeongtaek port

		No.	Berth Length (m)	Yards (1,000 ㎡)	Berth capacity DWT(1,000)×No. berth	Handling Capacity (1,000ton)	Cargo type handled
Posung area	East port	1	240	96	30,000×1	2,002	Steel
		2~4	720	270	30,000×3	6,593	Car, General cargo
		5	240	96	30,000×1	107,000TEUS	Container
	West port	1~2	480	268	30,000×2	1,186	General cargo, Container
Dangjin area	Songik port	1~2	480	38	30,000×2	998	Scrap metal
		3	280	22	50,000×1	558	Steel, Scrap metal
	Godea Industrial port	1	120	36	5,000×1	242	Steel

Source: Pyeongtaek Port Authority

Table 3 shows facilities of Incheon port. In Incheon port, the inner port consists of 8 terminals and 48 berths. 7 terminals are operated by private companies (TOC), while the only exception is a public owned one - terminal No.1, where the main cargo handled are steel, general cargo, lumber, container and grain. The outer port is divided into south and north part. South part is composed of 5 berths for container cargo and one for general cargo; the north part consists of 7 berths serving oil mainly.

Moreover, Incheon port has constructed extra 8 container berths outside of the port which faces to the south; 15 berths are in construction (Outer port - North) for general cargo, lumber and steel and other 34 berths (Outer port - South) for container and general cargo to the North. These projects will be finished in 2011.

Table 3. Facilities of Incheon port

		Berth length (m)	Yards (1,000 ㎡)	Berth capacity DWT(1,000)×No. berth	Handling capacity (1,000ton)	Cargo type handled
Inner port	No.1	1,799	155	50×1, 45×4, 35×2, 3×1, 2×3	4,601	Steel, General cargo, Lumber
	No.2	1,278	76	30×1, 20×2, 8×5	4,229	Steel, Lumber, Bulk cargo
	No.3	1,250	58	20×1, 10×2, 8×4	3,322	Steel, General cargo, Bulk cargo
	No.4	1,160	306	50×1, 40×1, 30×1, 20×1, 10×1	8,182	Container, General cargo, Grain
	No.5	1,150	178	50×4	3,920	Car, General cargo, Grain
	No.6	1,018	104	50×1, 30×2, 20×1, 5×2	4,411	Steel, General cargo, Car
	No.7	1,458	8	50×3, 20×1	4,787	General cargo, Grain
	No.8	910	111	50×3	3,647	Steel, Bulk cargo
Outer Port (South)	ICT	300	120	40×1	400,000TEUS	Container
	Korea Express	221	15	5×2	80,000TEUS	Container, General cargo
	Youngjin	170	3.4	10×1	10,000TEUS	General cargo
	SunKwang Container	407	76(On) 169(Off)	18×2	30,000TEUS	Container, General cargo
Outer Port (North)	Kepco	240	-	20,000×1	-	Crude oil
	Incheon Oil(1)	240	-	75,000×1	-	Crude oil, refined oil
	Incheon Oil(2)	390	-	60,000×1	-	refined oil, chemical
	Incheon Oil(3)	485	-	100,000×1	-	Oil, refined oil
	GS-Caltex Oil Dolphin	171	-	5,000×1	-	LPG, oil
	GS-Caltex Oil Buoy	200	-	40,000×1	-	LPG, oil
	Korean Air	315	-	50,000×1	-	Oil

Source: Incheon Port Authority

2.2 Vessels calling at ports

This section will display vessel types of Pyeongtaek and Incheon port. Information about hinterland's industrial of both ports are presented. Their main cargoes are general cargo and refined petroleum. In the years of 1997 ~ 2005, the types and numbers of vessels calling at Pyeongtaek and Incheon ports are shown in Table 4 and Table 5.

The main cargoes handled in Pyoengtaek port are refined petroleum products, bulk and general cargo. Container ships are also increased in both volume and quantity because of the proximity to the metropolitan such as Seoul and KyoungKi-Do.

Table 4. Pyeongtaek port's vessel types

Unit: vessels

Type	1997	1998	1999	2000	2001	2002	2003	2004	2005
General cargo ship	292	422	803	674	626	697	693	828	950
Refined petroleum products carrier	298	139	300	356	721	667	810	778	773
Car carrier	-	-	1	52	247	302	329	411	474
LPG/LNG carrier	154	132	238	244	207	249	271	232	234
Bulk carrier	725	125	14	529	559	565	601	596	607
Crude oil tanker	54	4	8	125	32	74	80	54	61
Container ship	-	-	-	18	90	194	458	548	634
Passenger ship	-	-	-	-	33	179	262	300	222
Semi container ship	-	4	4	5	8	21	22	12	16
Chemical tanker	28	40	80	87	125	209	205	176	195
Cement carrier	-	-	-	-	-	-	2	-	-
Wood carrier	9	4	7	5	2	2	4	1	1
Ref-Carrier	-	-	-	-	-	1	5	2	19
Etc.	4,226	3,438	3,012	2,812	3,217	3,450	3,271	1,612	1,750
Total	5,786	4,308	4,467	4,907	5,867	6,610	7,013	5,550	5,936

Source: Port-MIS(2006)

** etc : fertilizer, flesh, electrical machinery, sand and so on*

Incheon port's main cargoes are refined petroleum products, bulk cargo, general cargo and full container. Besides, Incheon port shares its metropolitan hinterland with Pyeongtaek port. Especially, passenger ships are increasing in quantity due to development of tourism in South Korea.

Generally, these ports serve general cargo, refined petroleum products, bulk cargo vessels, because they have cheap land cost for hinterland with many factories and manufacture industries.

Table 5. Incheon port's vessel types

Unit: vessels

Type	1997	1998	1999	2000	2001	2002	2003	2004	2005
General cargo ship	5,169	4,586	4,397	3,398	3,338	3,658	4,056	4,027	4,461
Refined petroleum products carrier	1,915	1,622	1,670	1,477	1,941	1,930	2,411	2,235	2,350
Car carrier	399	371	479	559	323	242	261	333	329
LPG/LNG carrier	993	898	954	823	794	718	761	767	746
Bulk carrier	935	1,006	1,298	2,988	3,141	2,741	2,277	2,181	2,497
Crude oil tanker	470	242	271	740	263	206	182	132	129
Full container	720	609	659	771	821	1,062	1,126	1,368	1,435
Passenger ship	346	413	589	614	725	1,004	1,172	1,187	1,336
Semi container	206	143	145	132	68	106	212	343	241
Chemical tanker	770	867	1,023	684	715	706	851	992	979
Cement carrier	264	288	262	217	267	394	429	511	461
Wood carrier	106	78	91	53	50	32	17	20	22
Ref-Carrier	171	157	226	304	260	356	375	388	443
Etc.	11,225	8,104	8,273	9,715	11,152	11,616	11,313	5,733	5,805
Total	23,689	19,384	20,337	22,475	23,858	24,771	25,443	20,217	21,234

Source: Port-MIS(2006)

** etc : fertilizer, flesh, electrical machinery, sand and so on*

2.3 Evolution of vessel size calling at port

This section introduces the evolution of vessel size calling at both ports. As the ports' facilities are not enough a few mother ships are calling at Pyeongtaek and Incheon port. We can know that the ports are developed through Table 6 and Table 7.

The vessels calling at Pyeongtaek port are various in types, but limited in size. Most of them are 100~500 tons and 1,000~3,000 tons. Large-sized vessels usually do not call at Pyeongtaek port, due to its shortage of facilities, superstructure and infrastructure in comparison with Incheon port (Table 2).

Table 6. Pyeongtaek port's vessel size

Unit: vessels

Size	1997	1998	1999	2000	2001	2002	2003	2004	2005
less than 100ton	164	158	2,666	2,438	2,359	1,948	1,673	779	563
100-500	1,017	1,104	322	540	1,142	1,838	2,093	1,345	1,681
500-1,000	3,842	1,916	63	176	88	93	86	70	118
1,000-3,000	164	485	391	533	568	643	734	895	1,058
3,000-5,000	184	123	223	333	460	526	670	672	637
5,000-7,000	119	56	108	142	233	277	270	208	285
7,000-10,000	67	267	460	394	398	423	493	493	432
10,000-15,000	44	28	20	24	22	24	51	29	102
15,000-20,000	18	16	7	26	67	212	234	345	255
20,000-25,000	22	17	24	42	80	73	77	55	70
25,000-30,000	6	20	20	28	25	58	116	61	89
30,000-50,000	14	7	26	78	216	258	273	313	323
50,000-60,000	1	7	3	13	57	74	90	127	157
60,000-75,000	-	-	-	1	4	7	6	3	7
75,000-100,000	66	51	81	76	81	83	88	87	100
Total	5,728	4,255	4,414	4,844	5,800	6,537	6,954	5,482	5,877

Source: Port-MIS(2006)

Incheon port serves similar-sized vessels to Pyeongtaek port, in the higher quantity. In addition, vessel size of 100~500 tons are its major service. Some reasons are that Incheon port has advantages of facility and it usually provides volume incentive programs to customers.

Table 7. Incheon port's vessel size

Unit: vessels

Size	1997	1998	1999	2000	2001	2002	2003	2004	2005
less than 100ton	1,855	1,520	4,357	4,932	5,247	4,471	3,727	2,094	1,703
100-500	1,032	1,181	4,881	6,011	7,448	8,545	9,099	5,027	5,526
500-1,000	4,375	3,157	1,144	1,454	1,449	1,104	1,370	928	826
1,000-3,000	9,619	7,445	3,567	3,608	3,542	3,867	3,984	4,571	5,067
3,000-5,000	2,290	2,111	1,837	1,809	1,765	2,030	2,400	2,777	2,935
5,000-7,000	861	799	851	815	830	1,033	1,005	1,096	1,046
7,000-10,000	360	300	321	464	406	285	349	331	470
10,000-15,000	814	712	801	712	647	911	1,018	942	897
15,000-20,000	932	863	949	766	823	874	855	784	1,006
20,000-25,000	393	343	321	290	257	261	286	249	195
25,000-30,000	320	316	403	610	567	582	609	715	696
30,000-50,000	619	468	615	622	529	529	457	392	487
50,000-60,000	138	90	185	257	210	138	139	137	174
60,000-75,000	-	2	2	8	17	11	4	12	15
75,000-100,000	45	44	66	67	76	72	83	107	144
Total	23,653	19,351	20,300	22,425	23,813	24,713	25,385	20,162	21,187

Source: Port-MIS(2006)

Chapter 3. Case studies in Europe

This chapter presents case studies about Rotterdam, Antwerp, Hamburg and Bremerhaven port in Europe, where feeder network is very active with the short sea shipping services. This chapter studies their strengths, weaknesses and strategies.

Feeder service is divided into Common Feeder service (General feeder shipping company and independent shipping company) and Dedicated Feeder service (seagoing shipping company).

First, European feeder service can be divided into 3 regions. Including:

- Scandinavia Pen & Baltic Sea
- England & Iceland
- Spain & Portugal

These ports are big in Europe, but they are also serving the feeder service.

Table 8. Handling volumes of each container terminal

Unit: TEUs

Port	2001	2002	2003	2004	2005	2006	Increasing Rate/year (%)
Rotterdam	6,096,142	6,506,311	7,143,920	8,280,787	9,286,757	9,690,052	9.79
Hamburg	4,688,669	5,373,999	6,137,926	7,003,479	8,087,545	8,861,804	13.6
Antwerp	4,218,176	4,777,151	5,445,437	6,063,746	6,488,029	7,018,799	10.75
Bremerhaven	2,972,882	3,031,587	3,189,853	3,469,253	3,743,969	4,449,624	8.54

Source : Hamburg Container Terminal (http://www.hafen-hamburg.de)

3. 1. Rotterdam port

Table 9 shows the feeder network structure of Rotterdam port. The market share of Rotterdam port are 68.5%, 18.9% and 12.6% in England & Iceland, Scandinavia Pen & Baltic Sea, respectively. The rate of trade is seemingly balance.

Table 9. Structure of Rotterdam port's feeder network

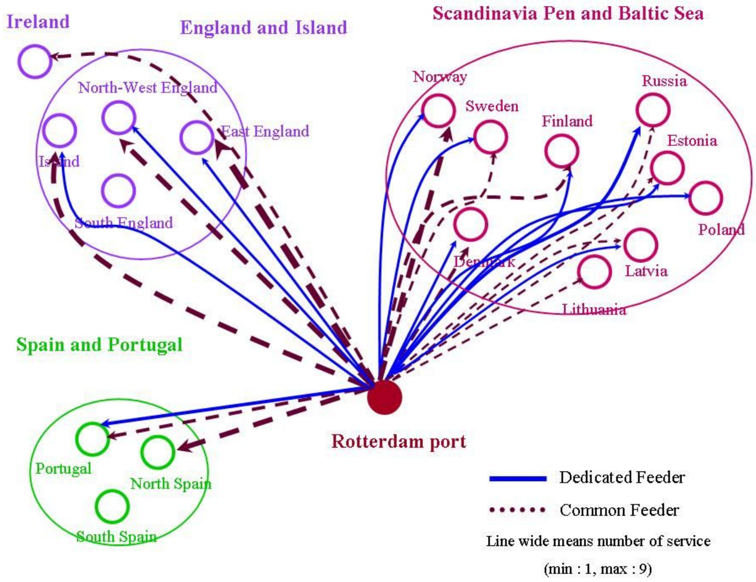
Unit : 1,000TEUs

Region	Export	Import	Total	Rate (%)
Scandinavia Pen & Baltic Sea	234.4	173.2	407.6	18.9
England & Iceland	744.2	733.2	1,477.4	68.5
Spain & Portugal	169.4	101.4	270.8	12.6
Total	1,148	1,007.8	2,155.8	100.0

Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

The line width means number of services. North Spain and Norway's rates of trade are higher than those of other countries, except England & Iceland area's ones. In general, Rotterdam port's feeder network serves equally for Dedicated feeder and Common feeder services. However it is a little different in each region's feeder service. For instance, dedicated feeder develops in the center of Russia, Finland and Scandinavia Pen & Baltic Sea, while common feeder develops in the center of East England & Iceland.

Figure 3. The region of feeder service by Rotterdam port



Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

3. 2. Antwerp port

Antwerp port's main feeder service area is Scandinavia Pen & Baltic Sea (49.1%) and England & Iceland (31.8%) as in Table 10. Antwerp port is different in comparison with Rotterdam port, where trade rate is unbalance. Although England & Iceland market has more advantages in distance, its handling volume is lower than that of Scandinavia Pen & Baltic Sea.

Table 10. Structure of Antwerp port's feeder network

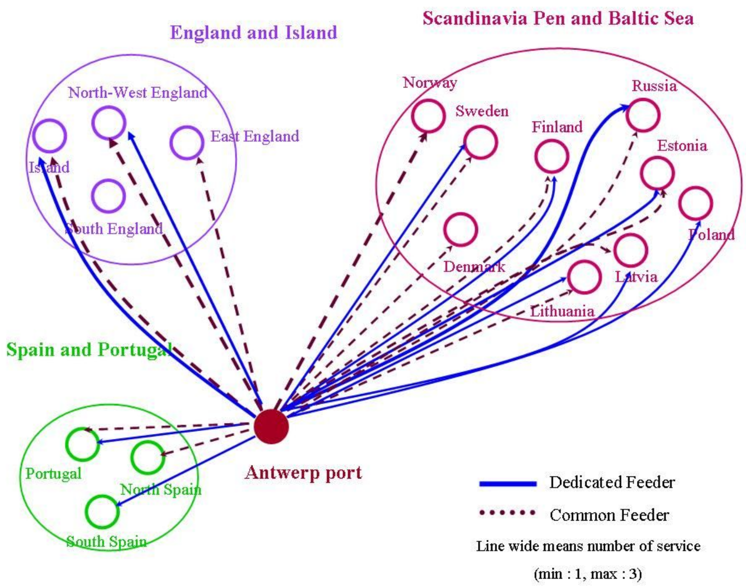
Unit : 1,000TEUs

Region	Export	Import	Total	Rate (%)
Scandinavia Pen & Baltic Sea	278.0	238.3	516.3	49.1
England & Iceland	173.5	161.2	334.7	31.8
Spain & Portugal	105.7	95.8	201.5	19.1
Total	884.2	495.3	1,052.5	100.0

Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

Dedicate feeder service of Antwerp port serves mainly for Baltic Sea area in which includes Russia, Estonia and so on. Common feeder service area is Scandinavia Pen including Norway, Finland and North-west England & Iceland. The feeder service is more active in Finland, Russia and Estonia of Scandinavia Pen & Baltic Sea. On the other hands, feeder service is being developed in center of West England & Iceland.

Figure 4. The region of feeder service by Antwerp port



Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

3. 3. Hamburg port

Table 11 shows structure of Hamburg port's feeder network. The Hamburg port's main feeder service area is Scandinavia Pen & Baltic Sea. The market share is highest (91.5%) because it is located near to Scandinavia Pen & Baltic Sea and rate of trade is also balanced a like Rotterdam port.

Table 11. Structure of Hamburg port's feeder network

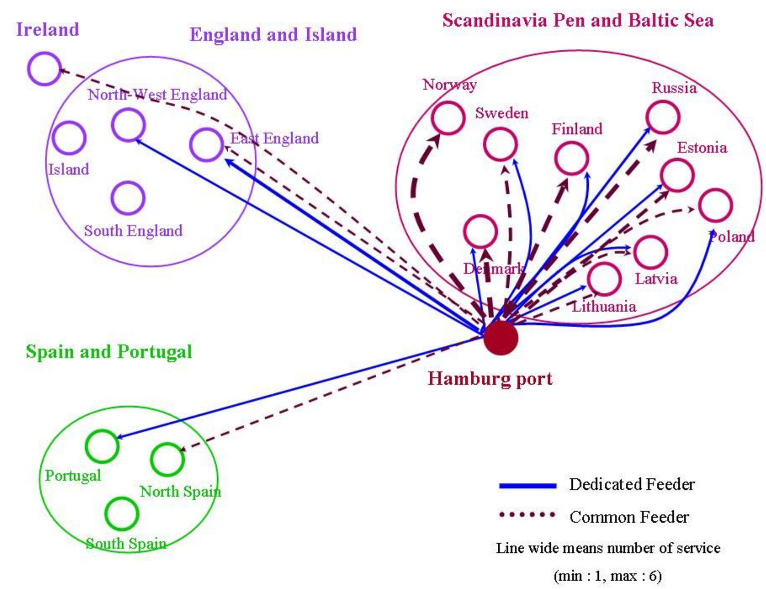
Unit : 1,000TEUs

Region	Export	Import	Total	Rate (%)
Scandinavia Pen & Baltic Sea	759.6	809.9	1,568.5	91.5
England & Iceland	38.1	82.6	120.7	7.0
Spain & Portugal	11.6	14.8	26.4	1.5
Total	808.3	907.3	1,715.6	100.0

Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

Especially, common feeder service is more active than dedicated feeder service. However, those feeder services are more active from Hamburg to Scandinavia Pen & Baltic Sea than from other counties. Hamburg is located near Denmark, Russia, Poland, etc.

Figure 5. The region of feeder service by Hamburg port



Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

3. 4. Bremerhaven port

Table 12 shows the structure of Bremerhaven port's feeder network. The Bremerhaven port's main feeder service area is Scandinavia Pen & Baltic Sea. The market share is highest (86.1%) because it is also the same as the situation of Hamburg port and the rate of trade is balance.

Table 12. Structure of Bremerhaven port port's feeder network

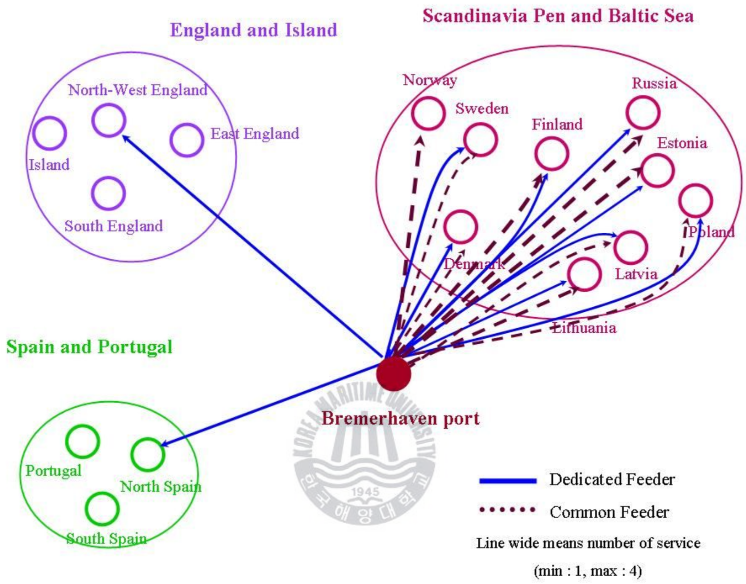
Unit : 1,000TEUs

Region	Export	Import	Total	Rate (%)
Scandinavia Pen & Baltic Sea	373.7	464.6	838.3	86.1
England & Iceland	14.5	61.7	76.2	7.8
Spain & Portugal	28.0	31.8	59.8	6.1
Total	416.2	558.1	974.3	100.0

Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

In the case of Bremerhaven port, common feeder is more active than dedicated service. The reason is the same as Hamburg port. Dedicated feeder develops in the center of Russia, Estonia, Poland and so on. Common feeder develops in the center of Norway, Sweden, Russia and so on.

Figure 6. The region of feeder service by Bremerhaven port



Source : "A northeast a feeder network consolidation plan" Korea Maritime Institute (2006. 01)

Chapter 4. Cost analysis of main and feeder routes

This chapter analyzes the competitiveness of Pyeongtaek port through 3 scenarios (Figure 5). First, for the analysis of competitive, three scenarios in each Pyeongtaek, Busan and Incheon are created. Second, the comparison between short sea shipping and road transport system which connect Busan and Pyeongtaek is analyzed to find out which mode is more efficient.

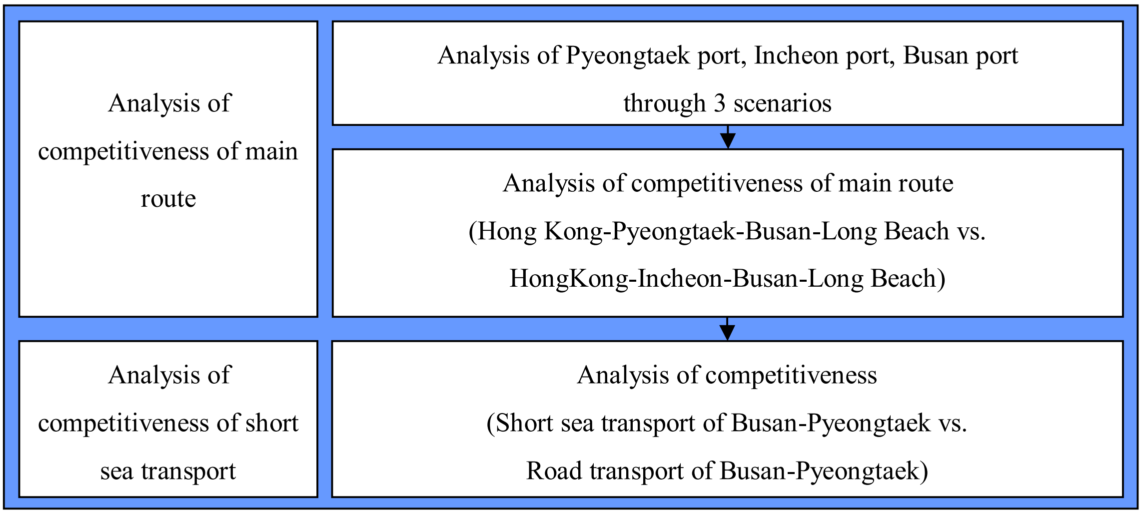
4.1 Service route planning

Figure 7 is a flow chart of analysis. First, this flow chart can be divided into data from main route and short sea shipping and then it is divided again into 3 steps. For the first step, it displays each scenario. Busan port is already big, but Pyeongtaek and Incheon port are small. So, the scenario of this step is most cargo (local cargo) goes through Busan port to Pyeongtaek or Incheon port, if some cargoes have to go to China. In the second step, competitiveness between Pyeongtaek and Incheon port about main route will be analyzed. The last step will analyze competitiveness of short sea transport from Busan to Pyeongtaek port.

It is assumed that shipping liners call at each port in the route of Europe - Far east Asia - North America, Europe - Far east Asia and North America - Far east Asia.

For pendulum route, the origin or destination is Hong Kong or Long Beach. For west bound route, the destination is Hong Kong. For east bound route, the destination is Long Beach.

Figure 7. Flow chart of analysis



4.2 Competitiveness of main route

This section will present the reason why Pyeongtaek port can not become hub port. Table 13 displays scenario specifications for main route. 3 scenarios are created for each port, a basic assumption is that shipping company must call at Pyeongtaek, Incheon and Busan port. First, if shipping company has the pendulum service, the route is from Hong Kong to Long Beach (scenario 1-1, 2-1, 3-1). Second, if shipping company has the West bound service, the route is from Hong Kong to Pyeongtaek, Incheon and Busan (scenario 1-2, 2-2, 3-2). Finally, if shipping company has East bound service, the route is from Long Beach to each port (scenario 1-3, 2-3, 3-3).

Table 13. Specification of scenarios

Scenario	Port	Route	Port of call
Scenario 1-1	Pyeongtaek	Pendulum	Hong Kong ↔ Pyeongtaek ↔ Busan ↔ Long Beach
Scenario 1-2		West bound	Hong Kong ↔ Pyeongtaek
Scenario 1-3		East bound	Pyeongtaek ↔ Busan ↔ Long Beach
Scenario 2-1	Incheon	Pendulum	Hong Kong ↔ Incheon ↔ Busan ↔ Long Beach
Scenario 2-2		West bound	Hong Kong ↔ Incheon
Scenario 2-3		East bound	Incheon ↔ Busan ↔ Long Beach
Scenario 3-1	Busan	Pendulum	Hong Kong ↔ Busan ↔ Long Beach
Scenario 3-2		West bound	Hong Kong ↔ Busan
Scenario 3-3		East bound	Busan ↔ Long Beach

From Pyeongtaek port, the total distance is 6.878miles and it takes total time is 14.33days to travel for pendulum route. Distance and time for east bound and west bound are 1,222miles, 2.55days and 5,656miles, 11.78days respectively.

Table 14. Distance and time for each scenario of Pyeongtaek port

Scenario	Port	Route	Port	mile	Port	mile	Port	mile	Port	Total
				day		day		day		
Scenario 1-1	Pyeongtaek	Pendulum	Hong Kong	1,222	Pyeongtaek	408	Busan	5,248	Long Beach	6,878
				2.55		0.85		10.93		14.33
Scenario 1-2		East bound	Hong Kong	1,222	Pyeongtaek	-				1,222
				2.55						2.55
Scenario 1-3		West bound	-		Pyeongtaek	408	Busan	5,248	Long Beach	5,656
						0.85		10.93		11.78

** Speed: 20knot/h*

Table 15 is about Incheon port. In the case of Incheon port, the total distance is 6.886miles and time is 14.34days for pendulum route. Distances and times for east bound and west bound are 1,226miles, 2.55days and 5,660miles, 11.78days respectively.

Table 15. Distance and time for each scenario of Incheon port

Scenario	Port	Route	Port	mile / day	Port	mile / day	Port	mile / day	Port	Total
Scenario 2-1	Incheon	Pendulum	Hong Kong	1,226	Incheon	412	Busan	5,248	Long Beach	6,886
				2.55		0.86		10.93		14.34
Scenario 2-2		East bound	Hong Kong	1,226	Incheon	-				1,226
				2.55						2.55
Scenario 2-3		West bound	-		Incheon	412	Busan	5,248	Long Beach	5,660
						0.86		10.93		11.79

＊Speed: 20knot/h

Table 16 shows the figure of Busan port. In the case of Busan port, total distance is 6.886miles and time is 14.34days with pendulum route. Distances and times for east bound and west bound are 1,226miles, 2.55days and 5,660miles, 11.78days respectively.

Table 16. Distance and time for each scenario of Busan port

Scenario	Port	Route	Port	mile / day	Port	mile / day	Port	Total
Scenario 3-1	Busan	Pendulum	Hong Kong	1,165	Busan	5,248	Long Beach	6,413
				2.43		10.93		13.36
Scenario 3-2		East bound	Hong Kong	1,165	Busan	-		1,165
				2.43				2.43
Scenario 3-3		West bound	-		Busan	5,248	Long Beach	5,248
						10.93		10.93

＊Speed: 20knot/h

4.3 Navigation cost per day

This section analyzes navigation cost per day of a ship. This section uses some formula, which is created from the other authors. (Cullinane, Khanna, 2000 / Baird, 2001 and Wijnolst & Waals, 1999) They have studied about cost of a ship per day. Daily navigation cost is composed of capital, operation, sailing, port use cost and so on. This real data are from Internal Shipping company of South Korea.

Table 17. Calculation method of cost

	List	Method
Capital cost	-	Apply to 10years redemption yield of cost of ship building
Operation cost	Repair	Cost of ship building × 0.75%
	Insurance Premium	Cost of ship building × 0.75%
	Management	Cost of ship building × 0.75%
	Lubricating Oil	Source: Internal Shipping company of South Korea
	Ship inspection	Cost of ship building × 0.50%
	Crew	Source: Internal Shipping company of South Korea
Sailing cost	Bunker Oil	Source: Internal Shipping company of South Korea
Port using cost	Voyage	Source: Internal Shipping company of South Korea
Etc	Supplies of Ship	Source: Internal Shipping company of South Korea

Source: Internal Shipping company of South Korea

4.3.1 Capital costs

First, capital costs will be calculated based on ship building costs. It applies to the redemption yield for 10 years about a ship building which the shipping company pays to ship building company.

"Modeled new-building contract prices are converted into an annual capital charge by applying a capital recovery factor which assumes that the life of the vessel is 20 years, the interest rate is 10% and the residual value is 0. Dividing the annuity value by 360 days gives a ship's daily capital cost." (*Cullinane, Khanna, Economies of Scale in Large Containership: Optimal Size and Geographical, Journal of Transport Geography, 2000 / Baird, A new economic evaluation of the hubport versus multiport strategy, 2001*).

$$\text{Capital cost per day} = (\text{cost of ship building} \times 10\%) \div 365$$

4.3.2 Operation costs

Second, operation cost is composed of crew cost, repair cost, insurance premium, management cost, ship inspection and lubricant cost, in which repair cost, insurance premium and management cost are occrued about 0.75% of ship building cost (*Wijnolst & Waals, Malacca-Max; The Ultimate Container Carrier, Delft University Press, 1999*).

$$\text{Repair cost per day} = (\text{cost of ship building} \times 0.75\%) \div 365$$

$$\text{Insurance premium per day} = (\text{cost of ship building} \times 0.75\%) \div 365$$

$$\text{Management cost per day} = (\text{cost of ship building} \times 0.75\%) \div 365$$

Ship inspection cost is occrued by the 0.50% of ship building cost (*Wijnolst & Waals, Malacca-Max; The Ultimate Container Carrier, Delft University Press,1999*).

$$\text{Ship inspection cost per day} = (\text{cost of ship building} \times 0.50\%) \div 365$$

4.3.3 Sailing costs (fuel costs)

This section will show the sailing cost of a ship. Table 18 displays amount of fuel used per day. Fuel is used for main engines and dynamo. When a ship on a voyage, the main engine is used and when they berth to a port, then the dynamo is used. The fuel cost is different in each country, so this paper uses the average cost of fuel in main route. Table 18 presents the daily amount use of fuel, in which ships are divided by size and details of 4,000TEUs ship will be applied in this table.

Table 18. Daily amount of fuel usage

Unit: ton

Ship size	Main engine (A)		Dynamo (B)		Total (A+B)	
TEUS	at Sea	at Port	at Sea	at Port	at Sea	at Port
3,000	132.45	17.92	0.76	2.14	133.20	20.06
4,000	157.09	21.25	0.90	2.54	157.98	23.79
5,300	200.21	27.09	1.14	3.23	201.35	30.32
5,600	204.83	27.71	1.17	3.31	206.00	31.02
6,500	229.16	31.00	1.31	3.70	230.47	34.70

Source: Internal Shipping company of South Korea

Table 19 shows the fuel cost of each country per ton. Each country has different fuel cost so in this section, use the average fuel cost of six countries is applied. The average cost of main engine is 176USD and dynamo is 256USD.

Table 19. Fuel cost of each country per ton

Unit: USD

Country	Main engine	Dynamo
Singapore	170	226
Korea	176	268
Japan	184	272
Hong Kong	180	233
U.S.	189	322
Netherlands	154	213
Average cost	176	256

Source: Internal Shipping company of South Korea

Table 20 shows the total fuel cost per day. The numbers are from Table 18 and Table 19. Total fuel cost per day will be calculated by multiplies the amount of fuel used per day and the fuel cost per ton.

Table 20. Total fuel cost per day

Unit: USD

Ship size	Main engine (A)		Dynamo (B)		Total (A+B)	
TEUS	at Sea	at Port	at Sea	at Port	at Sea	at Port
3,000	23,259	3,147	193	547	23,452	3,694
4,000	27,586	3,732	229	649	27,816	4,381
5,300	35,159	4,757	292	827	35,451	5,583
5,600	35,970	4,866	299	846	36,269	5,712
6,500	40,243	5,444	335	946	40,578	6,391

* *Fuel cost per day = Amount use of fuel per day × Average fuel cost per ton*

4.3.4 Other costs

In this section, other costs of a ship will be shown. The other costs include cost for food, drink, communication equipments, clothes, engine, components and so on.

Table 21. Other costs per day

Unit: USD

Ship size	Cost
3,000	838
4,000	1,238
5,300	1,011
5,600	1,225
6,500	1,600

Source: Internal Shipping company of South Korea

4.3.5 Total navigation cost per day

Total cost consists of capital cost, operation cost, fuel and other costs. Finally, 4,000TEUS container ship's total cost is 51,488USD per day.

Table 22. Total navigation cost for a 4,000TEUS container ship

Unit: USD/day

	Capital costs	Operation costs	Fuel costs	Other costs	Total
Cost	10,685	7,368	32,197	1,238	51,488

Source: Internal Shipping company of South Korea

4.4 THC (Terminal Handling cost) of each port

This section will present the Terminal Handling cost (THC) of Pyeongtaek, Incheon, Busan, Hong Kong and Long Beach port. Pyeongtaek, Incheon and Busan's THC are the same, but Hong Kong's THC is 8,463USD and 28,202USD in Long Beach as shown in the Table 23.

Table 23. THC of 4,000TEUS container ship

Unit: USD

	Pyeongtaek	Incheon	Busan	Hong Kong	Long Beach
THC	23,348	23,348	23,348	8,463	28,202

* *in case of Incheon, Busan and Pyeongtaek, using the officially tariff of Ministry of Maritime Affairs & Fisheries*
in case of Hong Kong and Long Beach, using the Internal Shipping company of South Korea

4.5 Total navigation cost of each scenario

Table 24 shows total navigation cost of each scenario. The total navigation cost of scenario 2-1 (Hong Kong ↔ Incheon ↔ Busan ↔ Long Beach) is the highest, scenario 3-2 (Hong Kong ↔ Busan) is the lowest. Busan port's total navigation cost is the lowest among the all scenarios, total navigation cost of Pyeongtaek and Incheon port are similar each other.

Table 24. Total navigation cost of 4,000TEUS for each scenario

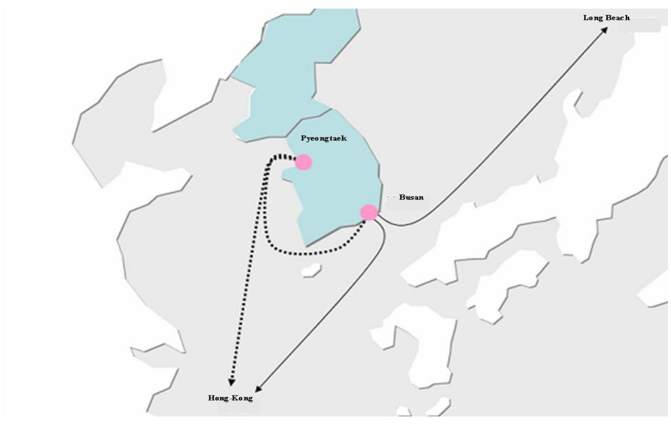
Unit: USD

Scenario	Port	Route	Port of call	Navigation	THC	Total
Scenario 1-1	Pyeongtaek	Pendulum	Hong Kong ↔ Pyeongtaek ↔ Busan ↔ Long Beach	737,823	83,361	821,184
Scenario 1-2		West bound	Hong Kong ↔ Pyeongtaek	131,294	31,811	163,105
Scenario 1-3		East bound	Pyeongtaek ↔ Busan ↔ Long Beach	606,529	74,898	681,427
Scenario 2-1	Incheon	Pendulum	Hong Kong ↔ Incheon ↔ Busan ↔ Long Beach	738,338	83,361	821,699
Scenario 2-2		West bound	Hong Kong ↔ Incheon	131,294	31,811	163,105
Scenario 2-3		East bound	Incheon ↔ Busan ↔ Long Beach	607,044	74,898	681,942
Scenario 3-1	Busan	Pendulum	Hong Kong ↔ Busan ↔ Long Beach	687,880	60,013	747,893
Scenario 3-2		West bound	Hong Kong ↔ Busan	125,116	31,811	156,927
Scenario 3-3		East bound	Busan ↔ Long Beach	562,764	51,550	614,314

4.6 Economic efficiency of shipping company point of view

In this section, scenario 1-1 and 3-1 will be compared to find, which one is more profitable for a shipping company. In table 26, it displays the total navigation costs, 821,184USD and 747,893USD each scenario, respectively.

Figure 8. The main route of scenario 1-1 and 3-1



4.7 Road cost and feeder cost for Pyeongtaek port and Incheon port

In comparison between Table 25 and 26, when the cargo moves from Busan, feeder cost (use the feeder service from Busan and then use the road system) is more economical than door to door service (use the road system from Busan to metropolitan area).

There is no possible way for Pyeongtaek port to trade with Busan port now. So it is assumed that feeder costs of Pyeongtaek and Busan port are the same as that of Incheon port.

Table 25. Feeder cost for Incheon port and Busan port

Unit : USD

	Going up(Busan→Pyeongtaek)		Going down (Pyeongtaek→Busan)		Average cost	
Container	20ft	40ft	20ft	40ft	20ft	40ft
Cost	267.77	316.68	208.63	260.53	236.23	288.14

Source: Internal Shipping company of South Korea

Table 26 displays cost of road system. The cost is between Metropolitan and three ports. Especially, this table shows comparison between Pyeongtaek and Incheon port. Look around, cost of Pyeongtaek is cheaper than one of Incheon. It means that Pyeongtaek port has cost advantages compared to Incheon port.

Between road and feeder cost, feeder cost is cheaper than road cost, but the problem is that there is no way from Busan to Pyeongtaek. Many scholars already knew that small ports have to connect with big port for feeder network service.

Table 26. Cost of road system

Unit : USD

	Pyeongtaek(A)		Incheon(B)	
	Busan - Pyeongtaek - metropolitan area		Busan - Incheon - metropolitan area	
Destination	20ft	40ft	20ft	40ft
Gapyeong	404.97	474.13	415.99	487.16
Goyang	356.85	421.00	315.75	374.89
GwangMyeong	335.80	396.95	309.74	367.88
Guri	383.92	450.07	367.88	433.03
Gimpo	353.84	416.99	315.75	374.89
Seoul	361.86	426.02	317.76	377.90
Sungnam	360.86	425.01	356.85	421.00
Suwon	334.80	395.94	349.83	412.99
Ansan	320.77	380.91	309.74	367.88
Ansung	320.77	380.91	401.96	471.12
Anyang	330.79	391.93	309.74	367.88
Yangju	399.95	469.12	389.93	457.09
Osan	319.76	378.90	380.91	447.07
Incheon	380.91	448.07	413.99	484.15
Paju	381.91	449.07	401.96	471.12
Pocheon	406.97	476.14	404.97	474.13
Hanam	367.88	433.03	363.87	428.02
Hwasung	333.80	394.94	387.93	455.09
Siheung	322.77	382.91	302.72	360.86

Source: Internal Shipping company of South Korea

＊ Metropolitan area is composed 35 cities.

Chapter 5. Conclusion

First of all, the disadvantage of Pyeongtaek port is lack of competitiveness which attracts shipping companies (or shipper) due to its insufficient handling capability. Second, Pyeongtaek is unattractive due to the inadequate port facilities; it owns two berths for general cargo and 1 berth for container cargo only. Thus, Pyeongtaek port should solve the super and infra-structure problems as soon as possible, because both of them are the basis of in generating handling cargo volumes. If Pyeongtaek port has sufficient super and infra-structure, shipping company will consider Pyeongtaek port as the first place to call.

On the other hand, Pyeongtaek port has great potential conditions to become the leading feeder port of South Korea. Since Pyeongtaek port shares the similar hinterland such as KyoungKi-Do, ChoongChung-Do and Seoul with Incheon port.

From the time and cost point of view, Pyeongtaek port is nearer and cheaper than Busan port to reach the hinterland. Before many shippers from Metropolitan area chose Busan port for trading with China, Japan and Southeast Asia, now it is possible for shippers to change from Busan to Pyeongtaek port. Although Pyeongtaek port has less potential to be a hub and Mega port, it can be operated as the main feeder port instead of Incheon, Pyeongtaek port has similar hinterland, time and cost effective inland transport and the potential industrial zone.

Table 27 displays about SWOT analysis of Pyeongtaek port in comparison with Incheon port.

Table 27. SWOT analysis of Pyeongtaek port

SWOT	Factors
Strength	- Wide hinterlands (Seoul, KyoungKi-Do and ChoongChung-Do) - It has a plan of building about Posung Industrial Zone - Unloading and Navigation cost are cheaper than Incheon port
Weakness	- Variety of route service is insufficient (route density) - Frequency of call of port is low - Market share in container cargo is less/ handling volumes is low - Number of container ship is 1/6 of Incheon port
Opportunity	- Cargoes are possible to transfer from Incheon port to Pyeongtaek port after getting the investment from shipping company - New built industrial zone as a reliable hinterland - Inland transportation cost is cheaper than Busan port - New built large scale logistics distribution zone provide the advanced service for shipping company - The possibility for existing shipping company to move out from Busan port to Pyeongtaek port is high. - It can reserve LCL (Less than Container Load) through the development of distribution and container terminal - The hinterlands is similar with Incheon port, Pyeongtaek is more competitive - The road transport cost to some hinterland is cheaper than Incheon port
Threat	- Incheon port offer the volume incentive program to the shipping company - Incheon port has a plan to build the New-Songdo Outer port

The main purpose of Pyeongtaek port is to attract investment from shipping companies, because it is very possible for shipping companies to move from Busan to Pyeongtaek. If the investment arrives at Pyeongtaek port, shipping companies will tend to berth their own ships at Pyeongtaek to ensure the profit return. Once the shipping company chooses Pyeongtaek for a port of call, its M&A (Mergers and Acquisitions) will be followed.

Pyeongtaek port has to extend the berths and facilities to attract big vessels and feeder ships due to the insufficiency in infrastructure and handling capability, which can make to lose both the cargo from global shipping company and transshipment to the feeder shipping companies. Thus, Pyeongtaek port offers the best service to global carriers and the volume incentive programs to transshipment cargo. At this stage, Pyeongtaek port has to make partnership with other ports. If feeder shipping company choose Pyeongtaek for their call and partner port, Pyeongtaek port will provide the incentive conditions to the feeder shipping companies. Besides, Pyeongtaek port should apply IT system to provide the reliable and real-time service.

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