Methods for Efficient Management of Transshipment between Busan North Port and New Port

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Abstract: This paper proposes methods for efficient management of transshipment occurring between Busan North and New ports, and reviews space expansion strategies and cases of major ports overseas. It prospects that the growing trend in transshipment between the ports is not temporary but will continue in the long term and provides evidence for this prospect. It analyzes the phenomenon that transshipment between the ports is currently transported intensively through roads and estimates the scales of accompanying traffic congestion and environmental costs. It suggests restoration of marine shuttle and introduction of railway shuttle to solve the problems accompanying transshipment concentrated on road.

Keywords: Container, Transshipment, Railway, Barge, Port.

1. INTRODUCTION

Busan Port is located on the 1st main route which is in the Pacific, and is the optimum port for shipping companies to reduce operating expenses. In spite of worldwide economic downturn, the container volume of the port in 2012 was 17,031,000 TEU (Twenty Feet Equivalent Unit), an increase of 5.2% compared to the previous year (16,184,000 TEU).

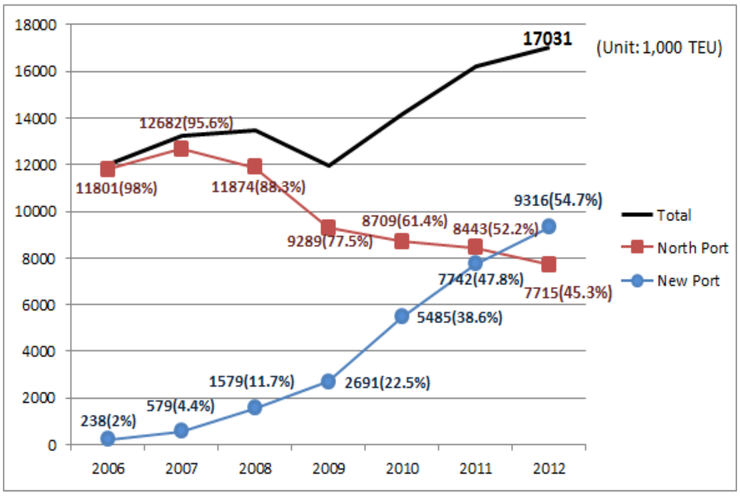

Figure 1. Container volume between Busan North and New ports

Transshipment out of the volume increased by 10.1% compared to the previous year to 8,100,000 TEU, which led an increase in overall container volume. It is thought to be affected by increased importance in transshipment of global shipping companies and shipping companies of major countries such as Maersk and CMA-CGM. In 2013, it is expected to increase by 6.5% compared to the previous year to 8,626,000 TEU (Busan Port Authority, 2012).

After opening New Port in Busan, considerable transshipment volume between North and New ports has been occurred. Transshipment was occurred only within North Port in the past, but after opening New Port, some of the cargo arriving at New Port should be sent to North Port, and vice versa even within Busan Port. Figure 2 shows the rapidly growing trend of transshipment volume in KTEU (1000 TEU) between North and New ports.

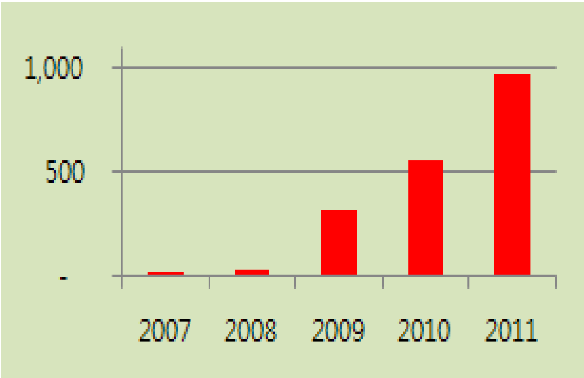

Figure 2. Transshipment volume between Busan North & New ports

Jun *et al.* (2007) predict that the share ratio of container volumes in the ports from 2009 to 2012 would be 35.9%:64.1% or 34.3%:65.7%.

Song (2011) introduces major ports in the world that are relatively close to and cooperating with each other, suggesting the necessity of rearrangement of terminal functions for each port and expansion of traffic network between the ports for their link development.

Kim (2006) propounds the necessity of reasonable specialization strategies for both ports. He prospects that the container volume of North Port will significantly decrease as many shipping companies move out when New Port is completely open. North Port needs to focus on revitalizing conventional port and New Port on securing transshipment cargo, according to him.

Cho (2009) proposes the method to vitalize railroad transport in conformity with the prediction of the quantity of goods transported through railway. He predicts that the container volume share of the ports will reach 27.1% to 72.9% in 2020 based on the announcement of the Ministry of Construction and Transport of Korea. He also prospects the quantity transported through railroad in the ports and suggests ways to vitalize railroad transport.

Jun (2009) points out that the container volume of coastal shipping companies reaches 22% of the whole container volume in Busan Port, and focuses on effective use of North Port to attract cargo of the coastal shipping companies.

Yap *et al.* (2013) predict directions in long-term developments of four ports with the highest productivities and the biggest container volume in the world. They classify and analyze the directions in development to cope with increase in container volume of each port into three types of space; (i) redevelopment of existing space, (ii) expansion into adjacent space, and (iii) development of new area. It is analyzed that among these, Shanghai Port in China and PSA (Port of Singapore Authority) in Singapore belong to the second type and Busan New Port to the third type.

Most transshipment between Busan North and New ports is currently transported through road using trucks. Various problems are indicated as transshipment volume is concentrated on road. This paper reviews the collateral issues on traffic and environment as the transshipment volume between the ports increases, and proposes ways to deal with the volume flexibly solving these problems.

First, it prospects the future container volume between the ports (growing trend). It is generally expected on the recent growing trend of transshipment volume between the ports that transshipment volume occurring between them will decrease as the container volume processed in North Port so far is gradually transferred to New Port. This paper agrees on the general prospect, but expects the point when the transshipment volume between them considerably decreases will be later than they think. This paper synthesizes case study of the Two-Port operations in foreign countries, the scope of redevelopment plan of North Port and research reports of related institutes to lay out the basis of the prospects.

It is analyzed that issues on traffic congestion and environment caused in case that transshipment between the ports stays in the medium to longer term and the volume keeps on being concentrated on road, and presented the methods to allot the container volume to marine and railroad shuttle in response to these problems. Marine shuttle had been operated using barge by the Busan Port Authority (BPA) since October 2007, but was discontinued as many problems were pointed out at the end of 2010. This paper reviews a variety of issues indicated before and suggests measures to allot road-centered transshipment to railroad and marine route.

This paper is constructed as follows. The following section 2 presents case investigation results of the Two-Port operation in foreign countries such as Shanghai Port (China), PSA Terminal (Singapore), and ECT Terminal (Netherlands). Section 3 prospects the container volume between North and New Ports. Section 4 analyzes problems caused by road-centered transshipment between the ports. Finally, section 5 proposes methods to share road-centered transshipment with railroad and marine shuttle.

2. SPACE EXPANSION OF OVERSEA PORT

This section reviews space expansion cases of Shanghai Port and PSA Ports according to a classification by Yap *et al.* (2013) and of Rotterdam Port in Netherlands with a large-scale terminal under construction.

2.1 Shanghai Port in China

WaiGaoQiao Port, an existing port in Shanghai Port, is located at the mouth of the Yangtze and shallow so it could not process quantity of large container carriers. It caused some transshipment not to go through Shanghai but other places, especially Korea and Japan, to which places it is observed the container volume was transferred. The depth of water reached 12.5 m by dredging, but berthing was still limited for large vessel.

To solve this problem, Yangshan Island which is 32 km away from land was developed as a port and the port was opened in November, 2005. Yangshan Port compensates the shortcoming of WaiGaoQiao Port which is hard for transshipment vessels to approach. The aragonite structure connected straight through water with 17m of depth worked to its advantage to berthing for large container carriers. Considering the objective of Yangshan Port construction is to increase share of transshipment, the quantity of container processes in Shanghai has drastically rose since the construction. Table 1 shows the recent share ratio of container volume between WaiGaoQiao Port and Yangshan Port.

Table 1. The container volume state of Shanghai port

Year	1st half of 2010	1st half of 2011	2012
WaiGaoQiao Port (1,000 KTEU)	6,366 (64%)	7,225 (61%)	15,000 (56%)
Yangshan Port (K (1,000 TEU)	3,600 (36%)	4,700 (39%)	12,000 (44%)

As of 2012, 7 years after Yangshan Port opened, it exceeds 50% of container volume share of WaiGaoQiao Port. It indicates that WaiGaoQiao Port is still performing a critical role, and is able to maintain this trend for many years.

Yangshan Port is over 50 km away from WaiGaoQiao inland terminal, so it operates the inland transport system which connects Yangshan Port and inland logistics complexes. It is connected to Luqiao through Donghai bridge and then to WaiGaoQiao by land. However, capacity of Donghai bridge is only 8,600,000 TEU/year, so it has been criticized as not being able to deal with cargo processing speed of Yangshan Port. The SIPG (Shanghai International Port Group) deployed 7 350-TEU container vessels to operate marine shuttle because road transport was limited (Lee *et al.*, 2007).

Marine transport by barge from Yangshan Port to WaiGaoQiao terminal costs 350 Yuan per TEU which is less than the cost for road transport. Replacement of the vessels with 1,000-TEU ones in preparation for an increase in transshipment volume is reviewed (KMI, 2005). It is to resolve delay in terminal due to low efficiency of marine shuttle service by using mega barge.

Table 2. Comparison of transportation fare by route

Route	Type	Fare
Yangshan-Luqiao-WaiGaoQiao	Road	500Yuan (180Yuan+320Yuan) / TEU 750Yuan (360Yuan+390Yuan) / FEU
Yangshan-WaiGaoQiao	Barge	350Yuan / TEU
Yangshan-Luqiao	Barge	180Yuan / TEU, 360Yuan / FEU

Role allocation is in progress as the Shanghai Port Administration is complementing littoral sea route such as WaiGaoQiao terminal to Southeast Asia, and Yangshan Port, deep sea route such as to the Americas.

2.2 Singapore PSA

PSA has opened Brani Terminal and Keppel Terminal in 1990 and 1991 each after it opened Tanjong Pagar Terminal in 1972. This helped the PSA terminals to grow rapidly by 20% per year in the early 1990's. The annual growth rate of PSA terminals somewhat lowered to 7.2% - 15% as the international competition with ports of Indonesia and Malaysia such as Tanung Pelepas Terminal was intensified in the 1990s.

PSA opened Pasir Panjang Terminal in 1997 again and handles 14,135,000 TEU in that year, then started operation of Pasir Panjang 2nd Terminal in 2005, and handles 31,649,000 TEU as of 2012.

Thus, PSA expanded Tanjong Pagar, Brani and Keppel Terminal, and continued with expansion development of terminals in the neighboring areas connected through the 1st and 2nd Pasir Panjang, which maintains its leading group position of productivity and cargo handling of the ports. Yap *et al.* (2013) expect such growing trend of PSA to last till 2025 consistently.

2.3 Rotterdam Port in Netherlands

Currently in Rotterdam Port in Netherlands, ECT is running ECT Delta terminal (Delta North, East, West terminals) in Maasvlakte and Euromax terminal which opened in 2008, within which approximately 3/4 of overall container volume is dealt with. 13 container terminals are being operated in total and they are handling 30% of container volume of the entire Europe. Container volume processed in Rotterdam Port has steadily risen and increased 8.8% compared with the previous year to 10,600,000 TEU in 2010, 12.3% to 11,900,000 TEU in 2011. It is expected to increase consistently by 4.5% annually until 2035.

Rotterdam Port expects difficulties in handling growing container volume in Maasvlakte 1 (MV1) in the future, and is planned to open Maasvlakte 2 (MV2) in 2013. MV2 is a port located in the entrance of the North Sea adjacent to MV1. 3 terminals including the Rotterdam World Gateway Terminal are going to be built in MV2. Capacity of the Rotterdam World Gateway Terminal is expected to reach 4 million TEU, and those of 2 other terminals, 4.5 and 2.3 million TEU each. MV2 is expected to reach its capacity limit in 2033 (Dávid *et al.*, 2010).

3. THE PROSPECT OF CONTAINER VOLUME

The transshipment between Busan North and New ports is rapidly increasing. It is considered because the overall container volume has increased since New Port opened. Some Korean researchers in related fields expect the growing trend in transshipment to be temporary and to be decreasing after completing the connecting system aiding New Port in the long term. This prospect is considered reasonable and corresponds to the political intent for New Port development. Also, additional transshipment process is a factor that increases logistics costs so shippers would like to avoid. Therefore, it is desirable to be settled in the long term. However, this paper expects the transshipment volume between North and New Ports to stay for a considerable period of time (in the medium to longer term).

The Korea Maritime Institute (KMI) presented research outcomes on demand and distribution forecast of container volume between Busan North and New Ports as shown in Table 3 (Sim, 2011). Alternative 1 is container volume allocation by cargo handling capacity of North and New Ports and Alternative 2 and 3 are by SP (Sated Preference) for the port users and the moving patterns of shipping companies plying.

In Alternative 1, the long-term share ratio of North Port (in 2030) is low as 26% but the container volume is expected to increase compared to 2011. Also, in alternative 2, the long-term share ratio reaches 36% and the container volume is expected to substantially increase. In these 2 alternatives, the container volume is expected to increase compared to the present. Finally, in Alternative 3, the long-term share ratio of North Port is 12%, the highest reduction level. However, even in this case, the container volume reaches 50% of the current level. It is not explicitly determined which alternative of the three would be the most powerful in the long term.

Table 3. Container volume allocation of Busan North and New ports

Category		2011	2020	2030	2030 Ratio (%)
Alternative 1	North Port	8,434	5,893	9,130	26%
	New Port	7,751	16,461	25,500	74%
	Total	16,185	22,354	34,630	100%
Alternative 2	North Port	8,434	8,137	12,605	36%
	New Port	7,751	14,217	22,025	64%
	Total	16,185	22,354	34,630	100%
Alternative 3	North Port	8,434	5,811	4,222	12%
	New Port	7,751	16,543	30,408	88%
	Total	16,185	22,354	34,630	100%

This paper expects the container volume of North Port and the transshipment between North and New ports to stay in the medium and long term for a considerable period of time. The Table 3 above suggested by KMI is presented as the 1st evidence of the prospect for the container volume of North Port and the transshipment volume between the ports. Table 3 shows that it is possible that the transshipment between the ports would keep its present scale until 2030.

The second evidence is the foreign port space expansion cases reviewed in the previous section. The purpose of port expansion of each country is to secure sufficient space to deal with increasing demand flexibly and efficiently as reviewed above. Major strategy of ports in each country is to improve its competitiveness by connecting port space already secured to newly expanded port. Busan Port is the 5th in cargo handling in the world and competes to secure the state as a transshipment center in East Asia. In this circumstance, it is difficult to decide to artificially reduce the existing role of North Port.

In addition, the scale of existing facility in North Port is very large. Figure 3 below compares Quay length of PSA (Keppel, Brani, Tanjong Pagar), WaiGaoQiao of Shanghai Port, and North Port. Considering that of Keppel, Brani, Tanjong Pagar is 8,169 m, WaiGaoQiao 6,080 m, North Port's 5,973 m shows the facility scale is not on the small side. If the activity ratio of such large-scale facilities turns low, the sunk cost could be substantial. Therefore, it is difficult to make such a decision on social and political aspects. Each local government responsible for administration of both ports in relation with container volume allocation of New Port and the utilization plan of North Port is enforcing policy for medium and longer-term development of port within its jurisdiction.

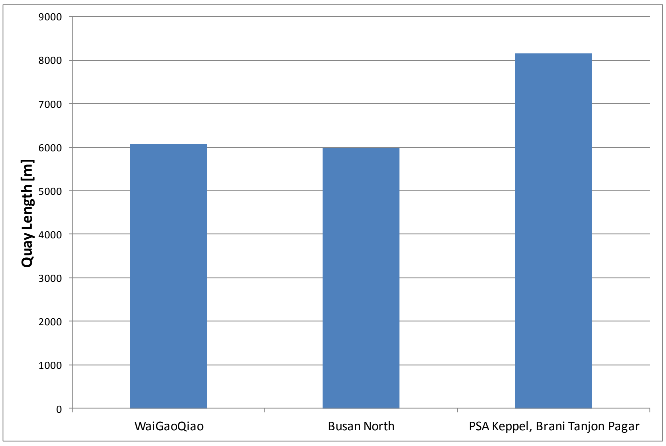

Figure 3. Comparison of quay lengths between three Eastern ports

Adjustment method of North Port's role following North Port redevelopment by Busan city recently gained attention. However, the redevelopment of North Port led by Busan city is focused on general piers that do not handle containers and has nothing to do with container-exclusive ports.

After all the evidence, container handling function of North Port will stay for quite some time, and the transshipment between North and New Ports is expected to arise in the medium to longer term.

4. ANALYSIS OF ROAD CONCENTRATION PROBLEMS

Most transshipment between North and New Ports is currently transported through road. As mentioned above, if transshipment between North and New Ports is concentrated on road, traffic congestion and environmental problems are expected to arise. Annul road congestion cost in Korea is 27,700,000 million KRW, reaching 2.6% of GDP and the cost of Busan is 3,792,000 million KRW, accounting for 21.5% of the national traffic congestion cost (The Korea Transport Institute, 2010). Severe road congestion issue in Busan shown in Figure 4 is heavily affected by container trucks running downtown and arterial highway around Busan Port. In addition to traffic congestion issue, environmental pollution is serious. Exhaust gas emitted from trucks and noise created while driving largely affect the quality of life of Busan citizens.

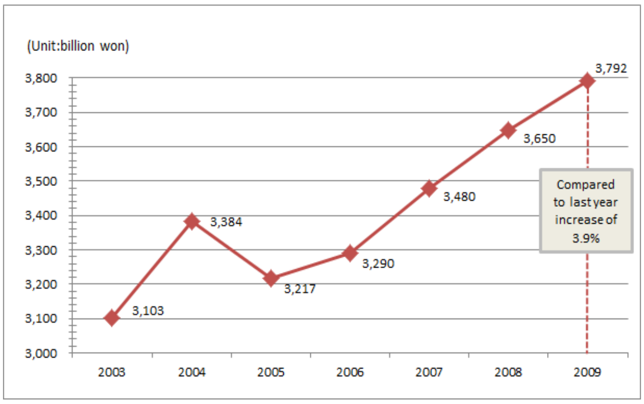

Figure 4. Increasing state of road congestion cost in Busan city

Table 4 represents various road transportation routes between North and New Ports. Among these, Route (1) and (2) are mostly used. North Port bridge connected from container-exclusive terminal is scheduled to be opened in 2014. When North Port bridge is opened, container trucks will not have to pass through Busan downtown but be connected with New Port through the coastal ring road of the south coast. Route (4) cutting across North Port bridge is 26.49 km long and it has merit in the shortest route extension.

Table 4. Road transportation routes between North and New ports

No.	Route	Distance by Section (km)	Total Distance (km)
(1)	North Port pier - East-west overpass - West Busan IC - New Port (4-lane highway)	·North Port pier - Hakjang intersection: 14.43km ·Hakjang intersection - Busan New Port: 17.78km	32.21km
(2)	North Port pier - Busan tunnel - Nakdong river estuary dam - Noksan bridge - Shinho bridge - Busan new Port (4-lane route)	·North Port pier - Busan tunnel: 8.07km ·Busan tunnel - Nakdong river estuary dam: 6.71km ·Nakdong river estuary dam - Noksan bridge: 6.06km ·Noksan bridge - Shinho bridge: 4.18km ·Shinho bridge - Busan New Port: 5.15km	30.17km
(3)	North Port pier - Yeongdo - North Port bridge - Eulsukdo bridge - Busan New Port(6-lane coastal ring road)	·North port pier - Yeongdo: 9.94km ·Yeongdo - Shinho bridge: 17.19km ·Shinho bridge - Busan New Port: 5.15km	32.28km
(4)	North Port pier - North Port bridge (opening in Apr, 2014) - North Port bridge - Eulsukdo bridge - Busan New Port (4-lane)	·North Port pier - Yeongdo: 4.15km ·Yeongdo - Shinho bridge: 17.19km ·Shinho bridge - Busan New Port: 5.15km	26.49km

Figure 5 shows the results of 'traffic assignment' by route when approximately 1,000 TEU in Figure 2 is transported through the roads in Table 4. The results in Figure 5 came out using TransCAD, software generally used in transportation planning. Figure 5 shows results of traffic assignment of the transshipment volume between the ports. Thus, traffics of Route (1) and (2) are the heaviest because they have high general road traffic and the transshipment between the ports added. However, most of the transshipment between the ports is transported through Route (3) or (4) because they are coastal ring road of which lengths are short.

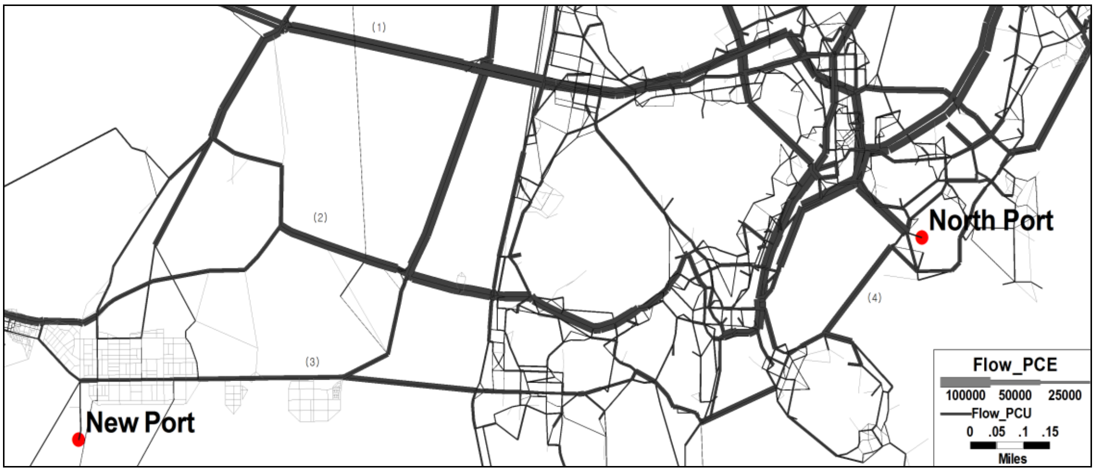

Figure 5. Result of traffic assignment between North and New ports

Table 5 is the results of the outcomes of traffic assignment analyzed in Figure 5 converted to cost factor. As expected before, major cost factor is on congestion and environmental element. The analysis shows the cost of 43,800 million KRW per year.

Table 5. Congestion & environmental costs due to road concentration

Categories of cost occurred	Cost (100million KRW/year)
Transit time cost	107.88
Operation cost	209.92
Accident cost	10.99
Environment cost	100.74
Noise cost	9.2
Total cost	438.73

The next section suggests the methods to restore existing marine shuttle and to newly introduce railroad shuttle to resolve the cost-incurring factors.

5. MRINE SHUTTLE RESTORATION AND RAILROAD SHUTTLE INTRODUCTION

The transshipment between North and New Ports is mainly transported through road. Thus, substantial traffic congestion and environmental cost is involved as shown in the previous section. We can consider the ways to distribute transportation route concentrated on road to ocean and railroad to resolve these issues.

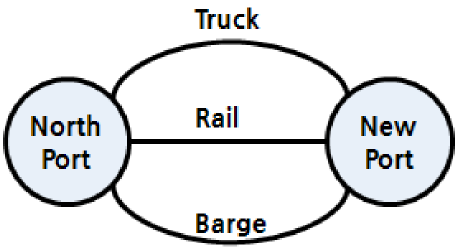

Figure 6. Transportation route by mode

5.1 Marine Shuttle Restoration

Marine shuttle using barge has been introduced in 2009 to process the transshipment between North and New Ports. Out of the transshipment of 310 KTEU in 2009, cargo transported through marine route accounts for 13.5%, 42 KTEU. This ratio decreased by 12.3% in 2010 compared to the previous year, but container volume increased by 28 KTEU to 70 KTEU. The marine shuttle between both ports was practically abolished in 2011 due to many problems.

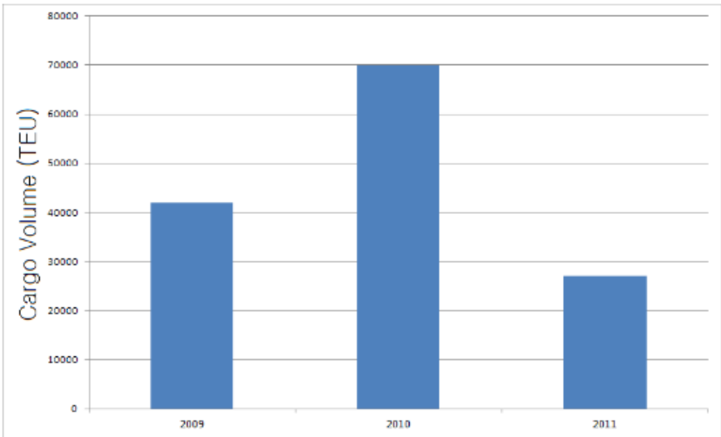

Figure 7. Container volume by marine shuttle between North and New ports

Table 6 shows the issues occurred in marine shuttle between North and New Ports in 2009 - 2010. The main reason why shipping companies turned away from marine shuttle was because the transportation cost is about as twice as that of inland. It is due to the unique freight charge system of Korean ports. Shanghai Port in Table 2 has lower marine transportation cost than inland transportation cost. Another reason is that transportation takes longer than that of inland.

Table 6. Issues of marine shuttle between North and New ports

Mode	Transportation Cost (KRW/TEU)	Length & Time
Inland	65,000	28 - 38km, 45 - 90min.
Marine	150,000	45km, App. 4hours (9 - 12km/h)

The business and operational issues made shipping companies did not prefer marine shuttle, so it was abolished in 2011. The shipping and port interested brought up the necessity of marine shuttle restoration because road-concentrated transportation generated congestion and environmental costs.

The biggest problem in restoration of marine shuttle between North and New Ports is a high cost. Especially, the short-term vicious cycle where high pricing to compensate transportation cost of insufficient container volume decreases container volume more should be broken. This issue arises by the features of Korean fare mechanism and it is able to be resolved through analysis of foreign cases and negotiation with labor organizations in related fields. Transshipment time of marine shuttle can also be reduced by developing technology which enhances the process loading container onto barge.

5.2 Railroad Shuttle Introduction

Another method to resolve problems from road concentration of the transshipment between North and New Ports is introduction of railroad shuttle. Railroad shuttle has an advantage over inland transportation in traffic congestion and environmental aspects. Also, the transportation speed is faster and the cost problem is relatively easy to solve compared to marine shuttle. Therefore, introduction of railroad shuttle is very convincing alternative to deal with transshipment between North and New ports.

Bujeon - Masan railroad line connecting environs of the ports is under construction. The line which is scheduled to be opened in 2018 has the shortest route connecting the ports. Thus, this line will be the method to handle transshipment between the ports in the medium and longer term.

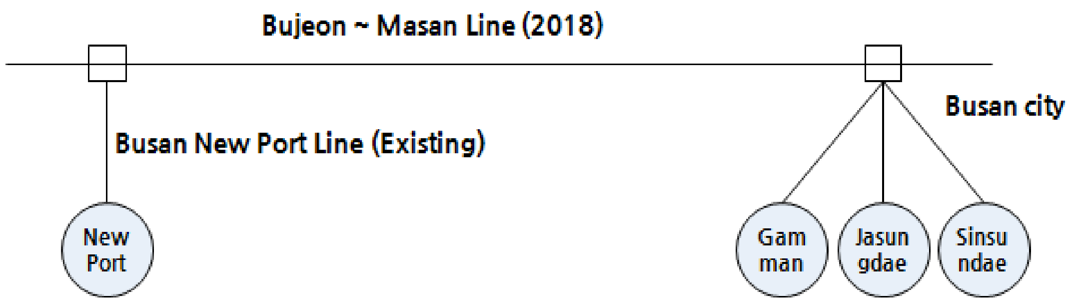

Figure 8. Railroad shuttle line between North and New ports

If organizing railroad shuttle using this line, there are two problems to be resolved first. First, shunting stations are not being built in the middle of Bujeon - Masan railway line under construction. It is essential to build shunting stations for overtaking between the trains in order to operate container transportation trains and passenger trains on the same line.

Another problem is Busan downtown passing issue. The last stop of Bujeon - Masan line under construction is in the outskirts of Busan city and passing through Busan downtown is unavoidable to connect the stop to North Port.

Table 7 shows pros. and cons. of each transportation mode and ideas on resolving problems given. But investment in research and development to restore marine shuttle and introduce railroad shuttle has not been immediately achieved in a way because it is judged that the growing trend in transshipment between North and New ports would be temporary.

Table 7. Pros-con and solutions for transport modes

Modes	Pros	Con	Solution
Truck	- Fast operating speed - Easy application	Congestions, environmental and noise issue due to road concentration	Opening of North Port bridge (2014) & coastal ring road
Barge	- Superior in aspect of congestion and environmental issue	- Slow operating speed - Higher fare than road(fare system problem)	- Mega Barge - Technology development to reduce Barge-land loading time
Rail	- High-speed. large-capacity transportation - Transportation cost reduction - Superior in aspect of congestion and environmental issue	Opening after 2018 The issue for Busan downtown passing from Gaya terminal has to be resolved	Application of Bujeon-Masan double track line subway

This paper expects this growing trend to last for a considerable amount of time in the medium and long term, and presented a variety of evidence for that in the previous sections. Therefore, investment in research and development which is preliminarily necessary to restore marine shuttle and introduce railroad shuttle should be accomplished as soon as possible.

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