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A Study on Modal Shift effect
- Focused on O/D between Busan-Gyeonggi Area -

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Abstract : *Interest about Modal Shift is not being decreased, and it is drawing limelight as green logistics which meets low carbon green growth of National development vision. As an effect of Modal Shift, not only reduction in CO2 emission but also reduction in social cost, logistics cost etc. are being discussed. However, until now research about its practical transformation effect has been scanty. In this study, the actual expenses via CO2 emission, social cost, and logistics cost etc. by road transportation and rail transportation of container cargo with Origin/Destination between Busan-Kyeonggi Area were calculated and we propose beneficial effects when transportation mode is transformed from road to rail with Scenario Planning.*

Key words : *Modal Shift, reduce CO2, social cost, O/D analysis, scenario planning*

1. Introduction

Interest about Modal Shift is not being decreased, and it is drawing limelight as green logistics which meets low carbon green growth of National development vision.

We are seeking legal systems in relation with Modal Shift such as green logistics certification system, green logistics partnership etc. through 'Environmentally Sustainable Transports and Logistics Law' which was enacted in Korea in the year 2009, environmentally friendly logistics policies such as enactment of '1st round Environmentally Sustainable transports development basic plan ('2011~2020)' etc. of 10 years National plan driven by Ministry of Land, Transport and Maritime Affairs being planned and executed.

According to target line of plan, transportation share in cargo is planned to be raised current 8.1% to 18.5% by rail and coastal shipping from 20.7% to 21.2%. Besides, it is planned to award subsidies to shippers or transport companies to promote Modal Shift by making agreement with them who are engaged in transportation of cargo as per transformation achievement[budget during 2011 USD 4,708,098].

As an effect of Modal Shift, not only reduction in CO2 emission but also reduction in social cost, logistics cost etc. are being discussed. However, until now research about its practical transformation effect has been scanty.

In this study, the actual expenses via CO2 emission, social cost, and logistics cost etc. by road transportation and rail transportation of container cargo with Origin/Destination (hereinafter referred as 'O/D') between Busan-Kyeonggi Area were calculated and we propose beneficial effects when transportation mode is transformed from road to rail with Scenario Planning.

2. Literature review

Lee et al. (2008) has examined the policies announced by EU and Japan to suggest directivity of Modal Shift related policies in Korea. They pointed that EU and Japan proposed practical and compatible policies for actual situation under clear target, and emphasized that these aspects would be required in consideration to invigoration of Modal Shift in Korea.

Jeon et al. (2008) has proposed establishment of environmentally friendly logistics system focusing Modal Shift for the alternative solution of environmental regulations which are being strengthened internationally. For that, they have surveyed drive cases of Modal Shift in abroad as well

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as domestic, and have proposed the role of bodies which are related with Modal Shift promotion plan for the set up of environmentally friendly logistics system.

Woo et al. (2009) has studied about characteristics of transportation services of railway container to transform road centered cargo transportation mode into rail transportation. They have proposed plan to improve transportation service level for railway container and promotion plan of Modal Shift.

Jeon et al. (2010) has examined revision cases of national transportation which are enforced in Korea as well as abroad, and proposed beneficial effect of revision in National transportation system, its validity, and effective support policies.

Kim et al. (2011) has analyzed beneficial effect of Modal Shift in Seoul-Busan road by classifying it in detail targeting railway passengers to obtain basic data for the raising railway use frequency which is environmentally friendly transportation means.

Jung et al. (2011) has proposed policy direction for the Modal Shift system set up on the basis of driving status analysis and its implications in Korea and abroad.

We can find out that major research stream has been about policy for the introduction of modal Shift in Korea in most of the cases. However, there have not been any researches yet about practical effect of Modal Shift of container cargo in Korea with quantitatively in detail.

Table 1 Review of precedent studies on Modal Shift

Author	Research detail
Lee, Yun-Mi et al. (2008)	Proposal of policy through research about Modal Shift case abroad
Jeon, Hyung-Jin et al. (2008)	
Jeon, Hyung-Jin et al. (2010)	
Jung, Bong-Hyun (2011)	
Woo, Jung-Wook et al. (2009)	Review of possibility of Modal shift by investigating Domestic transportation status
Kim, Cho-Young et al. (2011)	Practical effect analysis for the passenger

3. Analysis of current transportation status

3.1 Inland transportation of container and its O/D

As of year 2010, the transportation by container in National level was 12,962 thousand TEU(1Twenty-foot equivalent), and among these, the road transportation share was 91.6% with figure 11,656 thousand TEU.

The transportation volume per each transportation mode of container cargo in whole country is given in <Table 2>. The transported cargo volume by road has been increased by 13% from 10,140 thousand TEU during 2007 to 11,656 thousand TEU during 2010, whereas the transported cargo volume by rail has been decreased by 21% from 1,126 thousand TEU during 2007 to 934 thousand TEU during 2010 and that too, the decreasing trend is continuing. As transportation volume by road is increased, environment pollution and road congestion problem etc. caused by container transportation in domestic road becomes warning level.

Modal Shift means transformation of transportation mode by which existing passenger or cargo transportation mode via road is transformed into rail transportation or coastal shipping. (Fig. 1)

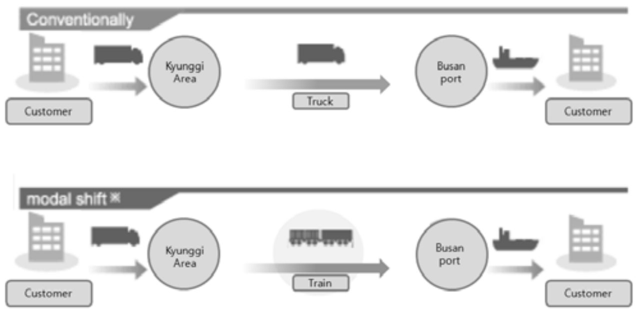

Fig. 1 The concept of Modal Shift

Transportation mode in Korea shows high share by road transportation while the mode by either railway or costal shipping are very poor, thus the plan to take optimum transportation at competitiveness level in future has to be driven.

Table 2 Container transportation result in whole country

(unit : 1,000 TEU)

			2007	2008	2009	2010
Container transportation result(A+B)			11,374	11,696	10,580	12,962
	Import		5,677	5,827	5,117	6,279
	Export		5,589	5,735	5,240	6,309
	(A)		11,266	11,562	10,357	12,589
	Costal shipping(B)		108	135	224	373
mode	Costal Shipping	Result	108	135	224	372
		Rate	0.90%	1.20%	2.10%	2.90%
	Rail	Result	1,126	1,161	801	934
		Rate	9.90%	9.90%	7.60%	7.30%
	Road	Result	10,140	10,400	9,555	11,656
		Rate	89.20%	88.90%	90.30%	91.60%
	Total	Result	11,374	11,696	10,580	12,962
		Rate	100%	100%	100%	100%

Source : The Korea Transport Institute(2011), Trend in Freight Tranport Market

In this study, O/D analysis has been carried out Busan port as a starting point at which 73.3% of total container transport volume is handled.

<Table 3> shows transportation volume by container transportation mode. During 2008, road transportation and rail transportation have been increased by 2.4% and 4.4% each as against those in previous year. Also the volume handled by rail was being increased continuously which indicates transformation of transportation mode caused by traffic and logistics cost are being progressed.

Table 3 Transportation mode wise volume from Busan Port

(unit : 1,000 TEU, %)

	2005	2006	2007	2008
Total (rate)	6,664 (-)	6,831 (2.5)	7,444 (9.1)	7,645 (2.6)
Costal Shipping (rate)	85 (-)	28 (-67.1)	7 (-75.0)	7 (0.0)
Rail transportation (rate)	686 (-)	750 (9.3)	818 (9.3)	856 (4.4)
Road transportation (rate)	5,893 (-)	6,053 (2.7)	6,619 (9.4)	6,782 (2.4)

Source : PORT-MIS, Korail logistics information system
Note : ( ) are Increased ratio compared to the previous year

As has seen in <Table 4> which indicates O/D of transport volume between Busan port to various areas in all over the country, the transportation volume between Busan port to Kyeonggi Area[1)] is almost 17.8% among total volume handled in Busan port. Considering the fact that considerable amount of transport volume is handled at Busan port, prominent part of volume addressed to Kyeonggi Area are being imported/exported through Busan port.

There can be two reasons why this much figure of transport volume in Kyeonggi Area are moving through Buan. First, shippers in Kyeonggi Area prefer variety of route and trip available in Busan port. Second, the infrastructure which makes transportation of large quantity volumes smooth is well established. Specially, Obong station located in Kyeonggi-do handles almost of all the transport volume by rail shipped via Busan-Kyeonggi Area.

The above factors are suitable for the analysis of Modal shift which requires accurate data about the transformation of transportation mode. In this study, on the basis of O/D data of Busan port and Kyeonggi Area, by applying transportation mode wise demand factors-road transportation (88.9%), rail transportation (11%) and utilized these factors for analysis after re-calculation of transport volume by road and rail container.

Table 4 Domestic O/D analysis Export/Import volume through Busan port

(unit : 1,000 TEU, %)

	Import			Export			total
	loaded	empty	total	loaded	empty	total	
Gangwon-do	6	9	15	17	2	19	34 (0.5)
Kyeonggi-do	456	85	541	389	59	448	989 (13.3)
Gyeongsang nam-do	542	323	865	629	245	874	1,739 (23.4)
Gyeongsang buk-do	314	273	586	466	114	581	1,167 (15.7)
Gwangju	34	55	88	119	12	131	220 (3.0)
Daegu	70	54	123	83	33	116	239 (3.2)
Daejeon	23	22	45	57	9	65	111 (1.5)
Busan	249	103	352	99	76	176	528 (7.1)
Seoul	61	7	68	56	8	64	132 (1.8)
Ulsan	180	329	509	496	98	594	1,103 (14.8)
Incheon	77	14	91	100	7	107	198 (2.7)
Jeollanam -do	49	73	121	104	29	133	255 (3.4)
Jeollabuk -do	67	62	130	114	22	136	265 (3.6)
Chungcheongn am-do	79	32	111	132	17	149	259 (3.5)
Chungcheongb uk-do	91	16	106	71	28	98	205 (2.8)
Total	2,296	1,457	3,753	2,932	759	3,691	7,444 (100)

Source : National logistics information center
Note 1: Container cargo volume from Busan port (2007)

Table 5 Transportation mode wise O/D analysis between Busan port-Kyeonggi Area (2007)

(unit : 1,000 TEU)

		Import			Export			Total
		loaded	empty	total	loaded	empty	total	
Total	Kyeonggi-do	8,571	196	8,767	7,310	136	7,445	16,212
	Incheon	1,449	32	1,481	1,885	15	1,900	3,381
	Seoul	1,152	15	1,167	1,055	19	1,074	2,241
	Total	11,172	244	11,416	10,250	170	10,419	21,835
Road	Kyeonggi-do	7,619	175	7,794	6,498	121	6,619	14,413
	Incheon	1,288	29	1,317	1,676	13	1,689	3,006
	Seoul	1,024	13	1,038	938	17	955	1,992
	Total	9,932	217	10,148	9,112	151	9,263	19,411
Rail	Kyeonggi-do	943	22	964	804	15	819	1,783
	Incheon	159	4	163	207	2	209	372
	Seoul	127	2	128	116	2	118	247
	Total	1,229	27	1,256	1,127	19	1,146	2,402

Note 1: In this study, container cargo volume via road and rail was re-estimated using road transportation rate, (88.9%) and Rail transportation rate(11%).
Note 2: Container weight itself 2.3 T was adopted and loaded container weight was adopted as 18.8T by Sum up average cargo weight 16.5 and empty (without load) container weight 2.3 Ton

1) In this study, Gyeonggi area includes Seoul, Incheon, and all the cities under Gyeonggi Administrative district.

If we look at transport volume between Busan port and Kyeonggi Area by transportation mode, total volume of import and export in Kyeonggi Area is 21,835 thousand tons, volume in road and rail transportation are 19,411 thousand tons and 2,402 thousand tons respectively. In this study, CO2 emission cost, social cost, and logistics cost were analyzed using <Table 5> as base data.

3.2 Transportation mode wise CO2 emission amount analysis

To calculate the emission amount of CO2, the CO2 emission factor, distance from Busan port to each area and total weight of cargo were required. To calculate the distance from Busan port to each area by road transportation, the shortest distance between city hall or provincial government building until Busan port was quoted.

Besides, to calculate CO2 emission cost, €13.19/TonCO2 was adopted which is being transacted in carbon emission trading scheme in EU as of Aug. 2011.

<Table 6> shows analysis data of transportation mode wise CO2 emission amount and emission cost. Total CO2 emission amount generated by container cargo transportation between Busan-Kyeonggi Area is 3,532 thousand tons and its cost is USD 68,249,529 (KRW 72 billion). Among this, total CO2 emission amount generated from road transportation is CO2 35 thousand tons and the cost is USD 677,966 (KRW 0.72 Billion).

Table 6 Transportation mode wise CO2 emission amount and emission cost analysis

(unit : g/ton-km, 100 million KRW)

	Local	CO2 Emission factor (A)	Total distance (Km) (B)	Total Weight (1,000Ton) (C)	CO2 emission amount (1,000Ton) (D)	CO2 emission cost (E)
Road	Kyeonggi-do	474.9	370.1	14,413	2,533	51,982
	Incheon		411.6	3,006	588	12,057
	Seoul		397.8	1,992	376	7,722
	Subtotal			19,411	3,497	71,761
Rail	Obong Station	35.6	410.4	2,402	35	720
Total					3,532	72,781

Source : Korea expressway corporation, Korea railroad corporation
Note 1 : CO2 emission factor was quoted from data from The Korea Transport Institute.(2005)
Note 2 : €1 was calculated as exchange rate €1=KRW1555.71 (as of Aug. 2011)
Note 3 : D=A×B×C, E=D×transaction cost(€13.19)×exchange rate

3.3 Analysis of Transportation mode wise social cost

The social cost in traffic part is categorized as car running cost, traffic facilities cost, road accident cost, environmental pollution cost, and marginal congestion cost etc. In this study, social cost was calculated based on KRW unit in <Table 7>.

Table 7 Transportation mode wise social cost calculation data and its rate in terms of Korean currency

(unit : KRW/ton-km, KRW/ton-hr)

Item		Quoted data	KRW (USD)
Road Accident cost	Road	Road congestion cost calculation and trends analysis, 2005, The Korea Transport Institute(KOTI)	65 (0.06)
	Rail	Preliminary feasibility quoted from Korea Development Institute(KDI)	1.9 (0.0019)
Road Congestion cost	Road	Road congestion cost calculation and trends analysis(2005), 2007, The Korea Transport Institute	7 (0.007)
	Rail		-
Maintenance and repair cost	Road	"Construction and transport Statistics", Ministry of Construction & Transportation, Korea Expressway Corporation, Korea Railroad Corporation	5.6 (0.005)
	Rail		22.3(0.021)
Noise cost	Road	Pre feasibility standard, Korea Development Institute, Noise value as KRW unit	13(0.012)
	Rail	Preliminary feasibility as standard from KDI, Noise value calculated as KRW.	2.3(0.002)
Time value cost	Road	"Calculation of time cost of cargo transportation for the evaluation of Transportation invest business, The Korea Transport Institute" (2007)	149(0.14)
	Rail		

Source : Korea maritime institute(2008), "The way to expand short sea shipping for building eco-friendly logistics system"

Total social cost was turned out as USD 667,171,374 (KRW 708.536 billion), it was composed of transportation cost USD 0.64 billion (KRW 680.444 billion), rail transportation cost USD 26.5 million (KRW 28.092 billion). In road transportation cost, the highest cost was road accident cost of USD 0.45 billion (KRW 478.656 billion) and among rail transportation cost, highest cost was due to maintenance and repair which was USD 20.6 million (KRW 21.983 billion).

Table 8 Transportation stage wise cost between Busan port. Kyeonggi Area

(unit : 100 million KRW)

	Road transportation				Rail transportation
	Kyeonggi-do	Incheon	Seoul	Subtotal	Obong Station
Road accident cost(A)	346,726	80,423	51,507	478,656	1,873
Road Congestion cost(B)	37,340	8,661	5,547	51,548	-
Maintenance and repair cost(C)	29,872	6,929	4,438	41,238	21,983
Noise cost(D)	69,345	16,085	10,301	95,731	2,267
Time value cost(E)	9,736	2,150	1,385	13,270	1,968
Total	493,019	114,247	73,178	680,444	28,092

Source : Korea expressway corporation, Korea railroad corporation
Note1 : Applied consumed time for transportation to Kyeonggi-do 272 min., to Incheon 288 min., to Seoul 280 min, and to Obong Station 330 min
Note2 : A,B,C,D = distance × throughput × unit(krw)
E = time × throughput × unit(krw)

3.4 Analysis of Transportation mode wise logistics cost

The detail of transportation cost in road transportation and rail transportation to analyze transportation mode wise is given in <Table 9>.

In case of road transportation, price in freight tariff table was applied. Transportation structure shows that two ways freight and one-way freight per each different area is set. Two ways freight was applied when loaded container is transported and it is returned to original point with empty load. Therefore, two ways freight was applied for empty container and one-way freight was applied for loaded container. In case of rail transportation, freight was constituted largely 5 categories, i.e., truck shuttle cost from shippers to ICD, loading and unloading expenses at ICD, transportation charges by railway, loading cost at station, and shuttle cost till Busan port.

Table 9 Transportation stage wise cost between Busan port. Kyeonggi Area

Category		Transportation stage	Reference
Transportation cost	Road	Road transportation	○ Container transportation freight Table, Korea Freight Forwarders Association (2011)
	Rail	Shuttle	○ KRW 2,000(USD1.88)/km is applied above basic slab KRW 100,000(USD 94.16)/40km
		ICD	○ Loading and unloading charges : KRW 29,200(USD 27.50)/1Twenty-foot equivalent unit(TEU)
		Station	○ Landing charges : KRW 12,000(USD 11.30)/1 TEU
		Rail transportation	○ Container (loaded) freight : KRW 449(USD 0.42)/km per 1 TEU
			○ Container (empty) freight : KRW 332 (USD 0.31)/km per 1 TEU
		Shuttle cost at Busan port	○ For 20 FT container : KRW 48,000(USD 45.20)

Source : Jo, J. R., "Forecasting of the Freight Transportation Demand in Grand Canal in the Korean"(2008) rearrangement

In case of road transportation, total logistics cost was found to be USD 0.62 billion of which round-trip cost USD 0.15 billion and one-way transportation cost USD 0.47 billion respectively. (Table 10)

Table 10 Road transportation haulage between Busan port-Kyeonggi Area

(unit : 1000 KRW, TEU, 100 million KRW)

	Two ways transportation			one way transportation			Total logistics cost
	transportation charge	Through put	logistics cost	transportation charge	Through put	logistics cost	
Kyeonggi-do	1,069	128,365	137,222	617	622,568	384,124	521,346
Incheon	1,120	18,307	20,504	640	139,345	89,181	109,685
Seoul	1,105	13,022	14,389	631	91,367	57,652	72,041
Total	3,294	159,694	172,115	1,888	853,280	530,957	703,072

Note : Assumed that empty container transportation distance is two ways

Total logistics cost for rail transportation was USD 49.46 million and this amount occupied 50.8% of total expenses. Among this shuttle cost occupied 26%. (Table 11)

Table 11 Rail transportation haulage between Busan port-Kyeonggi Area

(100 million KRW)

Cate gory	Shuttle cost	Loading unloading	Station	Shuttle cost at Busan port	Transportation cost		Total
					loaded	empty	
Obong Station	14,510	4,237	1,741	6,965	2,958	25,383	55,794

Note : Railway transportation between Busan port-Kyeonggi Area was quoted as in Obong station.

4. Scenario Analysis and Results

In this study, first of all CO2 emission cost, social cost, and logistics cost as of year 2007 was analyzed for the analysis of Modal Shift effect from road transportation to rail transportation.

On the basis of this result, scenario wise transport volume and practical effect were analyzed.

During analysis, Original /Destination between Busan Port-Gyeonggi Area of container cargo in 2007 were used. The rate of road transportation was 88.9% as compared 11% by rail transportation during this period.

Though rail and costal transport are being considered as Modal Shift transformation policy, practically the weight of transforming to rail transport is far larger than that of coastal transportation and this trend is expected to be continued in future also.

Therefore this scenario analysis is based on assumption that weight of rail transport is increased by 20, 30 % respectively.

In scenario 1, road transportation ratio was assumed as 80% and railway transportation ratio as 20% among total volume of 21,835 thousand tons cargo. Whereas in scenario 2, transportation ratio by road was assumed as 70% and 30% was assumed by railway.

<Table 12> shows scenario wise total cost analysis table. In scenario 1, total cost found as USD 1.38 million (KRW 1,463.415 billion) which indicates cost reduction by 5% as against running mode ratio. The largest reduction was achieved in CO2 emission cost which shows cost reduction by 9% as against no mode transformation case. Total transportation cost in scenario 2 was USD 1.29 million (KRW 1,376.631 billion) which shows cost reduction by 11%. More cost reduction was found in social cost (86%) than in logistics cost(93%). It indicates that effect of total cost

reduction was higher when transportation mode was transformed from road to railway.

Table 12 Scenario wise total cost analysis

(100 million KRW, %)

Category		CO2 emission cost	social cost	Logistics cost	Total
This study ('07)	Road	71,761	680,444	703,072	1,455,277 (100)
	Rail	720	28,092	55,793	84,605 (100)
	subtotal	72,481 (100)	708,536 (100)	758,865 (100)	1,539,882 (100)
scenario 1	Road	64,577	612,331	632,683	1,309,591 (90)
	Rail	1,309	51,072	101,443	153,824 (182)
	subtotal	65,886 (91)	663,403 (94)	734,126 (97)	1,463,415 (95)
scenario 2	Road	56,505	535,789	553,600	1,145,894 (79)
	Rail	1,964	76,608	152,165	230,737 (273)
	subtotal	58,469 (81)	612,397 (86)	705,765 (93)	1,376,631 (89)

5. Conclusion and future research plan

5.1 Conclusion

In this study, scenario analysis was conducted to find out reduction effect of CO2 emission, social cost, and logistics cost which are focused as benefit by Modal shift by using O/D between Busan port-Kyeonggi Area for container cargo.

When share of road transportation and railway transportation during 2007 was assumed as 80:20(scenario 1), the total cost reduction effect was analyzed as USD 72 million (KRW 76.467 billion) and when it was assumed as 70:30(scenario 2), cost reduction was assumed as USD 154 million (KRW 163.251 billion). The cost reduction in all CO2 emission cost, social cost, and logistics cost was found to be achieved. Especially, scenario analysis showed that CO2 emission cost is being reduced as highest.

This result indicated that Modal Shift would be one of the proactive plans to reduce greenhouse gas in Korea which is expected to be included among countries with obligations to reduce greenhouse gas as per Post Kyoto Protocol (Post Kyoto Protocol to the United Nations Framework Convention on Climate Change) which will be enforced from year 2013.

However, due to characteristics of road transportation which is suiting to short distance, there can be difference in detailed items such as logistics costs etc. according to subject area. That means, to reduce total logistics cost, after analyzing transportation distance, transport volume, and characteristics of area, appropriate transportation mode has to be chosen.

Detailed analysis for the effect of each issue which is considered as beneficial effect of Modal Shift through actual analysis using O/D between Busan port-Kyeonggi Area with container cargo was carried out and it is expected that this data could be utilized as basic data for policy making to invigorate the Modal Shift policy in future.

5.2 Future research plan

In this study, Modal Shift research scope was limited for the road transportation to railway transportation for container cargo only between Busan-Kyeonggi Area.

Keeping in view of current development, there is need to proceed research by extending scope of region and by comparing overall cost structure including merits and drawbacks of public road and railway infra in future.

Also, there is need to carry out detailed and practical O/D analysis and detailed yet accurate research about CO2 emission amount for different transportation mode, fuel, and speed.

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