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A Study on the Economical Feasibility Analysis For Development of Dual Mode Trailer System

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Abstract : *In light of the growing traffic congestion problem and congestion cost, the container transport by railway has to be increased. The freight transport by railway can have decided advantages over trucks in terms of energy efficiency, emissions and cost for certain freight movements, just as transportation in the metropolitan region can have great advantages over driving truck. But the freight transport by truck should gain significant mobility benefits from a freight railway system. Thus, the DMT(Dual Mode Trailer) transport system which is coupled railway transport advantages with load transport advantages has been developed and used in the european countries. The DMT transport will therefore serve the areas required by transport organizers. The purpose of this paper is to estimate economical feasibility analysis for development of DMT transport system. Consequently, this study analyzed the characteristics of the DMT system. The horizontal load · unload system is being considered as an adoptable DMT system in consideration of the situation in Korea.*

Key words : *rail-road physical distribution, dual mode trailer, horizontal loading and unloading, piggyback, bimodal, economical feasibility analysis.*

1. Introduction

The railway cargo transportation in Korea had been used as an important transportation method until the mid of 20th century, but the ratio of railway cargo transportation had been decreased rapidly from 17.2% in 1990 to 7% in 2004 due to the opening of highway and expansion of the land transportation system. In addition, the structure change of logistic pattern due to the small quantity batch production and the price and service competition to expand the logistics market share among the transportation companies decrease the ratio of railway transportation promptly.(Nam, 2007).

The railway transportation has encountered the new changes in the midst of such environment. The repeated strike of transportation cargo truck, the change of the government logistics policy and the ecological policy penetrating into the all industrial fields bring up the discussion on the competitiveness improvement of logistics system and the role and function of the railway transportation have been considered again. The perpendicular handling system utilizing the crane and reach stacker is adopted for loading and unloading in our railway transportation(Kim, 2008). However, it is in a trend that the diesel locomotive has been replaced with electric powered locomotive due to the need of speed increase for the conventional locomotive and the environment pollution. The horizontal handling system can not be adopted in the future because the catenary type power cables are installed.(Shin, 2007).

The DMT(Dual Mode Trailer) establishes the combined transportation system through combining the road transportation and railway transportation and it is one of the methods being developed for the railway logistics technologies to load · unload the container from train without adoption of the vertical handling system. Namely, the DMT system links the huge quantity nature of railway transportation and timing of road transportation and it is a transportation system considered to be induced for the reduction of load · unload time, cost saving for the replacement of loading and problem resolution of vertical handling system which are arisen during the railway cargo transportation.

According to the survey on the previous studies on the railway transportation, Lee et al classified the DMT system into rotational system and horizontal handling system depending on the load · unload system(Lee, 2008).

Park et al.(2009) asserted that the road transportation oriented conventional logistics system shall be converted into railway transportation oriented logistics system to reduce the total social cost of national logistics transportation and the DMT transportation system shall be induced for this purpose.

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Kim and In insisted that DMT project operation system shall be developed for the target pursuing the company logistics cost reduction(Kim, 2008), transportation time reduction and ecological logistics and it shall be developed to be linked with TSR and TCR not only in Korea. Ha(1996) compared the marine transportation system and trans China railway transportation system in terms of transportation cost for the container cargo transportation between the Far East and Europe

Ha(2002) analyzed how the railway combined transportation route started from Busan seaport has the relative competitiveness comparing to the main seaports of competition such as Hong Kong, Singapore and Shanghai for the cargo transporting between Japan and Europe focused at the transportation distance, level of service at the seaport, charge for the seaport use and reliability.

According to the survey on the previous studies mentioned above, there are many previous studies concerned the DMT, but a few researches focused at the technology development points of DMT itself were performed and the study related with the economy was not found. There are many theses considered the Economical Feasibility point of the railway, however the thesis analyzed the economy of DMT related was not found.

Accordingly this study will evaluate the economy of each alternative for the DMT which is reviewed for inducing in stead of the conventional transportation system as the role and function of the railway transportation are enhanced and the necessity of the combined transportation is emerged. This study is purposed to derive the alternative for the DMT transportation system which is suitable for the situation of Korea.

2. DMT system

2.1 Definition and the necessity of the induction

The establishment of the effective logistics network has been emerged as an important matter as a tool to acquire the competitiveness as the importance of the logistics part gains weight in terms of the national economy and company management. Furthermore, the introduction of the Modal-Shift system which utilizes the railway as a tool of mass transportation is urgent because the concern to the environment friendly logistics is emerged. The DMT system was introduced for the fundamental solution and introduction of new system for the railway transportation system which is the environment friendly method out of the transportations methods. The DMT transportation system is a new transportation system combining the huge quantity nature of railway transportation and the mobility of the road transportation. The door to door service and JIT service are available from DMT system which is improvised to reduce the time for and replacement cost of load · unload.

2.2 The types of DMT system

The DMT system categorize in the previous studies related with DMT includes the Piggyback, Bimodal, Flat freight wagon rotation type, parallel trans loading type. The Flat freight wagon rotation type is subclassed into Modalohr, Cargo Speed and Flexi-waggon. The horizontal moving type is classified into Beamer and Cargo Domino in detail.

Firstly, the Piggyback system is to transport the truck or the container with load · unload to the freight wagon and it is called as TOFC(Trailer On Flat Car) also. It is classified into horizontal type and vertical type depending on the loading method. The horizontal type uses the usual flat freight wagon and vertical type uses low base freight wagon. The horizontal type does not need the unloading equipment, but the vertical type requires the exclusive crane which has many demerits than the conventional railway transportation excluding the merit of door to door.(Yoo, 2008)

Secondly, the Bimodal system was developed in USA. It is the vehicle transportation(Bimodal System: Roadrailer) for both rail/road. The chassis of the trailer can be used as the freight wagon on the railway. The chassis and chassis are connected with bogie. The price of the bimodal system per unit is very expensive and it has a demerit of taking longer time than the other system during the change of the mode (Road/Rail).

Thirdly, the Modalohr system, the freight wagon rotational system, was developed by the Lohr Company in France and it is system commercially operated in 2007. It is an established system to move the trailer chassis combined container through rotating the bucket by the hydraulic motor installed on the railway on the center axis of freight wagon and accessing the truck. The Flexiwagon system is similar with Modalohr, but it is a method of load · unload the truck by rotating a part of freight wagon. The freight wagon is separated along the cart in the front and guide and the bucket is designed to be rotated on the axis of the cart in the rear. The cargo speed system is similar with Modalohr, but it is classified into the wellfloor which is the freight wagon and internal frame and the pop-up equipment for rotation. It uses the huge hydraulic pop-up equipment installed deeply inside for rotation. It is differed from the

modalohr in the point that the external frames of cart and freight wagon are fixed.

Fourth, the characteristics of cargo beamer system out of the horizontal load · unload types is that the bucket which can be moved horizontally on the terminal road and the driving equipment are installed independently. It is a system that the trailer access to the bucket to load · unload and the bucket moves horizontally to the railway.

The cargo domino system is a system that the truck stays at the side of the freight wagon and the horizontal load · unload is performed utilizing the conveyor and swap body typed equipment. It was developed by the SBB Cargo in Swiss and it was operated from 2002. It can be operated in parallel with the traditional terminal method, but the independent terminal construction may be required as the heights of freight wagon and trailer chassis to be aligned(Park, 2009).

3. Economic feasibility analysis

The piggyback system out of the DMT transportation systems is not suitable for the environment of Korea because of the construction of terminal. The bimodal system was excluded to import as it has a merit to reduce the initial investment cost but it is not a proper system to endure the inconvenience from the load · unload or to treat the increasing cargo quantity in the future depending on the working time(Hur, 2003).

The freight wagon rotating system was excluded in this study because the conventional terminal shall be repaired and the terminal for the loading shall be acquired(Baik, 1999). The economy analysis will be performed on the parallel loa d · unload system. The horizontal load · unload system can be classified into freight wagon driving system and trailer driving system depending on the location of load · unload equipment. The economy analysis on the two systems will be performed in this study in order to derive the optimal alternative.

3.1 Basic premises and consumption

As the costs of the freight wagon driving system and trailer driving system shall be estimated independently are different, it has to be estimated independently. The breakdown of the costs for the freight wagon driving system can be classified as the DMT terminal construction, price of freight wagon, transportation system (Tractor), maintenance cost, system operation cost (operation software, operation hardware, operational maintenance cost), labor cost, additional fuel cost, other sales cost and R&D cost.

The calculation of the DMT terminal construction is performed with division of the area for structure installation and other general area (civil construction area). The design standard is decided by the characteristics of the road, traffic volume, territorial condition, nature of ground and soil, weather condition and economy etc. The terminal construction cost in this study is estimated to spend around KRW 3.7 billion in case of utilizing the conventional railway transportation area.

Table 1 The terminal construction cost (unit: Million KRW)

items	construction cost	remark
roadbed	63	KDI, 『2008 railway construction cost』
road in terminal	889	
track	725	
operating system	585	
gate/operation room	650	
building moving	195	
sign board	130	
appurtenant work.	455	
sum total	3,692	

The purchasing cost for the freight wagon is calculated by the application of the unit price per each wagon for the number of the derived demand of freight wagon through the operation plan considering the characteristics in terms of demand such as the transportation demand for sector of the corresponding line, the facility characteristics of the line and the characteristics of the train. The estimation of the freight wagon cost was assumed to purchase at the previous year to treat the transportation quantity of the corresponding year at the price of the freight wagon input to treat the transportation quantity of the corresponding year. The number of the freight wagon to be purchased was derived in consideration of the transportation quantity of the corresponding year, transportation quantity, transportable quantity per trip and the operation days per year. The actual input quantity was assumed with addition of 2 units in consideration of the required input quantity for transportation and the maintenance and repair.

3.2 The cost analysis for the freight wagon driving system

The costs for the 1 unit of freight wagon in the traditional method and freight wagon driving system are shown in <Table 2>. The difference of KRW 9 billion was calculated as the additional cost in case of conversion from the

traditional system to the freight wagon driving system. And the yearly freight wagon cost was calculated under the assumption of re-investment in consideration of the depreciation period for the freight wagon and equipment.

Table 2 Flat car difference of freight wagon driving system (unit: Million KRW)

Items	durable years	traditiona method	wagon driving system
flat	25 years	80	80
shock absorption	10 years	-	10
outrigger system	10 years	-	20
transportation equipment	10 years	-	60
total	-	80	170
difference	-	90	

The costs for the 1 unit of trailer in the traditional method and freight wagon driving system are shown in <Table 3>. The difference of KRW 35 million was calculated as the additional cost in case of conversion from the traditional system to the freight wagon driving system.

Table 3 Trailer difference of freight wagon driving system (unit: Million KRW)

Items	durable years	traditional method	wagon driving system
trailer	10 years	170	170
outrigger system	10 years	-	20
transportation equipment	10 years	-	15
total	-	170	205
difference	-	35	

And the yearly investment was calculated as KRW 840 million in 2011, 2021, 2031 respectively in consideration of the depreciation period when the tractor and trailer are input the 6 units to the 1 terminal for each and total 12 units to the 2 terminals.

The maintenance cost was assumed to be created by 6.5% of cumulated investment for the maintenance of the freight wagon and transportation system and the yearly maintenance cost up to 2041 was calculated as same because the freight wagon will not be increased since 2022.

The system operation cost is composed of operation software, operation hardware and operation maintenance and repair cost and they were estimated as shown in <Table 4> based on the conventional cases.

Table 4 System operation cost (unit: Million KRW)

year	soft ware	hard ware	M&R	year	soft ware	hard ware	M&R
2010				2026			40
2011	200	150	40	2027	200	150	40
2012			40	2028			40
2013			40	2029			40
2014			40	2030			40
2015	200	150	40	2031	200	150	40
2016			40	2032			40
2017			40	2033			40
2018			40	2034			40
2019	200	150	40	2035	200	150	40
2020			40	2036			40
2021			40	2037			40
2022			40	2038			40
2023	200	150	40	2039	200	150	40
2024			40	2040			40
2025			40	2041			40

The labor cost was calculated around KRW 284 million 470 thousand per freight wagon and the details of the calculation is shown <Table5 >.

Table 5 Labor cost (unit: thousand KRW)

items	class salary	number of persons	average salary	cost
engineer	4 - 22	2.56	64,454	165,002
vice-engineer	5 - 10	2.56	46,670	119,475
total	-			284,477

The labor cost for each year was calculated in consideration of the number freight wagon. The 5% of increase was considered after the starting of the operation and it was analyzed as same after 2022 which is 10 years after the operation.

The additional fuel cost is the cost created from the system improvement and the distance per one way trip was calculated as 434 km. It was identified as KRW 1,118.41/(L) on the basis of fuel cost in 2008, but around KRW 2,417,969 was derived per operation with the application of KRW 1,509.85/(L) which is 135% when the fuel cost increase considered. The yearly additional fuel cost up to 2041 was calculated as same because the freight wagon will not be increased since 2022.

Table 6 Additional fuel cost

origin/destination	length	fuel consumption	numerical value	fuel cost (KRW)
Uiwang~Obong	12(km)	3.69(L/km)	1509.85	66,856
Obong~Busanjin	410(km)			2,284,257
Busanjin~Gaya	12(km)			66,856
total	434(km)			2,417,969

The other sales cost is composed of inspection cost, cost for sales activity, train control cost and train maintenance cost and they were estimated as shown in <Table 7> based on the internal data from domestic KORAIL.

Table 7 The other sales cost (unit: thousand KRW)

items	cost	items	cost
inspection cost	154,577	cost for sales activity	132,722
train control cost	163,550	train maintenance cost	411,303
total	865,152		

The yearly other sales cost like the additional fuel cost up to 2041 was calculated as same because the freight wagon will not be increased since 2022.

3.3 The cost analysis for the trailer driving system

The difference in the costs between trailer driving system and freight wagon is created from the cost item due to the combination of freight wagon and trailer transportation system. The cost difference with the freight wagon driving system are created form the freight wagon cost, trailer transportation system and maintenance cost and the other cost is created in the same structure with the freight wagon driving system.

Table 8 Flat car difference of trailer driving system (unit: Million KRW)

Items	durable years	traditional method	wagon driving system
flat	25 years	80	80
shock absorption	10 years	10	10
outrigger system	10 years	-	20
transportation equipment	10 years	-	
total	-	90	110
difference	-	20	

Accordingly, the cost analysis for the trailer driving system will be analyzed only for the cost of freight wagon cost, trailer transportation system and maintenance cost.

The difference of KRW 20 million was calculated as the additional cost in case of conversion from the traditional system to the trailer driving system. And the yearly freight wagon cost was calculated under the assumption of re-investment in consideration of the depreciation period for the freight wagon and equipment.

The costs for the 1 unit of trailer driving transportation system in the traditional method and trailer driving system are shown in <Table 9>.

Table 9 Trailer difference of trailer driving system (unit: Million KRW)

Items	durable years	traditional method	wagon driving system
trailer	10 years	170	170
outrigger system	10 years	-	20
transportation equipment	10 years	-	70
rebuildng cost	10 years	-	15
total	-	170	275
difference	-	105	

The difference of KRW 105 million was calculated as the additional cost in case of conversion from the traditional system to the trailer driving system.

And the yearly investment was calculated as KRW 1260 million in 2011, 2021, 2031 respectively in consideration of the depreciation period when the tractor and trailer are input the 6 units to the 1 terminal for each and total 12 units to the 2 terminals.

The maintenance cost was assumed to be created by 6.5% of cumulated investment for the maintenance of the freight wagon and transportation system and the yearly maintenance cost up to 2041 was calculated as same because the freight wagon will not be increased since 2022.

Table 9 Trailer difference of trailer driving system (unit: Million KRW)

item	2011	2012	2013	2014	2015	2016
cumulated investment	9,600	10,200	10,800	10,800	12,000	12,000
maintenance cost	624	663	702	702	780	780
item	2017	2018	2019	2020	2021	2022
cumulated investment	14,700	14,700	14,700	14,700	14,700	14,700
maintenance cost	955.5	955.5	955.5	955.5	955.5	955.5

4. Convenience analysis

The cost difference between the trailer driving system and freight wagon driving system is created from the cost items due to the difference of combination of freight wagon and trailer transportation system, however, there is no difference in the conveniences between trailer driving system and freight wagon driving system. Namely, the items of convenience are the convenience from the substitution of

crane equipment, convenience from the passing, convenience form the vehicle operation cost, convenience from environment cost reduction. convenience from the traffic accident reduction. The convenience from the substitution of crane equipment is created from the reduction due to no use of the traditional crane and maintenance cost reduction in case of system conversion into the horizontal load · unload method (freight wagon driving system, trailer driving system) and it is estimated in consideration of the year of duration etc.

Table 10 Basic premises and consumption - reduction of passing time

origin-destination	time	value of the time
Uiwang-Busanjin	6 (hour)	11,670(KRW)

The reduction of the passing time means the convenience created to the driver when the cargo to be delivered by highway uses the railway through the system conversion. The change of traffic pattern is created such as the transportation method, passing route, passing speed in case of system conversion and the passing time is differed to the passengers who are sitting inside the car not only to the driver. Namely, if the traffic speed is improved, the reduced time for the passing of driver and passenger can be used for the other purpose. On the contrary, if the traffic speed is lowered by the heavy traffic, the longer passing time is required for the driver and passenger.

The reduction of car operation cost means the convenience created when the cargo to be delivered by highway uses the railway through the system conversion. The car operation cost is usually composed of fixed cost and variable cost. The variable cost is composed of the fuel cost, engine oil cost, tire wearing, maintenance and repair cost etc. The fixed cost is composed the depreciation of the car, insurance and tax and withholding cost. The tax and withholding cost is simple transitional outcome which is not the economical cost and the insurance cost is against the traffic accident occurrence. It is excluded from convenience from the reduction of car operation cost as the cost for the traffic accident is calculated separately. Accordingly, fuel cost, engine oil cost, tire cost, maintenance and repair cost and depreciation are only considered in the calculation of car operation cost.

Table 11 Basic premises and consumption - reduction of car operation cost

items	fuel	engine oil	tire	M&R	depreciation	total
KRW	104.04	4.54	24.11	59.75	101.17	293.61

The convenience from the reduction of environment cost means the convenience created when the cargo to be delivered by highway uses the railway through the system conversion. The conveniences from the reduction of environment cost is the air contamination, water pollution, noise, vibration, ground subsidence, influence to the eco system such as vegetables and animals, change of landscape and global warming. However, it is not an easy job to estimate all environment values for the various changing factors of environment quality. It is difficult not only to identify the degree of influence but also to convert it to the Economical Feasibility value may includes more uncertainties. Consequently, the environment cost is calculated with focusing at the air contamination which has rather big influence and easy for the evaluation and conversion to the value.

Table 12 Basic premises and consumption - reduction of environment cost

items	Co	Nox	HC	PM	Co2	total
KRW	10.05	115.21	4.92	22.59	45.37	198.14

The convenience from the reduction of traffic accident means the convenience created when the cargo to be delivered by highway uses the railway through the system conversion. The traffic accidents can be classified in many types depending on the pattern of the road, shape of the road and accident pattern and the reasons are reported that it is created from the complicated factors mainly not from the individual factor. The cost from the traffic accident is considered as a convenience by converting it to the value in cash in foreign countries. The Korea Transport Institute has estimated from the 1995 with the study for the social cost due to the traffic accident in Korea and the cost and convenience from the traffic accident are applied to the evaluation of the road investment business through conversion the cost and convenience to the value in cash.

Table 13 Basic premises and consumption - reduction of traffic accident

items	deaths		injury		total	remark
	no.	cost	no.	cost		
KRW	1.12	363,740	31	30,570	1,355,059	per km

The cost from the traffic accident is the value converted from the all economical losses created from the traffic accident to the value in cash. The economical losses herein is the concept including the losses to the individual person and total society.

5. The criteria for the evaluation of economical feasibility

The criteria for the evaluation of economical feasibility adopts the benefit and cost analysis (B/C Ratio), Net Present Value (NPV) and Internal Rate of Return (IRR).

Table 14 Convenience of DMT system

items	crane equipment	passing time	vehicle operation	environment	traffic accident
2013	3,195				
2014	3,195				
2015	3,195	5,258	9,570	6,458	442
2016	3,195	7,240	13,177	8,892	608
2017	3,195	9,023	16,421	11,081	758
2018	3,195	10,249	18,652	12,586	861
2019	3,195	11,478	20,888	14,096	964
2020	3,195	13,376	24,343	16,427	1,123
2021	3,195	14,768	26,875	18,135	1,240
2022	3,195	16,960	30,865	20,828	1,424

The benefit and cost analysis is the ratio of discounted value of convenience and cost calculated by each item. It is a figure from dividing the present value of the convenience by the present value of the cost with conversion to the present value of the basic year from the cost and convenience to be created in the future. Net present value is the deduction of the total cost from the total convenience through discounting the all costs and conveniences accompanied to the present value of the basic year. Usually, it is identified as Economical Feasibility in case that the net present value is as same as 1 or bigger. Internal Rate of Return is the discount rate which makes the present value of the convenience and cost to be identical. If the IRR is bigger than the social discount rate, it is identified as Economical Feasibility.

Table 15 Results of the economy analysis

items	freignt wagon driving system	trailer driving system
total cost	8,039	5,732
present value of the cost	2,700	1,760
total convenience	17,082	17,082
present value of the convenience	4,678	4,678
B/C Ratio(6.5%)	1.73	2.66
NPV(6.5%)	1,979	2,919

The results of the economy analysis revealed out that the present value of cost for freight wagon driving system is about KRW 270 billion and the present value of convenience is about KRW 467.8 billion. The analyzed result on the base of present value of cost and present value of convenience for freight wagon driving system showed the net present value of about KRW 197.9 billion and B/C was 1.73 which means the quite favorable economic feasibility.

The present value of cost for trailer driving system is about KRW 176 billion and the present value of convenience is about KRW 467.8 billion. The analyzed result on the base of present value of cost and present value of convenience for trailer driving system showed the net present value of about KRW 291.9 billion and B/C was 2.66 which means the quite favorable economic feasibility.

The both of the freight wagon driving system and trailer driving system is analyzed as economical feasible. The trailer driving system is analyzed as economical feasiblility in the establishment of DMT system as the B/C for freight wagon driving system is 1.73 and the B/C for trailer driving system is 2.66.

6. Conclusion

The demander of the logistics requests the enlargement, speediness and globalization to the logistics supplier. The improvement of the transportation system is an urgent task in order to establish the logistics network(Choi, 2009). The demander request the effective and environment friendly logistics service for the railway logistics. The DMT transportation system is the answer appeared for such requests. If the conventional diesel locomotive is substituted by the electric power locomotive, the current vertical load · unload system can not provide the load · unload service to the freight wagon. Consequently, this study analyzed the characteristics of the DMT system. The horizontal load · unload system is being considered as an adoptable DMT system in consideration of the situation in Korea. The horizontal load · unload system is composed of freight wagon driving system and trailer driving system. This study analyzed the economic feasibility for the two systems. The economica feasibility study revealed out that the present value of cost for freight wagon driving system is about KRW 270 billion and the present value of convenience is about KRW 467.8 billion. The present value of cost for trailer driving system is about KRW 176 billion and the present value of convenience is about KRW 467.8 billion. The both of the freight wagon driving system and trailer driving system is analyzed as economical feasiblility. The trailer driving system is analyzed as economical feasiblility in the

establishment of DMT system as the B/C for freight wagon driving system is 1.73 and the B/C for trailer driving system is 2.66.

The technical matter is the important factor for selection for DMT system, but the introduction of the system to solve the problems contained in the conventional railway logistics system is important also. It is essential to select the system to be introduced through the economic feasibility study in consideration of the terminal construction cost, equipment importing cost and operation cost etc. This study analyzed that the trailer driving system is more excellent than the freight wagon driving system in terms of economic feasibility. However, this study analyzed the economic feasibility when the DMT system is induced and it has a restriction on the financial analysis in the viewpoint of business provider. If such study is performed in the future research, it is believed that more excellent achievement will be derived.

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