A STUDY ON THE POTENTIAL OF MODAL SHIFT WITH MOBILE HARBOUR

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ABSTRACT

The purpose of the paper is to suggest the possibility of modal shift by developing mobile harbour (MH) with container crane on board for container transport. As technical specification of MH, it has 8~15 knots speed, 250TEU laden capacity, 5 meters draft, 50 meters LOA, 26 meters breadth, 30 moves handling rate capacity per hour. With the specification, the strong point of MH is to reduce port time of mother ship by implementing cross docking handling system alongside mother ship or feeder ship. Furthermore, due to the crane on board, the berthing place will be expanded, i.e. MH is able to approach general cargo handling berth without dedicated quay crane. Other benefit of MH is to replace container road haulage with SSS(short sea shipping). Despite of MH's slow speed compared to road truck, it has a little advantage of distance within short range.

Key word: Mobile Harbour, Economic Analysis, Modal Shift

1. INTRODUCTION

The interest of short sea shipping in South Korea has increased due to the declaration of green logistics policy by Korea Government in August, 2008. The concentration to road transportation has reached 74% of total ton miles whereas the portion of costal shipping is 18% and that of rail is 8% in 2007. In a result, the problems of road congestion, oil energy consumption, CO2 emission and road damage drives to have an interest in short sea shipping.
According to SSS report about east coast of North America, the criteria of modal shift from road to sea transportation are suggested as services options, transit time, service cost, documentation and frequency of service and reliability of transportation service (A. Baird et

al., 2006). In a result of research, short sea shipping is perceived to be reliable by shippers, but a majority of them require a tight delivery window and so transit time is important.

Regarding to documentation issue which could be a key motivator in choosing a modal option, US shippers were quite concerned about purchasing a service requiring multiple carrier contracts and single contract. The single contract arrangement gives a greater chance of succeeding. In this paper, documentation factor by shippers is considered not to be a decisive factor for choosing modal option under the assumption of providing homogenous service to shippers.

As the biggest advantage of the truck mode is flexibility of departure time, short sea shipping has weak position over road service mode. The research result by A. Baird is that a portion of shippers have a willingness to switch truck modal to SSS in case of road congestion even if SSS is operated on weekly or biweekly service.

The result about the cost of service for the factor of modal shift is that a 10 percent discount is insufficient to trigger switching behaviour to short sea but a 20 percent discount is better. Likewise, a 10 percent premium is not a deterrent to the choice of short sea shipping, premium pricing for a better transit time may be acceptable.

In view of shipper, sea transportation is thought to be one of transportation modes. The choice is dependent on transit time, service cost, frequency or reliability from origin to destination.

The aim of paper is to find the conditions of changing modal shift from road mode to SSS in the coastal area of ROK under the concept of Mobile harbour. Mobile harbour has the dual function of sea transportation and container handling armed with high mechanical and systematic technology. As technical specification of Mobile harbour, it has different types in terms of LOA, GT, DWT, Draft and numbers of cranes on board (refer the figure 1). In addition, mobile harbour has different functions in comparing with container feeder vessel, barge or pontoon. As well known, container feeder ship does not fit her own cranes board and barge does not have her engine and thrusters. However, mobile harbour has on-board cranes and her engine for transportation.

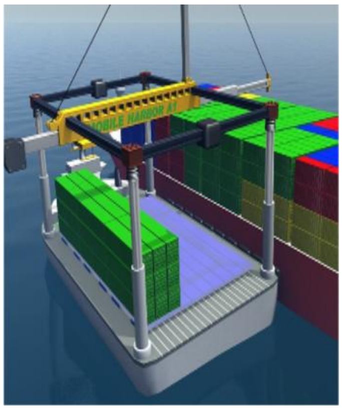
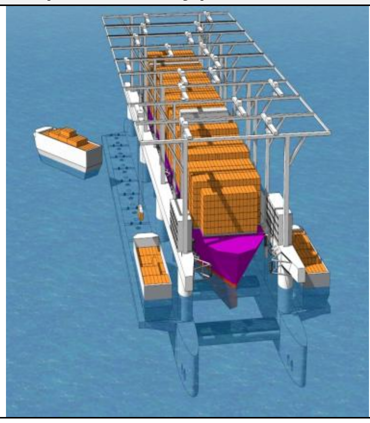
Integrated type	Separated Type
	

Figure 1 Mobile Harbour's Type

In order to solve the problem, scenario of case study and framework for computing total cost is to be designed including service cost and cargo time cost. The scenario for MH is as follows: As soon as a mother ship arrives at port of Busan, mobile harbours move to and berth at a mother ship, and discharge cargoes with self crane on the deck of mobile harbour. This activity for collecting cargos from mother ships continues until filling up its capacity, i.e. 250 TEU. After completing full loading activity, mobile harbours leave the port of Busan for the port of Yeo Su and discharge containers at calling ports on planned. Afterwards discharged containers are loaded on truck chassis for final destination at consignee door.

In comparison to MH transportation, road transportation tracks simple process. As soon as mother ship berths at container terminal i. e. PNC(Pusan New Container Terminal), containers are discharged on terminal yard, and waits for free time days until consignee's delivery request. On request of cargo owner, they are loaded on truck chassis one by one for final destination.

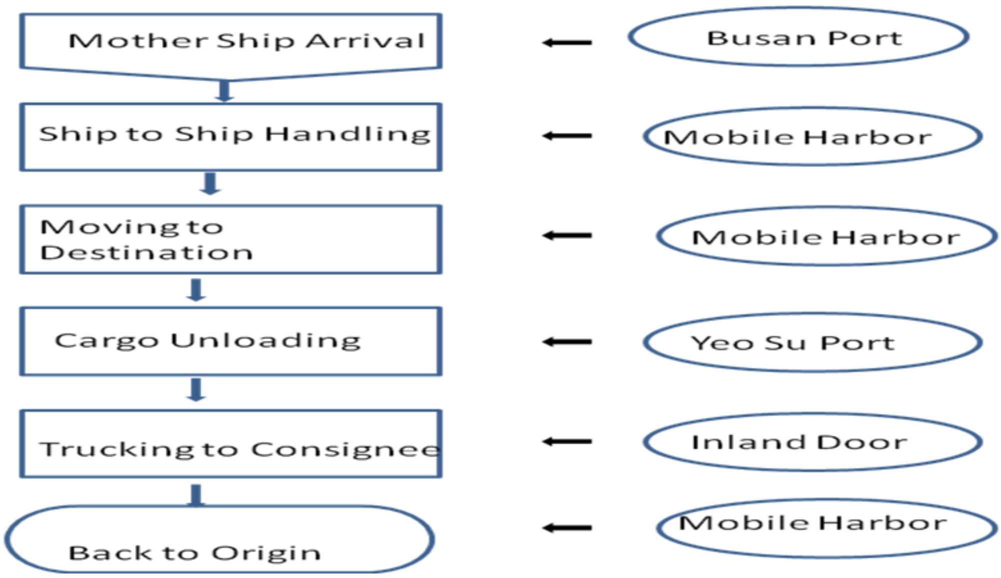


Figure 2 Scenario for Modal Shift

The research consists of literature review, demand estimation and transit time and cost of transit service and suggesting conclusion.

2. LITERATURE REVIEW

Bojan Beskovnik, M, Se(2006) have studied the Importance of short sea shipping and sea motorways in the European and Slovenia transportation policy, and provided insight that SSS and motorways of sea are the alternative to road and rail transportation. Further SSS transportation and the motorway of sea can help to reduce congest, air pollution and energy consumption in European road haulage.

Alfred Baird (2005) has studied EU Motorways policy in terms of total amount of investment of road transportation and sea transportation. His assertion is that there have been substantial public sector investments in roadway and railway infrastructure for last several decades. However the seaway has tended not to be supported to anywhere near the same degree, and in most cases the seaway has been ignored, in part due to the mistaken assertion by policymakers that the seaway represents some kind of free highway. The evolving EU Sea Motorways Policy to some extent recognises these distortions and mechanisms are now being put in place to enable short sea shipping to develop much further. Recognition that short sea shipping represents the only real hope in holding back the dramatic growth in road freight transport throughout the EU reflects the fact that policy is now beginning to move very positively in favour of maritime intermodal transport solutions. Recent EU-funded research on the subject of sea motorways reflects this shift and highlights the important role of the EU in this regard, whilst analysis of sea motorways in practice demonstrates the substantial modal shift that can be achieved by innovative carriers supported by appropriate policies.

Mary R. Brooks et al. have studied sea shipping on the east coast of North America in order to find opportunities and issues. The main findings from research are as follows.

First, the demand for the service must be large enough to support service development. Even if the market has enough demand, the distance has to be considered in order to overcome road haulage. In the case, the distance to Maine is too short to make short sea competitive against truck.

Second, the service must meet the requirements of shippers. They found two very distinct groups: those for whom time to market is critical (e.g., seafood shippers) and those for whom a slower service (short sea or truck) is still acceptable. Referring to short sea, a majority of shippers have a tight delivery window and so transit time is important. According to site survey, 25 percent of the shippers are unlikely to switch to short sea shipping unless trucking service deteriorates drastically; it is instructive to note that a majority of companies reported road congestion, with about one-half of those indicating it to be serious enough to encourage them to consider switching to short sea shipping. On levels of price, discounting do not need to be as large as found in Europe. The research indicates that appropriate pricing can induce trial, encourage switching and that, for some shippers, premium pricing for a better transit time may be acceptable.

Goksel Tenekecioglu (2004) analyzed the feasibility to produce more advantageous result and possible effect on transportation in Europe. They discussed and concluded the intermodal transportation is the way to prevent the emission and congestion than all-road alternative transportation. Conclusively the thesis summarized the benefit of intermodal transportation by short sea shipping industry, not only reduce the congestion and pollution but also produce the economic value than by the road transportation.

In the session, the reason for reviewing the research on SSS is that SSS concept is similar to that of MH in terms of sea transportation and also value of sea transportation such as environmental mode, low cost and scale mode can be sought. Through literature review, the conditions for occurring modal shifting from road mode to MH mode can be drawn for attain the aim of paper.

3. THE CONCEPT OF MOBILE HARBOR

As technical specification of MH, two types with different function and dimension are prepared by KAIST(Korea Advanced Institute of Science Technology) research team. The first type is integrated entity of handling and transportation capacity. MH has 8~15kts of designed speed, 250TEU laden capacity, 5 meters draft, 50 meters LOA, 26 meters breadth, 30 moves handling rate capacity per hour.

The other type is separated one of cargo handling and transit function. For the transit of cargo, feeder ships are available at pontoon of MH like Figure 1. B type of MH has eight cranes on board, 300~400 meters LOA, and can be operated with working condition of sea state 4, handles 200 moves per hour per one MH.

With the specification, the strong point of MH is to reduce port time of mother ship by implementing cross docking handling system alongside mother ship or feeder ship. Furthermore, due to the crane on board, the berthing place will be expanded, i.e. MH is able to approach general cargo handling berth without dedicated quay crane. Other benefit of MH is to replace container road haulage with SSS. Despite of MH's slow speed compared to road truck, it has a little advantage of distance within short range.

Table 1 Dimension of Mobile Harbour by Type

Type	Integrated		Separated
	(A-1 type) MH with Crane		(B-1 type) MH with Crane
Speed	8~15kts	12kts	n/a
Draft	5m	7m	n/a
LOA	50m	150m	300~400m
MH Height of Full Capacity	15.5m	15.5m	n/a
Capacity	250TEU	1,200TEU	n/a
Handling Capacity	30moves/Hour	120moves/Hour	200moves/Hour
Number of C/C	1	2	8

4. METHODOLOGY

On previous literature survey, modal shifting is simply incurred by transit time, cost of service and frequency. Choosing a mode is the function of difference of utility between MH transportation and other modes like road, rail or air. The probability that a shipper in region (r) select MH mode (s) can be expressed as (Veldman et. al., 2003, 2005, 2007):

$$P_s^r = \frac{e^{U_s^r}}{\sum_{m=1}^{m=P} e^{U_m^r}}, (m = 1,2,...,n) \qquad (1)$$

U is the "utility" attached to selecting mode (s) by shipper in region (r) and m is the index of modes in a total of n transit modes. In the paper, utility function is used as presenting the concept of selection among alternatives.

Considering the factors to be mentioned for modal shift, the utility function by applying the formulation introduced by Blauwens and Van de Voorde, can be expanded as:

$$U_m^r = \alpha_1 D_m + \alpha_2 M_m + \alpha_3 V_{n(x)} * T_m \qquad (2)$$

where
D_m is the dummy variable indicating specific preference for choosing mode m, M_m is the monetary cost for the transit selecting mode m, T_m is the time to complete transit choosing mode m from origin to destination. $V_{n(x)}$ is the value of time of cargo.
In this study, the monetary value of time is computed by Inventory carrying cost by Ballou.
, which can be expressed as

$V_{n(x)} * T_m$ = (Number of TEU) * Interest per day * Cargo cost per container * Transit time (3)

In order to estimate cargo cost per container, it is efficient to collect representative products which consist of computer tomography machine, whisky and poly ethylene from population. Each product represents high, middle and low value group. According to Korea Customs Statistics for three years, total weight of sample cargo is 421,134 tons, and its price is US$ 2,807,871. On average level, the price per ton is calculated in US $ 6,669.78, and price per container is estimated US$ 100,046.7 in assuming that 15ton is equivalent to a container. Using formula (3), the transit cost per container per day is US $24.67 in 10% yearly carrying interest.

Table 2 Weight and price of import and export sampled cargo

Year	Product Class	Weight(ton)	Price(US thousand $)
2007	High	3,042	477,149
	Middle	37,014	306,626
	Low	105,137	214,026
2008	High	2,906	472,856
	Middle	38,115	293,224
	Low	105,329	239,767
2009	High	2,216	380,009
	Middle	34,109	224,227
	Low	93,266	200,987
Total		421,134	2,808,871

In order to find parameters of equation 3 based on the multiple regression formulation, identifying the coefficient is not easy task due to shortage of accumulated data for 10 years or more. Even if regression relationship cannot be defined, total cost of service can be computed in the scope of region to compare utility cost between MH mode and the other mode in competition. That means U_m^r of a mode with lower value over the other mode in competition is selected by a shipper.

Conceptually, total cost which consist of monetary cost and cargo time cost can be expressed as $TC_m^r = D_m + M_m + V_{n(x)} * T_m \quad (\mathrm{D, M, V, T, x, n} > 0)$. (4)

The diagram provides insight to make decision between MH mode and road mode.

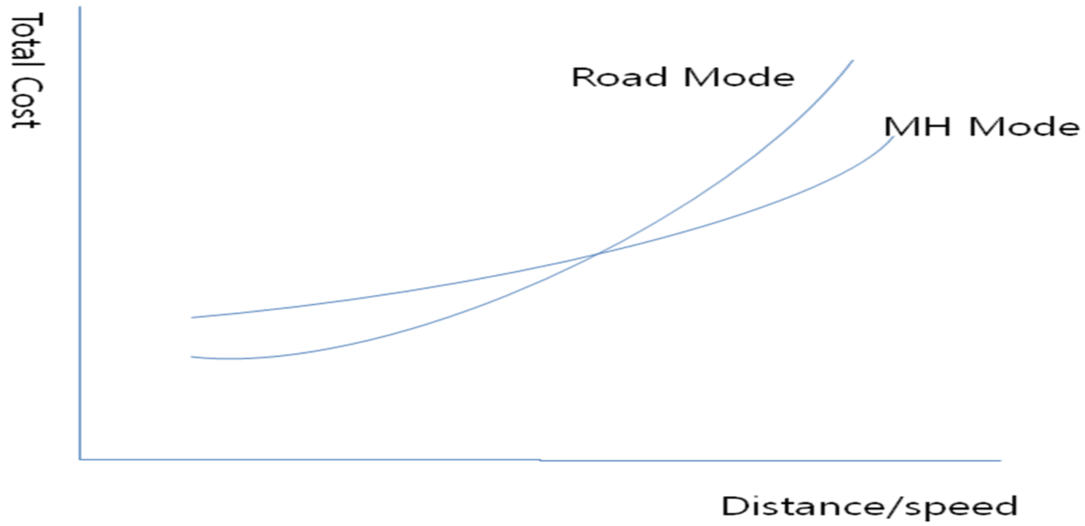


Figure 3 Decision variable for modal shift

5. DATA ANALYSIS

Total cost consists of service cost and cargo time cost. The former consists of shipping cost and inland transportation cost. Shipping costs consists of running cost as fixed cost, and bunker cost and port charges and dues as variable cost. In order to make quantity model for total cost, voyage routes from origin port to destination are set up in considering rout distance, demand volume and hinterland industry. In the model, the number of voyage routes is defined as m and daily running cost is defined Hc. The bunker cost per ton is defined Bc, and daily bunker consumption in navigation and in port is defined Fm and Fp each. Navigation time and port time in hour unit is defined Tm and Tp. According to above definition, daily bunker cost in navigation is modelled Bc x (Fm x Tm)/24, and bunker cost in port is modelled Bc x (Fp x Tp)/24. Daily port dues, berthing charge, cargo handling charge and line handling per voyage are defined Pc, Mc, Cc and Lc. Based on above definition, daily port charges per voyage can be modelled (Pc + Mc + Cc + Lc) x Tp/24. If three types of cost which are running cost, bunker cost and port dues are summed and divided by MH capacity G and add trucking fee to final destination, total service cost for SSS will be computed in unit of a voyage by each route as planned. Before computing the total cost, enough demand for transporting is to be guaranteed under condition that MH has better position than road mode from shipper's standpoint. According to internal report of Ministry of Land and Maritime Affairs, container volumes between city to city is as follows per year

Table 3 Demand Table Between Origin to Destination in Korea (Source: MOLM,. 2006.)

Origin and Destination	Port of Busan	Port of GwangYang	Port of Incheon
	Flow(TEU)	Flow(TEU)	Flow(TEU)

Seoul	127,853	472	74,152
Busan	491,210	10,725	12,203
Daegu	227,224	1,153	4,465
Incheon	191,165	577	616,904
Gwangju	207,043	157,979	1,309
Daejon	108,430	16,430	3,909
Ulsan	959,130	138	885
Gyungi	952,111	110,312	497,790
Kangwon	32,020	478	4,159
ChungBook	189,464	28,361	23,106
ChungNam	238,301	34,731	71,413
JoongBook	241,643	190,534	4,276
JoongNam	217,960	729,200	2,586
KyungBook	1,062,690	8,656	11,896
KyungNam	1,557,938	31,215	2,388
Sum	6,804,182	1,320,961	1,331,441

New shipbuilding cost of Mobile Harbour of which size is 250 TEU is estimated US$ 30Million by Korean ship builder (KAIST, 2009). The cost is 2 times higher than that of feeder ship in equivalent size (Drewry, 2008). The running cost which is fixed regardless of voyage consists of ship depreciation cost, ship store cost, lubricating cost, water supply cost, ship repair cost, manning cost, capital cost and general overhead cost.

Table 4 MH's Running Cost

MH Size (TEU)	250
Ship Building Cost (US $)	30,000,000
Yearly Running Cost (US $)	5,961,217
Daily Running Cost (US $)	16,332

Variable cost consists of port dues and charges and bunker cost in port and in navigation. As mobile harbour is mainly operated within a harbour or between domestic harbour, port dues, MH operator will pay for only MH berthing charge and line handling charge occurs, but it is assumed that container handling charge will be freed for utilizing own facility.

Table 5 MH's Port Dues and Port Charge

MH Size (TEU)	250

Port Dues (US $)	316
Berthing Charge (US $)	84
Line Handling (US $)	86
Cargo Handling	8,500
Total of Port Dues and Charges (US $) per Voyage	8,986

In calculation of bunker cost, navigation and port time is to be estimated because ship engine consumes two types of bunker oil of which cost is different in navigation or in port. As voyage time is dependent on the number of entering ports and distance from origin to destination, the voyage route is to be designed first before estimating navigation and port times of MH and bunker cost. Ten routes are developed in considering the frequency of departure, round trip time, calling ports in cluster and cargo demand.
Based on basic data including 8kts speed and 250 full demands, total cost which consists of transit cost and cargo time cost per TEU can be computed on each route as Table 6. Shuttle cost is computed by average value which has been implemented in port of Busan and port of Incheon. Cargo time cost is computed by the formulation of equation 3 with cargo value.

Table 6 Total Cost of MH on Designed Route

Route	Origin Port Busan	One way Distance (mile)	Shipping Cost (US $)	Shuttle Cost (US $)	Transit cost (US $)	Cargo Time Cost (US $)	Total Cost of MH
	Final Port						
1	Masan	43	213	55	268	36	304
2	Ulsan	44	153	55	208	24	232
3	Tongyoung	49	206	55	261	32	293
4	Pohang	104	215	55	270	36	306
5	Kwangyang	108	117	55	172	14	186
6	Wando	155	139	55	194	16	210
7	Gunsan	325	174	55	229	14	243
8	Boryung	354	173	55	228	12	240
9	Pyungtaek	425	252	55	307	24	331
10	Incheon	435	191	55	246	12	258

In comparison with MH, total cost of road mode can be drawn from rate tariff, which is published by Korea Cargo Transportation Association and distance table provided. The total cost is shown on Table 7.

Table 7 Total Cost of Road Mode on Designed Route

Route	Origin Port Busan / Final Port	One way Distance (mile)	Tariff (US $)	Cargo Time Cost (US $)	Total Cost of Road Transportation (US $)
1	Masan	43	185	2	189
2	Ulsan	44	198	2	202
3	Pohang	49	291	4	300
4	Tongyoung	104	285	3	291
5	Kwangyang	108	355	4	363
6	Wando	155	558	7	570
7	Gunsan	325	526	7	538
8	Boryung	354	620	7	633
9	Pyungtaek	425	720	8	735
10	Incheon	435	754	9	770

On the result of analysis, it is possible to get meaningful insights by changing the decision variable. The criteria of route distance from which modal shift occurs in Korea costal sea depends on ship speed. As shown on Table 6, port of Ulsan is excluded from object of modal shift because total cost of MH mode is higher than that of road mode. Even though port of Masan and port of Pohang show less total cost than that of road mode, modal shift cannot be happened due to small difference of total cost. If the journey distance is more that 100 nautical miles, possibility of modal shift is expected.

Table 8 Total Cost of MH and Road Mode on 8 kts

Distance (n. mile)	Total Cost of MH mode (per leg, per TEU, US $)	Total Cost of Road mode (per leg, per TEU, US $)	Ratio of TC of MH to Road(%)
43	304	189	161
44	232	202	115
49	293	291	101
104	306	300	102
108	186	363	51
155	210	570	37
325	243	538	45
354	240	633	38
425	331	735	45
435	258	770	34

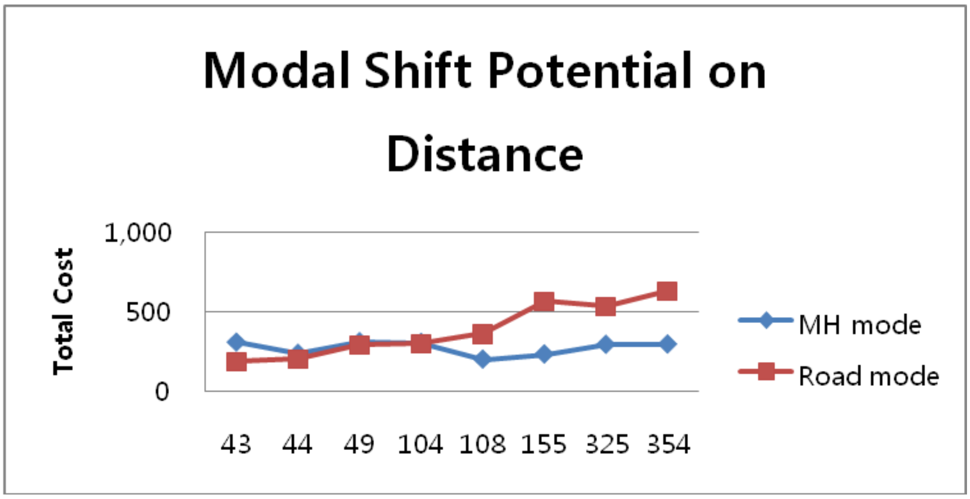


Figure 4 Modal Shift Potential on 8 kts

Second, if the MH speed is increased to 15kts, the result seems to be similar to 8kt. The above result means that distance is key role for modal shift from road to sea.

Table 9 Total cost of MH and Road mode on 15 kts

Distance (n. mile)	Total Cost of MH mode (per leg, per TEU, US $)	Total Cost of Road mode (per leg, per TEU, US $)	Ratio of TC MH to Road(%)
43	305	189	161
44	233	202	115
49	306	291	105
104	292	300	98
108	186	363	51
155	210	570	37
325	242	538	45
354	240	633	38
425	331	735	45
435	258	770	33

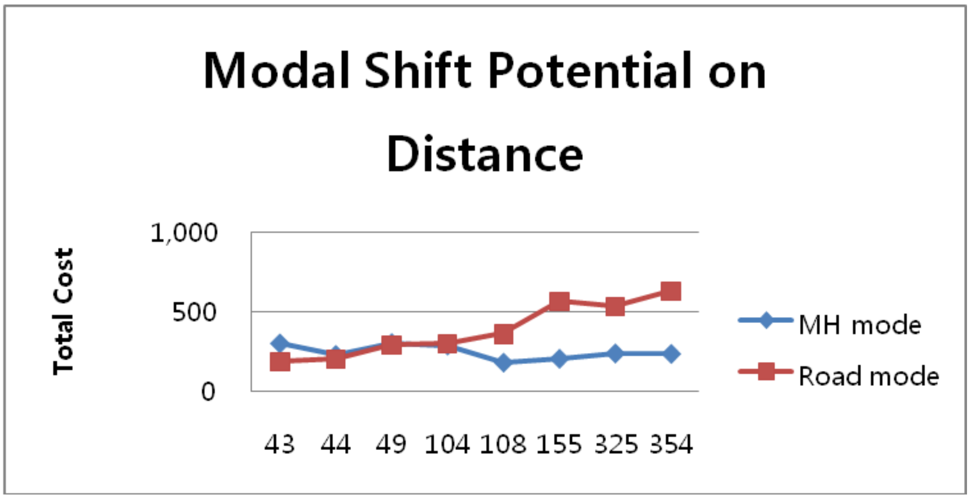


Figure 5 Modal Shift Potential on 15 kts

6. CONCLUSION

The aim of paper is to find potential for modal shift from road transportation to mobile harbour transportation. To attain the objective, it is required to design the MH's route, estimate demand from origin to destination by daily basis, and cost model for cost calculation of MH and road transportation. The cost components consist of transit cost, port dues and charges, and shuttle charge from door to port side. Especially time cost, which means the cargo cost accrued by transit time spending has to be considered in the cost model for strict comparison with road transportation. Although speed, frequency, price, distance are considered as decision factor for modal shift, distance and speed are considered to be endogenous variable factor, while price and frequency is considered to be external factor.

In a result, 100 nautical miles is decisive point to win the road mode regardless ship's speed, If distance is more than 100 nautical miles, mobile harbour has competition advantage to pulling cargo from road transportation mode. Even though the result of analysis shows positive signal for modal shift, real situation does not go to such a way. That means modal shift has several attributes for applying to real world.

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