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A Study on Optimized Size of a Mobile Harbor for South Korea Coastal Service

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Abstract : *The aim of paper is to calculate the optimized size of Mobile Harbor(MH) which would be operated in South Korea coast area. MH is the combined entity which has the function of both ship and container port. In estimating the optimized size, the total cost concept is applied to the different size of MH. Trade-off factors for calculating total cost are MH cost and the over-capacity lost cost. The factors for MH cost estimation are the cargo demand, distance from origin to destination, voyage route and MH's fixed and variable cost in both sailing and port. The other cost is the over-capacity lost cost which is occurred from dead space in case of oversize compared with a voyage demand. The alternatives for the least cost are 250TEU, 500TEU, 750TEU and 1,000TEU sized vessel. The result of research is that 250TEU sized vessel is optimized in a South Korea costal service. If the coastal area be separated in terms of voyage distance or the specific area in considering trade, the optimized size is changed depending upon distance.*

Key words : *Mobile Harbor, Optimized size, over-capacity lost cost, fixed cost, variable cost*

1. Introduction

Mobile Harbor(MH) has the dual function of sea transportation and container handling armed with high mechanical and systematic technology. As technical specification of Mobile Harbor, it has 8 to 15 knots speed, 250TEU laden capacity, 4 meters draft, 92 meters LOA, 26 meters breadth, 30 moves handling rate capacity per hour-ship. Depending on trade where MH plies, the optimal size of MH can be decided. The aim on the paper is to estimate the optimized size of MH which would be operated in South Korea coast area.

Mobile Harbor has strong point which is used for cross docking by which mother ship cooperates with MH in handling containers using cranes. As the trait of MH which has cranes and low draft, it can access the general cargo berth without container handling equipment or low depth channel. In reality, coastal shipping in Korean peninsula is not well developed due to short distance. Several steps and long transit time between origin and destination are main reason for under developed coastal shipping. In the difficulty of expanding coastal shipping in Korea, MH can be emerged as an alternative of modal shift from road to sea. Under the boundary of costal transportation with MH, the estimation of MH optimal size is prerequisite for designing and building.

This paper is to calculate the optimized size of MH which would be operated in South Korea coast area. In estimating the optimized size, the total cost concept is applied to the different size of MH. Two different costs of MH cost and the lost sales cost can be selected for estimating total cost. The several factors for MH cost are to be considered. Those are the cargo demand and distance from origin to destination, voyage route and MH' s fixed and variable cost in both sailing and port. The other cost is the over -capacity lost sales cost which is occurred from dead space in case of oversize compared with a voyage demand.

2. METHODOLOGY

The optimized size of MH in Korea costal area can be suggested with total cost concept. Total cost consists of ship operating cost and over-capacity lost cost which has trade off relationship. Ship operation cost is divided into variable cost and fixed cost. The variable cost as occurred in activity consists of the bunker cost and the port charges and dues when entering the port for loading and unloading. The fixed cost is called running cost which is the preparing cost for navigation regardless in navigating or in port or at lay up. As the items of running cost, depreciation cost, capital cost, ship store cost, repair cost, insurance cost and crew cost are included in the cost category. The fixed cost can be measured on yearly basis. Although there are some

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arguments about the classification of individual cost into variable or fixed cost (Mcconville, J., 1999, Branch, A.E., 2007), this paper follows Drewry classification based on usual practice.

The over-capacity lost cost has relationship between ship size and demand per voyage. If ship' s capacity is oversized than cargo volume per voyage, the shipping company has missed shipping freight equivalent to dead space. Theoretically speaking, bigger ship tends to enjoy lower unit cost than that of small ship due to the effect of fixed cost spreading. However, big ship has experienced some difficulties in terms of dead space which is occurred by shipping demand shortage, the performance of crane facilities, the time window of river channel by ebb tide which enables ship passing through without hindering for full day, and berth windows due to over draught.

As a consequence, it is obvious that optimal size is to consider not only shipping cost, but also over-capacity lost cost which is the missed revenue for over sized capacity. As optimal size is the function of total cost which is the sum of shipping cost and over-capacity lost cost, U shaped graph can be drawn as Fig. 1.

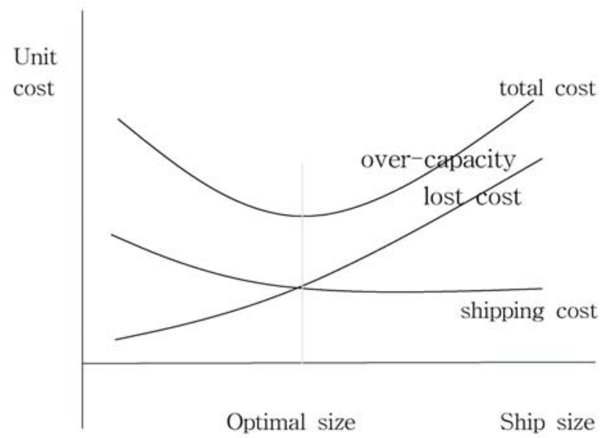


Fig. 1 Total cost concept for optimal size

For calculating the total cost, the optimization formula with minimum total cost is to be developed. As early mentioned, total cost consists of shipping cost and over-capacity lost cost. The former consists of running cost as fixed cost, bunker cost, port charges and dues as variable cost. Before solving the optimal size problem, quantity model for total cost is to be designed, then voyage routes from origin port to destination port are set up in considering route distance, derived demand volume occurred from hinterland industry. In designing route, 10 ports such as Pohan, Ulsan, Masan etc. among 27 trading ports in Korea, are selected in considering of 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 calculated Bc x (Fm x Tm), and bunker cost in port is calculated Bc x (Fp x Tp). Daily port dues, berthingicharge, 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 modeled (Pc + Mc + Cc + Lc) x Tp. Three types of cost being summed and being divided by decision variable G and the number of voyage, the consequence will be the total cost of shipping per unit and route.

Last component of total cost is over-capacity lost cost defined C_l. This cost is restricted within the lost revenue occurred by dead space. As MH' s draught is under 5m, the channel depth and berth time windows is not to be considered in the C_l definition.

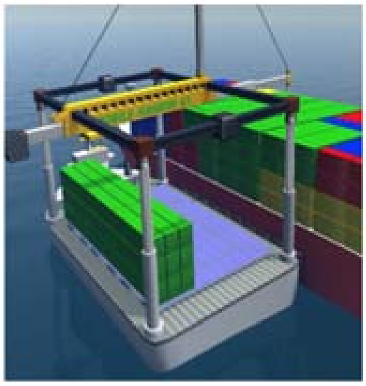
$$Min\,T_c = \frac{\sum_{m=1}^{M}\{H_c + B_c\,[(F_m \times T_m)+(F_p \times T_p)] + [(P_c + M_c + C_c + L_c)\times T_p]\}}{G\times M} + \frac{\sum_{m=1}^{M} C_l}{2\times G\times M}$$

s.t.

G,M > 0

G is decision variable dimension of which is one of 250TEU 500TEU, 750TEU or 1,000TEU capacity of mobile harbor.

M is 14 routes as adapted on table 3.

MH Size (TEU)	250TEU	500TEU
LOA (meter)	92	118
Gross Tonnage	2,468	7,506
Deadweight	4,386	8,726
Draft (meter)	5	6
Design Type		

750TEU	1,000TEU
144	169
13,379	16,731
16,640	22,740
8	9

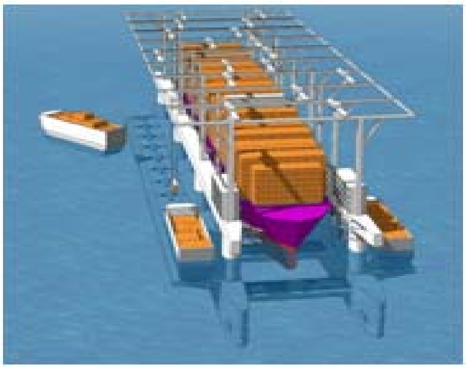


Fig. 2 Specification of MH on capacity

3. DATA COLLECTION AND ANALYSIS

New shipbuilding cost of Mobile Harbor of which size is 250TEU is estimated US$ 30,000,000 by Korean ship builder (KAIST, 2009). The cost is 2 times higher than that of feeder ship in equivalent size (Drewry, 2008). As the cost of others including 500TEU, 750TEU and 1,000TEU is not informed, the estimation is tried by the ratio based on feeder' s new building cost of equivalent size.

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, general overhead cost (Table 1).

Table 1 MH's running cost

MH Size (TEU)	250TEU	500TEU	750TEU	1,000TEU
Ship Building Cost (US $)	30,000,000	38,400,000	46,800,000	55,200,000
Yearly Running Cost (US $)	5,961,217	7,291,352	8,621,486	9,951,621
Daily Running Cost (US $)	16,332	19,976	23,621	27,265

Variable cost consists of port dues and charges and bunker cost in port and in navigation. As MH is mainly operated within a harbor or between domestic harbors, 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 2 MH's port dues and port charge

MH Size	250TEU	500TEU	750TEU	1,000TEU
Port Dues (US$)	316	961	1,713	2,142
Berthing Charge (US$)	84	255	455	569
Cargo Handing(US$)	7,500	15,000	22,500	30,000
Line Handling (US$)	86	86	86	86
Total of Port Dues and Charges (US$)	7,986	16,302	24,753	32,796

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. Fourteen routes are developed in considering the frequency of departure, round trip time, calling ports in cluster and cargo demand. Annual cargo demand from the port of Busan to destination port can be drawn from origin destination statistics (Inner Report of MOLM 2009), which shows container flow between sixteen origin cities and provinces to sixteen destinations on land transportation. As statistics is the only official data, it is necessary to allocate O-D(Origin and Destination) volume to that of destination port from the port of Busan. First step is to select 10 calling ports from the port of Busan in considering the distance from origin, proximity between ports and hinterland industry. Second step is to apply the assumed ration of O-D volume based on Baird research result, that is the future volume of coastal shipping will be average 16% of total land transportation in Europe(Baird 2007).

In designing routes, the assumed scenario is that mother vessel call at the port of Busan and then the MH is alongside of mother ship and handles containers for transporting to destination port. Destination ports which do not own the dedicated quay crane facility are selected in elevating the value of MH function.

Table 3 Route specification from Busan port to final port

Route	Origin : Port of Busan		Distance (mile)
	Calling port	Final Port	
1		Ulsan	88
2		Pohang	208
3	Ulsan	Pohang	227
4		Masan	87
5		Tongyoung	99
6	Masan	Tongyoung	119
7		Kwangyang	216
8		Wando	310
9	Kwangyang	Wando	375
10		Gunsan	650
11		Boryung	707
12	Gunsan	Boryung	716
13		Pyungtak	850
14		Incheon	870

Route	Navigation Time (Hour)	Port Time (Hour)	Demand[1] (TEU)
1	11.0	10.3	210
2	26.0	13.9	290
3	28.4	24.2	500
4	10.8	16.2	342
5	12.4	16.2	342
6	14.9	17.2	342
7	27.0	5.2	94
8	38.8	6.2	94
9	46.9	6.2	94
10	81.3	5.2	95
11	88.4	4.4	76
12	89.5	9.6	171
13	106.3	10.3	209
14	108.8	4.1	70

According to the above route, daily bunker consumption and cost are estimated on each route. Summing the bunker cost, port charges, the total variable cost per voyage on each route can be produced on Table 4 and then daily total cost per voyage after summing the variable and running cost will be shown on Table 4. The cost which is occurred from over sized capacity than the demand volume is called over-capacity lost sale cost. After calculating the difference value between ship capacity and demand volume, the value is multiplied by lost profit. On the case of MH with 250TEU capacity and 8 knots speed, the daily average total shipping cost is estimated US$ 77.7 and lost sale cost is US$ 53.9. Following the same procedure for estimation, daily average shipping cost on route and daily lost cost will be drawn as table 5. In a consequence, daily cost of MH with 250 TEU and 8 knot speed is drawn as optimal size.

1) Demand by port is derived from official statistics provided by MOLM(2009).

Table 4 Daily total cost on route of MH with 8 knots speed and 250 TEU capacity

(Unit US $)

Route	Bunker Cost in Navigation	Bunker Cost in Port	Port Dues and Charges
1	1,980	6,186	7,986
2	4,659	6,471	7,986
3	5,081	7,301	15,971
4	1,940	6,655	7,986
5	2,215	6,655	7,986
6	2,668	6,736	15,971
7	4,839	5,770	7,986
8	6,944	5,850	7,986
9	8,400	5,850	15,971
10	14,561	5,773	7,986
11	15,838	5,707	7,986
12	16,039	6,125	15,971
13	19,041	6,180	7,986
14	19,489	5,686	7,986
Route Average Daily Cost per TEU			

Daily Variable Cost	Daily Running Cost per Voyage	Daily Total Shipping Cost per Voyage	Daily lost and profit by Over-capacity
12,222	16,332	28,554	5,286
8,531	16,332	24,863	-8,963
8,861	16,332	25,193	-79,994
9,216	16,332	25,548	-16,463
9,047	16,332	25,379	-17,049
12,367	16,332	28,699	-18,774
11,960	16,332	28,292	24,330
9,767	16,332	26,099	33,296
12,255	16,332	28,587	38,594
7,416	16,332	23,748	59,382
7,297	16,332	23,629	70,420
8,423	16,332	24,755	35,992
6,286	16,332	22,618	21,923
6,804	16,332	23,136	87,729
Route Average Daily Cost per TEU		114	54

Table 5 Daily total cost per TEU on MH size with 8 knots

MH Size	250TEU	500TEU	750TEU	1000TEU
Daily Shipping Cost per TEU	102.6	71.5	57.8	55.9
Daily Over-capacity Lost Cost per TEU	53.9	90.4	109.3	118.7
Daily Total Cost per TEU	156.5	161.9	167.0	174.6

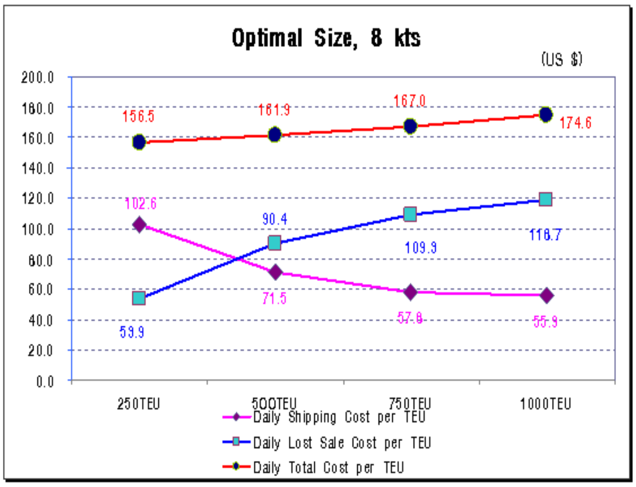


Fig. 3 Optimal size of MH in keeping 8 kts speed

On second sensitivity analysis, if the speed of MH is increased to 15 knots, the optimal size would be changed in to 500TEU~750TEU capacity.

Table 6 Daily total cost per TEU on MH size with 15 knots

MH Size (TEU)	250TEU	500TEU	750TEU	1000TEU
Daily Shipping Cost per TEU	116.2	83.2	68.0	66.6
Daily Over-capacity Lost Cost per TEU	32.4	57.3	71.2	78.2
Daily Total Cost per TEU	148.6	140.5	139.3	144.8

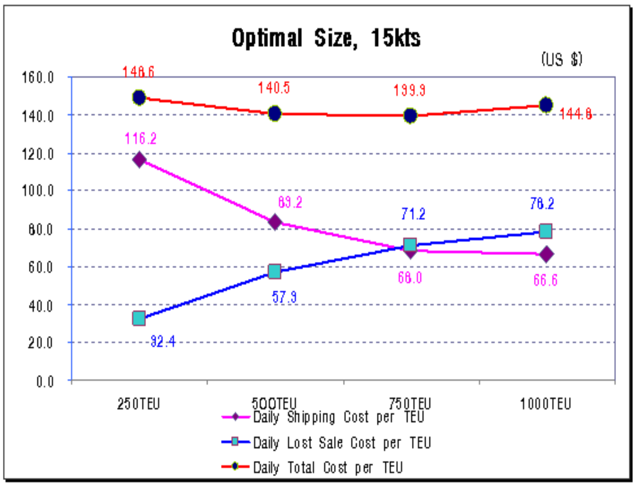


Fig. 4 Optimal size of MH in keeping 15 kts speed

4. SENSITIVITY ANALYSIS

The change of distance from origin to destination gives insights to make optimal size. This session deals with sensitivity of distance variation.

4.1 Less than 100mils distance with 8 knots

If the costal sea distance less than 100 miles is handled for shipping business with 8 kts speed, the optimal size of mobile harbor has 250 TEU laden capacity. As the total cost curve has steep inclination on the figure, 250 laden capacity has dominant position in comparing other size.

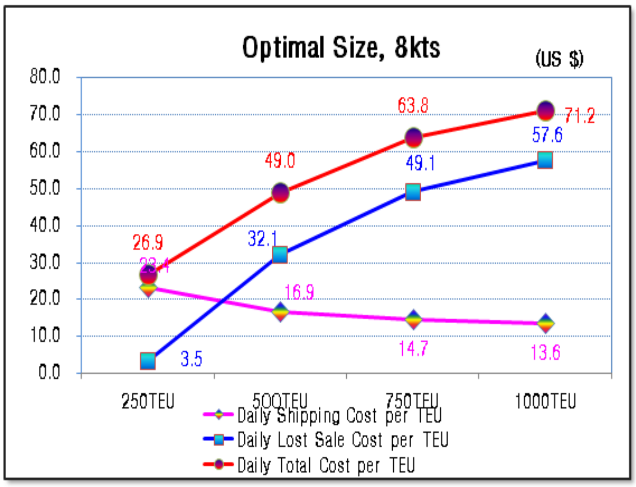


Fig. 5 Optimal size of MH in keeping 8 kts within 100 n.m. distance

4.2 Less than 300 miles distance

If the route distance expanded to more than 100 n.m and less than 300 n.m., how the optimal size is changed? The result of analysis is that even if business route is expanded to more than 100 n.m., there is no change in optiamal size. However as it is shown the inclination of curve is more smooth than the case of short distance, 250 TEU laden capacity will lose the dominant position, 500 TEU wil be alternative size ship.

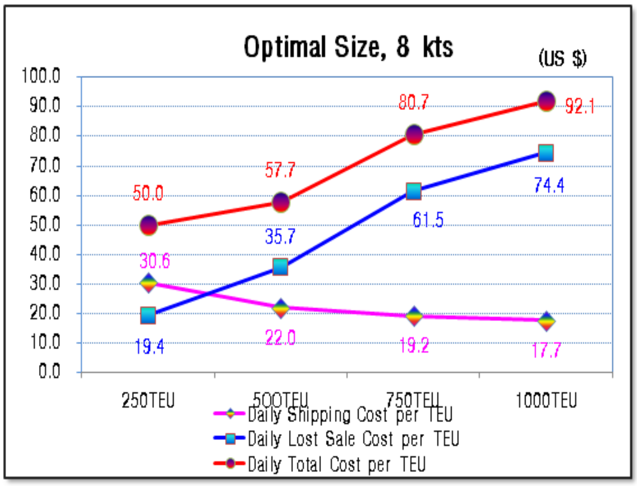


Fig. 6 Optimal size of MH in keeping 8 kts within 100~300 n.m. distance.

4.3 More than 300 miles distance

If the route distance expanded to more than 300 n.m., how the optimal size is changed ? The result of analysis is that evenif business route is expanded to more than 300 n.m., there is no change in optimal size. This means that optimal size of mobile harbor is strongly impacted from port demand volume.

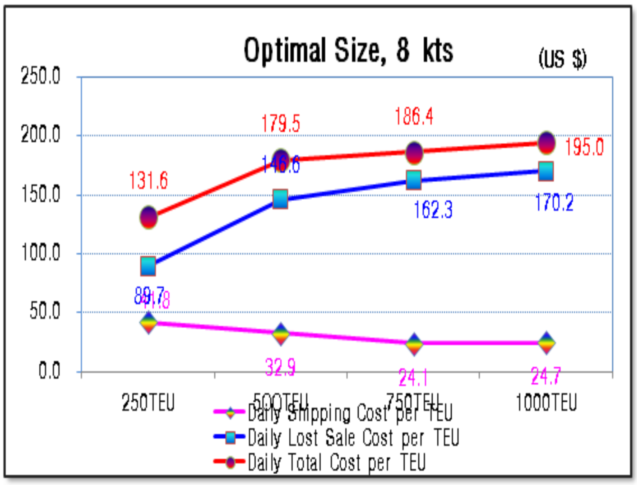


Fig. 7 Optimal size of MH in keeping 8 kts beyond 300 n.m. distance.

5. CONCLUSION

This paper's aim is to identify the optimal size of mobile harbor which is used for the tool of coastal shipping strategy. Due to a mobile harbor having limitation with low speed mobility, the scope of usage is assumed to be restricted on costal or river transportation. Within the coverage, total cost which consists of total shipping cost and oversized-capacity lost sale cost is to be estimated. As the designed specification of MH is 250TEU laden capacity, 8 knots speed, 30 van handling capacity per hour and 5 meter draft, the quantitative model and rout design on Korea costal area is to be developed for calculating total cost.

In a result, among alternatives of 250TEU, 500TEU, 750TEU and 1,000TEU, MH with 250TEU capacity is selected as the optimal size. In a sensitivity analysis with increase speed or distance, the speed variable only brings the push up of optimal size.

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References

[1] Adolf Baird, J. Richard Hodgson (2006). Short Sea Shipping on the East Coast of North America: An analysis of opportunities and issues, CanadaDalhousie University. Transportation Planning/Modal Integration Initiative Project ACG-TPMI-AH08 March.

[2] Adolf Baird (2005). Eu Motorways of the sea policy" at European conference on sustainable good s and passenger transport, Kriistiansand.

[3] Adolf Koi Yu Ng (2009). Competitiveness of short sea shipping and the role of port: the case of North Europe, The journal of Marit. Pol. MGMT Vol.36, No. 4, 337-352.

[4] Adolf Koi Yu Ng and Jeremy K. Y. Kee, 2008, The optimal ship size of container liner feeder services in southeast asia: a ship operator's perspective, Maritime Policy Management, vol. 35, No. 4 353-376

[5] Bojan Beskivnick, M.SC (2006), Importance of short sea shipping and sea motorways in the European and

Slovenian transport policy, Pomorstvo, god, 20, br 1str. 23-35.
[6] Branch, A.E., 2007, Elements of Shipping, 8th edn (Chelten: Stanley Thorenes)
[7] Containerisation International (2007), Year Book 2007.
[8] Drewry (2008). Annual Container Market Review and Forecast(2007/2008).
[9] Goksel Tenekecioglu (2004). Increasing Intermodal transportation in Europe through Realizing the Value of Short Sea Shipping.
[10] KAIST(2009), Inner Report of MH cost.
[11] KMI (2003). Economic Feasibility Study in Port Development, Research Report of KMI, p. 46.
[12] Mary R. Brooks (2009). Short sea developments in Europe: lessons for Canada, North America Centre for Transborder Studies in Arizona state university No. 10.
[13] Market Shares (2005). Maritime Economics & Logistics, Vol 7, No 4.
[14] Mconville, J., 1999, Economics of Maritime Transport: Theory and Practice (London: Withby)
[15] MOLM(2009), Inner Report of O-D volume.
[16] Ocean Shipping Consultants (2007). Container Port Strategy, Emerging issues.
[17] Ocean Shipping Consultants (2007), Marketing of Container Terminals.
[18] T. Notteboom (2006), The Time Factor in Liner Shipping Services", Maritime Economics & Logistics, 8, (19-39)
[19] Veldman, S. and Vroomen B.(2007). A model of container port competition: an application for the transhipment market of the Mediterranean, IAME Conference Athens.

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