Calculating the Unit Voyage Cost in Maritime Transportation: An Implementation Study

Sercan Erol

Abstract— Maritime transport includes intensive political risks, and it is classified according to factors such as speed, time, distance, cost, stability and type of cargo. Considering cargo types, maritime transport is divided into two sections which are liner shipping and tramp shipping. The cost concept in the tramp shipping – the type of shipping which mainly captures the world, especially in circumstances where competition is intense- is quite effective for ship management. The reason for the affordability of tramp shipping costs is that tramp vessels sail to the place of the cargo and the last cargo sets the next destination. Because the vessels in Tramp Shipping are sailing to the place of the cargo and the last cargo defines the next destination. This brings about an intense competition among tramp vessels. Therefore, ship owners should adopt a cost oriented management approach in terms of sustainability. In other words; the vessel should be appropriate for the cargo, and the cargo should be appropriate for the vessel. In this study, commercial transport capacity and unit voyage costs were calculated, by using the real values of a 61461 DWT bulk cargo vessel. Data set used in this study consists of official figures, which were taken from the operator company. As a result; under certain conditions, the commercial capacity of the vessel is calculated as 60448, 73 tones and the unit voyage costs are calculated as 17, 70 USD/ton.

Index Terms— Cost analyses, Maritime transportation, Voyage cost.

I. INTRODUCTION

Maritime transport is a kind of service which enables the cargoes and the people to translocate via ships and other vessels that navigate through lakes, rivers and seas in a way that provides them with the opportunity to save time [1]. Maritime transport can be classified according to various aspects. One of the most common classifications of maritime transport in terms of cargo types is liner shipping and tramp shipping. In liner shipping, goods are transported by means of high-capacity vessels that transit regular routes on fixed schedules [2]. However, cargo handling activities in maritime transport are mainly carried out by tramp shipping [1]. Unlike liner shipping, tramp shipping is a service that has no definite routing or fixed schedules and is available to carry general cargo to any destination among different ports [3]. In tramp trade, shipping companies cannot transport their vessels on fixed routes or schedules since there is an irregularity of time and line routes in tramp shipping. Therefore, cost structure of voyages in tramp trade can differ from one another. Accordingly, all the costs of a

voyage are calculated for that specific voyage and this procedure is repeated for each voyage which causes an increase in the workload [4][5]. This requires the accounting entries of each ship and voyage to be kept just like a different order [6].

Ship administrators who need to calculate the cost structure of each voyage separately decide whether to perform the freight operation according to the freight income of that specific voyage. It is one of the most important strategies of business administrations in sectors in a fierce competition environment to choose the cost-oriented method [7]. For this, it is necessary to have knowledge of the cost structure and constituents of the transport service sold.

The cost of an in service ship's transport service sold consists of operation costs, voyage costs and capital costs. Operation costs of the ship are salaries of the personnel, equipment, insurance, maintenance and repair, general costs, etc. Regarding voyage costs of the ship, we can mention bunker, maritime pilot, port fees, cargo handling, tugboat, etc. Lastly, capital costs of the ship are interest, amortization, commission costs, etc. [8][9].

In addition to the classification mentioned above, costs of transport service sold are divided into two groups considering their operating volume: fixed costs and variable costs. In order to be able to classify the costs according to the operating volume, the capacity measure fitting the industry must be available. In tramp trade, the most appropriate measure of the operating volume is voyage-day numbers. Within this context, capital costs, operation costs and administrative costs are fixed costs according to the capacity measure whereas voyage costs are accepted to be variable costs [1].

In this study, the unit voyage cost of a specific ship is calculated. The data set used in this study is taken from its shipping company and consists of real dates. However, company information and the name of the ship are adapted for commercial grounds.

The remainder of this paper is organized as follows. In section 2, information is given about the unit transport cost of the ship. In section 3, an implementation of calculating the unit voyage cost in maritime transport is done. Finally, we concluded by giving a summary of the implementation in Section 4.

II. UNIT VOYAGE COST IN MARITIME TRANSPORTATION

Voyage costs involve the ship's bunker costs, primage, strait and canal tolls as well as cargo handling costs, towboat, pilotage and port fees and all the other expenses. These costs may undergo changes according to the route of the tramp vessel and the characteristic structure of the ports to be called. Voyage

Sercan Erol Author is with the Karadeniz Technical University Department of Maritime Transportation and Management Engineering, 61600 Turkey (e-mail: sercerol@ ktu.edu.tr).

costs that are accepted to be working expenditures are explained one by one below.

Strait and canal tolls: They consist of the national and international strait tolls and canal tolls (e.g. the Suez Canal and the Panama Canal). These pass fees are dependent upon the ship's route and are calculated based upon the ship's tonnage.

Port charges: They contain handling fees, wharfage and expenses paid for all the services provided by the port such as port operations. In addition to the fees of the services that the port authority provided, there are also port charges required by the public authority [1].

The structure and amount of port charges change from port to port according to the characteristic features of the port itself. For example, port expenses, the substructure of the port, servicing, berthing and wharfage fees and working hours are some factors that determine the characteristics of the port [10][11]. This is called the custom of the port and according to the custom of the port, port fees are calculated by the pricing policy of port authority depending upon the load weight or space, the time to be spent at the port and the ship's tonnage (GRT or net tonnage) [9]. Cargo handling fees are determined according to the tonnage, time and value of the cargo but pilotage dues, towage and wharfage are in relation with time [11].

Bunker costs: They contain all the expenses done for fuel and bunker that the ship consumes during the voyage and in port. Bunker costs are dependent on bunker consumption, bunker price and bunker type. Bunkers used in modern ships can be listed as marine diesel-oil (MDO), marine gas-oil (MGO), heavy fuel oil (HFO) and international fuel-oil (IFO) [12]. As to bunker consumption, it is in direct proportion to machine output and is affected by the ship's type, size, speed, loading condition and working hours as well as oceanographic factors such as topography, distance and water depth and weather conditions [13] [14]. Bunker prices also vary according to criteria such as oil prices, bunker consumption and refueling stop [1][12]. Although bunker can be taken on from almost every port in the world, world bunker market is centered in three important regions. The regions mentioned here are the Ports of Rotterdam, Singapore and Houston [15]. In consideration of the explanations above, voyage cost can be formulated as Formula 1 [1][16]

$$Voyage\ Cost = f(S \times L \times O + WF + BC + T + TP + \varepsilon) \quad (1)$$

S : Ship Size
L : Loading factor (%)
O : Cargo handling cost
WF : Wharfage
BC : Bunker cost,
T : Pass fee
TP : Pilotage fee
ε : Other

Voyage costs which are known to be variable costs are directly proportionate to the ship's voyage duration. In other words, the voyage costs increase as the voyage time is extended. Accordingly, in order to be able to calculate the voyage costs, the knowledge of the voyage duration of the specific ship needs to be reached. In tramp shipping, the voyage duration is the sum of the time the ship spends to go to the port to be loaded, the time it spends in the port of lading and to the port of destination as well as the time it spends in the port of destination. Within this framework, voyage duration can be formulated as shown in Formulas 2 and 3 below [1].

$$E_q^t = E_q^b + E_q^l + E_q^p + E_q^a \quad (2)$$

$$E_q^t = \frac{L_b}{V_{qb} \times 24_{saat}} + \frac{L_l}{V_{ql} \times 24_{saat}} + E_q^p + E_q^a \quad (3)$$

E_q^t : q Total voyage duration
E_q^p : Cargo handling duration
E_q^b : Voyage duration with ballast
E_q^l : Voyage duration with laden
L_b : Cruising range to go to the port of lading to be loaded
L_l : Cruising range between the port of lading and the port of discharge
V_{ql} : Speed when the ship is loaded

On the other hand, when calculating the unit voyage cost, different calculating systems are used in terms of transportation model, type of chartering and accounting systems. As a cost unit of voyages, measures like 1 ton/mile cost, the ship's daily operation cost, cost per tonnage, cost of 1 ton/mile per voyage and 1 voyage cost of the ship are used [6]. The formula of unit voyage cost is shown in Formula 4 below.

$$Unit\ voyage\ cost = \frac{Voyage\ cost}{Q} \quad (4)$$

Q = Freight weight/ton carried in the specific voyage.

III. An Implementation Study

The 61461 deadweight vessel named M/V Asaf belonging to Poyraz Shipping Company departed from the port of Trabzon to take the cargo from the port of Yuzhny, Ukraine and to unload it in the port of Bandar Imam Khomeini (BIK), Persia.

The ship spent 5 days in the port of Yuzhny for loading operations. The loaded ship started to navigate towards the port of discharge. The ship passed through the Turkish straits and sailed across the Aegean Sea to the south coast of the Mediterranean Sea and reached the Suez Canal. After passing through the Suez Canal, the ship navigated through the Gulf of Aden and the Persian Gulf and reached to BIK, the port of discharge. The time it spent at the port of discharge for disembarkation operations is 6 days. The ship's voyage legs can be seen in Figure 1 below.

Figure 1. Voyage legs of M/V Asaf [17] Figure 1. Voyage legs of M/V Asaf [17] Figure 1. Voyage legs of M/V Asaf [17].
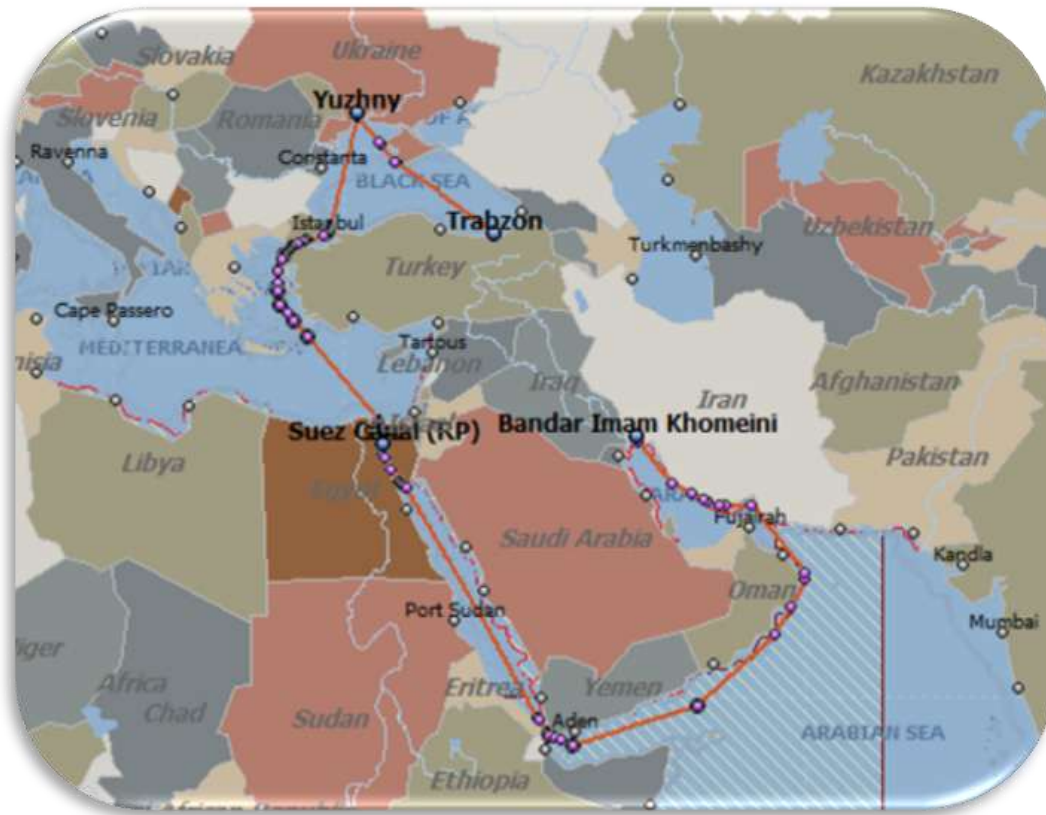
Fig. 1. Voyage legs of M/V Asaf [17]

The economic speed of the loaded ship in ballast is 13 kt's and Figure 2 gives the data including the distance and running time of the ship in the destinations.

As seen in Figure 2, the total turnaround cycle of the ship is 16, 07 days. The sum of the voyage duration is obtained by adding the time the ship spends in the ports to the time it spends under way. On this basis, the ship totally spent 11 days in the ports; 5 days in the port of lading and 6 days in the port of discharge. So, the total turnaround cycle of the ship is 27, 07 days. The calculation of the ship's turnaround cycle is made below.

Shipping turnaround cycle $_{day} =$

$$= E_q^t = \frac{L_b}{V_{qb} \times 24_{saat}} + \frac{L_l}{V_{ql} \times 24_{saat}} + E_q^p + E_q^a$$

$= 16, 07 + 5 + 6$

$= 27, 06$

After calculating the total turnaround cycle of the ship, we can display the calculation of the ship's voyage costs in Table 1

No	Port Name or Coordinates	Distance TTL	(S)ECA	Weather	Speed	Sea	Port	Port Charge	Arrival	Departure
	Create Voyage To Estimator				5.014 NM	16,07 days	Speed : 13,0 kt's	Simple Estimation		
1	Trabzon (TR) [+02:00]						0,00	0,00	12.3.2015 13:13	12.3.2015 13:13
2	Yuzhny (UA) [+02:00]	522	0	0 %	13,00	1,67	0,00	0,00	14.3.2015 05:24	14.3.2015 05:24
3	Suez Canal (RP) [+02:00]	1.232	0	0 %	13,00	3,95	0,00	0,00	18.3.2015 04:11	18.3.2015 04:11
4	Bandar Imam Khomeini (IR) [+03:30]	3.259	0	0 %	13,00	10,45	0,00	0,00	28.3.2015 16:25	28.3.2015 16:25
5										
6										
	Total	5.014	0 NM			16,07	0,00	0,00	12.3.2015 13:13	28.3.2015 16:25
							Port Local	PC Time	Port Local Time	

Fig. 2. Running time of the ship and port distances [17]

TABLE 1. VOYAGE COSTS

Voyage Costs								
Vessel M/V Asaf Spd 13 Distance 312				**Daily Bunker Expense**				
				Loading		**Work**	**Idle**	
				Factor	IFO	MDO	IFO	MDO
Cargo Maize				Laden	26	1,5	-	1,5
				Ballast	22	1,5		
Port Rotation			Distance	Days	IFO	MDO		
Ballast	Trabzon (TR)-Yuzhny (UA)		552	1,67	36,74	2,50		
Loading	Yuzhny (UA)			5		7,50		
Sail	Yuzhny (UA)-Suez Canal (RP)		1.232	3,95	102,7	5,92		
Sail	Suez Canal (RP)- Bandar Imam Khomeini (IR)		3.259	10,45	271,7	15.67		
Discharging	Bandar Imam Khomeini (IR)			6		9		
		Total	5013	27,07	411,14	31,59		
Bunker Expense					333.554,42 USD			
IFO	Quantity	Port	Price	Expense				
	411,14	Yuzhny	730,00 USD	300.132,20 USD				
MDO	31,59	Yuzhny	1.058,00 USD	33.422,22 USD				
Other Expense					73.6916,22 USD			
	Loading Port L/D			178.000,00 USD				
	Discharge Port D/A			52.000.00 USD				
	Suez Canal D/A			188.461,00 USD				
	Suez Canal D/A			221.282,00 USD				
	Commission			20.023,44 USD				
	Loading Port Dispatch			60.763,89 USD				
	Discharge Port Dispatch			16.388,89 USD				
Total Voyage Cost					1.070.473,64 USD			

As seen in Table 1, the ship's daily bunker expense is 26 tons (IFO) when it is loaded. However, the ship's daily bunker expense is 23 tons (IFO) when it is in ballast. Besides, the ship's daily discharge of MDO which is used for auxiliary engines is 1, 5 tons. The data related to the bunker consumption is obtained from the ship's bunker tracking form. The ship fuelled up for the voyage in the port of Yuzhny. The bunker price is 730, 00 USD/ton for IFO and 1.058,00 USD for MDO. Within the light of this information, the bunker costs of the ship are calculated as follows.

$$Bunker\ cost = BC = f(BP, B_{comp.}, BT)$$
$$BC = BP \times B_{comp.}$$
$$BC = 333.554,42\ USD$$

BP : Bunker Price
$B_{comp.}$: Bunker Consumption
BT : Bunker Type

Furthermore, the sum of the ship's cargo handling costs, canal pass fees and other expenses in the voyage is 73.6916,22 USD. As such, the grand total of voyage costs reached 1.070.473, 64 USD as seen in Table 1.

After calculating the total sum of the ship's voyage costs, the first thing to do is to calculate the load weight of the ship in order to be able to estimate the unit voyage cost. If the ship is loaded in full capacity, we need to calculate the ship's commercial capacity. The calculation of commercial capacity is made by using Formula 5 below [18]:

$$Commercial\ capacity\ (CC) = DWT - (Running\ time \times$$
$$daily\ bunker\ and\ water\ consumption +$$
$$Reserve) \tag{5}$$

$$CC = 61461 - [16,07 \times (26) + 16,07 \times (1,5) + 16,07 \times (5) + 490]$$
$$= 60448,73\ tons$$

Accordingly, the calculation of the commercial capacity of M/V Asaf dry bulk carrier is shown in Table 2.

TABLE 2. THE CALCULATION OF THE COMMERCIAL CAPACITY OF M/V ASAF

Commercial Capacity				
Loading Dock				=60448,73 tons
Dwt				=61461 tons
Consumption	IFO full	26 ton/day	16,07 days	=417,82 tons
	MDO	1,5 ton/day	16,07 days	=24,10 tons
	Water	5 ton/day	16,07 days	=80,35 tons
Reserve	Bunker			=420 tons
	Water			=70 tons

According to the calculation of the commercial capacity, if the vessel M/V Asaf which has a capacity of 61461 dwt is fully loaded, its commercial capacity will be 60448, 73 tons. Within this framework, the unit cost of the ship's given voyage is calculated as 17, 70 USD/ton. The calculation is given below.

$$Voyage\ cost\ per\ ton = OM = \frac{Voyage\ cost}{Q}$$

$$OM = \frac{1.070.473,64\ USD}{60448,73\ ton} = 17,70\ USD/ton$$

IV. Conclusion

1) Tramp trade is governed by free market conditions and freight rates in tramp shipping are determined by supply and demand. Because of this, we can see ever-changing fluctuations in freight rates. These changes in freight rates may disrupt the cash flow and balance of payments of the companies. Therefore, cost-oriented decisions are the most remarkable strategies of today's competitive markets. In this study, the unit voyage cost of a ship which is in tramp shipping service is calculated. As a result of the calculations made, the commercial capacity of the vessel (loaded to its full capacity) have been calculated as 60448, 73 tones, and the unit voyage costs have been calculated as 17, 70 USD/ton. However, it is not possible to decide on transporting operations just by considering voyage costs. In order to properly decide the transport operations, it is necessary to calculate the total sum of the prime cost of transport service. In this case, in addition to the calculations made, it is necessary to calculate the prime cost of unit transport service by considering operation and capital costs as well. It will be possible to reveal the profit-loss account of the transport operation after the cost of the operation is calculated pursuant to the charter contract signed up for the relevant voyage. By this means, it will be possible to make the right decision whether to carry out the voyage by evaluating the costs before the voyage starts. Because, it should be noted that, in order for the voyage to take place in tramp trade, the ship needs to be suitable for the cargo and the cargo needs to be suitable for the ship.

Acknowledgment

References

[1] Erol, S. "Denizyolu Taşıma Maliyetlerinin Finansmanında Türev Ürünlerin Kullanımına Yönelik Bir Uygulama", Doktora Tezi, Erzurum: Atatürk Üniversitesi Sosyal Bilimler Enstitüsü, 2013.

[2] Wang, S. and Meng, Q, "Sailing Speed Optimization for Container Ships in a Liner Shipping Network". *Transportation Research, Part E*, 48, 701-714, 2012.

[3] Trivedi, S. M., "An Analysıs of Fınancıal Performance of State Road Transport Corporatıon in Gujarat". (Published Ph.D. Thesis). Rajkot: Saurashtra Unıversıty, 2010.

[4] [Altuğ, O., "Deniz Taşıt İşletmelerinde Maliyetler ve Maliyetlerin Yönetim Yönünden İncelenmesi". İstanbul: Marmara Üniversitesi Sosyal Bilimler Enstitüsü, 1974.

[5] [5] Çakı, S., "Deniz Ulaştırma İşletmelerinde Maliyetler ve Maliyet Sisteminin Kurulması", (Ed. A. G. Cerit, H. Kişi, H.F. Yercan, A.Ö. Dedeoğlu) *Çağdaş Denizcilik Stratejileri İşletme Yönetimi Yaklaşımı..* İzmir: Dokuz Eylül Yayınları:, 175-186, 1998.

[6] [6] Özdemir, Ö., "*Denizyolu Yük Taşımacılığında Maliyetler ve Bir Uygulama*". Doktora Tezi. İstanbul: İstanbul Üniversitesi Sosyal Bilimler Enstitüsü, 2009.

[7] [7] Karcıoğlu, R., "*Stratejik Maliyet Yönetimi*". Erzurum: Aktif Yayınevi, 2000.

[8] [8] Drewry, "*Ship Operating Costs Annual Review and Forecast-2007/08*". London: Drewry Shipping Consultants Ltd., 2007.

[9] [9] Stopford, M., "*Maritime Economics*". London and New York: Routledge. 2009.

[10] Spring, L., "The *Cost of Nontariff Barriers to Trade in Shipping*, Constantino Stylianos Halkias Substantial Research Paper. Access date: 27.03.2012, http://www1.american.edu/ted/projects/halkias.htm#_ftn2

[11] Hsu, C.I. and Hsieh, Y.P., "Shipping Economic Analaysis for Ultra Large Containership". *Journal of the Eastern Asia Society for Transportation Studies*, 6, 936-951, 2005.

[12] Erol, S. and Baştürk, S., Latterly Marine Fuel Problem, "Cat Fines", International Conferance Innovative Challenges of Maritime Industry, Preceeding Book, 107-108, 2015.

[13] Hellström, T. "Optimal Pitch, Speed and Fuel Control at Sea" *Journal of Marine Science and Technology,* 12(2), 71-77, 2004.

[14] Wong, H.L., Hsıeh, S. H. and Wang, C. C. "Optimizing Containership Size and Speed: Model Formulation and Implementation". *WSEAS Transactıons on Busıness and Economıcs,* 4 (7), 111-116, 2007.

[15] [15] Alizadeh, A. H. ve Nomikos, N. K. (2009). *Shipping Derivatives and Risk Management.* London: Faculty of Finance, Cass Business School, City University.

[16] Erol, S., "The Impact of Distance and Narrow Waterway on Voyage Cost: Cost Formulation and Implementation on a Dry Bulk Carrier", Journal of ETA Maritime Science, 4(1): 49-59, 2016.

[17] Netpas Distance 3.3, 2016, https://www.netpas.net/auth/loginAndCreateId?ref=/pages/download.

[18] Pocuca, M. and Zanne, M., "The Impact of Global Economic Crisis on the Dry Bulk Shipping Industry". *Pomorstvo*, 23 (2) 477-493, 2009.

Sercan EROL was born in Trabzon, 1983. Mr. Erol a lecturer in the Sürmene Faculty of Marine Science, Department of Maritime Transportation And Management Engineering Karadeniz Technical University (KTU), Trabzon, Turkey. His main research fields are maritime economics and finance, maritime law and insurance. He published scientific articles about those fields. He teaches maritime economics, maritime law, maritime insurance and technical management and leadership, safety at sea. His research focuses on maritime transportation and commerce sector