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THE RELATIONSHIP BETWEEN TECHNICAL AND ECONOMIC VARIABLES IN MARITIME TRANSPORT

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Abstract:*The current paper deals with the relationship between a vessel optimal speed and its profit in maritime transport, based on a model. The two variables are determined in turn by a series of other influential factors which are being presented in a systemic framework. The study of this relationship is especially important in terms of the planning of a vessel's voyage, which allows to assess the profits based on the evolutions of the respective freight and costs on different transport routes.*
Key words: *freight, Charter Party contract; bill of lading; bunkering; running cost*

INTRODUCTION

The main objective of maritime transport and trade is to ensure the regular circuit of goods nationally and internationally in safety, on time with economic efficiency and in accordance with the conventions, laws and contractual terms in force. Transport stands for an essential element of life, as it gives people the opportunity to understand, perceive and assimilate easily from what human civilisation and culture offer.

The existence and improvement of means of transport allowed the contact between different countries and peoples which has led to humankind economic, political and cultural life.

Transportation contributes to bridge geographic areas, the development of economic branches, the territorial distribution of production and sale.

The level of transport development determines directly the social division of labour which in turn leads to specialisation as well as to the growth of accessibility to natural riches and the products of human labour.

Economic literature highlights the following characteristics of goods and people transportation:

- It is defined as a continuation of the productive processes in the sphere of circulation, so it's an additional production process, mediated by the movement of goods and people. So transport is an intermediate consumption compared to the final consumption at destination;
- Specific to transport processes is the movement in space of goods and people which is carried out by way of special means of transport (means of transport and infrastructure);
- In transport, there are not material goods but services, which add a new value to goods;
- Specific to maritime transport is that the production of the usage value corresponds in time and space with its consumption; therefore, the proceeds of the transport service add to the value of the goods transported as additional value.
- In order to ensure the irregular demand for transport, it is necessary to ensure supplies of means of transport; this aspect requires the achievement of some feasibility studies;
- Transportation is a big space consumer, which determines an influence of the infrastructure on the socio-economic geography.

From the analysis of data provided by UNCTAD, there appears the trend of decline in the share of transportation in world trade services as a result of:

-the diversification of services types;
-change of structure of human needs;
-information conversion to goods and the explosive development of information.

However, due to the structure of the world economy, shipments cannot objectively descend below a certain threshold, which maintains its important role within it.

The basic elements indispensable for the achievement of the basic objective of shipping are:

- vessels as means of maritime transport of goods;
-goods as object of maritime transport;
-ports as junction points for transhipment, storage of goods;
- the specific economic and juridical framework, nationally and internationally.

The interdisciplinary approach of these elements requires a wider space. For this reason, we will focus in this paper only on the first element presented, namely - "ships -means of maritime transport of goods".

The developments, conditions and specific characteristics of modern maritime transport have caused and are decisive in the conception and development of vessels' construction and equipment as means of maritime transport.

We have to point out that modern shipping has a number of features:

-volume and wide range of goods;
-long distance to travel;
-variation in climatic and hydrometeorology conditions;
-vessels' confrontation with the dangers and risks of the sea;
-relatively long duration of journeys;
-high volume of investments;
-profit based on freight fluctuations in various maritime markets.

These features require at least two categories of requirements:

a) technical and constructive conditions;
b) technical and economic conditions.

a) Technical and constructive conditions - are meant to ensure ship's resistance to sea demands for the navigation area corresponding to its class and established by class certificate. Generally, the ship's design ensures their achievement. Compliance with technical and economic conditions ensures the safety of both the ship and the crew.

From this perspective, ergonomics may become a valuable instrument in this process. Together with other conditions regarding the recruitment of the crew and its proper professional qualification, by means of logistics, the so-called seaworthiness is being achieved, personal liability of the ship-owner and default condition for the vessel prior to the beginning of the voyage. In order to achieve proper seaworthiness, a series of laws in the field have been enforced.

b) Technical and economic conditions – refer to the body of constructive qualities and operating characteristics in terms of performance, which should ensure the economic efficiency of each vessel, shipping company, and of the whole fleet.

The achievement of these conditions is especially determined by the following elements:

- achieving adequate spaces, proper arrangements and units for goods' stowage, protection and handling according to ships' type and destination;
- achieving a deadweight coefficient and high economic speed to ensure that the ship may carry out a large number of transport cycles;
- reducing consumption and operating costs;
- the growth of investments effectiveness by increasing the ratio between the operating time of fixed assets and the time of return on investment.

The development of ships and ports is determined by cargo by means of the following factors:

-the physical state;

-the quantity and regularity of different transport relations;
-the quality, diversity, handling and stacking characteristics;
-freight rates.
A special mention should be made regarding freight. Thus, ship owners in the capacity of economic agents naturally seek economic rationality in order to maximize their profits.
Based on this objective, managers can apply depending on the context, one of the three principles, with the following results:

The principle of the maximum economic -	The increase of transport demand and consequently of freight leads to higher incomes with the given transport capacities.
The principle of the minimum economic -	In the case of decrease of transport demand and implicitly of freight, it is necessary to reduce shipping costs by adequately using shipping capacities, which are at a disadvantage as regards their sale possibilities.
The principle of the mini-maximum economic -	It involves the achievement of maximum income by reducing shipping costs.

The adoption of any of these principles is determined by the context in which the respective activity is being carried out. In either case, the economic entity, the owner will seek to avoid any waste of resources.
Freight represents the amount due to the owner, which he receives from the beneficiary of the shipping in return for transporting goods by sea and their deliver to destination in good condition, as described in the shipping contract.
The shipping contract may be of several types. Activities in this field are at least of two types:
a. Charter Party;
b. Shipping contract proved through Bill of lading.

a) Charter Party - in Latin Charta Partia - split document, has as objective to place usually the entire ship at the charterer's disposal, as a tramp vessel;
b) The shipping contract proved through Bill of lading - document that represents the proof of the shipping contract and has as objective to place a part or the entire ship at the charterer's disposal, generally as a line vessel.
Functions:
1. the proof of the shipping contract
2. the proof of receiving the goods on board in order to be carried;
3. the function of representative title - represents the loaded goods.
Freight rate - the price of the shipping done by the owner, set according to:
- weight unit;
- volume unit;
- per parcel.
The quotation may be given based on the above classification either per dwt, tonne capacity, tonne freight, or ad-valorem. Freight rate may be estimated in two ways, according to the type of activity:
a) For 'tramp' transport:
- freight rate is calculated for each voyage, without consulting the freighter;
- the ship owner seeks those shipping demands which are profitable at the time being;
- long term hire is preferred only if an increase or stability of the freight market is being anticipate by means of a traffic study.
b) For line vessels transport - freight rate is decided by determining the flow of goods from voyage to voyage and assessing the costs.
The leverage factors that determine the freight rates are: competition between ship owners; the rivalry between ports; competition between geographical areas; competition between the charterers; the stowage factor; the flow of goods (it must be ensured the opportunity to obtain transport cargo for the return trip); oversized rates; currency stability - the adjustment factor that can be changed as often as necessary for maintaining the ship's income whenever the need arises.
The presentation of these elements allows us to capture within a case study the relationship between the technical and constructive characteristics of the vessels and their economic performance.

THE RELATIONSHIP BETWEEN THE TECHNICAL AND CONSTRUCTIVE CHARACTERISTICS OF THE VESSELS AND THEIR ECONOMIC PERFORMANCE

In this chapter we intend to analyze the following aspects:
a) determine the vessel's optimum speed;
b) determine the daily turnover (DT) according to the optimum speed, the daily total cost (DTC), the maximum gross profit (GP), respectively the daily turnover.

Let us analyse each of them:
a) Determining the vessel's optimum speed - the optimum speed of the vessel is determined by the following factors:

- The bunkering price of the fuel/tonne;
- Freight amount set by the market;
- The duration of the voyage.

For vessels that stay at anchor just for a few hours (containers, RO-RO, Lash, tanks), the optimum speed, measured in knots, can be determined with the help of the following formula:

$$Vopt = \sqrt{\frac{8 \times Q \times Nv}{K_c \times D}}$$

where:
Q - the quantity of carried goods; D - distance; NV – freight rate;
Kc – consumption coefficient, determined with the formula: $\mathrm{Kc} = \frac{\mathrm{Cznom} \times \mathrm{Pbunk/t}}{\mathrm{V}_{\mathrm{nom}}^3}$

In the above formula, the following symbols have been used:
C_{znom} - daily nominal consumption;
$P_{bunk/t}$ –bunkering price per tonne;
V_{nom} - the vessel's nominal speed.

b) Determining the daily turnover (DT) according to the optimum speed, the daily total cost (DTC), the maximum gross profit (GP), respectively the daily turnover.

$$\mathrm{CAZ} = \frac{\mathrm{Q} \times \mathrm{Nv}}{\frac{\mathrm{D}}{\mathrm{Vopt} \times 24}};$$

$$\mathrm{CTZ} = \mathrm{C_k} + \mathrm{Ccomb};$$

$$\mathrm{PB} = \frac{\mathrm{Q} \times \mathrm{Nv}}{\frac{\mathrm{D}}{\mathrm{Vopt} \times 24}} - \mathrm{CTZ} \quad \text{where:}$$

Costs are made up of:

- ***C_k - running cost*** – costs that appear only when the vessel operates and are made up of: crew expenses: salaries, pensions, tuition costs, locations, insurance; protection against complaints, compensation for losses caused by strikes, galley, maintenance of the hull, PSI equipment, and lifesaving equipments; expenses for expandable goods for cleaning; spare parts; expenses for food and antidote; repairs and maintenance to keep the class of the ship; administration, request for supervision, managerial staff or agents.

- **Fuel expenses *Ccomb*** are generated by the formula: $\mathrm{Ccomb} = \mathrm{Kc} \times \mathrm{V}_{\mathrm{opt}}^3$ where Kc – is known

Example:
A vessel of 30.000 dtw has a cargo on board of Q = 25.000 tonnes it carries on a route with the distance D = 10.000 Mm. The dayly consumption corresponding to a nominal speed of Vnom = 17 Nd is of C_{znom} = 19 tonnes/day.

The bunkering price per tonne is Pbunk/t = 260 dollars per tonne. Freight rate is Nv = 14 dollars per tonne. Running cost is Ck = 7,000 dollars/day. Stay time in ports is unimportant.

It is required:
a) the calculation of the vessel's optimum speed.

The consumption coefficient is:

$$Kc = \frac{19 \times 260}{17^3} \approx 1{,}0055$$

Optimal speed is:

$$Vopt = \sqrt{\frac{8 \times 25.000 \times 14}{1{,}0055 \times 10.000}} \approx 16{,}70 \text{ Nd}$$

The daily turnover, total daily costs and daily gross profit

$$CAZ = \frac{25.000 \times 14}{\frac{10.000}{17 \times 24}} = 14.017 \text{ dol/zi}$$

Ck-7000dollars/day;

$$Ccomb = 1{,}005 \times 17^3 = 1{,}005 \times 4.913 = 4937{,}565$$

Total daily costs are:

CTZ=7.000 +4937, 565=11.937,565

$$PB = \frac{25.000 \times 14}{\frac{10.000}{17 \times 24}} - 11.937{,}565 = 2345 \text{ dol/zi}$$

Profit sensitivity and its related components to different speeds situated outside the zone close to optimal speed are shown in the following table:

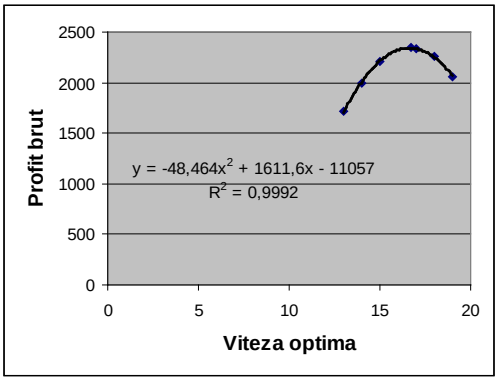
Table 1. Profit values for different values of the vessel's speed

V_{nom}	V_{opt}	CAZ	V_{nom}	CTZ		PBZ
				Ck/zi	C_{comb}/zi	
17	13,00	10.920	7.000	7.000	2.209	1.711
17	14,00	11.760	7.000	7.000	2.759	2.001
17	15,00	12.600	7.000	7.000	3.394	2.206
17	16,69	14.017	7.000	7.000	4.672	2.345
17	17,00	14.280	7.000	7.000	4.940	2.340
17	18,00	15.120	7.000	7.000	5.864	2.256
17	19,00	15.960	7.000	7.000	6.897	2.063
17	13,00	10.920	7.000	7.000	2.209	1.711
17	14,00	11.760	7.000	7.000	2.759	2.001

Calculations highlight the fact that the profit according to different speeds considered optimal varies as shown in figure below.

Gross profit variation depending on the speed of the ship can be highlighted with the help of a formula that may be determined by using the Excel program.

Fig. 1 The function which allows the estimation of the evolution trend of gross profits according to the vessel's nominal speed



The function determined has a small degree of approximation, highlighted by the value of the average square error R = 0,9992 and therefore allows to detect the relationship between optimal speed and obtained profit.

Considering vessels' stay (Ts) and port costs, freight rates can be determined from the following equality:

$$Kc \times V_{opt}^2 \times (16 \times V_{opt} \times Ts + D) = 8 \times Q \times Nv$$

$$Nv = \frac{Kc \times V_{opt}^2 \times (16 \times Ts \times V_{opt} + D)}{8 \times Q}$$

Considering the stay time Ts = 3 days according to the above data, freight rate has the following value:

$$Nv = \frac{1{,}0055 \times 278{,}89 \times (16 \times 3 \times 16{,}7 + 10.000)}{8 \times 25.000} =$$

$$= \frac{3.029.026{,}744}{200.000} = 15{,}145 \text{ u.m.}$$

Similarly, formulate for different values of stay time can be estimated, considering all the other constant variables.

Conclusions

Ship owners, on the basis of the practice, produce tables with costs and revenues estimates according to the evolution of freight for different routes and by considering restrictions such as external environment (hydro meteorological conditions, socio-political developments in the area, etc.).

Basically, it seeks to maximize profit, taking into account internal and external factors of restriction.

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