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PRE-INVESTMENT STUDIES IN SHIPPING

SUMMARY

In this paper different aspects of pre-investment studies in shipping in view of uncertainty of the shipping market and developing complexity of transportation systems are presented. Several methods and techniques of investment appraisal adapted to shipping are critically highlighted and various computer simulation models of transportation systems, especially of modern container-based ones, are discussed.

The shipping industry is in relation to other modes of transport characterized by a large degree of risk and uncertainty with its capital-intensive process of production of transportation services.

The rational selection of the ship size as measured by cargo capacity and the economically justified ship speed should be adapted to the demands of a given shipping market (range), taking into account the growing competition and technical progress.

The present shipping investments are not only very costly, having in mind the level of costs and prices of the new generation vessels, but also the demands of technical progress are giving them a shorter useful life (pay back period) than it was the case in the past.

If a designer in a shipyard design unit wants to demonstrate to the ship operator the economic feasibility of an unconventional design, a description of the risks and uncertainties involved is at least as important as cost information.

Future cost and profits can seldom be predicted exactly. This does not matter if the expected scatter is small. But when the scatter is relatively large, neglecting the influence of the risk involved might lead to wrong decisions. When analysing the present value of future ship's costs and revenues, the following combination of circumstances may be taken into account:

1. Determinate case where the future amount and the time of its occurrence are determined.
2. Random amount, determinate time, where the future amount cannot be precisely predicted. In such case the assumption of the distribution (distribution function, distribution density) of the future amount might serve much better than the use of any particular amount such as medium value.
3. Determinate amount, random time where in some situations there exists a possibility of estimating the future amount but without having any idea of when it may occur.
4. Random time and amount, where it is not known when an expense will occur or how costly it will be for a given time.

This same example could serve in the case of an estimate of the present value of multiple future amounts and the required freight rate.

In the last example the determinate case of a required freight rate is the revenue per unit of cargo that the ship operator must collect in order to secure sufficient revenue to repay his investment and cover the interest on the invested capital. Having in mind the present and expected situation in seaborne trade and shipping, where the annual returns vary from year to year, trial and error procedures are needed to find the rate giving a cumulative present value of all future returns equal to the sum invested.

There are many different methods and techniques of investment appraisal adapted to shipping. All of them have been expected to answer the basic question in the field of investment of whether the differences between the costs and revenues over the life of the vessel are sufficiently large to justify the risk of the expenditures involved in that kind of capital intensive and risky commercial activity.

According to UNCTAD, the following methods are very effective in specific cases:

1. The pay-back period, estimating the maximum length of time that the shipping company's capital will be outstanding in the project of this kind.

2. The average rate of return, comparing in the form of a ratio the average of the annual differences between receipts and costs with the costs of investment.
3. The internal rate of return, presented as a rate of discount equating the present value of the earnings with the cost of the asset.
4. The net present value calculating the sum of the discounted annual earnings over the working life of the asset, the discount factor employed the cost of finance to the enterprise [1].

In other words, the net present value is the difference between the capital cost of an asset and the present value of the flow of receipts, expected over the life of the asset discounted at a defined per cent.

Unfortunately, the aforementioned economic criterion (methods of investment appraisal) turned out to have a serious flaw in this particular application. It was found that any major change in the trend, as for instance of predicted cargo availability, would produce a marked change in the overall rate of return.

This implied a change in the attainable time-value of money, which in turn altered the relative values of future returns. The selection of optimality thus became distorted simply because the derived level of profitability varied to unrealistic extremes. In short, the measuring device was influencing that which was to be measured.

There are many proposals in connection with the implementation of various alternative measures of merit. According to Benford, the best of an imperfect lot could be the method of Required Freight Rate (RFR) [2].

RFR is a freight rate a shipowner would have to charge if he wanted to earn a reasonable profit, after taxes of about 10 per cent on his investment.

The Required Freight Rate is derived from an equation

$$RFR = \frac{\text{investment + present worth of operating costs}}{\text{present worth of cargo transported in tonnes}}$$

The optimal ship is defined as the one that has the lowest RFR; and to keep the calculation under control, a constant freight rate for life of the ship was assumed. Analysis is being undertaken by the author for a typical cargo forecast for a liner of the seasonal fluctuation of cargo which differs greatly between the two legs of a round trip. Furthermore, the average freight rate per tonne of cargo may vary appreciably between inbound and outbound voyages. Under these circumstances, the optimal size of a vessel must fall between two extremes which can be found only by analysing the potential economics of several arbitrary designs representing the continuum of all intermediate sizes. There are also many other factors influencing the optimal size of a vessel, such as length of voyage, port turn-round time, fuel costs, bunkering schedule and so on.

The Benford computational procedure had been used to calculate, on the basis of a 20 year vessel life, the optimum size of vessel based on input: arbitrary displacement, available cargo, ship weight, building costs, annual operating costs, cargo carried per year, fuel cost corrected for partial displacement comparing the ship's capacity with cargo availability, future amounts discounted to present time. While the presented procedure is theoretically interesting, its practical application is limited to one factor which is the optimal size of the vessel.

When analysing, at the Maritime Institute in Gdańsk, the problem of an optimum vessel for a given shipping range (shipping line), two basic ship parameters - size (cargo loading capacity) and speed - have been simultaneously taken into consideration [3].

Special attention has been paid to the selection of the optimum speed of the ship, affecting its cargo carrying capacity, costs and global revenue. Economic analysis establishing the optimum ship shows that there are three factors in functional relation: deadweight (size), speed and service output efficiency. Based on this relation, there are several design variations for ships as regards speed and deadweight at different ranges. The United Nations Convention on International Multimodal Transport of Goods 1980 established a new legal regime for carriage of goods by at least two different modes of transport. Following the demands of the developing countries and suggestions of UNCTAD's Shipping Division, the Gdańsk Maritime Institute has expanded the scope of pre-investment studies to include computer models for a multimodal system [4]. Construction of simulation models is based on investigation of the object modelled as a digital system. In the case of a shipping line the simulation model is used mainly for the evaluation of the system stability, i.e. dependence of line operation results on the dynamic variability of transport conditions and prices of the production factors as well as random perturbations of basic transport conditions. It is thus possible to evaluate the scale of risk that the financial result of the investment will not be as planned or, in other words, to evaluate the degree to which one may be sure that results expected will be obtained. In practice such a model may be applied where:

1. Significant changes of conditions in the period of operation of the objects designed are expected.
2. Production conditions are not stable and are subject to the influence of random factors.
3. Some qualities describing these conditions cannot be regarded as certain or where it is possible to calculate a definite degree of risk.

It has been assumed that the calculation models should cover that part of the general system of goods transport from manufacturer to consumer which depends on decisions made by the shipowner.

As a result of the introduction of modern container-based transport systems, this scope extends significantly beyond that typical of classic shipping. It may also depend on the system type and hinterland conditions of the ports serviced. For this reason it is necessary to specify in the studies the scope of the activities included in the general transport system. These will be covered by the optimizing studies and regarded in calculations as data independent of the shipowner's decisions.

The analysis is concerned with the passage of cargo that is concentrated for some part of its sea route for transport on board a given type of vessel capable of carrying containers. The operations and events included in a door-to-door transport chain concern the following systems:

1. lo-lo container system and semi-container system;
2. ro-ro container system and carriage of containers on board vehicle carriers;
3. transport system utilizing barge carriers.

The analysis covers successive operations and events associated with the carriage of goods from the shipper to the recipient. From the point of view of the shipowner the most important part of the operation is transport from the quay in the loading port to the quay in the discharge port. This defines simultaneously the scope of the shipowner's activity, that is the smallest set of activities defined as separate transport system. In classical shipping this was as a rule the only part the shipowner was interested in.

In classical shipping only ships together with their cargo handling facilities were the technical means of transport in that system. In container shipping containers (or barges) are added and in some cases trailers and various means of horizontal cargo handling.

All these means (that is containers, barges, trailers etc.) upon unloading remain with the cargo as it is transported along inland roads or waterways or, at least, upon a change of location within the port area which results - in contrast with the situation at sea - in a large scattering of the cargo over numerous transport lines and modes. These means are owned by the shipowner or leased by him for the duration of the transport. The time of their circulation over land routes defines the number of units necessary for given cargo traffic. Therefore, it effects significantly the level of investment costs as well as that of fixed and variable costs of shipping line operation.

The shipowner involved in container transport of commodities becomes interested in the carriage of cargo beyond the sea route, i.e. at least within the port zone (if the cargo units are operated in a port-to-port system) but more often all the way to land terminals or inland ports where the cargo is unloaded from or loaded into the containers or barges operated by the shipowner.

Hence, the transport of cargo units within the port zone or further along land roads or inland waterways becomes a component of the process of operation of the shipping line, that is an element of the maritime transport system. This fact influences essentially the process of designing shipping lines as follows:

1. The range of optimized factors i.e. the decision variables of optimizing procedures is extended significantly. Besides, the number of seagoing ships and their main partners, the choice of the number and parameters of cargo units and of their type becomes essential. Beside the functioning of the ship during the maritime part of transport, the procedure deals also with optimization of cargo unit traffic on land.
2. The set of conditions describing the surroundings of the maritime system that ought to be taken into account as data for the optimizing procedure is also extended. Included in the set is information on the state of objects and transport means of the general transport system in all zones of cargo delivery subsystems or in a large part of them.
3. Relatively simple procedures for optimization of the system in its maritime part must be developed into more involved procedures suitable for designing a system composed of a number of component subsystems. Along with the extension of the range of factors (of the system) optimized and the conditions (of the surroundings) taken into account, this forms a new class of problems of pre-investment design, that is problems which are more difficult and, first of all, more expensive than those concerning designs of classic transport systems.

This was the reason for developing other models within the set of models worked out at the Maritime Institute for designing complete systems (beside the developed ones) using a simplified approach that consists in regarding the factors engaged in delivery subsystems as dependent on solutions used for the base system.

Such models may be especially useful for developing countries which lack of experience in the use of econometric models and computer technology. These methods could be used in the ship design process, allowing the shipbuilder to make the most favourable decisions [5].

They could be also very useful for the ship operator engaged in the multimodal transport of goods. With the help of the models the operator could evaluate the financial and operational results of the various possibilities of different types of ships, including conventional ships, semi-container vessels, fully cellular container carriers, barge carriers and ro-ro vessels as well as different hold configurations of each type of ship.

The adaptation of sea-going vessels and port infrastructure to the quicker circulation of cargo and the necessity of diminishing the costs of transportation have created the needs for construction of mathematical models. The ship operator today works in a rapidly changing situation in which he has no time to acquire rule-of-thumb experience. The development of Operational Research (O.R.) has provided management with the ability to analyse situations with the rigour of mathematics and the use of models has been developed to aid decision making. Building and running a simulation model permits observation of the dynamic behaviour of a system under consideration and experiments may be run to test hypotheses about the system under study.

The main task of a model is to calculate the relative rentability of different kind and types of the ships employed on optional shipping ranges including existing links with other modes of transport. Deployment of merchant shipping fleets covers a wide range of problems concerned with ship operations, scheduling, routing and ship design. Many of these problems use some kind of economic criteria, such as profitability, income and costs, on which to base decisions, others use non-economic criteria such as utilization of service in models of liner trade.

Following the demands of the operators the universal model has been built adapted to the evaluation of financial results of different kinds of vessels, different ship holds and technologies in use, including containers. The program was based on a standard input data set to be processed by computer. Having in mind the necessity of the formulation of more detailed programs representing the multimodal economic interdependence, other simulation models have been built. All models have the character of universal models adapted to the calculation of:

- arbitrary ship type;
- arbitrary percentage of cargo capacity for different types of specialized holds of the ship;
- arbitrary type of cargo units, cargo transportation techniques and operation conditions.

The models dealt not only with the optimization of means of transport in liner or tramp shipping but also pertained to the optimization modelling of sea transport systems. In addition to the choice of appropriate, economically and technically justified parameters of the ships, the number of ports of call was determined and the combined sea-river or sea-road transportation system has been optimized. The basic operator's decisions concerning the development process of the shipping line involves the determination of the following ship and shipping line technical parameters:

- Ship type and proportional capacity of the specialized ship holds;
- Ship deadweight and speed;
- Number of ships on the line;
- Type and number of cargo units which would ensure the rational functioning of the line; it may be mentioned that containers form the system's equipment.

Final decisions depend on the assumed selection criterion and on the conditions limiting the possibilities of manoeuvring. Requested basic technical parameters are not selected automatically. The selection is made by the designer based on the criterion assumed for a given economic system, also a system of elimination has been used based on multi-criterion analysis.

The automatically optimized parameters:

- Transportation techniques for separate cargo holds, specified in the input data set;
- Cargo matrix presenting: code, weight, volume, freight forming the cargo supply of the line;

- Set of ports of call taken from input set of possible ports of call;
- Cargo conditions per port/port and hinterland relations.

In order to satisfy the needs of the shipping practice and especially the demands of the multimodal operators, five models have been developed representing different specifications which might help solve various problems of planning, programming and management.

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