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MODELING THE PROCESS OF ASSESSING THE EFFICIENCY AND DEVELOPMENT OF PRODUCTION ACTIVITIES OF THE PASSENGER FLEET IN DIFFERENT OPERATING CONDITIONS

The object of research is the efficiency of production activities of the passenger fleet. Assessment of the production capacity of the passenger fleet is one of the most important stages for modelling the options for its functioning and development, the process of which is currently insufficiently studied.

The functioning of the passenger fleet is influenced by such factors as the size of passenger traffic, the technical condition of ships, the level of organization of the technical and commercial operation of the fleet, methods of forming tariffs for transportation and the cost of cruises, navigation conditions, seasonality, economic and political situation in the region of operation of the fleet. It is proposed to use the indicator of the financial result and the carrying capacity of the fleet as the main indicators of the efficiency of the passenger fleet. Using the method of simulation modelling, the process of assessing the efficiency of the functioning of the passenger fleet in various operating conditions is characterized.

It is determined that provided that the passenger traffic on the routes under consideration (linear and cruise) is fully developed and there is a reserve of the fleet's carrying capacity, it is advisable for the ship-owner to master new routes. As a result of solving an economic and mathematical model for the optimal distribution of ships along existing and new routes, it becomes possible to make a decision on attracting an additional fleet on lease terms to increase the carrying capacity of the fleet. To assess the effectiveness of the functioning of our own and leased fleets, it is advisable to use an economic and mathematical model of the optimal distribution of the aggregates of the fleet – our own, leased and competitors. As a result of solving the problem, it is possible to conclude about the efficiency of the fleet and the need for modernization.

The proposed simulation model takes into account the performance of the tasks facing the ship-owner. On the one hand, this is an increase in the profit of the ship-owner, on the other, full satisfaction of the needs of passengers and tourists in water transport services due to the efficient use of the carrying capacity of the fleet in various operating conditions. This also allows the ship-owner to make decisions on the further development of production activities.

Keywords: *passenger fleet, sea passenger line, operational efficiency, simulation model, technical operation.*

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1. Introduction

Assessment of the production capacity of the passenger fleet is one of the most important stages for modeling options for its operation and development. The ability of a shipping company to develop the maximum number of services of a given quality per unit of time (quarter, year) with full use of its production potential determines the size of the production capacity of the passenger fleet. As a rule, the unit of measurement of production capacities is the unit of measurement itself, with the help of which the services produced are recorded.

When analyzing the statistics of the world cruise tourism market, the indicators of the number of transported tourists and the total income, passenger capacity and the number of cruise fleet are considered. However, these indicators are not able to fully reflect the efficiency of using the production capacity of the passenger fleet as a whole.

The structure of income and expenses for cruise and linear forms of organization is different. These differences can be seen in the example of tariff rates and the elements from which they are formed.

Linear fare and cruise rates differ mainly across the range of services. And also because of the level of comfort, the area of the premises per 1 passenger, the speed of the ships, the quality, quantity and variety of food for passengers (tourists), the availability and range of entertainment events, etc.

For ships operating on the lines, increased comfort and a large range of additional services for passengers are not typical. On liner ships, as a rule, there are no entertainment facilities inherent in cruise (cinemas, casinos, ice skating rinks, pools and water parks, fitness rooms, beauty salons, shops, etc.). Linear transportation tariff includes:

- the cost of transporting a passenger and cargo;
- the cost of carriage of a passenger's motor vehicle (for ferry lines);

- accommodation and meals;
- cost of excursion service on the shore (for international and tourist lines).

As an additional income, there can be a fee for using the bar, and some other services that are designed to increase the level of comfort of passengers on international and tourist lines.

The cost of a cruise has a more complex structure than a line fare. The cost of the same cruise is influenced by the class of cabins, the number of people in the cabin, the presence or absence of a discount at the time of purchase of the ticket. Additional income consists of the sale of services and goods that are not included in the cruise price (for example, the use of the services of beauty salons is paid separately; alcoholic beverages are also not included in the cruise price, etc.). From the foregoing, it is obvious that when measuring the production capacity of the passenger fleet, it is impractical to use the indicator of the number of services provided. The primary task of the functioning of the passenger fleet is to fully meet the demand for transportation and related services at minimal cost (Fig. 1).

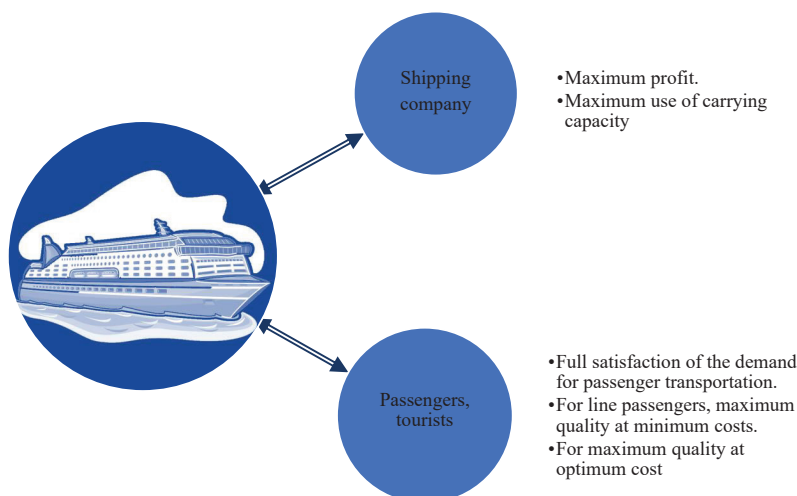


Fig. 1. Efficiency of production activities of the passenger fleet

However, this statement loses its meaning in the cruise shipping market. A tourist who buys a cruise ticket strives for relaxation in comfortable conditions. This means that it is ready to spend some money on travel and travel. The ship-owner and tour operator do not seek to minimize the costs of organizing a cruise, but rather optimize them in such a way as to fully satisfy the needs of cruise tourists and at the same time obtain the greatest financial result. However, ship-owners of the liner passenger fleet are also striving to increase the financial result.

2. The object of research and its technological audit

The *object of research* is the efficiency of production activities of the passenger fleet.

The production activity in the passenger fleet is carried out with the interaction of ships, ports and ship repair enterprises and is aimed at generating profit for ship-owners and meeting the needs for transportation and cruises of passengers.

The functioning of the passenger fleet is influenced by such factors as the size and mobility of passenger traffic, the technical condition of ships, the level of organization of the technical and commercial operation of the fleet.

As well as methods of price formation for a ticket, navigation conditions, seasonality, economic and political situation in the region of operation of the fleet.

Thus, there is a need for constant monitoring of the efficiency of the production activity of the passenger fleet, which can change depending on changes in the conditions of the external and internal environment, to ensure the reliability of the fleet's functioning and its further development.

3. The aim and objectives of research

The *aim of research* is to develop a simulation model for assessing the efficiency and development of the production activity of the passenger fleet in various operating conditions. To achieve this aim, it is necessary to complete the following objectives:

1. Determine the indicators for assessing the efficiency of the passenger fleet.
2. Determine the composition and sequence of operations in assessing the efficiency and development of the production capacity of the passenger fleet.

4. Research of existing solutions of the problem

A significant amount of research has been devoted to the problems of the efficient functioning of passenger transport and the organization of passenger transportation.

The impact of severe weather conditions on the efficiency of urban passenger transport is discussed in [1]. This work substantiates the need to adjust the number of vehicles and flights depending on weather conditions, and allows to increase the efficiency of the transportation process by reducing operating costs. At the same time, the solution to the problem of transport downtime caused by a decrease in passenger traffic due to weather conditions is not considered.

The authors of the work [2] propose, on the basis of the «break-even analysis», to determine the volume of passenger traffic required to ensure a certain level of profit for water transport. By comparing the required and predicted passenger flows, the reserve or lack of traffic is determined to ensure the break-even functioning of the fleet. However, the volume of production capacity (fleet), due to which the shipping company will develop the passenger traffic necessary to ensure profitability, is unreasonable in the work.

Ensuring the efficiency of the functioning of the fleet through effective technical operation is considered in [3, 4]. So, in work [3] the need for repair and modernization of the fleet to ensure its seaworthiness is substantiated. And in work [4], options for modernizing ships are considered as one of the ways to improve the efficiency of the cargo fleet. At the same time, the above studies do not pay attention to the problems of determining the influence of the technical condition of the fleet on its carrying capacity and the transportation process as a whole.

In work [5], a methodology for assessing the efficiency of transport companies is proposed, which provides for an assessment of a group of transport companies according to a system of technical and economic indicators, but the composition of indicators in the system is not specified.

The considered method allows to analyze an indefinite number of objects, evaluate tens and hundreds of indicators of their activity. However, the method is cumbersome and requires a lot of initial data.

A number of studies by other researchers are examining the impact of the quality of transport services provided on the functioning and development of passenger transport. So, as a result of a survey among passengers of sea transport by the authors of the work [6], it is revealed that the development of linear passenger transportation is hindered due to the low quality of transport services and high cost. In [7, 8] criteria and methodology for assessing the quality of transport services are defined. And in the work [9], a method is proposed for improving the quality of transport services by managing financial flows that ensure the functioning of the transport services market. However, these studies consider the efficiency of transport from the point of view of passengers and do not take into account how the satisfaction of passengers' needs for quality and low cost of services affects the carrying capacity and profitability of transport.

As a result of the analysis of the system of public passenger transport in [10], the connections between the subsystems «passenger», «vehicle», «station», «line» are revealed. And also 7 criteria have been established that characterize the throughput of the public transport system, the management of which will optimize the system. However, the question of the influence of the established criteria on the economic component remained not disclosed.

From the analysis of literary sources, it can be seen that the authors of the experiments highlight certain issues of organizing the functioning of passenger transport. The research pays much attention to the influence of the quality and cost of transport services on the formation of demand, while the problems of using the carrying capacity of vehicles in full remain illuminated. Economic efficiency and technical efficiency of transport operation are considered separately in most scientific works. Whereas, in the field of maritime transport, economic efficiency is ensured by the efficiency of the technical operation of the fleet and its ability to perform transport work. Thus, there is a need to study the process of assessing the economic and technical efficiency of the functioning of the passenger fleet and its further development, depending on the assessment results.

5. Methods of research

The problem of the passenger fleet operation is structured on the basis of a system analysis. To describe the process of assessing the efficiency of the passenger fleet operation, simulation modeling is used.

6. Research results

The financial result is defined as the difference between the income D that comes from the ship operation and the expenses R of maintaining the ship in operation (1). Characterizing the excess of receipts over expenses, the financial result expresses the goal of the shipping company and is taken as the main indicator of its effectiveness [11]:

$$F = D - R. \quad (1)$$

In the process of operation, the moral and technical wear of the fleet occurs. The rate and degree of wear is different for each series of ships and depends on a number of factors:

- design characteristics and quality of materials from which the ships were built;
- operating conditions of ships;
- quality and frequency of maintenance and scheduled repairs;
- quality of fuels and lubricants;
- influence of the natural environment;
- experience and qualifications of the crew, whose duties include ensuring safe navigation, as well as monitoring the technical condition, maintaining serviceability, restoring resources, eliminating failures and damage to ship technical equipment.

With moral and technical wear and tear, the profit from the operation of the passenger fleet decreases for the following reasons:

- increase in the cost of repairing and maintaining ships, to keep them in working order;
- decrease in income from a decrease in productivity, which leads to a reduction in operating time due to frequent breakdowns and failure of mechanisms;
- decrease in income from a decrease in demand and tariffs for transportation through the unattractive state of ships.

So, the technical condition of the passenger fleet directly affects the financial result from its operation, which, the more, the greater the productivity of the passenger fleet.

Of the entire system of indicators characterizing the transport operation of the passenger fleet, the indicator of the carrying capacity of the fleet occupies a key place:

- determines the transport capabilities of the fleet in specific operating conditions;
- depends on the passenger capacity of ships, the degree of its use, the operational period of the ship, the navigation period and the conditions of the line (voyage), the technical speed of the ships, the speed of movement according to the schedule, the length of the circular voyage, the number of event points. As well as the productivity of operations for handling and servicing ships in ports, the range of passenger transportation and the shift of passengers [12].

The carrying capacity of a passenger fleet is the amount of work in passenger miles and in passenger seats that a ship can perform in a certain period of time under certain conditions. There are two ways to calculate the carrying capacity: by the number of flights and by indicators (meters). The first method is based on the specific operating conditions of ships. The second method is based on indicators, set for a certain period of time, and is used when calculating the carrying capacity for long periods of time, when the specific arrangement of ships on the rails, loading of ships and ports of call on individual voyages is unknown [13].

The carrying capacity of a passenger ship in passenger seats for the operational period is determined as:

$$P = \alpha \beta W r, \quad (2)$$

where α – utilization rate of the passenger capacity of the ship; β – coefficient of the shift of passengers on the ship; W – passenger capacity of the ship; r – the number of voyages in a given period.

Or in passenger miles like:

$$P = \alpha \beta W r L, \quad (3)$$

where L – range of the ship or the length of the voyage.

Carrying capacity for the operational period T_e according to indicators is determined as:

$$P = \mu W T_e, \quad (4)$$

where μ – productivity of 1 passenger seats per gross day.

It should be noted that the determination of the carrying capacity of the ship is influenced by the navigation period (summer or winter) in which it is operated. For example, in the summer, ships operating on the line have more passenger capacity than in winter. This is due to the ability to use open deck space for passenger transportation.

Using formula (2), let's transform formula (1) and get the expression:

$$F = \bar{f}P - R, \quad (5)$$

where \bar{f} – the average net income rate per 1 passenger seat.

From formulas (2)–(4) it can be seen that the indicator of the carrying capacity of the passenger fleet is a function of a number of quantities that characterize the functioning of the fleet. At the same time, formula (5) shows that the financial result from the work of ships directly depends on the carrying capacity of the fleet.

Thus, the indicators of the financial result and the carrying capacity of the fleet make it possible to assess the efficiency of the functioning of the passenger fleet in various conditions.

Based on the foregoing, the composition and sequence of operations in assessing the efficiency and development of the production capacity of the passenger fleet in various operating conditions are as follows:

Stage 1. Input.

Stage 2. Collection, analysis and processing of information on the operating linear and cruise routes in the region, passenger traffic and the number of tourists they serve.

Stage 3. Selection of linear and cruise routes based on the criterion of sustainable passenger traffic. Analysis and determination of the potential number of passengers and tourists whose need for passenger transport services must be satisfied on the selected routes.

Stage 4. Calculation of operational and economic indicators for its own fleet: profit from the operation of each ship on each route and the carrying capacity of ships.

Stage 5. The solution of the economic and mathematical model (EMM) of the problem of the optimal distribution of ships along linear and cruise routes.

In this problem, linear and cruise ships are used as control parameters. The objective function maximizes profit and a number of the following restrictions are met:

- the number of ships used should not exceed the total number of all selected ships;
- the volume of passenger traffic on all routes must be mastered.

Stage 6. Analysis of the results of solving the EMM of the problem of optimal distribution of ships along linear and cruise routes.

Stage 7. Checking the fulfillment of the restriction: are passenger and tourist flows fully utilized? If «yes» go to stage 8, if «no» go to stage 12.

Stage 8. Making a decision on the development of new routes.

Stage 9. EMM solution of the problem of optimal distribution of passenger fleets along existing and new routes.

In this problem, passenger ships are used as a control parameter. The objective function maximizes profit and a number of the following restrictions are met:

- the number of ships used should not exceed the total number of all selected ships;
- the volume of passenger traffic on all old and new routes must be mastered.

Stage 10. Analysis of the results of solving the EMM of the problem of optimal distribution of passenger fleets along existing and new routes.

Stage 11. Checking the fulfillment of the restriction: are passenger and tourist flows on existing and new routes fully mastered? If «yes» go to stage 8, if «no» go to stage 12.

Stage 12. Decision-making on the need to rent a fleet for the full blocking of passenger and tourist flows.

Stage 13. Analysis of the freight market for the passenger fleet. A selection of ships can be attracted on a rental basis. When choosing, it is possible to give preference to ships that are already in the given region or close to it.

Stage 14. The attractiveness of solutions for assessing the effectiveness of the functioning of our own and the fleet can be attracted on lease terms, in comparison with competitors.

Stage 15. Analysis of the activities of competing shipping companies that successfully operate in a given region. Selection of competitors' ships from those that constantly operate in a given region.

Stage 16. Solving the problem of optimal distribution of the aggregates of the passenger fleet (own, that can be rented, competitors) along existing and new routes.

In this problem, passenger ships are used as a control parameter. The objective function maximizes profit and a number of the following restrictions are met:

- the number of ships used should not exceed the total number of all selected ships;
- the volume of passenger traffic on all old and new routes must be mastered;
- the cost of renting ships should not exceed the financial resources with which the shipping company.

Stage 17. Analysis of the results of solving the EMM of the problem of optimal distribution of the aggregates of the passenger fleet (own, that can be rented, competitors) along the existing and new routes. The solution of the problem assumes a number of options for the optimal distribution of the aggregates of the passenger fleet, when for the development of passenger traffic on a given route, the carrying capacity of the fleet in question (its own, which can be rented, competitors) is fully used (F), partially (P), or not at all (N). Combinations of these indicators are given in Table 1.

Table 1

Variants of combinations of indicators of the use of carrying capacity in the development of passenger traffic on linear and cruise routes

Cruise fleet affiliation	Variants			
	1	2	3	
own	F	P	P/N	P
which can be rented	F/P	F/P	F/P	H
competitors	N/P	N	F/P	F/P

Note: the carrying capacity of the fleet is fully used (F), partially (P), or not used at all (N)

Stage 18. Comparison of the results of the EMM solution with the options for using the carrying capacity (Table 1): Option 1? If yes, go to stage 19; if «no», go to stage 22.

Stage 19. Conclusion on the effectiveness of the functioning of the own fleet of the analyzed shipping company.

Stage 20. Making a decision to attract ships on lease terms for the further development of the shipping company.

Stage 21. Exit.

Stage 22. Comparison of the results of the EMM solution with the options for using the carrying capacity (Table 1): Option 2? If yes go to stage 20 and 23, if no go to stage 24.

Stage 23. Making a decision on the need to modernize its own passenger fleet. Go to stage 16.

Stage 24. Comparison of the results of the EMM solution with the options for using the carrying capacity (Table 1): Option 3? If yes, go to stage 13, if «no», go to stage 18.

The given simulation model makes it possible to assess the efficiency of the passenger fleet operation, taking into account the fulfillment of the tasks facing the ship-owner. On the one hand, this is an increase in the profit of the ship-owner, on the other, full satisfaction of the needs of passengers and tourists in water transport services, due to the effective use of the carrying capacity of the fleet in various operating conditions.

Depending on the results of the assessment of the functioning of the passenger fleet, the ship-owner can make decisions regarding the directions of the company's further development.

7. SWOT analysis of research results

Strengths. The value of the ship-owner's profit and the satisfaction of the population's needs for transportation by water transport for various purposes depends on the correct organization of the functioning of the passenger fleet. Compared with other methods, the proposed simulation model allows not only assessing the efficiency of the passenger fleet, but also making a decision about:

- opportunities for the development of new routes;
- the need to attract ships on lease terms;
- the need to modernize ships and the competitiveness of its own and leased fleet in comparison with the fleet of competitors.

Weaknesses. The weaknesses of the presented simulation model are:

- assessment is carried out according to the already established passenger traffic, the issues of forecasting passenger traffic are not considered;
- requires an array of statistical information on the fleet of competitors.

Opportunities. For the optimal distribution of ships along the routes, an economic and mathematical model should be developed.

Implementation of the developed simulation model will increase the profit of ship-owners by increasing the use of the fleet's carrying capacity. Or make a decision on the need to modernize the fleet to maintain its competitiveness.

Threats. The implementation of the proposed simulation model for assessing the efficiency of the passenger fleet does not require additional costs. However, the need for additional costs will arise if the ship-owner makes a decision to attract ships on a lease basis or the need to modernize its own fleet.

8. Conclusions

1. As an indicator for assessing the efficiency of the passenger fleet operation, the financial result indicator is determined. It is shown that the indicator of the carrying capacity of the fleet directly affects the level of the financial result.

2. The proposed simulation model for assessing the efficiency of the passenger fleet operation, the introduction of which will increase profits and satisfy the needs of passengers and tourists in water transport services through the effective use of the carrying capacity of the fleet in various operating conditions.

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