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SECURITY ASSURANCE OF PORT SERVICES AS A FACTOR OF THEIR COMPETITIVENESS

Об'єктом дослідження є процес підвищення конкурентоспроможності портів. Одним з найбільш проблемних місць є надійність наданих портами послуг, яка впливає на конкурентоспроможність портів.

В ході дослідження використовувалися методи кількісної оцінці можливості надійної поставки, методи обчислювання параметрів інфраструктури та суперструктури портів, методи розв'язання з використанням теорії масового обслуговування.

Проведено аналіз досліджень і робіт міжнародних організацій з питань визначення чинників вибору клієнтурою портів, враховуючи зміну пріоритетів на користь надійності сервісу. Порти сьогодні в цьому сенсі розглядаються як вузли в логістичних ланцюгах. У критеріях, за якими ланцюги поставок розробляються, оцінюються та вибираються, пріоритет над ціною та часом транзиту надається надійності.

Визначено, що спроможність портів з забезпечення надійності сервісу повинна розглядатися з позицій створення відповідних потужностей у складі елементів інфрастуктури і суперструктури портів, а також трудових ресурсів. Для кожного елементу (причали, склади, обладнання, докери) у відібраних апробованих методах визначено, за рахунок чого забезпечується надійність. Так, потрібне число причалів визначається з урахуванням їх річної пропускної здатності, що обгрунтовується з урахуванням коефіцієнту використання причалу в часі, застосування якого дозволяє забезпечити надійність наявності необхідної кількості причалів.

Надійність наявності необхідної ємності складів визначається з умови забезпечення безперебійної обробки флоту. Необхідний склад перевантажувального обладнання залежить від умов обробки флоту. Надійність у забезпеченні трудовими ресурсами може бути забезпечена урахуванням особливості організації праці в портах, пов'язаної із нерегулярним попитом на працівників у наслідок переривчастого і непередбачуваного прибуття суден і вантажів у порт.

Запропоновано визначення сприятливих вантажопотоків порту з урахуванням додаткових продажів і лояльності клієнтури та критерій ефективності завдання визначення кількості докерів, сегментації судновласників. У підсумку в роботі розроблено науково-методичний продукт, придатний для використання як постачальниками, так і замовниками послуг з доставки вантажів.

Ключові слова: *надійність транспортних послуг, морські порти України, конкурентоспроможність порту, інфраструктура та суперструктура портів.*

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1. Introduction

The functioning of the seaports of Ukraine is provided by the Ukrainian Sea Ports Authority (USPA). Its mission, according to the charter of this enterprise, is to promote the development of the sea transport infrastructure of Ukraine and increase the competitiveness of Ukrainian seaports.

In order to ensure compliance with the requirements of the ship-owner until the time the ships are in the port and the cargo owner until the time and volume of cargo transit, the responsible port operator must have adequate resources, especially berths, warehouses, transshipment equipment, dockers. And the supply chain operator is confidence in their sufficient availability. Therefore, the need to formulate methods for the quantitative assessment of reliable supply capabilities is urgent, and the task of the proposed suitable tools for this is relevant.

2. The object of research and its technological audit

The object of research is the process of increasing the competitiveness of ports. One of the most problematic places is the port services provided, which affects port competitiveness.

The need to ensure the reliability of seaports in the cargo delivery chains is connected with the fact that the proposals for determining the adequate characteristics of the infrastructure and superstructure of the port operator have a number of features. These features are based on the authors' own research, as well as, in particular, selected from the sources used in the work.

3. The aim and objectives of research

The aim of research is determination of the ability of ports to ensure adequate reliability of the service in terms

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of volume and term, which should be considered from the standpoint of creating appropriate capacities as part of the infrastructure elements and superstructure of ports and port operators.

To achieve this aim, it is necessary to complete the following objectives:

1. To substantiate the need to ensure the reliability of seaports in the chains of cargo delivery.

2. To develop proposals to determine the adequate characteristics of the infrastructure and superstructure of the port operator.

4. Research of existing solutions of the problem

The study [1] summarizes the latest works of more than ten other researchers, provides the following port attributes related to port services and affect the decision of ship lines and shippers on the choice of ports:

- infrastructure and superstructure of ports;
- geographical position;
- port efficiency;
- port relationships (call frequency);
- quality and costs of ancillary services, such as pilotage, towing, customs, etc.;
- efficiency and costs of port management and administration;
- availability, quality and costs of logistics activities with added value (for example, warehousing);
- availability, quality and costs of port community systems;
- port security and environmental profile;
- port reputation;
- reliability, power, frequency and costs of domestic transport services.

Competitive factors that are close in meaning are listed and characterized from the point of view of specialized ports, in particular, container ones [2], and as a justification of the World Bank's ports reforming tools [3].

In addition, it notes that, taking into account customer service expectations, they are moving towards increased flexibility, reliability and accuracy, ports are increasingly competing not as places for processing ships, but as nodes in supply chains. That is, the criteria for choosing ports apply to the entire network in which the port is located as only one of its elements, and ports are selected that will help minimize the amount of costs at sea, in the port and internal, including the inventory considerations of shippers.

As a result, when choosing a chain and an appropriate port of travel, directors can choose more expensive ports and/or types of inland transport if the additional costs associated with ports and inland transport are offset by savings in the following logistics costs:

- time costs for the goods;
- costs associated with inventory management;
- indirect logistics costs associated with the overall quality of the transport chain, and the ability of various participants to configure operations in accordance with customer requirements.

In these costs, it is also possible to take into account the increase in revenues of the clientele of transport from increased sales in the markets due to the quick response to the demand of their customers already due to fast and reliable delivery.

That is, the decision on the choice of port and type of inland transport, supply chain managers are increasingly based on reliability and ability accounting instead of considering only costs.

Almost all of the above port selection factors in a particular delivery chain are explicitly or implicitly used in the formula for determining the competitiveness of one port compared to another, described in the report of the secretariat of the United Nations Conference on Trade and Development (UNCTAD) [4] back in 1992. They are concentrated in spending money and time for ship-owners and cargo owners, taking into account the corresponding risks. The following formula allows to compare the competitiveness of one port with the competitive positions of another in the processing of a specific consignment or category of cargo, which is delivered by specific ships to a specific destination or specific destination.

The competitiveness of C_{aij} port «*i*» for cargo «*a*» when using it compared to port «*j*» is determined from the expression:

$$C_{aij}=\frac{\left[Rm1Cm1+Rm2Cm2+Rt1Ct1+Rt2Ct2\right]j}{\left[Rm1Cm1+Rm2Cm2+Rt1Ct1+Rt2Ct2\right]i}-1, \qquad (1)$$

where $Cm1$ – cash costs for the ship-owner, counting on a ton of cargo handled. $Cm1$ include: port charges; other expenses associated with servicing the ship, in linear ships – the costs of loading and unloading, etc; $Cm2$ – cash costs for the shipper, counting on a ton. This indicator includes all port charges related to the cargo, all transportation costs from the port of shipment through the port to the final destination or vice versa, and all turnaround costs; $Ct1$ – time spent for the ship-owner, counting on a ton of cargo handled. Include all the monetary time costs of the ship at the port, as well as the difference in travel time to the port being compared; $Ct2$ – time spent for the cargo owner, counting on a ton. This includes all the time spent for the cargo owner for the entire transportation period, as well as the time spent in the port to receive various services; $Rm1$ – cost of risks for the ship-owner; $Rm2$ – cost of risks for the cargo owner; $Rt1$ – risk of time loss for the ship-owner; $Rt2$ – risk of time loss for the cargo owner.

A positive calculation result encourages you to send the consignment considered to this port. By performing these calculations, it is possible to develop measures to retain existing cargo. If they are insufficient to meet their needs, it is possible to attract cargo of customers with a negative value of C_{aij} from competing ports. To do this, it is necessary to influence the factors that form the value $Cm1$, $Cm2$, $Ct1$, $Ct2$, $Rm1$, $Rm2$, $Rt1$, $Rt2$.

Also, do not underestimate the loyalty of individual service buyers in their individual suppliers. Their consideration in the formula for determining the competitiveness of the port can by introducing appropriate coefficients.

In [5], citing a study conducted by Erasmus University Rotterdam, regarding the study of the criteria by which supply chains are developed, evaluated and selected, it is shown that priority is given to price and transit time reliability, which is called the most important criterion. And the main factor that the ship-owner will take into account, and which, accordingly, the chain manager should take into account when choosing the port of call, there is a risk of time loss for the ship-owner [4].

Among the literature sources identified in the resources of the world scientific periodical devoted to studying the problems of infrastructure and port superstructure, one can single out [1, 2], in which there is a lack of consideration of the competitiveness of ports. Most authors analyze the right aspects of a competitor:

– running strategies, hypotheses, chances [2];
– agreement of strategies, understanding of strengths and weaknesses, potential reactions [3];
– analysis of market share, understanding of financial stability [4].

Analysis of the design and nature, definition and interpretation of the concept of «port competition» gives the right to turn further conclusions: the idea of «port competition», proposed by the authors in versatile terms in [5–7], does not fully comply with the rules of systemicity and complexity. They recommend only one of the many port competition plans established by other authors, each in its own field of study.

Almost all definitions consider the category «enterprise competitiveness» as a constant, but it, like many other economic categories, is not. Given these shortcomings, the following definition of enterprise competitiveness is formulated [8]. Under the competitiveness of the enterprise refers to the complex characteristics of the enterprise, characterizing its ability at any time and within the competence to provide its competitive advantages and profitability. It takes into account adaptation to constantly changing conditions of the external and internal environment, and also distinguishes the company from competitors and gives market advantages of the products or services provided.

A study of the competitiveness of seaports [9] clarifies the definition of this category as port characteristics, describes the market's compliance with the requirements of port users. These studies identify market positions (port market share) and prevent market redistribution in favor of competitors. From these positions, it is proposed to assess the port's competitiveness based on an integrated indicator that takes into account the potential of a complex port in its development dynamics. Also, a formalized model of the redistribution of goods between ports, but it does not describe the characteristics of port resources and modes of transport to optimize the efficiency of their development. It is necessary to evaluate the competitiveness of ports as the ability of ports to provide services through the efficient use of their resources.

In [10], a competitive port strategy means a combination of management measures and actions that provide a competitive advantage. The task of creating a competitive strategy is being solved regarding the situation on the market, taking into account the totality of external and internal factors affecting the competitiveness of enterprises. The authors of [10] recommend priority factors affecting competitiveness: the quality of port services, the value of port services, port management, the information system, the psychological climate in the port, the relationship with related organizations, and staff competence.

It is argued in [11] that in order to maintain competitiveness and integrate major manufacturers and distributors into the supply chain structures, the port should shift its focus from the sea front to the logistics center and develop it as a logistics center. However, methodological aspects or the implementation of these provisions have not been done.

Thus, the analysis results allow to conclude that the consideration of Ukrainian ports in the system of all ports operating in the supply chain requires a hierarchical management system at the same time. This is a problematic and not fully explored issue. In this work, a task has been prepared, it solves many problems, that is, it offers many methodological aspects of port competitiveness management based on the analysis of available approaches.

5. Methods of research

The characteristics of the infrastructure and superstructure of a port operator are determined primarily by the volume, structure and nomenclature of its cargo handling, or expected cargo flows. The latter are proposed to be found with the simultaneous selection and distribution of selected cargo flows between the planned berths and warehouses in such a way as to ensure maximum profit for the development of the entire cargo turnover in the billing period. To solve this problem, a mathematical model of the problem is proposed [6].

The methods for calculating the parameters of the infrastructure and superstructure, described in [7], have the necessary «safeguards» against risks, the qualified use of which will provide an acceptable degree of reliability of their sufficiency.

6. Research results

6.1. Calculation of infrastructure parameters. The number of transshipment complexes of moorings determines, first of all, the number of fixed infrastructure objects – moorings and warehouses.

The required number of berths is determined taking into account its annual throughput, which is determined using the berth utilization factor in time, can be determined, for example, according to the recommendations of UNCTAD or other sources. Its use allows to ensure the reliability of the availability of the required number of berths:

$$N_b = Z_{liopt},$$

where l – the design type of ship; Z_{liopt} – the optimal number of simultaneously processed ships from the i-th cargo group is determined in a simplified way as follows:

$$Z_{liopt} = \frac{Q_i}{P_y K_{occ}}, \quad (2)$$

where Q_i – the annual volume of processing of the i-th cargo; P_y – berth throughput at 100 % of its use:

$$P_y = T_b \cdot P_{dayi} \cdot K_{meti}; \quad (3)$$

K_{occ} – berth occupancy rate over time, the more interchangeable berths, the more it; T_b – the number of days the berth operates per year; P_{day} – daily berth throughput on the i-th cargo; K_{meti} – coefficient taking into account the simple weather reasons.

When calculating the required warehouse area, the reliability of its availability is ensured by the following.

In the case of the traditional use of the composition for transit cargo (technological storage), the required storage capacity is determined from the conditions for ensuring

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uninterrupted processing of the fleet by the methods set forth in the standards for technological design of seaports (STP), which take into account:

– characteristics of the cargo;
– loading and direction of movement of ships;
– type of shipping;
– feed mode of railway rolling stock [8].

Ships should not stand in anticipation of freeing up storage space when unloading them or awaiting cargo at loading. In the latter case, the storage capacity should allow to concentrate the necessary amount of cargo in it.

The prerequisites for the calculation are as follows:

– the warehouse capacity E_w is especially sufficient to accommodate the cargo in an amount equal to the load of the ship Q_s;
– the necessary supply of capacity for the placement of goods in the event of a mismatch in the approach of ships and the import (export) of the composition by adjacent modes of transport L_i:

$$E_w = K_c \cdot Q_s + L_i \text{ (tons)}, \tag{4}$$

where K_c – the coefficient of complexity of cargo flow, takes into account the need for an additional reserve of the storage capacity for cargoes, ensures the best loading of the ship, as well as the divergence of the destination of a specific cargo lot and a specific port of the ship on this voyage.

STP gives recommendations on the value of K_c depending on the characteristics of the cargo flow and destination ports from 1.1 to 1.6. If the terminal includes several berths, $K_c=1$ for all but one berth. The reserve capacity for the mismatch of the transport mode:

$$L_i = t_n \cdot \Pi_{day}, \tag{5}$$

where t_n – the norm of the reserve capacity in days; Π_{day} – daily berth throughput, t/day. L_i should not exceed $1.5Q_s$.

The capacity of the group's of n warehouses, where each γ warehouse has a capacity E_γ, $\gamma=\overline{1,n}$, can be defined as:

$$E = k\sum_{\gamma=1}^{n} E_\gamma, \tag{6}$$

where k – decreasing coefficient, taking into account the time mismatch in the warehouses of the maximum cargo balance, is 0.9 for $n=2$, 0.8 for $n=3$ and 0.75 for $n>3$.

If the composition is used for commercial storage, the warehouse area can be determined on the basis of the methods of technological design standards for packaged units and long goods warehouses, which take into account:

– the amount of cargo and its storage time are needed;
– the general expeditionary area of the warehouse is also provided for useful [9].

In this case, the storage capacity during the passage of cargo to and from the sea should not be less than that determined from the fleet processing conditions.

The usable area or the area occupied directly by goods, racks, stacks is determined as follows:

$$S_u = \frac{E_w}{q_w} = \frac{Q_w}{q_w} = \frac{Q_{day} \cdot t_{st}}{q_w}, \tag{7}$$

where E_w – the warehouse capacity equal to the size of the established stock of the type of cargo in the warehouse Q_w, $Q_w=Q_{day} \cdot t_{st}$; Q_{day} – the average daily consumption of a given cargo; t_{st} – estimated shelf life, days; q_w – load rate per 1 m^2 of warehouse useful area, $q_w=q_e \cdot Kf$.

The area of the expeditionary (receiving S_r and loading S_l) sections of the warehouse where sorting, packaging and other work is performed are determined by this calculation:

$$S_r = \frac{Q_r \cdot Kr \cdot t_r}{365 \cdot q_{w1}} = \frac{q_r \cdot K_r \cdot t_r}{q_{w1}}, \tag{8}$$

$$S_l = \frac{Q_l \cdot K_l \cdot t_l}{365 \cdot q_{w1}} = \frac{q_l \cdot K_l \cdot t_l}{q_{w1}}, \tag{9}$$

where Q_r, Q_l – the annual warehouse turnover from the receiving and loading of goods; r, q_l – the corresponding values of the daily turnover:

$$q_r = \frac{Q_r}{365},\ q_l = \frac{Q_l}{255},$$

K_r, K_l – unevenness coefficients for the receiving of goods (3)–(7) and the loading of goods from the warehouse (1)–(3); T_r, t_l – the time spent on goods in the corresponding expeditionary sections; q_{w1} – the floor load of these sections is taken equal to 0.25 of the operational load on the useful area of the warehouse.

6.2. Superstructure parameter calculation. The number of moving objects of the superstructure, in particular, transshipment equipment, can be determined by the methods described in the special literature [10].

The number of overhead cranes, loaders, stowing machines depends on the required number of technological lines for ship work, which is determined based on the following fleet processing conditions:

– linear ships, the calculation includes the time of the ship's stay according to the schedule;
– ships, the processing intensity of which is known, stable and suits the clientele or can be determined as a result of research;
– ships that should be processed as quickly as possible according to clientele requirements.

Determination of N_{li} – the average number of production lines (t. l.) for processing the design type of a ship carrying cargo of the i-th group for each category.

1. For a linear ship N_{li}, it is determined on the basis of the quantity of cargo Q_s on the ship, its planned stay at the port under cargo operations t_c and the productivity of one processing line P_{ci}:

$$N_{li} = \frac{24 \cdot Q_s}{n_{shi} \cdot t_{shi} \cdot t_c \cdot P_{ci}}, \tag{10}$$

where n_{shi} – the number of processing shifts during the day of the ship carrying the cargo of the i-th group; t_{sh} – the average shift duration, h.

2. For ships of known processing intensity:

$$N_{li} = \frac{M_d}{n_{shi} \cdot t_{shi} \cdot P_{ci}}, \tag{11}$$

where M_d – the daily intensity of loading and unloading, t/ship-day.

3. For ships with the desired maximum speed of cargo operations, N_{li} is determined from the conditions of the highest concentration of technological lines per ship and the complexity of processing each hold in the following sequence [10].

For holds, the processing of which is carried out by the number of t. l. $n_l > 1$, their average concentration limit at each f-th hold n_{lf} is determined by the formula:

$$n_{lf} = \frac{(1-k_d)\cdot n_{ld}\cdot t_d + n_{ld}\cdot t_n}{(1-k_d)\cdot t_d + t_n}, \quad (12)$$

where k_d – the coefficient of decrease in productivity of each production line when they are concentrated on one hold of the ship:

– at $n_{lf} \le 1, k_d = 0$; $n_{lf} \le 1, k_d = 0$;

– at $n_{lf} = 2$ and $9 \le l_h \le 20$ m, $k_d = 0{,}15$; $n_{lf} = 2$ and $9 \le l_h \le 20$ m, $k_d = 0{,}15$;

– at $n_{lf} = 2$ and $l_h > 20$ m, $k_d = 0$, $n_{lf} = 2$ and $l_h \ge 20$ m, $k_d = 0$, l_l – hatch length in meters;

n_{ld} and n_{ln} – the number of lines by which the f-th hold of the ship is processed during the day and night, respectively; T_d та t_n – respectively, the duration of daylight and night time. Taking into account the rules for changes in the work of port workers, it is recommended that the average daylight hours be 8 hours. In this case, for a hold of length $9 \le l_h \le 20$ m with a width => 8 m, during three – shift operation, the concentration limit $n_{lf} \le 1.3$.

The complexity of unloading (loading) of each hold is determined:

$$\tau_{lf} = \frac{24\cdot q_{lf}}{P_{avi}\cdot\left[(1-k_{dn})\cdot t_d + t_n\right]}, \quad (13)$$

where q_{lf} – the amount of cargo in the f hold of the ship type l, tons; P_{av} – the average productivity of the technological line for the implementation of ship work.

The time of unloading (loading) of each hold is determined:

$$t_{lf} = \frac{\tau_{lf}}{n_{lf}}. \quad (14)$$

The smallest processing time of the estimated ship type l is determined:

$$t_{l\min} = \max(t_{lf}). \quad (15)$$

Estimated number of processing lines for processing the ship:

$$N_{li} = \frac{\sum_{1}^{n_h}\tau_{lf}}{t_{l\min}}, \quad (16)$$

where n_h – the number of holds in the estimated ship.

The required number of transshipment machines (cranes, transshippers, loaders) is determined including taking into account the time they were taken out of service for the duration of the repair, reliably ensures the constant availability of the required number of transshipment equipment.

The number of boundary cranes N_{cr} is determined by the formula:

$$N_{cr} = 1.1\cdot N_h\cdot N_b\cdot K_{ad}, \quad (17)$$

where 1.1 – the factor that takes into account the repair and maintenance of machines; K_{ad} – the adjacency coefficient of berths having a single line of crane tracks decreases with increasing number of berths N_b. With a fixed number of N_{cr} and N_b, the average number of processing lines for processing one ship:

$$N_{tl} = N_{cr}/(1.1\cdot N_h\cdot K_{ad}). \quad (18)$$

It is the greater, the greater the number of berths in the port division.

The required number of rear transshipment machines (cranes, transshippers) for loading and unloading the i-th group of cargoes in ships is determined:

$$N_{mi} = \frac{1.15\cdot Q_i\cdot K_r}{24T_b\cdot P_{ci}^r\cdot K_{ui}^{cr}}, \quad (19)$$

where K_r – a coefficient taking into account the volume of i-th cargo group transshipped by the rear cranes; for one line of rear cranes it is 0.65–0.7, for two lines – K_r=1.0–1.2; Q_i – the volume of processing from the i-th group of goods, tons; T_b – the duration of the passage of cargo through a berth or group of berths, specialized for transshipment of the i-th group of goods, days; P_{ci}^r – the productivity of the rear crane (transshipper), which is part of the technological line specialized in the transshipment of the i-th cargo group, t/h; if the rear cranes operate in the same circuit with the boundary, it is possible to take $P_{ci}^r = P_{ci}$; K_{ui}^{cr} – the utilization rate of cranes in time, which transships the i-th group of cargoes or as a whole for the port division.

The gross time of ships in the port also includes the waiting time for the berth.

The ratio of the waiting time for the commencement of cargo operations to the duration of cargo operations with a universal ship is shown in Fig. 1 [11].

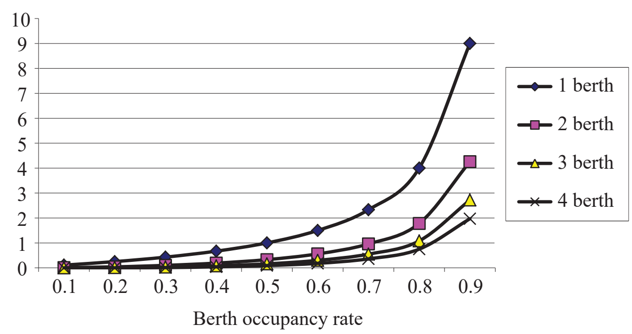

Fig. 1. The ratio of the waiting time for the beginning of the freight work the duration of the freight work with a universal ship

Dependency lines in Fig. 1 are less steep for bulk carriers, Ro-Ro ships and container ships.

6.3. Calculation of labor parameters. Port labor costs typically range from 40 to 75 % of the total operating costs of general cargo terminals. Even in capital-intensive container handling, the share of labor costs in total operating costs can reach 50 % [12]. In all Ukrainian ports, most of the expenses also fall on wages.

The main problem underlying the organization of the labor market in ports is the irregular demand for workers,

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which is a direct consequence of the intermittent and to some extent unpredictable arrival of ships and cargo at the port. Demand for labor depends on daily, weekly, seasonal and cyclical fluctuations and, in addition, varies by type of ship and type of cargo.

Overtime and additional changes to the working week solve the problem of irregularity only partially. In the vast majority of ports, the main workforce must still be supplemented by casual workers, who may be pool workers.

The term «casua» port worker is used for professional port workers working on a daily basis. These employees are registered and enjoy an income guarantee or are constantly employed by a pool agency. Their employment is «random» in the sense that they do not work for one employer, but can be distributed for different operators for short tasks. According to Convention No. 137 of the International Labor Organization (ILO), these workers are «regularly available for work as dockers» and «depend on their work as such for their basic annual income» [13].

Tables 1, 2 show the importance of the problems of modern irregularity with data on the programmability of demand for port labor and on the reasons for the use of temporary workers in Italian ports in 2012, collected by the Institut des Sciences de la Forêt tempérée (ISFORT) [14].

Table 1

Programmability of demand for port work in Italian ports by cargo category

No.	Cargo	Programming demand for dockers, %		
		High	Average	Low
1	Ro-ro	31	42	27
2	Containers	35	39	26
3	General	5	27	68
4	Bulk	10	42	48

Table 2

Reasons to rely on temporary workers in Italian ports

No.	Reasons	Gradation	
		From «often» to «sometimes»	From «rare» to «never»
1	Incompatibility of long-term planning with maritime transport characteristics	18	82
2	Economic convenience of the terminal operator	22	78
3	Difficulties for shipping companies to plan loading and unloading	27	73
4	Unpredictable weather and sea conditions	31	69
5	Inadequate workers at peak demand	76	24
6	A large number of ships arriving at the port at the same time	74	26

Determining the number of dockers necessary in a pool remains a «balancing exercise» – as the work [12] says. These words can be interpreted as an enumeration of many options for the number of dockers in the pool and their corresponding indicators characterizing the requirements of market participants. Variants can be determined by a fixed step between some minimum and maximum values. The algorithm of such a solution can be cumbersome without guaranteeing the optimality of the solution.

An alternative to it is the proposal described in [15] and contains the conclusion of the optimality criterion and a solution method using the queuing theory. In this work, in particular, it is proved that the profit of the port will be the greater, the lower the total costs for the idle time of ships, waiting for dockers (during the peak of aggregate demand), and dockers, waiting for ships (decline in aggregate demand). This conclusion at a substantial level clearly agrees with the understanding of the port's marketing activities, the purpose of which is to satisfy the client's needs with benefit (minimum cost) for both himself (the port) and the client.

6.4. Testing of the research results. The above justifications of expediency and methods for determining the necessary parameters are selected as a result of research from reliable sources or our own work, links to which can be considered part of a comprehensive proposal.

The use of open information from the capabilities of the constituents of the cargo delivery chain is not always advisable in connection with its reliability that they may be contradictory, static and averaged for the indicated purposes of use.

For example, the data with a total annual for 2018 from the capacity of the ports of Ukraine differs from 262 million tons from the USPA to 313 million tons from the Center for Transport Strategies of Ukraine. For more detailed information about the throughput of port terminals, the Register of Ukrainian seaports is given for bulk, dry cargo and containers with one value for each. But the intensity of ship handling, which directly affects these values, can vary hundreds of times for dry cargo, depending on the name of the cargo on universal berths. At specialized berths for dry cargo, the difference in this indicator depending on the direction of movement (for example, a change in coal exports for its import) is also significant. And transshipment at container terminals of other dry cargoes, including swift ones, leaves the possibility of using these data.

7. SWOT analysis of research results

Strengths. The strength of this research is the use of a formalized model that allows to obtain current information about competing ports, their optimal cargo turnover and the synergetic effect for the entire supply chain.

Weaknesses. The weakness is that the methodology does not take into account the criterion, minimizes the time of delivery of goods from the supply chain.

Opportunities. The methodology allows to take into account many factors affecting the competitiveness of ports and, if they change, it is possible to reproduce the calculations in order to develop a competitive strategy in the current planning and operational monitoring of the consequences.

Threats. The threat to the research results is that the conditions for the formation of cargo supply chains are uncertain, therefore, to increase the reliability of calculations, it is necessary to consider the production and financial risks of the port.

8. Conclusions

1. It is shown that modern supply chains of goods, including seaports, are faced with the need to introduce administrative and industrial innovations. Considering the practice of other states, it is noted that the classification of port structures is based on two concepts – «infrastructure» and «superstructure» of the port. To the concept of «infrastructure» give:

– port water area;
– approach channel;
– hydraulic structures;
– land plots and newly formed territories;
– systems ensuring the safety of navigation in the port water area and approaches to it;
– access railways and roads, as well as communications;
– emergency rescue fleet, including ships for the elimination of emergency oil spills.

The objects of the superstructure include transshipment equipment, all buildings (covered warehouses, administrative buildings and workshops) vehicles, port fleet, computer networks, communications.

Summing up the above, it is possible to conclude that, depending on which generation the port belongs to, what kind of government system it uses, what type it belongs to, it is influenced by the development trends of world trade. As well as reforms carried out in the port industry in dissimilar countries, and policies introduced by the international community. As a result of this, the pattern of determining the reliability of seaports in cargo delivery chains under the new conditions of the global market environment revolves.

2. It is proposed to determine the adequate characteristics of the infrastructure and superstructure of the port operator to solve by formalizing the calculations of key indicators of port production, increasing the role of personnel and the impact of the application of information technologies.

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