KRUK YU.YU.
Institute Of Market Problems And Economic&Ecological Research of the
National Academy Of Sciences Of Ukraine
Frantsuzskiy Boulevard, 29, Odessa, Ukraine
E-mail: kruk.yurii.2@gmail.com
HTTPS://ORCID/ORG/0000-0001-7794-7452

STRUCTURAL ADAPTATION MECHANISMS OF THE STEVEDOR ACTIVITY MANAGEMENT SYSTEM

Topicality. In the context of economic and organizational transformations, the fulfilment of the stevedoring activity by national maritime terminals was considerably more complicated and proved to be prone to the impact of unpredictable market phenomena, faced with the need to maintain a competitive level and the ability to manage these processes in the new environment. Such variability of the market environment in the provision of stevedoring services requires appropriate methods for managing marine terminals, the application of approaches based on the principles of adaptability, flexibility of both management decisions and the organizational structure of the management system of stevedoring activities.

Aim and tasks. The existing situation in this area of activity was analysed, the conclusion was reached on the existence of an acute need of methodological support formation for the introduction of the newest forms of management in the national sphere of stevedoring services' provision, which was the purpose of this article.

Research results. In the article, the adaptation mechanisms of the regulation system of stevedoring activity at sea port terminals have been formulated and proposed for use in the practice, and a list of conditions for application of the principle of stevedoring management adaptability has been formed. During the study, attention is focused on the analysis of the concept of adaptability and the application of this approach to the management of terminals. Taking into account the fact that the modern sea terminals on which the stevedoring activity takes place, it should be attributed to complex stochastic, dynamic and open systems that at different times can be in different states, it is proposed to represent them as a structurally complex mass service system. An approach to the optimization of adaptive management, based on methods of mass service theory, which also allows one of the main risks in the operator's activity to be assessed, namely, the risk of its destruction as a result of drop in expected turnover of goods has been proposed in the article.

Conclusions. The mechanism of finding a management decision for obtaining the desired level of competitiveness by stevedoring companies per distributing cargo flows between competing port operators at terminals located at different ports, and based on the determined profit of each operator of the port terminal received during the planned period.

Since the quality of the port terminal operator depends essentially on the choice of the management type of its organizational management structure, which is a complex scientific problem, the decision of this problem has been offered in the article by using the research of operations methods and economic-mathematical modelling.

Keywords: stevedoring activity, control system, structural adaptation.

КРУК Ю.Ю.
Інститут проблем ринку та економіко-екологічних досліджень НАН України,
Французький бульвар, 29, м. Одеса, Україна, 65044
E-mail: kruk.yurii.2@gmail.com
HTTPS://ORCID/ORG/0000-0001-7794-7452

МЕХАНІЗМИ СТРУКТУРНОЇ АДАПТАЦІЇ СИСТЕМИ РЕГУЛЮВАННЯ СТИВІДОРНОЇ ДІЯЛЬНОСТІ

Актуальність. В умовах економіко-організаційних перетворень здійснення стивідорної діяльності національними морськими терміналами істотно ускладнилося та виявилося схильним до впливу непередбачуваних ринкових явищ, зіткнувшись із необхідністю збереження конкурентного рівня та здатністю управляти цими процесами в нових умовах. Така мінливість ринкового середовища в сфері надання стивідорних послуг потребує доцільних методів управління морськими терміналами, застосування підходів, заснованих на

принципах адаптивності, гнучкості як управлінських рішень, так й організаційної структури системи управління стивідорною діяльністю.

__Мета та завдання.__ Проаналізовано існуюче положення у цій сфері діяльності, дійдено висновку про існування гострої потреби у формуванні методичного забезпечення впровадження новітніх форм управління національною сферою надання стивідорних послуг, що й склало мету цієї статті.

__Результати.__ У статті сформовано та запропоновано до використання у практиці механізми адаптації системи регулювання стивідорної діяльності на морських портових терміналах, сформовано перелік умов застосування принципу адаптивності управління стивідорною діяльністю. Під час дослідження увагу сконцентровано на аналізі поняття адаптивності та застосуванні цього підходу у практику управління терміналами. Приймаючи до уваги той факт, що сучасні морські термінали, на яких відбувається стивідорна діяльність, слід віднести до складних стохастичних, динамічних і відкритих систем, які у різні моменту часу можуть перебувати у різних станах, запропоновано їх представляти у вигляді структурно-складної системи масового обслуговування. У статті запропоновано підхід до оптимізації адаптивного управління, заснований на методах теорії масового обслуговування, який дозволяє також оцінити один з основних ризиків в діяльності оператора, а саме - ризик його руйнування в результаті зниження очікуваних показників вантажообігу.

__Висновки.__ У статті запропоновано механізм знаходження управлінського рішення щодо отримання бажаного рівня конкурентоспроможності стивідорними компаніями шляхом розподілу вантажопотоків між конкуруючими портовими операторами на терміналах, розташованих у різних портах, та грунтуючись на визначені прибутку кожного з операторів портового терміналу, отриманого у плановий період.

Оскільки якість роботи оператора портового терміналу істотно залежить від вибору його менеджментом типу своєї організаційної структури управління, що являє складну наукову проблему, для її вирішення у статті запропоновано рішення цієї проблеми шляхом використання методів дослідження операцій і економіко-математичне моделювання.

__Ключові слова:__ стивідорна діяльність, системи регулювання, структурна адаптація.

Problem statement and its connection with important scientific and practical tasks. The problem of management enhancement in direction of the production process, achieving high end-results of production and economic activities of enterprises, increasing their competitiveness becomes of particular importance and relevance in the fundamental changes in market conditions. With full confidence it can be insisted that today the very competition of management systems and organizational decisions is beginning to determine the overall success of the sectors of the national economy, their ability to survive and the prospects of development.

Since the stevedoring activity in Ukraine takes place today under the new institutional conditions, this means, first of all, the adoption of the Law "On Sea Ports in Ukraine" [1], and ports realization of their functions on the basis of the new legislation, the question of finding the latest organizational forms of management of the functions execution is arisen, expedient to be uses in difficult conditions. Taking into account the accumulation of a number of problems, the government faced the challenge of updating the legislative provision of the port activity, and fulfilling its main function in providing stevedoring services to port customers. Within the framework of the latest version of the Strategy for the Development of Seaports of Ukraine until 2038, the issue of optimizing the management of the port sector is devoted sufficient attention, nevertheless, the scientific basis for solving these problems is still limited, taking into account world tendencies and the permanent state of uncertainty and increased risk level the operators of national maritime terminals of their main activities

Analysis of recent publications on the problem. Theoretical and methodological foundations of adaptive change management, the base of conceptual and methodological decisions to ensure the effective organizational development of enterprises in market conditions are developed in the works of J. Cotter [2], P. Senzha [3], L. Colins [4]. According to the theory of changes, processes of organizational change are regarded as a new synthetic interdisciplinary trend in economic theory and practice, as a modern scientific toolkit for the development, reorganization of enterprises, an effective means of transformation, change and adaptation.

For example, the concept proposed by J. Cotter "ahead of changes" involves the development of a set of successive stages of organizational changes, including staff explanation of the need for changes, creating a team of reformers, developing and promoting a new vision of prospects for future markets and defining a strategy for their conquest, providing workers with the conditions of their broad participation in changes [4. Pp. 10-11, 14].

Currently, the theory of an organization that is self-taught and capable of self-organization is increasingly popular [5. Pp. 156-157, 164-165]. One of its founders, P. Senzh, states that "... It is not enough to be able to survive or adapt, it is also important to accumulate and multiply the knowledge gained by the organization, which will increase its ability to create." He highlights five main "component-technologies" that form the self-learning organization: system thinking, mental models, personal skills, the construction of spatial vision and team training [4].

Considering that the port terminal is an important part of the transport and logistics chain, it is important to analysis this chain as an adaptive system. The first one who began researching this problem was the famous logistics specialist American scientist Yossi Sheffi. In his monograph [6] he investigated the problem of the impact of supply chain management on enterprise security. He has proved that supply chains are a key factor in the long-term sustainable development and security of modern business.

Selection of previously unsolved parts of the general problem. Any enterprise operates in an environment characterized by a high degree of uncertainty, the sources of which may be the behaviour of consumers of its products, suppliers, competing enterprises, legislative authorities, etc. As a result, enterprises constantly face the unexpected impact of the external environment on the results of their economic activity. And the success of enterprises in the market to a large extent depends on how their management can adapt to the specified impact. One of the main tasks of the science of adaptation is the development of recommendations for management staff, which, above all, are based on a clear understanding of the adaptation concept and its components in relation to the subject of economic activity. The analysis of special literature shows that among specialists there is currently no equal understanding not only in the construction of mechanisms for adapting the adaptive model to the management of stevedoring activities in Ukraine, but also in the formulation of the term "adaptation" itself.

Formulation of research objectives. Analysis of the work and results on the problems of managing stevedoring activities in conditions of increasing the level of competition between port terminals not only at the local level but also in international port services markets led to the conclusion that there is an urgent need to form a methodological provision for the introduction of modern management forms of the national port area into the practice of Ukrainian ports, which is the purpose of this article.

Presentation of the main results and their substantiation. One of the newest areas of management development, along with theories of institutes and institutional changes, is the theory of organizational behaviour, is a theory of change that explores the organization's behaviour in order to survive and develop in an ever-increasing rate of change in the environment.

It is important to note that the need for changes and restructuring applies not only to transport companies in crisis, but also to successful organizations in which managers make the necessary decisions, without waiting for a crisis situation (so-called, proactive solutions). The importance of such mechanisms of management, methodological support and instrumental methods as means of economic adaptation of enterprises, due to the fact that in a dynamic environment, enterprises are forced to change continuously. Hence the need to develop a concept in which, firstly, the object of study is the production system and its environment as a holistic object, and secondly, functioning and development are considered as mutually complementary processes [6-7].

From the point of view of the systemic approach, the modern maritime trading port (as a complex of enterprises operating on its territory and in the water area) is a complex open dynamic system functioning in conditions of uncertainty and risk. From a formal point of view, the system is a large number of elements and processes in which a given R ratio with fixed properties of P is implemented in advance. As such, the requirements of a particular order, the relationships between elements of the system are: the events occurring in one of the elements systems, in some way affect the events in other elements. Like any open system, the port operates in a well-defined external environment, which is a set of clients (port structures, different enterprises). The interaction of the system with the external environment is through the input and output of the system. The input is understood as the point or area of influence on the system from the outside, the output – as the point or region of the system's impact on the external environment. Input influences are uncertain or random, which creates additional difficulties in managing this system, but mainly external influence is systematized by contracts of carriage, purchase and sale, etc. [8-9].

The port community as a dynamic system can be in different states at different times. Usually, the range of possible states of such a system is fixed. The conditions of any system at a certain point in time can be characterized with a certain precision with a set of values of internal parameters. For the port, such

parameters are, for example, the number of vessels located near berths under cargo handling or in anticipation of its beginning, the number of vehicles or cars under freight operations, the number of units of reloading machinery, the number of dockers, machine operators, etc. [8]. However, the most important parameter is freight turnover, its volume and processes of distribution management by port operators (stevedoring companies).

Any dynamic system is characterized by three groups of variables:

• input variables generated by the environment, $x = (x_1, x_2, ..., x_n)$;

• input variables which are summed up by the analysis system and determine the system's impact on the environment, $y = (y_1, y_2, ..., y_m)$;

• state coordinates characterizing the dynamic behaviour of the system being studied, $z = (z_1, z_2, ..., z_r)$;

All three groups of variables are associated with time functions, i.e. $x(t), y(t), z(t)$.

The management of these variables involves taking into account the assumptions about the activities of the port operator, where the inputs can be preparedness of staff, the composition and quality of the transhipment equipment, the level of technology, the amount of the wage fund. The outputs will be the amount of overloaded cargo, the level of quality of reloading operations, the cost of monetary and material resources, etc.

At any time t, the state of the system is a function of the initial state $z(t_0)$ defined for the initial time t_0, and changes the input function $x(t_0, t)$ in the time interval (t_0, t), that is

$$z(t) = F(z(t_0), x(t_0, t)), \tag{1}$$

where F – some function from the arguments $z(t), x(t)$.

Similarly, the output vector at time t can be represented as follows:

$$y(t) = \Psi\left(z(t_0), x(t_0, t)\right), \tag{2}$$

where Ψ − some given function.

The above equations are *state equations* of the system. Typically, the functions F and Ψ are determined by solving the initial problem for differential equations describing the trajectory of system state changes, that is, the equations of the form

$$dz(t) / dt = f(z(t), x(t)), \tag{3}$$

$$dy(t) / dt = g(z(t), x(t)), \tag{4}$$

where $f(.,.), g(.,.)$ – given function. Solutions of these equations − this is the initial, but very important stage of the analysis and synthesis of systems in the modern theory of management. Affecting the inputs of the system, you can transfer it from one state to another, and thus obtain changes in the output that forms the new state of the system. The transfer of a system from one state to another is accompanied by certain organizational, economic, financial, labour and other costs. In this case, management should be considered optimal if the transition of the system from one state to another, corresponding to the achievement of the goal, will be accompanied by minimal costs.

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The path of passing information in the management system is largely determined by the organization of the system and the tasks that it solves at a specific time or at a certain time interval. Therefore, when studying control tasks, it is important to have the sequence of information passing through the elements of the contours that are part of the system, and the account of the transformations that are subjected to information within the centralized information system.

The system receives some or other values of the input parameters. By changing them, you can change the current state of the system. The latter can be installed by observing the state of the system's output parameters.

Depending on the nature of the connections between the elements of the system and the events occurring within its boundaries, deterministic and probabilistic (stochastic) systems are distinguished. In the

reality of strictly deterministic systems does not exist, therefore, it is more correct to define a deterministic system as a special case of a probabilistic system in which the probability of the expected event is close to unity.

From the point of view of the time-stable legislative framework and forecasting cargo turnover, the system of port terminals is deterministic; from the point of view of the influence of random factors of economic, financial, hydrometeorological, navigation, ecological, sanitary, and even criminogenic - it is probabilistic. The task of management – to build stochastic system as close as possible to deterministic.

A modern seaport should be classified as complex dynamic and open systems. In the analysis of a complex system, it is important not only its elemental consideration, but also the study as a whole, in the all set of relationships, emphasizing inherent property of its *emergence*. Regarding the management of stevedoring activities, this means highly efficient organization of work, the possibility of vertical and horizontal cooperation between different terminals, between the port administration and operators of these terminals, etc.

The dynamic nature of the system means that it is in dynamics, that is, during a post gap of time it moves from one steady state to another. This is different from a static system that does not change its structure or state over time. Whereas static systems practically does not exist in the reality, dynamical systems, in contrast to static, are usually called systems, the transition of which to a new state can not occur instantaneously, but takes some time. An example of such a system can be the system of port terminal management, or port area as a whole.

As a stochastic dynamic system, the port terminals on which the stevedoring activity takes place, can most adequately be represented in the form of a structurally complex queue system (QS) [9-11]. It should, however, keep in mind that port terminals of different specializations may differ from each other by some features of economic, financial, technological and organizational nature.

Port terminals, as a dynamic system, are constantly evolving. Many large overseas ports have their own laboratories, which, along with external organizations, carry out scientific research on the further development of terminal capacities. Thus, to the elements of the managed system, we shall refer to the processes of development of ports: organizational, legal, economic, financial and social. At the same time, the adaptive management system for these processes will be considered as a dialectically integral system that harmonizes market relations and links, involves applying a set of forms and methods of survival in competitive environment, and is a subsystem of the government economic mechanism that determines the integrity of the formation of economic, intraeconomic and market functioning mechanisms, as well as a component of the economic policy of the state, which provides support and economic regulation of the stevedoring activity in Ukraine.

From the point of view of a system approach the controllable system, that is, a production system, the port system can be divided according to its management processes into the following subsystems: development of port services, their preparation, own transhipment, provision and maintenance, implementation of auxiliary services.

The subsystem of development, in turn, consists of subsystems of organizational, economic, scientific and technical and social development. Subsystem of preparation of port terminal services is divided into such subsystems: organizational, economic, technical and personnel. The construction of the appropriate organizational subsystem ensures the conditions and procedures for the implementation of all operations for the provision of services. The economic subsystem is composed of subsystems of planning, material and financial training. The personnel subsystem includes training, retraining and advanced training of staff and provides efficient personnel allocation for solving the main and auxiliary functional tasks of port terminal operators.

It should be noted that the main thing - is the provision of port services, in the first place, stevedoring, all other systems or subsystems are intended to provide basic production, and are subordinate to it.

From the point of view of the system approach to the operation of port terminals, the most important factor is the organization of a managed system, which is considered as a certain ordering of its constituent elements and their interaction.

The concept of an organization includes the formation of a system and the management of its functioning. Since the port has been established, all of its elements must function interrelated so that the selected performance criteria reach extreme values and, consequently, their goals would be realized in the best way. The purpose of the management system of stevedoring activities is to provide maximum or

minimum values of the performance indicators of port terminals in accordance with selected criteria. In this case, the management system is characterized by organizational and functional structures. The organizational and functional structures of the control system, as a rule, reflect the structure of the control object in the sense that the main units of the port terminals correspond to similar units of the control system.

As the main functions of port terminal management, it is understood that [8]:
- Planning of production and economic activity;
- Operational management of cargo handling;
- Management of development and technical preparation of cargo handling;
- Management of material and technical supply;
- Quality control of products;
- Accounting of services provided and financial activities;
- Management of technical support and organizational&economic services of port terminals;
- Selection, placement, training and raising the cultural and technical level of staff;
- Management of social development of port terminals;
- Improving the organization of services, work and management.

To implement these functions, it is necessary to ensure implementation a complex of work with the solution of individual problems related both to strategic and operational management.

Naturally, the processes of the transhipment of goods and their management proceed in parallel and mutually agreed.

From a modern point of view, port terminals are elements of the logistics system that transforms the flow of goods and are prone to stochastic effects of the environment.

The function of management directly related to the material flow is the function of ensuring the handling by the necessary resources: objects of transhipment, that is, cargoes, tools, reloading equipment and personnel, turning this object of labour with the help of tools in the finished service. For the cyclic implementation of this management function, it is necessary to plan the implementation of port services. Therefore, this function should include personnel management, maintenance of inventories, energy supply, tools and repair, maintaining the basic production assets at the proper level.

In order to maintain the level of resources in the right amount and condition for each moment, it is necessary to manage the process of their provision in time. These tasks should be carried out at the following two levels of the management system hierarchy: levels of operational planning and operational regulation levels. Both of them play an important role in the process of ensuring a steady and efficient production of port terminals. The system of operational regulation takes information about the necessary and actual state of the reloading process, produces control impacts and implements them. Information about the required state of the process is provided to it from the system of operative production planning, which, in essence, gives the current settings of the regulated parameters of the control object (for a month, day, shift). These guidelines can be set based on normative data and annual production programs.

Formation of an annual production program is a function of the next level of the hierarchy - the subsystem of organizational and economic planning. This subsystem should be based on tasks from the higher authority, information on the state of production and the environment, and, based on the results of the forecasting subsystem and general development of the port, the tasks of this level occupy the very high position in the hierarchy of the port management system.

The function of the forecasting subsystem in the general managing system of the port terminal is the analysis and evaluation of the efficiency of the terminal total economic activity, the whole port, and predictions the prospects for their development, depending on the requirements of the economic system of society and the environmental conditions. The result of this subsystem affects the social and technical development of management objects - port terminals and ports itself.

However, the latest and most original approach to enterprise organization is the model proposed by the Danish consultant on corporate restructuring and enterprise planning L. Colins. For L. Collins's model, multiple intertwining and overlap of employees' individual roles, is characteristic. Within this model, there is a complete rejection of the bureaucratic model (or its minimization) in favour of the most flexible organizational structure [4]. L. Colin reconsidered the organization, which has located in the very core of its interaction, cooperation and the ability to consolidate people, customers, suppliers and ideas. His model differs from other specific features:

The choice - the employee chooses for himself a certain project, forming a team around him (in this case, people invited to the project, during its implementation can be changed, and managers are engaged in coordination activities);

Multiplicity roles - the project approach creates, educates multidisciplinary people;

Transparency - the uniform distribution of knowledge throughout the organization [4. Pp. 130-131].

Note that the view on adaptation, as self-adjustment is the most common, characterizes the very essence of adaptation and can be used in any field of science. However, this understanding of adaptation is used in those cases where general scientific issues are discussed, without going into the kernel of a particular problem.

Derived from the notion of "adaptation" is the concept of "adaptive management", which is fundamental interest for further research. In accordance with the definition given in [7], under adaptive control we will understand the management of the system under conditions of incomplete a priori information in a controlled process, which changes with the accumulation of information and is adopted in order to improve the quality of the system. Sometimes adaptive management is associated with the notion of performance, although performance as a criterion for the success of an enterprise is justified only when the market provides additional sales opportunities.

The purpose of adaptive control is to diagnose everything that occurs inside the system (i.e., enterprises): processes, research processes that occur outside the system and based on the results of the diagnosis of planning the development prospects.

The main task of adaptive management is to support the internal stability of the system in an ever-changing environment.

Definition of adaptive control as a process of purposeful change of parameters, structure and properties of any object in response to changes occurring both in the external environment of the enterprise and inside of it, is universal, it can be used by enterprises of any industry at the occurrence of changes in the external environment and in the enterprise itself, which affect its activities.

The necessity of adaptive management of the port operator is conditioned:

a) Unbalanced national legislation, which in turn constantly "responds" to national factors and changes in international norms related to global maritime trade either directly or through "providing" rules (conventions on safety, environmental protection, etc.); here we can also talk about contractual "flexibility", referring to the possibility of revision of contracts during its period of validity;

b) Flexible tariffs on stevedoring services as a reaction to the changing domestic and foreign trade conditions affecting the volumes of freight traffic;

c) Scientific and technical advance in the field of technical and transport technologies, including cargo handling;

d) Qualitatively new staffing, including its qualifications, social needs, employment;

e) Influence of political, economic, hydrometeorological factors, accidents on the process of vessels arrival and overload of cargo.

Adaptability is closely linked to the risks accompanying the stevedoring activity in each of the referred aspects. Therefore, using adaptive management should always take into account possible risks, use modern risk management techniques to reduce their impact.

Since the development of the stevedoring activity is also closely linked to certain changes that directly affect the operational and management procedures for providing stevedoring activities in seaports, these changes should meet the requirements for the formation of adaptive management structures for this activity, taking into account the implementation peculiarities of this activity in Ukraine and modern world conditions.

Undoubtedly, the formation of adaptive organizational structures should be accompanied by advisable methodological principles that will enable them to meet the set goals and objectives of the operational and strategic levels put forward by the stevedoring companies. Therefore, it is extremely important for stevedoring activities of the desired level of efficiency and competitiveness, it is advisable to use the methods of determining equilibrium management decision in conditions of oligopoly. This approach will enable operators of port terminals to build a competitive strategy that is adequate to meet the requirements of the modern world port services market.

To find a management solution in the sense of increasing the competitiveness of the port terminal it is advisable to dwell on the problem solution of freight traffic distribution between n-competing operators on port terminals located at different ports. In order to make a thorough decision in this direction, we have

chosen the profit definition of each operator obtained in the planning period T. It is assumed, as is usually done in the firm's theory [13], that the price for overloading 1 ton of cargo linearly decreases with the growth of cargo turnover of the terminal. For i-th operator this profit will be

$$\Pi_i(T) = \left[p_i - r_i - k \sum_{l=1}^{n} \sum_{j=1}^{V_l(T)} \Upsilon_{lj} \right] \sum_{j=1}^{V_i(T)} \Upsilon_{ij}, i = 1,2,\dots,n, \tag{5}$$

where p_i − the maximum possible price for the cargo overload on the i-th terminal;

r_i − operating costs for the i-th terminal;

k − the coefficient that determines the elasticity of demand for terminal operator's services;

$v_i(T)$ - the number of ships that arrived at the i-terminal in time intervals $(0, T)$;

Υ_{ij} - net load in the j-th account of the vessel arriving at the i-th terminal.

Usually, when simulating port work, they take the hypothesis of the Poisson character arriving ships at the port, which is confirmed by numerous statistical checks [12]. Therefore, we assume that $v_i(T)$ is a Poisson random process, and it being known that

$$P\{v_i(T) = k\} = \frac{(\lambda_i T)^k}{k!} e^{-\lambda_i T}, k = 0,1,2,\dots, \tag{6}$$

where λ_i − the intensity of the ships flow arriving at the i-th terminal.

All Poisson flows of ships arriving at port terminals are assumed to be statistically mutually independent.

Regarding random variables γ_{ij}, we will assume that they are mutually independent, and assume that they are all distributed according to the same law $G(x)$.

Expression (5) expresses the desire of the i-th operator in the considered oligopoly to attract more ship traffic due to discounts on basic charges for overloading the cargo p_i.

Taking into account the assumptions made, one can calculate the mathematical expectation of profit (5). For example, for a duopoly (n = 2) we find

$$M\Pi_i(T) = (p_i - r_i)\lambda_i g T - k\lambda_i \left(g^{(2)} + \lambda_i T g^2 \right) T - k\lambda_1 \lambda_2 T^2 g^2, i = 1,2, \tag{7}$$

where $g = \int_0^\infty x dG(x) < \infty$; $g^{(2)} = \int_0^\infty x^2 dG(x) < \infty$.

Using expressions (7), we can find the values of the intensities of the ships flows λ_i that provide the maximum value (7) and lead to various equilibrium oligopoly solutions, for example, in the sense of Cournot or Stackelberg [13-14]. Consider, for example, the simplest case of the Cournot equilibrium. Purpose we equate the partial derivatives of functions (7) with the parameters $\lambda_i = 1,2$, to zero, and then we obtain the system of equations:

$$\frac{\partial \Pi_1}{\partial \lambda_1} = (p_1 - r_1)g T - kT\left(g^{(2)} + 2\lambda_1 g^2 T + \lambda_2 g^2 T \right) = 0, \tag{8}$$

$$\frac{\partial \Pi_2}{\partial \lambda_2} = (p_2 - r_2)g T - kT\left(g^{(2)} + 2\lambda_2 g^2 T + \lambda_1 g^2 T \right) = 0$$

Enter the following notation:

$$q_i = \lambda_i g T, i = 1,2.$$

The introduced variables have the meaning of the average cargo turnover of the i-th terminal at the planning interval T. Using them, the system (8) will be rewritten in the following form:

$$2q_1 + q_2 = \frac{p_1 - r_1}{k} - \frac{g^{(2)}}{g},$$

$$q_1 + 2q_2 = \frac{p_2 - r_2}{k} - \frac{g^{(2)}}{g},$$

The solution of this equations system has the form:

$$q_1 = \frac{1}{3}\left(2\frac{p_1 - r_1}{k} - \frac{p_2 - r_2}{k} - \frac{g^{(2)}}{g}\right), \tag{9}$$

$$q_2 = \frac{1}{3}\left(2\frac{p_2 - r_2}{k} - \frac{p_1 - r_1}{k} - \frac{g^{(2)}}{g}\right),$$

The equilibrium solution of the duopoly Cournot (9) has a physical meaning only when the conditions are fulfilled

$$2\frac{p_1 - r_1}{k} > \frac{p_2 - r_2}{k} + \frac{g^{(2)}}{g}, \tag{10}$$

$$2\frac{p_2 - r_2}{k} > \frac{p_1 - r_1}{k} + \frac{g^{(2)}}{g},$$

Conditions (10) are necessary for the existence of the Cournot equilibrium in the considered duopoly. In this case, each operator will receive its maximum expected (that is, average) profit.

Similarly, the equilibrium can be analysed according to Stackelberg, but the appropriate analysis is more complicated

If both operators agree to co-operate, that is to work for the overall result, in this case they should strive to maximize the total average profit, that is, the expression (see (7))

$$\text{МП}_1(T) + \text{МП}_2(T) = \sum_{i=1}^{2}\left[(p_i - r_1)\lambda_i gT - k\lambda_i\big(g^{(2)} + \lambda_i Tg^2\big)T\right] - 2k\lambda_1\lambda_2 T^2 g^2 \tag{11}$$

It's easy to make sure that the maximum of this expression by parameters is achieved with

$$q_1^* = \frac{1}{3}\left[\frac{2(p_2 - r_2) - (p_1 - r_1)}{k} - \frac{g^{(2)}}{g}\right], \tag{12}$$

$$q_2^* = \frac{1}{3}\left[\frac{2(p_1 - r_1) - (p_2 - r_2)}{k} - \frac{g^{(2)}}{g}\right],$$

where $q_i^* = \lambda_i^* gT, i = 1,2$. Comparing this solution with (9), we can see that

$$q_1^* = q_2, \qquad q_2^* = q_1$$

Thus, the method of oligopoly analysis in the conditions of uncertainty caused by uneven arrival of vessels to terminals is given; it can be used in the development of the maritime port terminal operator of a competitive strategy within the framework of constructing an adaptive control system.

The above approach to the optimization of adaptive management, based on the methods of queue system theory, also allows one of the main risks in the operator's business to be evaluated, namely, the risk of bankruptcy as a result of a decrease in the expected turnover of goods. For example, it might be of interest to him to assess the probability that for the i-th terminal at the end of the period T it turns out that

$$\sum_{k=1}^{v_i(T)} \gamma_{ki} < \lambda_i gT \tag{13}$$

that is, the actual turnover will be less than predicted. This condition means the potential risk of bankruptcy the operator. The specified risk can be minimized by means of various risk management methods: insurance, self-insurance, temporary decrease of operating expenses, etc. From the stochastic theory of stocks, it is known [12] that for $T \rightarrow \infty$ the following asymptotic formula holds true:

$$P\left\{\sum_{k=1}^{v_i(T)} \gamma_{ki} < \lambda_i gT\right\} \approx N\left(\frac{2\lambda_i gT}{\sqrt{\lambda_i Tg^{(2)}}}\right), \tag{14}$$

where $N(x)$ − standard normal distribution with zero mathematical expectation and unit dispersion

The given approach can be applied also for the decision of the ship-owner to solve the problem of choosing the terminal for the vessel's approach. The criterion of type (5) reflects the operator's interest in terms of attracting the ship's flow due to flexible tariff policy. However, from the ship owner's interest point of view, the criterion of minimizing its expected costs associated with the vessel's approach to the port where the terminal is located, processing it and with the unproductive downtime of the ship is a more appropriate criterion.

Conclusions and prospects of further research.

The referred adaptive methods of managing stevedoring activities are more sophisticated and flexible; since the essence of adaptation here is that the model is following the process. This causes the changes in the model to be taken into account from new trends in the real process. However, the longer the waiting time, the greater the discrepancy between the forecast and the actual values of the row. Consequently, the model of the considered class can be recommended, mainly, for obtaining short-term forecasts.

Many of the considered models describe the relationship between the investigated quantity and time. This circumstance itself is a rather serious constraint. On the other hand, time in the model reveals the evolution of the whole complex of conditions for the process. After some time, the output series is implicitly combined with a multitude of interconnected factors, which take into account the impact of which is somewhat difficult. Due to the simplified representation of the investigated quantity associated with only one factor of time, modelling becomes possible even with the scantiest information. The positive feature of adaptive methods is their help in investigation of the internal structure of the time series, the interrelation of its consecutive members, and the models that are the tool of the forecast, are sensitive to dynamic changes and are accordingly rebuilt in one way or another, in view of the depreciation outdate information.

The above analysis shows that in the conditions of competition and occurrence of various risk situations, the most adaptive organizational structures of management are most effective because of their flexibility. At the same time, their use in port practice has a number of specific features that reflect the type of production activity of the terminal associated with the provision of various material and information services to the customers. For all that, the leading role should be played by scientific methods of forecasting the occurrence of adverse situations (reduction of cargo turnover, competitors' actions, political, commercial, etc.).

The quality of the port terminal operation, which is the most important competitive factor, essentially depends on the choice of the terminal type of its organizational management structure. However, the discovery of this dependence is a complex scientific problem, for solving which requires appropriate research using the methods of investigation of operations and economic-mathematical modelling.

More perfect methods for forecasting the cargo flow of the terminal allow formulating and solving important tasks concerning the improvement of the terminal's work management. This is, first of all, the effective competitive policy design in conditions of oligopoly and uncertain fluctuations in cargo turnover on the horizon of planning using a combination of the firms theory and operations research methods, namely, the queue theory and the theory of inventory management. The advantage of this approach is the ability to use the principles of adaptive management in a constantly changing production situation, which is characterized by the number of vehicles currently in the terminal, their levels of loading and the presence of goods in warehouse. The criteria of optimality reflect equally the interests of the terminal operator and the cargo owners, since the stoppage of both the vessels and the railway vehicles must always minimize. The build model may well be used in developing variable-day plans for the terminal based on the use of standard mathematical support.

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