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MULTI-AGENT ORGANIZATIONAL MODEL OF ADAPTIVE MANAGEMENT OF A TRANSPORT AND LOGISTICS SYSTEM AND DETERMINATION OF EFFICIENCY CRITERIA FOR THE SYSTEM'S TRANSPORT-PRODUCTION PROCESS

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The transformation of managerial interactions and economic relations in the country's transport sector requires the development and improvement of the organizational model of the transport and logistics system in order to create an alternative system with properties of self-maintenance and self-adaptation to ongoing changes in the interaction of participants in the transport-production process. This is necessary for the implementation of strategies that are currently difficult to realize using traditional organizational and managerial methods and mechanisms.

The high level of development of transport enterprises, firms, and companies, the intensification of external influences, and the emergence of new technological products increase the risks to their stable improvement, resulting in a growing need to maintain their competitiveness. Many transport and logistics enterprises, firms, and companies feel the necessity to combine efforts and integrate processes to preserve development dynamics and competitiveness.

To develop and improve the organizational model of the transport system, an alternative model has been designed, presenting a cluster-based concept for the development of transport enterprises, firms, and companies through the integration of transport-production processes and the cluster formation of transport services. This model is based on the concept of intersectoral interaction within a unified national transport system and the pooling of resources to achieve a common goal. In other words, it is a form of integration characterized by the preservation of the autonomy of system participants, structural flexibility, long life cycle, and coordinated actions of the participants.

The theory of territorial-industrial complexes has been studied most extensively, while the theory of cluster formation of integrated transport services—where the core of the cluster is a complex of transport services using various modes of transport—has been explored to a lesser extent. The problem of forming transport services is particularly important, as the sphere of transport services represents the transition of products from the production sector to the sphere of consumption, completing the production cycle and transforming products into material value for the consumer and profit for the transport system/company. It is also one of the key indicators of the socio-economic development of a country and a measure of the population's standard of living.

A multi-agent organizational model of managing the transport and logistics system has been developed for domestic freight transportation, as well as a multi-agent model for managing the transport and logistics system in the sphere of international freight transportation.

These models represent systems of organization and management of integrated transport services, where the interaction of system participants relies on the use of resources of structural units involved in the transport-production process on the basis of self-maintenance and self-organization. Self-organization links profit, investment, and the objective function of structural units.

The adaptation mechanism is considered as a multi-level system:

- the upper level is the coordination and management apparatus;
- the second, third, and fourth levels represent the self-organizing element;
- the lowest level includes consumers (manufacturing enterprises) and the structural units of the transport company.

The variation of states of the transport and logistics system and its multi-objective function depend on the following parameters: $A = A_1, \dots, A_N$, $B = B_1, \dots, B_N$, $C = C_1, \dots, C_N$, $D = D_1, \dots, D_N$. The combination of these parameters creates the mechanism for regulating and coordinating the system $\Sigma = \{A, B, C, D\}$ and is represented as follows: all parameters determine the state of the transport and logistics processes of the representatives of the self-organized element the key indicators of the quality criteria of the integrated transport service.

Using the theoretical foundations of adaptive mechanism formation, we define the profitability of the i -th structural unit of the transport system as follows: A_i :

$$A_i = (Z_i - C_i)(1 - gn_i)N_i, \quad (1)$$

where Z_i - the costs associated with the transport-production process;

C_i - the cost of the process itself;

gn_i - the profit tax rate;

N_i - the number of transport services provided.

Indicator B_i determines the effectiveness of investments in the development of the transport system:

$$B_i = r_i(1 + S_i) \quad (2)$$

where r_i - investment efficiency;

S_i - the support of investments by the management and coordination authority.

Indicator C_i determines the depreciation of transport-production assets:

$$C_i = 1 - a_i R_i. \quad (3)$$

where a_i - the depreciation rate;

R_i - the individual depreciation coefficient.

Indicator D_i shows what share of the profit retained by the i -th structural unit depends on the depreciation allowance and the profit tax rate:

$$D_i = 1 - gn_i - f_i. \quad (4)$$

where f_i - depreciation allowances.

Thus, the task of achieving the optimal synergistic effect of the self-organization mechanism in the developed organizational model consists in ensuring the development of all subjects of the integrated transport service, without exception, that belong to the structure of the self-organizing element, as well as in creating such a transport and logistics process that will provide the maximum value of the objective function of the integrated transport service on the existing set of coordinating and optimal criteria.

The application of a multi-agent organizational model of adaptive management of the transport and logistics system ensures the development of competition in the provision of transport services, guaranteed accessibility to road transport services and rolling stock, a competitive level of service quality, and the improvement of freight transportation technologies, which reduces transport costs and the added value of products.

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