Modern market requirements for transportation of cargo flows according to the «quality, speed, and cost» criteria were studied. It was found that multimodal routes have the lowest delivery time, high reliability, and minimum transit time, which provides a more accurate level of control of costs, traffic schedules, and transport safety. It was determined that the effectiveness of multimodal transportation schemes depends on a degree of realization of resource capabilities and management technologies of a multimodal transport operator (MTO).

The functional features and the MTO classification were generalized, which makes it possible to generate the MTO business model as a responsible integrator of transport and logistic processes, rather than consider it only from the point of view of the organizer of mixed transportation schemes.

The technology of the organizational transportation process was systematized, based on which a system of strategic goals and key performance indicators (KPI) was developed, which makes it possible to determine the «bottlenecks» according to the main business processes of a multimodal transportation operator.

The modified multifactor DuPont model was proposed, which makes it possible to establish the priority of factor evaluation of more time-stable indicators based on determining the levers of the MTO resource efficiency with greater coverage of factors.

The performed research can become the basis for further development of the multimodal cargo transportation system based on the development of the model for optimal management of the MTO business processes

Keywords: multimodal transport operator, key performance indicators, modified DuPont factor model

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DEVELOPMENT OF CONCEPTUAL PROVISIONS TO EFFECTIVELY MANAGE THE ACTIVITIES OF A MULTIMODAL TRANSPORT OPERATOR

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1. Introduction

Multimodal transportation is a modern concept aimed at increasing the efficiency of the world economic system by transforming the relationship between trade and economic partners and global carriers.

The key figure that should organize the «door-to-door» transportation process with the participation of various types of transport within a unified responsibility system at optimal costs is the Multimodal Transport Operator (MTO). It is the existence of MTO responsibility for the complete transport and logistic cycle that contributes to the formation and development of an effective system of management, control, and coordinated work of all elements of the transport and logistic system of different levels. The prospects for the MTO development are primarily associated with a possible increase in return on invested capital, provision of lower transport and logistic tariffs, as well as the best organizational, technological, and financial conditions.

Taking into consideration the fact that the MTO has the right to conclude a unified agreement of mixed transportation and assume responsibility for the entire transportation chain, it must be a recognized company in the market of transport and logistic services. Hence, it turns out that the MTO is the only responsible party that can coordinate all types of transport and organize multimodal transportation. Shippers and cargo receivers are not able to perform the functions of the MTO regarding the formation of the optimal transportation route and the optimal price of the complete delivery chain due to the lack of experience in controlling various modes of transport and ensuring their effective interaction. These key participants do not have the ability to identify, predict, and even solve problems with their cargo that may arise during transit.

That is why the issues of determining the features of the MTO activities and ensuring their effective development are relevant and require a detailed study.

2. Literature review and problem statement

Paper [1] proposed the basic aspects of the organization of optimal interaction of transport systems. The presented research results provide the main provisions for ensuring the

economic efficiency of their comprehensive activities. However, the issues related to determining the conceptual apparatus of mixed transportation remained unresolved. The option to overcome the corresponding difficulties may be associated with the unification of the main concepts arising in the process of interaction of transport systems. This approach is used in research [2], which generalized the key concepts of mixed transportation and proposed to distinguish between the concepts of multimodal and intermodal transportation based on the degree of responsibility of a carrier and by the scope of application. In addition, it is stated in this paper that the transportation distance should also be considered as a difference between the two above categories, which is a controversial issue.

The system of key performance indicators of cargo transportation from the point of view of logistics is given in paper [3]. However, these proposals do not answer the question of how to assess the effectiveness of the transportation process within a complete delivery chain.

The problems of the development of multimodal transportation systems and intermodal technologies are explored in a significant number of scientific developments. Thus, the authors of paper [4] study in detail the features of interaction and coordination of modes of transport, as well as the use of intermodal technologies in multimodal transportation. At the same time, the activity of a multimodal transport operator almost was not considered by scientists, and in general, is identified with the concept of «a freight forwarder».

Paper [5] examined the basic concepts of multimodal transportation, proposed the classification of the criteria for the quality of multimodal transportation management, and developed mathematical models according to the specificity of the transportation process. A multimodal transport operator acts as a contract carrier, taking responsibility to its client for the cargo safety along the entire route, and this is what distinguishes it from a freight forwarder. This approach makes it impossible to recognize the MTO as a responsible integrator of the «door-to-door» transport and logistic process of cargo delivery.

Tasks and technologies of transportation management within transport-terminal networks of multimodal transport operators, as well as their mathematical descriptions, are explored in research [6], in which the authors determine the features of the activities of transport and forwarding companies in the organization of multimodal transportation. At the same time, it is not entirely clear how the scientists interpret the concept of «a multimodal transport operator» and by what criteria it is possible to distinguish it from traditional freight forwarders.

The author of paper [7] conducts a detailed analysis of the main technological processes of mixed (multimodal) transportation based on economic and mathematical modeling. At the same time, the tools and methods given in this work are inherent in maritime transport and do not take into consideration the specific features of the organization of mixed transportation with an air leg. Paper [8] states that multimodal transportation results in saving the time of cargo delivery from a producer to a consumer, decreasing the stock, establishing competitive prices for products, reducing logistical risks, etc. In addition, the author proposes a procedure for calculating the effectiveness of multimodal transportation of the *i*-th group, from which it is not clear what the at-a-load tariff rate involves and how this indicator is determined.

Conceptual provisions of mixed transportation, functions, and tasks of operators of multimodal transport, as well as the role of sea transport in the international transportation system, are studied in detail in paper [9], however, in this work, the emphasis is placed on organizational aspects of multimodal transportation. The proposed scientific and methodological approaches are inherent in the specifics of sea transport and do not take into consideration the peculiarities of other modes of transport, which significantly narrow the possibility of their use in practical activities.

The problems and prospects for the development of multimodal transportation in Ukraine are considered in article [10]. At the same time, the focus is on rail transport in the multimodal transportation system.

Thus, the conducted literature analysis makes it possible to assert a sufficiently significant theoretical and methodological substantiation of the problems associated with the organization of multimodal transportation. However, in the scientific circle, the issues related to determining the peculiarities of functioning and ensuring the effectiveness of the activities of multimodal transport operators remain unresolved. All this gives grounds to state that it is appropriate to conduct a study devoted to the development of conceptual aspects of the efficiency of activities of a multimodal transport operator.

3. The aim and objectives of the study

The aim of this research is to develop conceptual provisions for the effective management of the activities of multimodal transport operators. This will make it possible to perform a quantitative and qualitative assessment of key performance indicators of the system of multimodal cargo transportation management.

To achieve the set aim, the following tasks should be solved:

– to identify the specific features of multimodal transport operators as key participants in the market of transport and logistic services, as well as to improve their classification according to the relevant characteristics and to develop a mechanism for the formation of the MTO products;

– to develop a system of goals and key performance indicators of a multimodal transport operator;

– to adapt the DuPont factor model to modern conditions for constructing a multiplicative model for assessing the profitability of the capital of a multimodal transport operator.

4. Materials and methods of research

In the process of research, we used the methods for analysis and synthesis to determine the key conceptual provisions of scientific research works on the issues of multimodal transport organization.

To clarify the essence of the concept of «a multimodal transport operator», we used the methods of logical generalization.

Methods of systemic analysis were used in the study of the role of a multimodal transport operator in the process of forming a complete cargo delivery chain.

In the development of a system of key performance indicators of multimodal transport operators, we used the methods for evaluating economic efficiency and optimization of managerial solutions.

The methods of statistic and factor analysis became the basis for assessing the analytical materials of companies DHL Supply Chain & Global Forwarding (Germany) and Kuehne+Nagel (Switzerland) to determine the degree of the key factors' influence on the profitability of their own activities.

5. Results of development of conceptual provisions for effective management of activities of multimodal transport operators in the market of transport and logistic services

5. 1. Determining organizational and functional features of multimodal transport operators as key participants in the market of transport and logistic services

The UNO Convention «On International Mixed Cargo Transportation» enshrines the status of an operator as any person who, on his own behalf or through another person acting on his behalf, concludes a contract of mixed transportation. An operator is not an agent but rather acts as a party to the contract that assumes responsibility for its implementation [11].

It was found that the MTO competitiveness largely depends on how effectively they apply all available methods of transportation process management. At the same time, the key direction of activity should be the optimal use of existing capacities, resources, and operating conditions of each particular kind of transport.

Based on the specific features of MTO functioning, a generalized classification, which takes into consideration the status of an operator in relation to the existence of a fleet of vehicles of various types and the possibilities of their organizational and technological integration, was proposed (Table 1).

It should be noted that linear conferences can also act as the MTO. This is a formal agreement between several carriers on the implementation of linear transportation on specific routes under agreed terms of activity, in particular, tariff policy, transportation conditions, reloading, etc.

Linear conferences, on the one hand, contribute to adherence to the use of established tariff rates and eliminate price manipulation in domestic transport markets. However, on the other hand, they lead to aggravation of internal and external competition, as well as create conditions for removing carriers specializing in only one transport mode, and accelerate the monopolization processes.

According to the world practice, the MTO solves a set of complex problems and can independently perform separate transport or terminal operations related to multimodal transportation. The typical technology of MTO transportation is shown in Fig. 1.

Fig. 1 shows that the tasks of the MTO are numerous and multi-aspect. That is why their implementation under the responsibility of one company is a beneficial solution for a customer of multimodal transportation, not only from the organizational but also from the financial point of view.

A multimodal transport operator is responsible for losses resulting from the cargo loss or damage, as well as delivery details if the circumstances that caused them occurred while the cargo was under its control. The MTO is exempt from liability if it is proved that it, its staff, or agents have taken all measures that could reasonably be required to avoid such circumstances and their consequences [12–16].

Table 1

Classification of multimodal transport operators (MTO)

Classification feature	Type of MTO	Brief characteristic
According to the sphere of activity	Container MTO	Operators specializing, as a rule, only in container multimodal transportations
	Conventional MTO	Operators specializing in multimodal transportation of conventional (non-container, general) cargoes (bulk, loose, fluid cargoes)
	Combined MTO	Operators specializing in both container and conventional multimodal transportations
According to the degree of independence of «door to door» transportation	Actual MTO	Operators who use their own fleet of vehicles and independently provide transportation activities
	AgreementMTO	Operators who carry out and provide transportation activities based on agreements on managing the vehicles with enterprises of different types of transport (management agreement)
According to the existence of the own fleet of vehicles	MTO that own vehicles (Carrier-MTO)	Operators who have their own fleet of vehicles of different modes of transport and carry out transportation independently
	MTO that do not own vehicles (Non-Carrier-MTO)	Operators that do not own vehicles of different modes. Non-Carrier-MTO will arrange «door to door» delivery under their responsibility on a non-reloading basis using consolidated cargo loading into their own or leased consolidated cargo units (containers). In case of acceptance of responsibility for cargo delivery by an operator, forwarding documents are submitted and a multimodal bill of landing is made. A freight forwarder can act as an MTO of this type
According to the scope of proposed additional services	Universal MTO	Operators that were formed to provide a wide range of additional multimodal transportation services without resorting to investment in various types of vehicles. They can choose an economical and efficient delivery method at any time. This type of operator is focused on customers and requires significant volumes of cargo for successful activities
	Specialized MTO	Operators specializing only in certain types of additional services in the process of organizing and performing multimodal transportation. This type of operator focuses mainly on the implementation of transportation activities and the development of a fleet of various types of vehicles
According to the rate of territory coverage	Global MTO	MTO operating at the global level (multinational companies)
	Regional MTO	MTO operating within a specific region of the world
	International MTO	MTO operating between separate countries, within the international transport corridors (ITC)

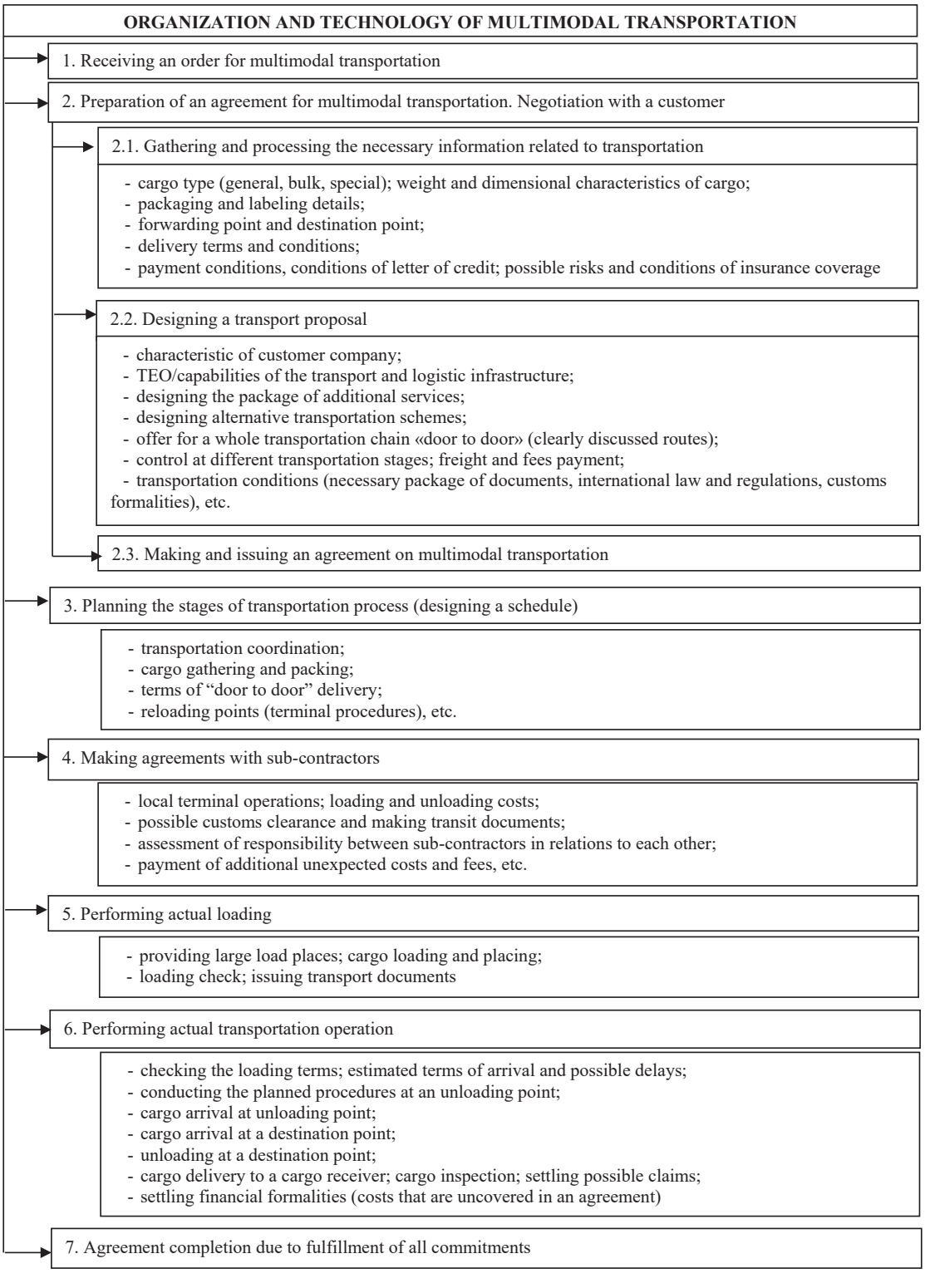

Fig. 1. Technology of organization of MTO transportation

The basis for designing and planning technological operations of multimodal transportation should be an assessment of the state of a certain transport and logistic system. Thanks to this, the MTO will be able to comprehensively approach the management and operation of various transport modes, traffic optimization in order to reduce the total time of «door to door» delivery.

Multimodal routes are usually shorter and more reliable, with minimal transit time, which provides a more accurate level of control of costs, traffic schedules, and transport security. All this is usually related to the possibility of coordination and synchronization of various technological procedures, which leads to the elimination of delays. In addition, with the help of proactive methods of multimodal transportation management and a high degree of control over a cargo flow, significant savings throughout the transport chain are achieved. The key result, at the same time, is an increase in the overall efficiency of functioning of the transport and logistic system of a particular region or a country.

When interacting with other participants of the transportation process, an important task for the MTO is to calculate the competitive tariff. The existence of a favorable tariff is one of the key factors in deciding on the choice of a transportation operator since in most cases this makes it possible to realize the financial interests of each of the participants in the transportation process. Tariffs for cargo transportation along multimodal routes are constructed taking into consideration their useful value for shippers, which is created as a result of:

– achieving a higher level of transport safety due to the general responsibility of the MTO (including for the incidents where the place of their occurrence is not established);

– obtaining the optimal ratio of the magnitudes of costs and time, which is determined by the effective combination of different kinds of transport;

– ensuring a high level of flexibility and reliability of cargo transportation, which is a consequence of centralized management of business processes.

The conducted study of the world experience in setting end-to-end rates of multimodal transportation shows that the key distinction of tariff formation of separate MTO is associated with the presence or absence of a transport fleet and depends on the share of their output. Operators that own vehicles (Carrier-MTO), from financial and economic points of view, have a greater interest in loading them. However, on the one hand, this may not always cause minimal costs for transportation options, but on the other hand, it makes it possible to offer the most favorable tariff conditions in case of incomplete commercial loading of transport.

The MTO that do not own vehicles (Non-Carrier-MTO) consistently select the optimal transportation variants according to the level of costs and the possibility of obtaining substitution effects. Note that a lower share of own output compared to Carrier-MTO, as a rule, leads to a low level of profitability. However, at the same time, Non-Carrier-MTO, even with a not good enough market position, can perform its activities even with cost coverage, which is caused by a lower level of fixed costs.

The tariff offered by the MTO cannot be only the amount of costs for each link of the transportation process (subcontractor services). It should take into consideration the added costs of additional services (warehousing operations, logistic support, labeling, packaging, delivery from the destination point, etc.) (Fig. 2).

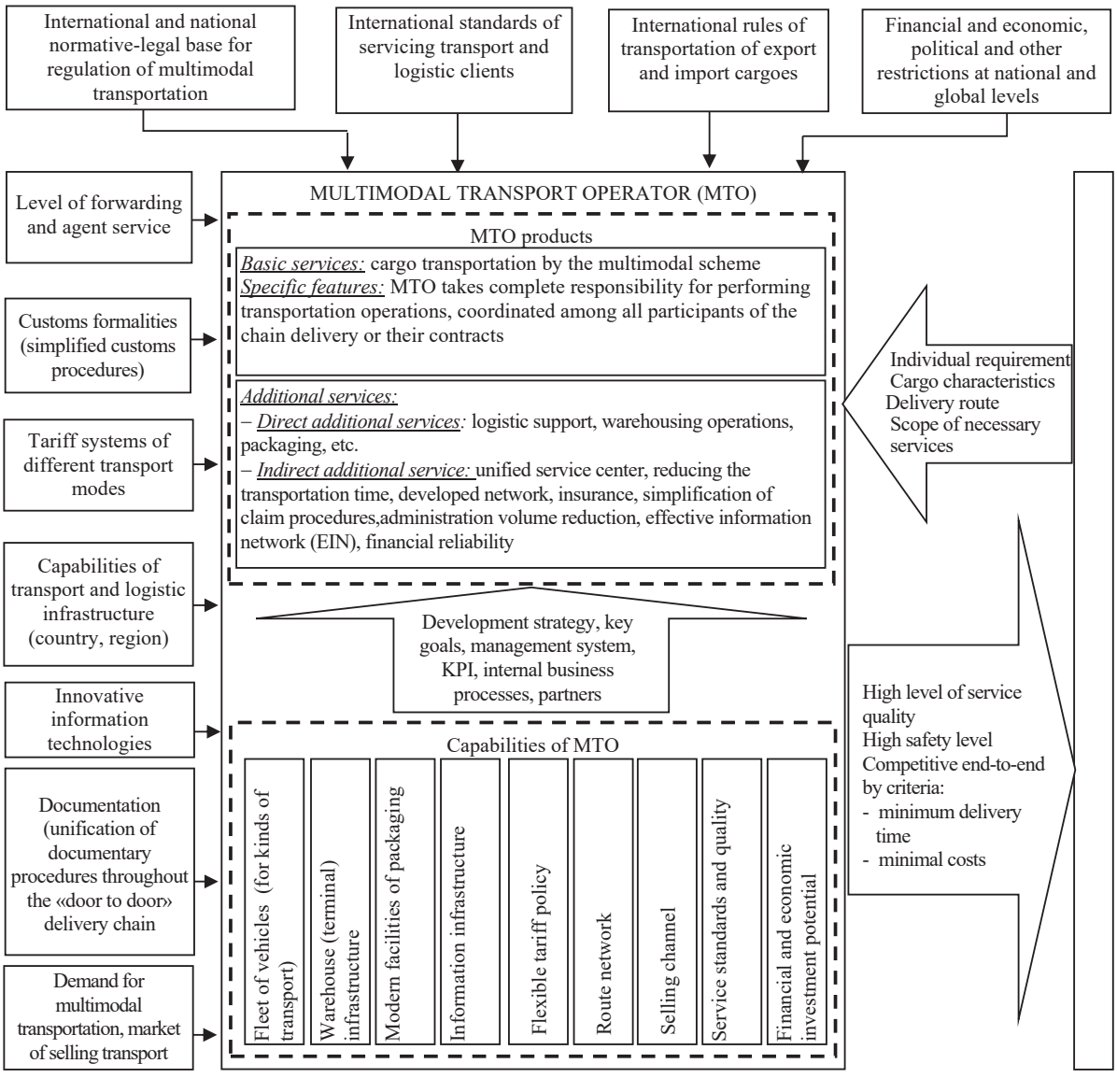

Fig. 2. Mechanism of formation of products of the multimodal transport operator (MTO)

In other words, the MTO not only organizes the «door-to-door» transportation, which can be called the basic product but also offers a complete logistic concept that includes additional value-added services [8]. This is what distinguishes MTO from traditional transport service providers. It turns out that an increase in interest in multimodal transportation depends on how attractive for a customer the proposed «package» of operator's services will be. At the same time, such interest lies in the benefit for each participant of multimodal transportation associated with a decrease in the cost of the transport and logistic delivery chain, specifically:

– packaging costs due to the use of modern packaging facilities, transportation, and handling technologies;

– stock costs for both cargo shippers and conciliators based on providing high-quality, reliable, and rapid transport and logistic services;

– costs for warehouse operations and reduction of the need for warehouse areas, which is a consequence of minimizing the level of stocks;

– total transport and logistic costs due to the reduction of transportation time according to the multimodal scheme compared to the unimodal or combined (separate) scheme, etc.

All this proves that the MTO activity is aimed at optimizing and increasing the value of not only a separate link in the transportation process, but also of the entire transport and logistic system of a particular region (country).

5. 2. Development of a system of goals and key performance indicators of the activity of a multimodal transport operator

Adequately set strategic and operational goals, the achievement of which should be evaluated according to the relevant criteria, are the basis for the effective operation of the management system. In this regard, considerable attention was paid to scientific approaches to establish the values of these indicators. One of these approaches is the Balanced Scorecard (BSC) system, the main goal of which is to transfer the company's mission to specific goals, objectives, and indicators that are measured and can be achieved [17, 18].

Therefore, taking into consideration the above, it is proposed to consider the possibility of using the BSC for the MTO, for which it is necessary to determine the goals and prospects of its development (Fig. 3).

The results of the set goals are measured using Key Performance Indicators (KPI). In a general sense, KPI (Key Performance Indicator) is an indicator of attaining success in a particular activity or in achieving certain goals. We can say that the KPI is an indicator that makes it possible to quantify the actual results achieved. In practical activities, the relations between KPI and BSC are as follows: the strategy provides the KPI system with indicators and plans, and the KRI system provides the strategy with actual data on the direct implementation of the plan [18].

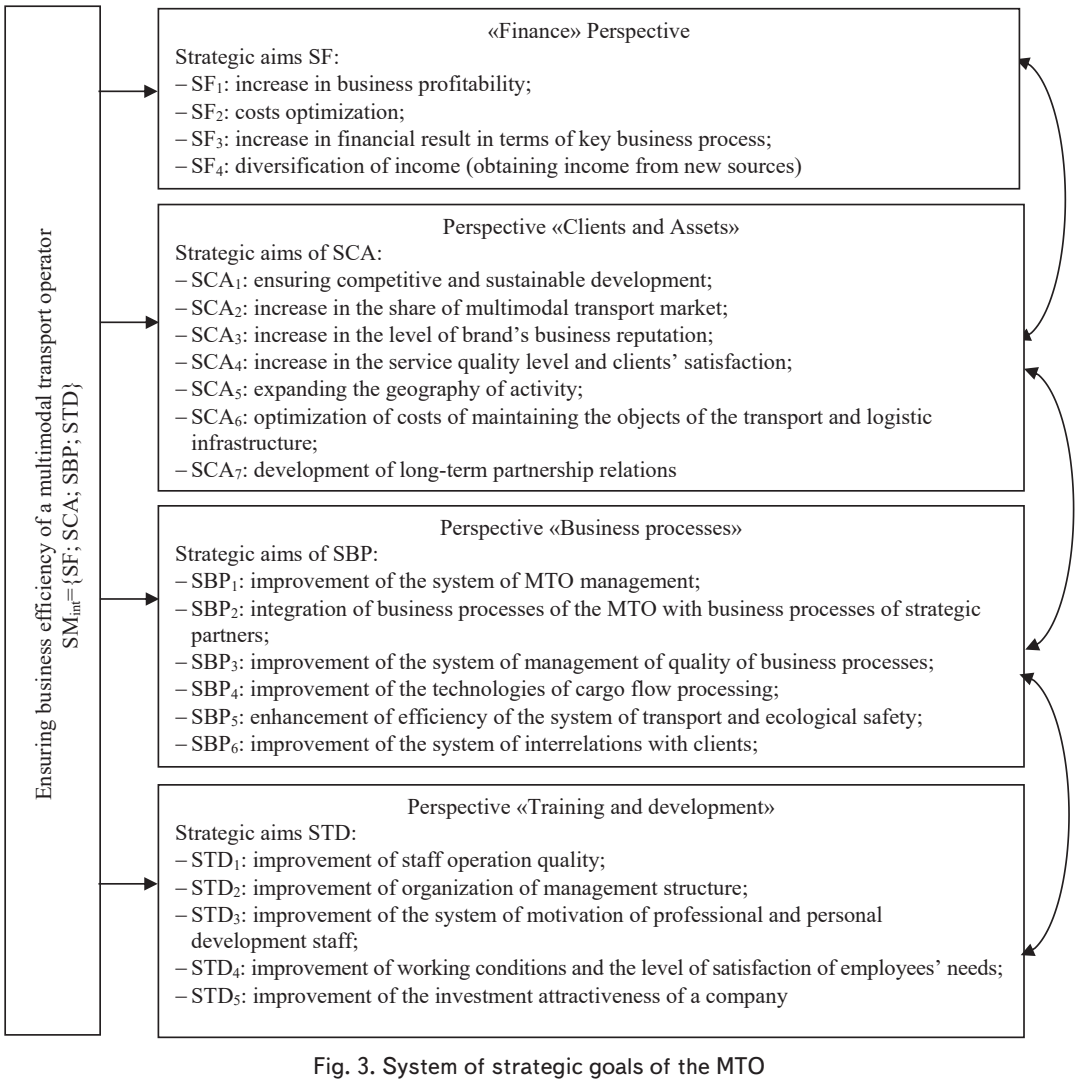

Fig. 3. System of strategic goals of the MTO

The best results of strategic management of the MTO can be achieved on the basis of a well-developed KRI system, the indicators of which will be aimed at the development of the «client-oriented» program. This approach to the management process will enable an operator to get the following advantages:

– access to new market segments with the unified quality criteria for all structural elements of the MTO;

– expansion and promotion of provided services for maximum compliance with market requirements and individual needs of customers;

– increase in effective financial and economic indicators of the MTO;

– increase in the efficiency of production activities and competitiveness in the transport and logistic market in accordance with the strategic goals and values of a company.

Thus, Table 2 shows the KPI system developed for the MTO, the criteria of which are indicators of achieving the set strategic goals.

To calculate comprehensive indicators of the system efficiency, it is necessary to bring all private indicators to a comparable form, in other words, to present it in the form of dimensionless relative magnitudes. In qualimetry, this procedure is called formalization or normalization of heterogeneous information [19, 20].

Table 2

System of key performance indicators (KPI) of MTO

Strategy	Key Performance indicators
1	2
Perspective «Finance»	
$SF_1(Y_1)$	*Y*1. 1. Net Sales; *Y*1. 2: Earnings Before Interest, Taxes, Depreciation, and Amortization – EBITDA); *Y*1. 3: Net Income; *Y*1. 4: Return On Sales – ROS; *Y*1. 5: Financial Leverage – FL; *Y*1. 6: Return On Invested Capital – ROIC; *Y*1. 7: Return On Equity – ROE
$SF_2(Y_2)$	*Y*2. 1: Ratio of cost of transportation to sales; *Y*2. 2: Share of costs of key business processes in the total costs of a company; *Y*2. 3: Ratio of administrative costs to the company's income
$SF_3(Y_3)$	*Y*3. 1: Average yield per cargo unit; *Y*3. 2: Share of the market of cargo transportation in specialized containers; *Y*3. 3: Volume of cargo transportation in containers; *Y*3. 4: Volume and structure of transported cargoes in the context of various transport modes, routes, markets; *Y*3. 5: Share of additionally provided logistic services
$SF_4(Y_4)$	*Y*4. 1: Evaluation of fulfillment of the plan of services scope expansion; *Y*4. 2: Revenues from new services (in dynamics)
Perspective «Clients and Assets»	
$SCA_1(Y_5)$	*Y*5. 1: Availability of certificates of compliance with international standards, bonuses, and awards in the field of management (service quality); *Y*5. 2: Level of service quality; *Y*5. 3: Total index of satisfaction with service; *Y*5. 4: Efficiency of top-managers
$SCA_2(Y_6)$	*Y*6. 1: Share of multimodal transport market at the global, national and regional levels
$SCA_3(Y_7)$	*Y*7. 1: Coefficient of the ratio of positive and negative reviews in mass media and social networks; *Y*7. 2: Evaluation of the structure of the company's regular customers (in dynamics)
$SCA_4(Y_8)$	*Y*8. 1: Average income per customer; *Y*8. 2: Perfect Order Index – POI); *Y*8. 3: Coefficient of performing cargo development «exactly on time»; *Y*8. 4: Coefficient of documents return in due time; *Y*8. 5: Utilization level (ratio of actual volume or weight of the transported cargo to the total capacity of a vehicle, capacity of warehouse infrastructure); *Y*8. 6: Average service time for one order; *Y*8. 7: Number of documents issued without mistakes; *Y*8. 8: Coefficient of customers' satisfaction with service quality in terms of servicing
$SCA_5(Y_9)$	*Y*9. 1: Geographical structure of representative offices; *Y*9. 2: Geographical structure of the route network
$SCA_6(Y_{10})$	*Y*10. 1: Specific costs for the maintenance of the fleet of vehicles; *Y*10. 2: Specific costs for the maintenance of terminal equipment; *Y*10. 3: Specific costs for the maintenance of containers; *Y*10. 4: Coefficient of downtime of vehicles under cargo operations
$SCA_7(Y_{11})$	*Y*11. 1: Specific weight of cargo volume transported on multimodal routes without the participation of third parties; *Y*11. 2: Specific weight of cargo volume transported on multimodal routes with the participation of third parties

Continuation of Table 2

1	2
Perspective «Business processes»	
$SBP_1(Y_{12})$	*Y*12. 1: Level of using the MTO potential; *Y*12. 2: Level of competitiveness of MTO product; *Y*12. 3: Level of entrepreneurial risks; *Y*12. 4: Costs of the company management apparatus; *Y*12. 5: Deviation of the actual sales value from the estimated one
$SBP_2(Y_{13})$	*Y*13. 1: Structure of business processes for executors; *Y*13. 2: Revenues from business processes performed on contractual terms; *Y*13. 3: Number of partners with who long-term agreements are concluded; *Y*13. 4: Dynamics of revenues obtained through a partnership
$SBP_3(Y_{14})$	*Y*14. 1: Share of transferring and cancellation of vehicles' loading by the fault of the MTO; Y14. 2: Share of services that were not performed by the fault of MTO; *Y*14. 3: The number of planned activities aimed at improving the service quality and their deviation from those actually implemented; *Y*14. 4: Indicator of compliance of the quantity and quality of delivered cargo TTN; *Y*14. 5: Dynamics of costs for improving the company's quality management system
$SBP_4(Y_{15})$	*Y*15. 1: Share of recorded TV that does not correspond to the order by technical characteristics and quality; *Y*15. 2: Share of TV that was late to arrive to be loaded (unloaded); *Y*15. 3: Average duration of unplanned downtime of TV; *Y*15. 4: Share of cargo volume delivered with delays; *Y*15. 5: Average time of terminal handling of cargo; *Y*15. 6: Stock level
$SBP_5(Y_{16})$	*Y*16. 1: Availability of certificates in the field of transport and environmental safety, labor protection; *Y*16. 2: Indicator of preservation of cargo accepted for transportation; *Y*16. 3: Number of incidents that occurred during cargo delivery; *Y*16. 4: Number of cases of industrial injury; *Y*16. 5: Costs for implementation of environmental protection measures, ensuring transport and industrial safety; *Y*16. 6: Level of implementation of energy-efficient technologies; *Y*16. 7: Number of insured cases
$SBP_6(Y_{17})$	Y17. 1: Number of complaints, appeals, and claims received by a transportation operator (in dynamics); *Y*17. 2: Time to handle one appeal
$SBP_7(Y_{18})$	*Y*18. 1: Level of automation of services provided to customers; *Y*18 2: Level of the introduction of electronic document flow in the context of business processes; *Y*18. 3: Dynamics of costs for development of information infrastructure
Perspective «Training and development»	
$STD_1(Y_{19})$	*Y*19. 1: Employees' efficiency; *Y*19. 2: Assessment of the implementation of the plan of professional development and training of personnel; *Y*19. 3: Assessment of the quality company's management performance
$STD_2(Y_{20})$	*Y*20. 1: Effectiveness of organizational management structure; *Y*20. 2: Effectiveness of relations between structural units; *Y*20 3: Level of compliance of the profile of posts in accordance with the distribution of responsibility in the system of business processes
$STD_3(Y_{21})$	*Y*21. 1: Stimulation of professional and personal development of personnel based on achieving target values of key performance indicators; *Y*21. 2: Assessment of career opportunities for employees
$STD_4(Y_{22})$	*Y*22. 1: Staff turnover rate; *Y*22. 2: Level of employees' satisfaction with working conditions; *Y*22. 3: Level of employees' satisfaction with salary; *Y*22. 4: Dynamics of average salary; Y22. 5: Level of employees' satisfaction with the socio-psychological climate in the workforce
$STD_5(Y_{23})$	*Y*23. 1: Revenues from the introduction of innovative projects (structure, growth rate); *Y*23. 12 Coefficient of investment attractiveness of a company

The most appropriate is the method of natural normalization, which makes it possible to normalize the values of different indicators. That is, according to this method, values are reduced not only to the general dimensionless scale, but also to the general interval range [0; 1], where 0 means that an indicator is the least important, and 1 is the most important.

Thus, let us assign $i=1, ..., m$ is the number of comprehensive KPI; $j=1, ..., n$ is the number of private KPI, included in one comprehensive indicator. The following designations are introduced: Y is the integrated KPI; Y_i is the comprehensive KPI; Y_{ij} is the normalized value of the private KPI. In this case, q_{ij} is the private KPI; q_{ij}^b is the basic or opti-

mal value of the private KPI; $q_{ij}^{lim}\left\{\max\left(q_{ij}\right);\min\left(q_{ij}\right)\right\}$ is the boundary or boundary admissible values of the private KPI, maximum and minimum, respectively.

In the general case, each comprehensive indicator Y_i complex can contain a different number of private indicators Y_{ij}. However, to simplify the mathematical description of the applied calculation methods, it is assumed that the number of private KPIs of each comprehensive indicator is the same ($j=1, ..., n$).

Different methods are used to calculate the normalized values of Y_{ij} private indicators KPI q_{ij}.

For example, if boundary values are set for some private KPI, in other words, a «admissible corridor» is assigned, the normalized value of this indicator can be determined as follows [18, 19]:

$$Y_{ij}=\frac{q_{ij}-\min\left(q_{ij}\right)}{\max\left(q_{ij}\right)-\min\left(q_{ij}\right)}. \quad (1)$$

In this case, if private KPI values are restricted only on one side, one can reduce this formula to another form [18, 19]:

$$Y_{ij}=\frac{q_{ij}-q_{ij}^{lim}}{q_{ij}^{b}-q_{ij}^{lim}}. \quad (2)$$

If a basic or optimal value of private KPI is assigned, it is possible to use simplified normalization formulas [18, 19]:

$$\begin{cases} Y_{ij}=\dfrac{q_{ij}}{q_{ij}^{b}}, \text{if with increasing } q_{ij} \\ \text{there is an improvement of } Y_{ij}, \\ Y_{ij}=\dfrac{q_{ij}^{b}}{q_{ij}}, \text{if with increasing } q_{ij} \\ \text{there is a deterioration of } Y_{ij}. \end{cases} \quad (3)$$

The first formula of system (3) corresponds to the case when an increase in the value of a private indicator leads to the improvement in a comprehensive indicator. The second formula, on the contrary, is used when an increase in the value of a private indicator leads to a deterioration of a comprehensive KPI.

In the case when the indicators of quality of the basic one and objects have almost the same values, the following formulas are used [18, 19]:

$$\begin{cases} Y_{ij}=\left(\dfrac{q_{ij}}{q_{ij}^{b}}\right)\cdot q_{ij}^{k}, \text{when } q_{ij}\le 1, \\ Y_{ij}=\left(\dfrac{q_{ij}}{q_{ij}^{b}}\right)\cdot q_{ij}^{-k}, \text{when } q_{ij}\ge 1. \end{cases} \quad (4)$$

where k is the degree indicator.

When evaluating any process that causes a change in the value of a private indicator for a certain period from basic value q^b to current value q_{ij}, the corresponding level of a private KPI can be calculated from formula [18, 19]:

$$Y_{ij}=\left|\frac{q_{ij}-q_{ij}^{b}}{q_{ij}^{b}}\right|. \quad (5)$$

It is also possible to convert in a simplified form the values of private KPIs to dimensionless magnitude using the linear dependence in the form given in [18, 19]:

$$Y_{ij}=w\cdot q_{ij}, \quad (6)$$

where w is the conversion factor.

Note that the above calculation formulas are used to normalize indicators that are subject to quantitative evaluation. If a private KPI has a qualitative or relay assessment, other normalization methods should be used for it.

The value of comprehensive performance indicator Y_i can be obtained based on the following formula:

$$Y_i=\frac{\sum Y_{ij}}{\sum Y_{ij}^{b}}. \quad (7)$$

Where Y_{ij}^{b} is the basic (optimal) value of the totality of private KPIs.

If all comprehensive indicators are considered conditionally equivalent, the integrated KPI Y is determined as follows:

$$Y=\frac{1}{m}\sum_{i=1}^{m}Y_i. \quad (8)$$

In order to take into consideration the different significance of comprehensive indicators, it is necessary to introduce weight coefficients ω_i, then the formula for calculating the integrated KPI Y will take the following form:

– at a linear «convolution» (additive form):

$$Y=\sum_{i=1}^{m}\omega_i\cdot Y_i; \quad (9)$$

– at nonlinear «convolution» (multiplicative form):

$$Y=\prod_{i=1}^{m}\sqrt[\omega_i]{Y_i}=\prod_{i=1}^{m}Y_i^{\gamma_i};\ \ \gamma_i=\frac{1}{\omega_i}. \quad (10)$$

In this case, the sum of the values of all weight coefficients should be equal to unity:

$$\sum_{i=1}^{m}\omega_i=1. \quad (11)$$

Understanding what the business process consists of, what factors within a company affect its effectiveness forces transport operators to review the methods for evaluating the effectiveness of their activities. The traditional measurement of the effectiveness of an enterprise, which is focused only on financial indicators, quickly becomes outdated and does not give a complete picture of the state of a company, it does not make it possible to construct an accurate forecast of its development.

Factor models reveal the most important causal relations between the indicators of the financial state of an enterprise and its financial results. That is why they are an indispensable tool for assessing the current situation [20, 21].

5. 3. Construction of a multiplicative model for assessing return on equity of a multimodal transport operator based on the adaptation of the DuPont factor model

To determine the efficiency (return) on the company's equity as one of the most important KPIs, the classical formula for calculating the DuPont factor model was adapted to modern conditions and a multiplicative model, which will take the following form, was constructed:

$$R_{\text{equity}}(ROE)=\frac{PTP}{SR}\cdot\frac{SR}{DR}\cdot\frac{DR}{CA}\cdot\frac{CA}{STL}\times$$
$$\times\frac{STL}{BK}\cdot\frac{BK}{EQ}\cdot\frac{EQ}{A}=a\cdot b\cdot c\cdot d\cdot k\cdot l\cdot m, \quad (12)$$

where *PTP* is the pre-tax profit; *SR* is the revenues from sale; *DR* is the magnitude of debt receivable; *CA* – current assets; *STL* is the short-term liabilities; *BK* is the borrowed capital; *EQ* is the equity; *A* is the assets; R_{equity} (*ROE*) is the Return On Equity (*ROE*); *a* is the Return On Sales (*ROS*); *b* is the turnover of debt receivable; *c* is the share of debts in current assets; *d* is the coefficient of current liquidity; *k* is the share of short-term liabilities in borrowed capital; *l* is the ratio of borrowed capital and equity; *m* is the autonomy factor.

The essential task to determine Return on Equity as one of the KPIs for increasing the business profitability is to generate initial information, on the quality and reliability of which the result and certain management decisions will depend.

Thus, to prove the feasibility of applying this model in practical activities, we will carry out appropriate calculations for global players in the multimodal transportation market, namely: DHL Supply Chain & Global Forwarding (Germany) and Kuehne+Nagel (Switzerland).

It should be noted that according to the annual rating of global freight forwarders-suppliers of transport and logistic services Armstrong & Associates, these companies shared the first position in 2019 (Table 3).

Table 3

Top 5 of global freight forwarders-providers of transport and logistic services in 2019 [22]

Rank	Provider	Gross income (USD million)	Marine transport (TEU)	Air transport (t)
1	DHL Supply Chain & Global Forwarding	27,302	3,207,000	2,051,000
1	Kuehne+Nagel	25,875	4,861,000	1,643,000
2	DB Schenker	19,349	2,294,000	1,186,000
3	DSV	14,355	1,907,126	1,071,266
4	Sinotrans	11,200	3,770,000	502,000
5	Expeditors	8,175	1,125,137	95,5391

Companies DHL Supply Chain&Global Forwarding and Kuehne+Nagel belong to the group of freight forwarders, which by all accounts are multimodal transport operators. In other words, they assume full legal responsibility for all transport and logistic risks and cargo delivery with the participation of various modes of transport.

All the necessary data to determine the return on equity according to the multiplicative model of the selected companies are shown in Table 4.

Based on the data of Table 4, we determined Return on Equity (R_{equity}) of the studied providers of transport and logistic services. The constituents of R_{equity}: Return on Sales (R_{sales}), turnover of debt receivable (*TDR*), the fraction of debt receivable (*DR*) in current assets (*CA*), coefficient of current liquidity $C_{liquidity}$, the fraction of short-term liabilities (*STL*) in borrowed capital (*BC*), coefficient of borrowed capital and equity ratio ($C_{BC/EQ}$), autonomy factor (C_{aut}).

In the process of factor analysis of Return on Equity, we used the method of relative differences to determine the influence of factors on an increase in the effective indicator only in multiplicative models according to relative indicators (expressed by a coefficient or percentage).

Based on this methodology, changes in Return on Equity were determined as follows:

$$\Delta YTDR = \left(R_{equity}^{9\text{ months }2019} + \Delta YR_{sales}\right) \cdot \frac{\Delta TDR}{TDR^{9\text{ months }2019}}, \quad (13)$$

$$\Delta YFraction_{\frac{DR}{CA}} = \left(\begin{matrix} R_{equity}^{9\text{ months }2019} + \\ +\Delta YR_{sales} + \Delta Y\text{TDR} \end{matrix}\right) \cdot \frac{\Delta Fraction_{\frac{DR}{CA}}}{Fraction_{\frac{DR}{CA}}^{9\text{ months }2019}}, \quad (14)$$

$$\Delta YR_{sales} = R_{equity}^{9\text{ months }2019} \cdot \frac{\Delta R_{sales}}{R_{sales}^{9\text{ months }2019}}, \quad (15)$$

$$\Delta YC_{liquidity} = \left(\begin{matrix} R_{equity}^{9\text{ months }2019} + \Delta YR_{sales} + \\ +\Delta YTDR + \\ +\Delta YFraction_{\frac{DR}{CA}} \end{matrix}\right) \cdot \frac{\Delta C_{liquidity}}{C_{liquidity}^{9\text{ months }2019}}, \quad (16)$$

$$\Delta YFraction_{\frac{STL}{BC}} = \left(\begin{matrix} R_{equity}^{9\text{ months }2019} + \Delta YR_{sales} + \\ +\Delta YTDR + \\ +\Delta YFraction_{\frac{DR}{CA}} + \Delta YC_{liquidity} \end{matrix}\right) \times \times \frac{\Delta Fraction_{\frac{STL}{BC}}}{Fraction_{\frac{STL}{BC}}^{9\text{ months }2019}}, \quad (17)$$

$$\Delta YC_{\frac{BC}{EQ}} = \left(\begin{matrix} R_{equity}^{9\text{ months }2019} + \Delta YR_{sales} + \\ +\Delta YTDR + \Delta YFraction_{\frac{DR}{CA}} + \\ +\Delta YC_{liquidity} + \Delta YFraction_{\frac{STL}{BC}} \end{matrix}\right) \cdot \frac{\Delta C_{\frac{BC}{EQ}}}{C_{\frac{BC}{EQ}}^{9\text{ months }2019}}, \quad (18)$$

Table 4

Source information for determining return on equity of MTO [23, 24]

No. by order	Indicators, Euro million	Conditional designation	DHL Supply Chain & Global Forwarding			Kuehne+Nagel		
1	Return on Sales	*SR*	46,385	47,690	1,305	14,571	13,652	–919
2	Pre-tax profit	*PTP*	2,396	2,392	–4	721	718	–4
3	Current assets, including:	*CA*	15,052	16,913	1,861	4,788	8,588	3,801
3.1	Debt receivable	*DR*	8,561	8,397	–164	3,313	3,012	–301
4	Borrowed capital, including:	*BC*	37,777	39,924	2,147	6,903	6,532	–371
4.1	Short-time liabilities	*STL*	16,873	165,75	–298	4,535	4,663	129
5	Equity	*EQ*	14,392	13,360	–1,032	2,136	2,056	–80
6	Assets, total	A	52,169	53,284	1,115	9,039	8,588	–451

$$\Delta YC_{aut} = \begin{pmatrix} R_{equity}^{9\text{ months }2019} + \Delta YR_{sales} + \\ +\Delta YTDR + \\ +\Delta YFraction_{\frac{DR}{CA}} + \Delta YC_{liquidity} \\ +\Delta YFraction_{\frac{STL}{BC}} + \Delta YC_{\frac{BC}{EQ}} \end{pmatrix} \cdot \frac{\Delta C_{aut}}{C_{aut}^{9\text{ months }2019}}, \quad (19)$$

$$\Delta YC_{cumulative} = \Delta R_{equity}^{9\text{ months }2019} + \Delta YR_{sales} + \Delta YTDR + \\ +\Delta YFraction_{\frac{DR}{CA}} + \Delta YC_{liquidity} + \\ +\Delta YFraction_{\frac{STL}{BC}} + \Delta YC_{\frac{BC}{EQ}} + \Delta YC_{aut}. \quad (20)$$

All received data are summarized in Table 5, based on which factor analysis of Return on Equity of the studied MTO was carried out.

Conducted calculations revealed that Return on Equity of companies DHL, Supply Chain & Global Forwarding in 2020 (for 9 months) amounts to 4.49 %, which is by 0.10 lower than 2019 (9 months). It was also determined that this indicator of company Kuehne+Nagel in 2020 (for 9 months) increased by 0.38 % compared to the similar period of the previous year and made up 8.36 %.

The assessment of the impact of the factors on Return on Equity of DHL Supply Chain & Global Forwarding and Kuehne+Nagel can be presented graphically (Fig. 4).

Consequently, the obtained data of factor analysis indicate that an increase in return on sale led to a decrease in return on equity by 0.13 %. As a result of accelerating the turnover of debt receivable, the key criterion increased by 0.22 %. As the share of debt receivable decreased, the effective indicator decreased by 0.59 %. An increase in the current liquidity factor led to an increase in return on equity by 0.59 %. A decrease in the share of short-term liabilities in borrowed capital caused a decrease in the return on equity of MTO by 0.33 %. An increase in the coefficient of the ratio of borrowed capital and equity led to an increase in effective indicator by 0.6 %. Within the reporting period, there is also a decrease in the autonomy factor, due to which the company's return on equity decreased by 0.45 %.

As conducted calculations for Kuehne+Nagel company reveal, the growth of return on sale and turnover of the company's debt receivable led to an increase in return on equity by 0.49 % and by 0.26 %, respectively. As a result of a decrease in the share of debt receivable, the effective indicator decreased by 4.31 %. An increase in the current liquidity rate and the share of short-term liabilities in borrowed capital led to an increase in the return on equity of MTO by 3.29 % and 0.67 %, respectively. A decrease in the ratio of borrowed capital and equity led to a decrease in effective indicator by 0.14 %. At the same time, an increase in the autonomy factor led to an increase in the company's return on equity by 0.11 %.

Thus, the obtained findings prove that companies DHL Supply Chain & Global Forwarding and Kuehne+Nagel are cost-effective and attractive in terms of investing in their development.

Table 5

Results of calculation of Return on Equity (R_{equity}) according to the modified DuPont multiplication model

No. of order	Indicators	DHL Supply Chain & Global Forwarding			Kuehne+Nagel		
		9 months 2019	9 months 2020	Changes (+,–)	9 months 2019	9 months 2020	Changes (+,–)
1	R_{sales}, %	5.2	5.0	–0.15	5.0	5.3	0.31
2	TDR	5.42	5.68	0.26	4.40	4.53	0.13
3	Share of DR/CA	0.57	0.50	–0.07	0.69	0.35	–0.34
3.1	$C_{liquidity}$	0.89	1.02	0.13	1.06	1.84	0.79
4	Share of STL/BC	0.45	0.42	–0.03	0.66	0.71	0.06
4.1	$C_{BC/EQ}$	2.62	2.99	0.36	3.23	3.18	–0.05
5	C_{aut}	0.276	0.251	–0.025	0.236	0.239	0.003
6	R_{equity}, %	4.59	4.49	–0.10	7.98	8.36	0.38

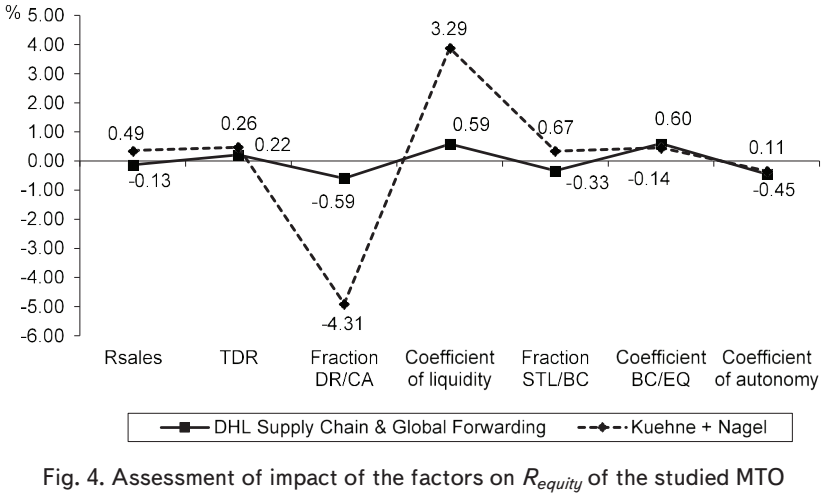

Fig. 4. Assessment of impact of the factors on R_{equity} of the studied MTO

6. Discussion of the results of the proposed conceptual provisions for ensuring effective management of the activities of a multimodal transport operator

It should be noted that the activities of the MTO as a principal of a unified contract of transportation belong to more than one mode of transport, regardless of who is the actual carrier. The MTO differs from other transport intermediaries, in particular from traditional freight forwarders, taking legal responsibility and all risks for cargo transported with all possible consequences.

At the same time, the competitiveness of the MTO depends on how effectively it manages available resources and realizes its own potential. Given this, the authors conducted a study of the organizational and technological characteristics of MTO activities in the market of transport and logistic services. The classification of operators according to the following features was improved by (Table 1): the scope of activity; the degree of independence of «door to door» transportation; the existence of its own fleet of vehicles; the range of additional services offered; the coverage of the territory.

The proposed classification makes it possible to form the business model of the MTO as an integrator of transport and logistic processes of cargo delivery, rather than to consider it only from the point of view of belonging to the operation of any type of transport (mainly water), as proposed in research [8]. The authors of [8] divide the MTO into two types: Vessel Operating Multimodal Transport Operators and Non-vessel operating common carriers.

During the movement of the «door to door» cargo flow, the cargo can be involved in numerous transport links. That is why it is fundamentally important that the MTO can design and ensure the effective integration of various modes of transport, with their peculiarities taken into consideration. The authors systematized the technology of transportation organization of the MTO, which will make it possible to comprehensively approach designing and planning technological operations according to multimodal transportation schemes.

The MTO ensures the satisfaction of interests of the participants of the transportation process not only under the condition of providing more profitable financial and economic offers but also because of the creation of an individual package of services, that is, in addition to the basic (transport) component, it will take into consideration additional service. In scientific and practical developments [5, 9–11] there is only a list of basic and additional services of the MTO, but it was not established due to what opportunities and criteria they are not implemented. The product formation mechanism, proposed in Fig. 2, shows how external conditions and internal business processes of an operator affect the quality of offered services according to the established criteria and resource capabilities.

The system of strategic goals of the MTO developed based on the Balanced Scorecard approach (Fig. 3), is the basis for its effective development by perspectives: finance, clients and assets, business processes, training and development.

To achieve the best results of strategic management of the MTO, the KPI system was proposed (Table 2).

It should be noted that in paper [8] business indicators of the MTO activities aimed at assessing the service component and its capabilities in the field of sea transportation, were stated. This indicates the incorrectness of application of this approach for operators specializing in other modes of transport and various types of additional transport and logistic services.

In addition, these criteria do not reflect the relations for the MTO strategies and do not make it possible to determine the effectiveness of its activities according to internal business processes.

In contrast to [8], this study proposes a more informative KPI system, the use of which makes it possible to quantify the strategic goals of an operator. On this basis, it is possible to timely determine the «bottlenecks» in the MTO activities, as well as to take effective measures to eliminate them.

It was established that in order to achieve the key goals of the MTO, it is important to determine the causal relationships between the indicators of its financial condition and its financial results. DuPont's modified multifactor model prioritizes factor assessment of the indicators that are more stable over time at a wide coverage of factors.

The application of this model in the practical activities of the MTO provides a comprehensive assessment of return on equity. This generally indicates its investment attractiveness but does not make it possible to fully reflect the relation between its production indicators and financial results. At the same time, its use can be a harmonious transition to the formation of the methodology for evaluating detailed KPIs, constructed on the principles of minimizing contradictions between production and financial capabilities to improve the main strategy.

7. Conclusions

1. It was proven that MTO is a responsible integrator that organizes the transportation process with the participation of various modes of transport and offers additional logistic service on favorable terms at a competitive tariff. The proposed classification of the MTO and the technology of multimodal transportation organization, proposed in this paper, taking into consideration the available resources and existing opportunities, provide more accurate control of costs, traffic schedules, and transport safety. The use of proactive methods of managing the transportation process and a high degree of control over the cargo flow makes it possible to obtain cost savings throughout the transport chain, which leads to an increase in the overall efficiency of functioning of the transport and logistics system of a particular region, country.

2. The developed conceptual provisions for ensuring effective management of the MTO activities, namely the proposed system of strategic goals and the KPI, provide an opportunity to get competitive market positions.

3. The approbation of the modified DuPont multifactor model to assess return on equity of the MTO as one of the KPIs proves its feasibility in applying the process of complex determining of resource opportunities, investment attractiveness, and further development of the MTO at the first stage. The proposed model prioritizes more time-stable indicators based on determining the levers for increasing the efficiency of MTO resources with greater coverage of factors during the factor assessment. It can become the basic stage of the formation of the methodology for evaluating detailed KPIs.

Our research can form the basis for the subsequent development of the system of multimodal cargo transportation based on the development of a model for optimal management of the MTO business processes.

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