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DEFINING COMPROMISE AREA IN THE PROCESSES OF MULTIMODAL DELIVERY ORGANIZATION WITHIN THE AGILE APPROACH

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The level of competition in the transport market requires delivery organizers to implement better approaches based on modern management methodologies, in particular, agile, which makes it possible to provide a modern level of service to cargo owners.

The object of this research is the processes of organizing multimodal delivery. The subject of the study is the area of compromise in the processes of organizing multimodal delivery based on the agile approach.

The term «compromise area» is introduced, which reflects the numerical limits of product parameters in the general case. For the transportation domain under consideration, the «trade-off area» reflects the limits of the characteristics of multimodal delivery, which is the «product» for the multimodal operator.

A set of alternative options for multimodal delivery forms the basis for establishing the dependence of the cost of delivery on time and its reliability (possible time deviation). The area in the «time-reliability-cost» space, which is formed on the basis of this dependence, on the one hand, and the requirements of the cargo owner, taking into account their possible adjustment, on the other hand, is the area of compromise. This area is proposed for use in agile approaches to the organization of multimodal delivery. Balancing the interests of the cargo owner and the multimodal operator allows changing the limits of the compromise area within the framework of the proposed scheme of agile cycles in the process of planning and organizing delivery.

On the example of delivering a container with cargo from China to Kyiv, regression linear models were built. These models formalize the dependence of delivery cost on reliability and/or time. Using the example of varying the requirements of the cargo owner regarding the limitations of some delivery characteristics, the formation of the compromise area and its adjustment was carried out, which demonstrated the practical aspects of the formation of the compromise area for multimodal delivery.

The results are the basis for the implementation of the agile approach in the field of multimodal transportation. The further development of these results consists in the construction of mathematical models that could form the basis for finding solutions in the area of compromise

Keywords: digital space, delivery parameters, area of compromise, regression models, balancing of interests, agile cycle

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1. Introduction

According to the accepted interpretation, multimodal transportation [1] is a type of cargo transportation that involves the use of at least two different types of transport under one end-to-end contract. Significant volumes of such transportation are carried out using sea transport and we are talking about the transportation of goods in containers. The term «delivery» is mostly applied to container transportation with the participation of sea transport, as it involves the transportation of cargo, for example, to a warehouse by road transport. According to [2], most end customers of the transport market do not need only a separate «transportation», they are interested in delivery to the specified point. Therefore, the term «multimodal delivery» will be used in this study in the established sense.

Multimodal delivery has a certain specificity, in addition, the multimodal operator deals simultaneously with a system of local deliveries, each of which is carried out at a certain rate. The operator can vary both the geography of transportation of each specific delivery (that is, options for physical movement), as well as the composition of participants.

Thus, in the process of work, the multimodal operator must ensure a balance of own interests and the interests of cargo owners under the conditions of the diversity of offers from suppliers from each section of cargo transportation in a container. In addition, there is an alternative of geographical schemes of cargo delivery through different base ports [3], which justifies the alternative of multimodal delivery options. Each delivery option is characterized by a system of indicators, the main ones of which are: «delivery time», «delivery reliability», «delivery cost». Therefore, a situation arises in which the operator is able to provide multiple offers of these parameters according to alternative options. The cargo owner, in turn, having initial certain requirements for transportation, is ready to discuss the deviation in certain parameters (for example, the cost), if time and reliability suit him. Of course, «negotiations» and «improvements» of the delivery option have certain time limits. Therefore, the best approach to managing the situation of finding a certain compromise in the parameters of multimodal delivery is an agile approach. Its use in various fields has rapidly spread in recent years, owing to the main advantage of agile – the ability to obtain a result that fully satisfies the customer, within the set time, based on close cooperation in the «contractor-customer» tandem.

All this, on the one hand, corresponds to the core values of agile [4]:

– people and collaboration are more important than processes and tools;

– a working product is more important than comprehensive documentation;

– cooperation with the customer is more important than discussing the terms of the contract;

– readiness for change is more important than adherence to the plan.

On the other hand, it corresponds to the situation currently present in the market of transport services in the process of organizing multimodal delivery.

Thus, the implementation of better approaches based on modern management methodologies, in particular, agile, will make it possible in the transport sector to provide a modern level of service and provide cargo owners with services that meet a set of requirements. In other words, as a result of agile implementation, the parameters of the «transport product» meet customer requirements, even if these requirements differ from the initial ones.

2. Literature review and problem statement

Cargo delivery is the object of many studies, usually related either to the optimization of the physical movement of cargo (for example, [5]) or to the optimization of the composition of suppliers, that is, companies that implement a specific variant of physical movement of cargo (for example, [6]). The new ideology of the transport domain involves the introduction and use of new technologies for the physical movement of goods, which is considered, for example, in [7, 8]. But the results of all the above studies are focused on finding the best option for cargo delivery from the point of view of a specific cargo owner. For the operator of multimodal transportation, the proposed models do not take into account the possibility or necessity of integrating shipments of different cargo owners within a certain period of time and obtaining a synergistic effect owing to the integral optimization of shipment data.

In turn, an assessment of the optimization of the synergistic effect due to the effect of scale in the transport sector based on the integration of works with a project-oriented approach is proposed in [9]. These solutions are aimed specifically at solving organizational issues and organizing customer service and are practically not related to transport and technological issues, but these results provide a new perspective on the organization of cargo delivery, which can also be extended to the field of multimodal transportation. Nevertheless, the cited paper did not substantiate the feasibility and correctness of considering delivery as a project. This gap was eliminated in work [10], in which all features of the project for the cargo delivery process were carefully considered and defined. Thus, the results of [10] formed a theoretical basis for the use of a project-oriented approach in the field of transport.

A project-based approach to delivery makes it possible to apply appropriate approaches and methods within the framework of modern project management methodologies, including agile.

The main postulates and values of the agile methodology are formulated in the manifesto [4], from which the spread of this methodology began. It should be noted that a significant number of modern publications consider the problems of agile implementation. It is natural that most of them are related to the IT domain and IT projects since initially agile methodology was formed for them. Examples of such studies are [11, 12], which at the conceptual level reveal the essence and problems of agile implementation and can be used as a basis for the applied development of the presented provisions. There are studies that consider the implementation of agile in supply chain and logistics projects, examples of such works are [13, 14]. However, the cited studies can only serve as an ideological basis for the development of an agile approach for the field of cargo delivery organization as they are project-oriented in the classical sense for the logistics field, that is, for projects related to investments in this field.

The use of the agile approach requires the availability of appropriate tools to solve the tasks of planning the «product» or its parameters. It is natural that the specificity of the product is maximally taken into account in the proposed methods and models. However, it should be noted that some results, for example, reported in [15], can be considered quite universal. Thus, in [15], a model and algorithm based on the agile methodology is proposed for the selection of infrastructure objects for development taking into account the priority, preference, and flexibility of goals based on a system of criteria. This result can be used to form a set of objects for the further implementation of development projects in various areas, not only transport infrastructure. In addition, the proposed algorithm can be applied in the field of services, including transport. Nevertheless, in the process of forming the preference of one option in relation to others, there is a problem of evaluating the options from the point of view of the result for the customer, which is not considered in this study.

In the process of implementing agile methods and models, there is a «compromise», which is the main category after the category «flexibility». Agile compromises are addressed by many authors, for example, [16]. But, as a rule, it is about the emphasis on the «importance and necessity» of compromise, as well as on organizational issues – how to reach a compromise. In some works, compromise is mentioned in the context of quality – «there is no compromise in matters of product quality» [17]. Thus, the research data only raise the issue of compromise in agile but do not provide specific proposals for its formalization and scheme of use.

Unlike the above studies, in [18] the authors propose a schematic diagram of agile cycles in the process of organizing delivery with a project-oriented approach, but they do not touch on the problem of reaching a compromise in these cycles.

It should be noted that for «products» in the transport sector – whether it is a development project or delivery within the framework of a project-oriented approach, the specific parameters of this product [9, 19], which have a specific numerical measure, are important. For example, cost, time, reliability. Thus, there is not just a «compromise» but a «compromise area», which has a numerical measure that has not been the object of modern research to date. But it is in the area of compromise that the search and selection of an acceptable option is carried out, with or without the use of special models or algorithms.

Therefore, the development and spread of the agile methodology affected the transport sector as well. But many problems that arise in the process of implementing agile approaches remain ignored, for example, determining the area of compromise. Note that this problem arises not only in the process of organizing multimodal delivery – the subject area of this study, but also in other areas where «product parameters» can change, therefore, a corresponding «area of compromise» arises. Thus, solving this problem is necessary for the development of the theoretical basis of the agile methodology in general, and not only within the framework of applied research, which is only a basis for future generalizations and extension to other areas.

3. The aim and objectives of the study

The purpose of this study is to identify the essence and determine the area of compromise as an element of the agile approach implementation system in the organization of multimodal delivery. This will ensure an increase in the efficiency of the implementation of the agile approach in the transport sector.

To achieve the goal, the following tasks were set:

– to determine the essence and concept of the numerical evaluation of the area of compromise on the example of the organization of multimodal delivery;

– to investigate the practical aspects of the formation of the area of compromise based on regression models on the example of specific delivery of goods in containers;

– to build a scheme of adjustment and coordination of the «compromise area» within the framework of the agile approach to the work of the multimodal operator with the cargo owner.

4. The study materials and methods

The object of this research is the processes of organizing multimodal delivery.

The subject of the study is the area of compromise in the processes of organizing multimodal delivery based on the agile approach.

Research hypothesis: the set of alternative options for multimodal delivery, which are determined by the diversity of delivery schemes (geographical aspect) and the alternativeness of carriers and the corresponding conditions of transportation for each part of the given schemes, form the domain for the set of limiting criteria (for example, time and reliability), as well as the domain of values for the main criterion (as a rule, costs), taking into account the presence of a corresponding dependence. The area in space, the size of which corresponds to the number of considered criteria (in this study, three – «time-reliability-costs»), and which is formed on the basis of the integration of indicators by sections of delivery schemes and the presence of a corresponding dependence of costs on reliability and time (as the main indicators), is an area of compromise in the processes of organization of delivery based on the agile approach.

Structural analysis, correlation-regression analysis, and functional analysis were used as methods. Calculations were performed using the standard Microsoft Office Excel application (USA); three-dimensional graphs were built using online resources.

The statistical basis of the research was information on the market of maritime transport services, in particular, the costs and time of transportation of goods in containers by ships of various carrier companies.

5. Results of examining the definition and use of the area of compromise

5. 1. The essence and concept of the assessment of the area of compromise using an example of the organization of multimodal delivery

Studying alternative delivery options, as mentioned above, is a function of a multimodal operator. Analyzing the given conditions for cargo and delivery, on the basis of information about container linear services, service schedules of container trains, other carriers, the specificity of ports, forms alternative delivery options.

Taking into account the characteristics of each component of an alternative delivery option, its final characteristics are formed – cost, time, reliability, and a possible increase in time [18], which are the basis for making a decision on choosing the appropriate option. Changing at least one element in this system leads to a change in the characteristics of the entire delivery. This is used to adjust the options in the process of finding the one that would meet the requirements. Taking into account the decomposition of multimodal delivery, alternativeness can be manifested both at the level of physical movement of cargo (through different ports of transshipment, for example), and at the level of enterprises that provide certain services. For example, the use of lines of different container carriers that call at the same ports.

A generalization of existing approaches to the formation of alternative delivery options [3], taking into account the specificity of cargo transportation in containers, is shown in Fig. 1.

The criteria for choosing the best option in a single-criterion approach to optimization are, as a rule, total costs. With a multi-criteria approach, in most cases, the minimization of delivery costs is complemented by the minimization of time and the maximization of reliability [18].

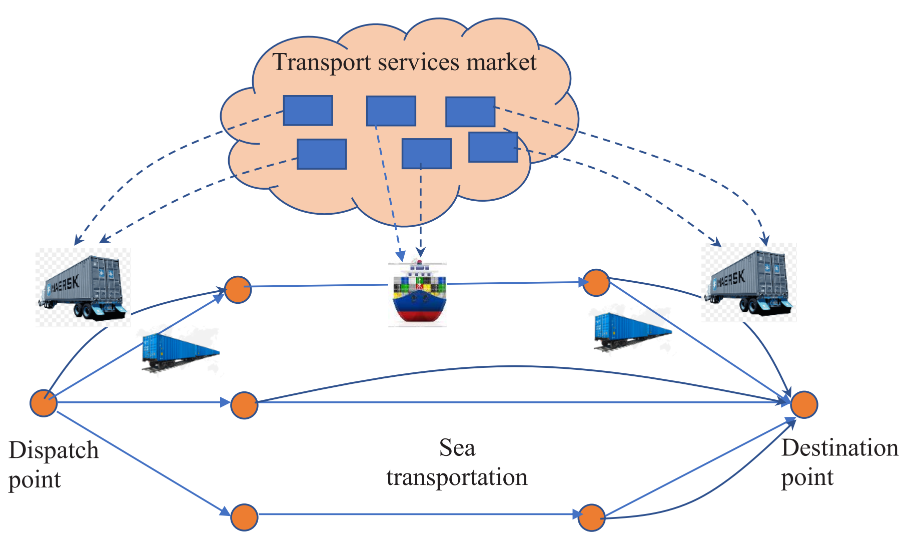


Fig. 1. The alternativeness of multimodal delivery

So, the traditionally generalized description of the model for choosing the optimal delivery option (with a single-criteria approach):

$$R \to \min,$$

$$T \le T^*,\ R \le R^*,\ I \ge I^*,\ \Delta T \le \Delta T^*, \quad (1)$$

where T^*, R^*, I^*, ΔT^* are, respectively, the limits of time, cost, reliability, and a possible increase in delivery time set by the cargo owner (initial delivery requirements).

From the point of view of the balance of interests of the cargo owner and the multimodal operator, additional delivery characteristics are important, which are determined in the process of agile cycles (so-called sprints, if scrum is chosen as an agile tool, for example [7]). For example, $\Delta T'$, $\Delta R'$, $\Delta I'$, – an acceptable increase in delivery time and/or costs, as well as an acceptable decrease in delivery reliability. In practice, most cargo owners allow an increase in both time and costs, so the task of specialists who handle the application is to identify their limits in the process of implementing an agile approach to delivery planning. In addition, the time for the cargo to be ready for shipment can also be adjusted, for example, in a situation where the cargo owner is offered a tariff level at which he is ready to «accelerate» the process of cargo readiness for shipment.

The possibility of variation in the time and cost of delivery (the moment the cargo is ready for shipment) forms an area of compromise, in which, in fact, the balance of interests of the parties – the cargo owner and the multimodal operator – is established. Fig. 2 demonstrates this idea.

So, the cargo owner, on the one hand, puts forward certain requirements for delivery. On the other hand, a multimodal operator, taking into account the demand for transportation, the capabilities of various carriers and their tariff policy, forms options that may not completely «fit» into the given conditions. As a rule, the cargo owner is ready to adjust his initial requirements, taking into account allowable increases or decreases. For example, to «sacrifice» delivery time and reliability but ensure a certain level of delivery costs.

It should be noted that the interests of the multimodal operator are connected with the existence of a certain system of tariffs for transportation. Thus, carriers provide a special level of tariffs for companies with large volumes of transportation, which gives the operator the opportunity to provide such a cost of transportation in a specific area, which is not available to an individual cargo owner. Thus, the effect of scale manifested in the indicated way forms the operator's «interest» in a certain carrier. Therefore, in the process of «balancing» the interests of the parties, this factor is definitely taken into account.

Thus, the «compromise area» is a set of values of delivery characteristics that are, on the one hand, available taking into account market offers, transportation technologies, and operator capabilities. On the other hand, they are satisfactory, taking into account the accepted deviations, for the cargo owner.

Extending this term to any field, we obtain the following definition. «Compromise area» is the possible values of product (project) parameters, which are, on the one hand, technologically and commercially possible for the supplier, on the other hand, possible for acceptance by the customer.

The search for the final values of the product (project) parameters, or, for this case, the characteristics of multimodal delivery, is carried out within the framework of the compromise area.

Fig. 3 shows a schematic illustration of the time-cost compromise area. $T_i^{\min}$ corresponds to the minimum time possible (from a technological and commercial point of view) delivery option; R_1, R_2 – respectively, the cost of delivery, where R_2 corresponds to the option with delivery time. T^*, and R_1 – the variant with delivery time $T^*+\Delta T'$. Despite the fact that, as a rule, in theoretical studies, the dependence of costs on delivery time is represented as a continuous function, in fact, this is a theoretical representation that shows some idea (concept) of dependence. In fact, the options available are spot-on and some time and cost values are just available. However, such continuous dependences are regression models, and their analysis makes it possible to outline the possible options first theoretically, and then, taking into account actual information, to adjust the found solution. Fig. 4 illustrates this thesis.

Thus, the search for a delivery option within the compromise area, if it occurs using mathematical methods, is then adjusted taking into account the presence of «close» to the found (theoretical) option. This approach corresponds to the approaches [20] – searching for the optimal set of project product parameters taking into account their dependences.

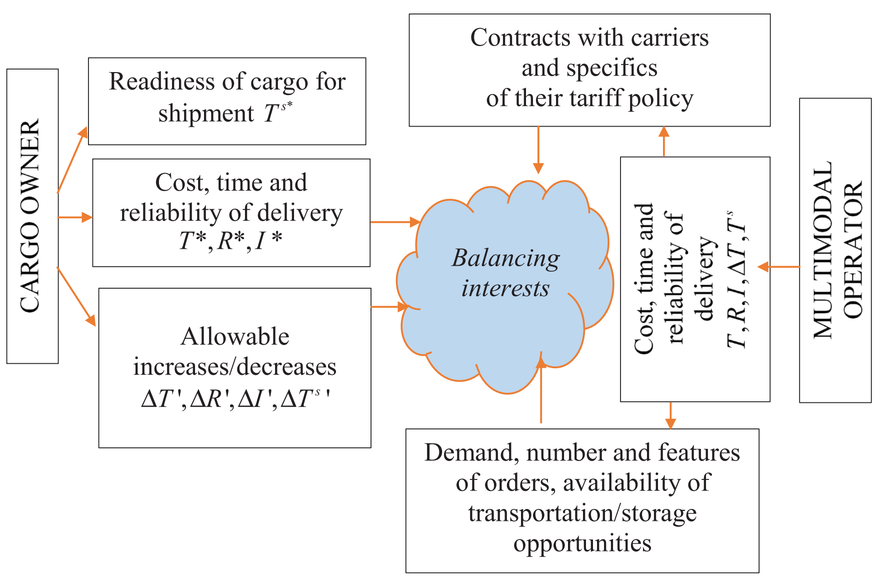


Fig. 2. Balancing the interests of the cargo owner and the multimodal operator

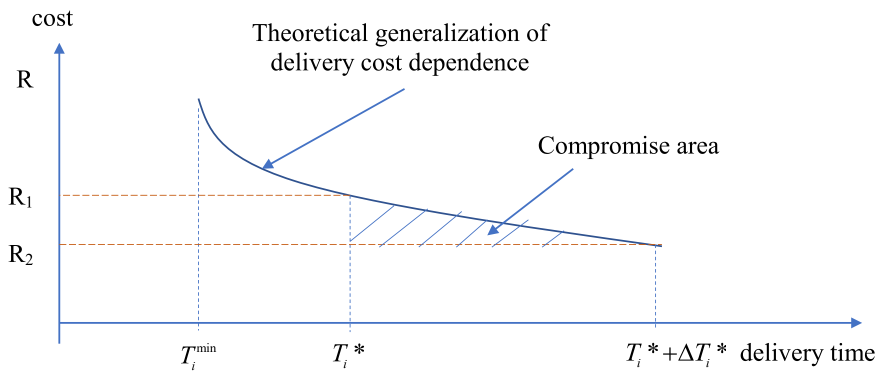


Fig. 3. Formation of the «compromise area» on the example of delivery time

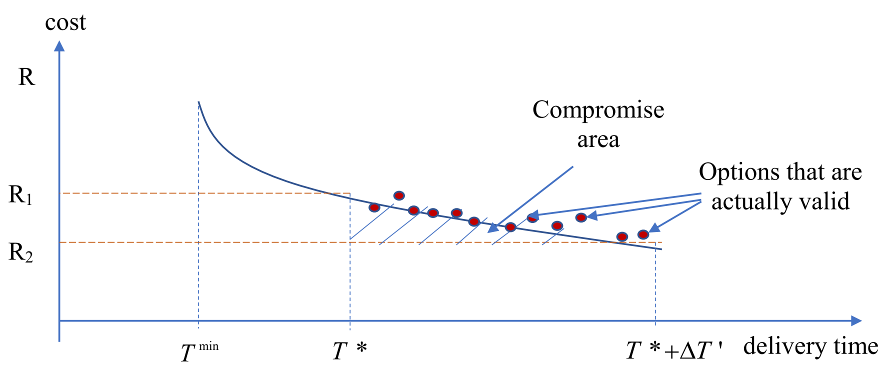


Fig. 4. Establishing an acceptable delivery option within the «compromise area»

So, the mathematical essence of the compromise area (for the multimodal delivery under consideration) is the area in the «time-reliability-costs» space, which is formed on the basis of the dependence of costs on time and reliability (Fig. 3) on the one hand. On the other hand, the area of compromise is limited by the requirements of the cargo owner regarding delivery (maximum delivery cost, maximum delivery time, as well as a possible increase in cost and delivery time, which are adjusted and agreed upon in the process of agile cycles (which will be described in chapter 5. 3). The mentioned dependences are formed as a result of the analysis of the integral characteristics of possible delivery options, taking into account the variation in delivery schemes (geographic aspect of delivery), modes of transport and carriers in each section of the schemes (Fig. 1). Regression models are used to obtain the limits of the area of compromise in terms of costs.

5. 2. Practical aspects in the formation of a compromise area based on regression models using an example of cargo delivery in containers

Above, the demonstration of the «compromise area» for multimodal delivery was carried out on the example of its two-dimensional «time-cost» representation $R_i(T_i)$ – the easiest option to study. In fact, this area is four-dimensional, but for the possibility of graphic analysis and further research, we consider the three-dimensional version $R_i(T_i,\Delta T_i)$ of the dependence of delivery costs on time and its possible increase. It should be noted that within the framework of this study, the area of compromise is considered from the point of view of the cargo owner.

Below is an example of the delivery of one container from China to Kyiv.

As a rule, the more reliable option, and the option with a smaller possible increase in time are more expensive, and this dependence can be taken as linear. Fig. 5 shows a fragment of the statistical analysis of the cost of shipping one container from China to Kyiv using various carriers and modes of transport for the ground component. The minimum delivery time is 27 days, the actual cost of delivery is between USD 8000–9380 USD per TEU (container). The regression equation $y=-207.68x+14{,}933$ was built, where y is the cost of delivery, x is the delivery time (T). The reliability of the approximation is $R^2=0.884$, which indicates a high enough level of relationship between delivery time and cost in accordance with the derived dependence equation.

Fig. 6 shows a similar dependence on a possible increase in delivery time (as a numerical measure of delivery reliability), Fig. 7 – results of multiple regression analysis.

The dependence of the delivery cost on the possible increase in delivery time is as follows: $y=-836.73x+9{,}235.4$, where y is the cost of delivery (USD), x is the possible increase in delivery time (ΔT).

The reliability of the approximation is $R^2=0.78$, which indicates a high enough degree of correspondence of the derived dependence with the original data.

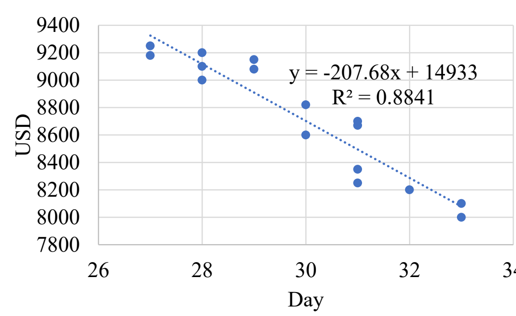


Fig. 5. A partial fragment of the statistical analysis of the dependence of the cost of shipping one container from China to Kyiv on the time of delivery

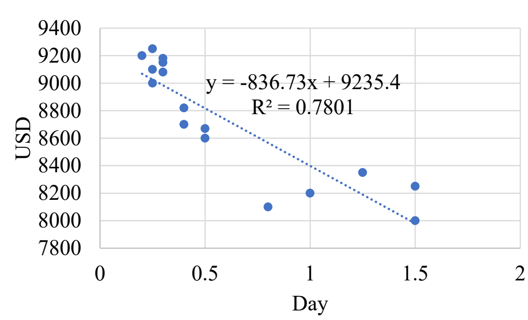


Fig. 6. A partial fragment of the statistical analysis of the dependence of the cost of shipping one container from China to Kyiv on a possible increase in delivery time

Regression statistics	
Multiple R	0,977173431
R Square	0,954867914
Adjusted R Square	0,943584893
Standard Error	111,9539775
Observations	11

ANOVA

	df	SS	MS	F	Significance F
Regression	2	2121421,365	1060710,682	84,62874243	4,14898E-06
Residual	8	100269,5445	12533,69307		
Total	10	2221690,909			

	Coefficients	Standard Error	t-stat	P-value	Lower 95%
Y-intersection	12323,09493	750,2851271	16,42454913	1,90357E-07	10592,93433
Variable X 1	-556,685568	114,5652049	- 4,859115544	0,001257214	- 820,8734042
Variable X 2	-110,8139748	26,69403521	- 4,151263527	0.003203408	- 172,3705303

Fig. 7. The results of the regression analysis (two-factor) of the dependence of the cost of shipping one container from China to Kyiv on a possible increase in delivery time and delivery time

The result of the multiple regression analysis is the following relationship: $y=-651.7x_1-106.21\ x_2+12255.8$, where y is the cost of delivery (USD), x_1 is the delivery time (T), x_2 is the possible increase in the delivery time (ΔT), $R^2=0.9758$, which characterizes the high degree of compliance of this model with the original data.

Despite the small number of observations (16 for this example), statistical studies allow us to draw a conclusion about the linear nature of dependences, which can be used to adopt a theoretical type of dependence.

Regarding the dependence of the cost of delivery on the number of containers – for the multimodal operator there are certain discounts for each delivery section. Fig. 8 shows the dependence of the cost of shipping 1 container (from China to Kyiv) on the example of one of the alternative delivery options. The «stepped» scale of discounts results in a non-linear dependence – for this, a polynomial example (of the second degree). This ultimately determines the effect for the operator that was mentioned above. The dependence of the cost of shipping one container on the volume of a batch of containers is as follows: $y=1.6834x^2-56.97x+9{,}079$, where y is the cost of shipping one container (USD), x is the number of containers (TEU), the reliability of approximation is $R^2=0.9764$, which makes it possible to characterize the derived dependence as having a high degree of correspondence with the original data.

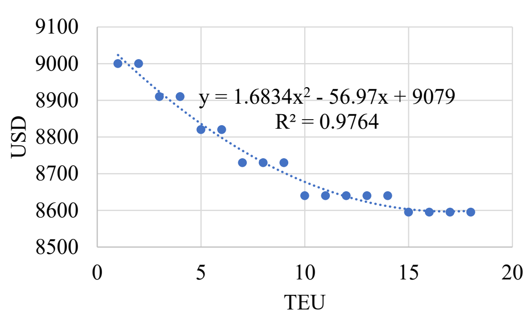


Fig. 8. A fragment of the statistical analysis of the dependence of the cost of shipping one container from China to Kyiv on the number of containers

Fig. 9 shows the dependence of delivery cost on the delivery time and its possible increase, which is built taking into account the results of the regression analysis provided above ($y=-651.7x_1-106.21x_2+12255{,}8$, where y is the delivery cost, x_1 is the delivery time (T), x_2 – possible increase in delivery time (ΔT)).

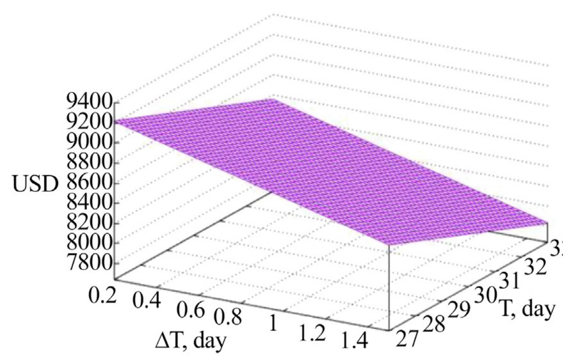


Fig. 9. Dependence of the delivery cost R of one container from China to Kyiv on the delivery time T and its possible increase ΔT

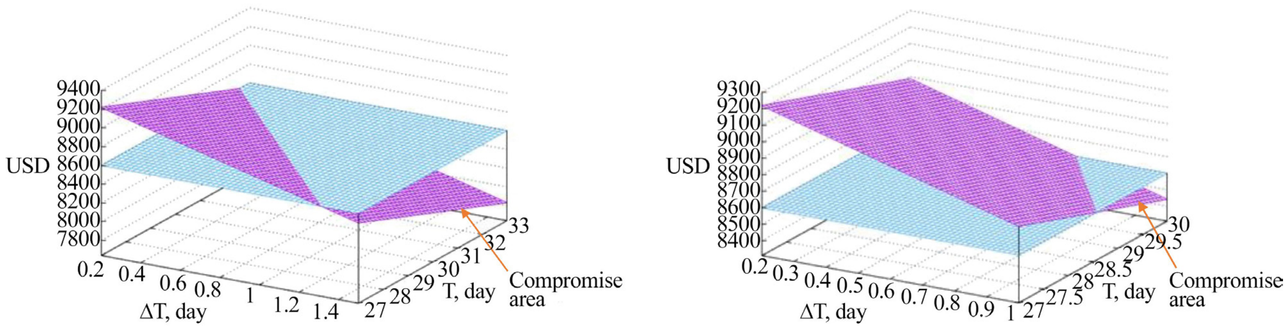
If the cargo owner limits, for example, costs to the level of $R^*=8{,}600$ USD, the corresponding plane cuts off the «unacceptable» part of the alternatives for the cargo owner (Fig. 10):

a) limitation only on the cost of delivery;

b) additional limitation on delivery time $T^*=30$ days and a possible increase in delivery time $\Delta T^*=1$ day.

It is easy to see that for the second option (*b*), the area of compromise is quite small, but if the cargo owner agrees to certain concessions, then the area of compromise and, accordingly, the number of possible delivery options increases. For example, concessions at the cost of $\Delta R'=100$ USD or time $\Delta T'=1$ day (Fig. 11).

It should be noted that this example demonstrates the formation and adjustment of the compromise area region, based on the resulting dependences of the delivery characteristics, which were found using regression analysis.



a *b*

Fig. 10. «Area of compromise» (stage one): *a* – limitation of delivery cost $R^*=8{,}600$ USD; *b* – limitation of delivery cost $R^*=8{,}600$ USD, delivery time $T^*=30$ days, and a possible increase in delivery time $\Delta T^*=1$ day

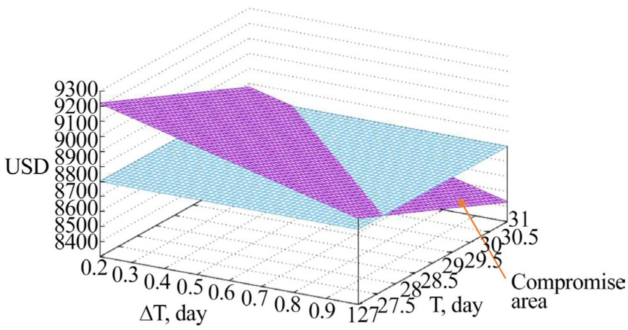


Fig. 11. «Area of Compromise» (stage two)

timodal operator taking into account the already existing orders for deliveries and a possible reduction of the cost, taking into account, of course, their own interests. But such an adjustment can be carried out under the condition of having complete and reliable information about current deliveries within the framework of a certain integrated information system.

According to the above, the application of an agile approach for a multimodal operator is associated, among other things, with the coordination and adjustment of the «compromise area». Fig. 12 shows the cycles of the agile approach to the organization of multimodal delivery, which are represented based on the ideas from paper [18].

So, to sum up: in order to obtain a compromise area in the processes of organizing multimodal delivery, first of all, the dependence of costs on time and reliability of delivery, which is proposed to be established using regression analysis, is necessary. On the example of the delivery of one container with cargo from China to Kyiv, regression linear models (univariate and multivariate) were built based on information about the characteristics of alternative options for delivery through different ports using the linear services of various sea carriers and involving rail and road transport. The reliability of the data approximation of the models (0.76–0.88 for univariate models, 0.97 for multiple regression) allows us to conclude about a sufficiently high degree of their correspondence to the original data. Using the example of varying the requirements of the cargo owner regarding the limitations of some delivery characteristics, the formation of the compromise area and its adjustment was carried out, which demonstrated the practical aspects of the formation of the compromise area for multimodal delivery.

5. 3. Scheme of adjustment and coordination of the «compromise area»

The area of compromise, which as a category for the agile approach is proposed in this study, can be adjusted by the mul-

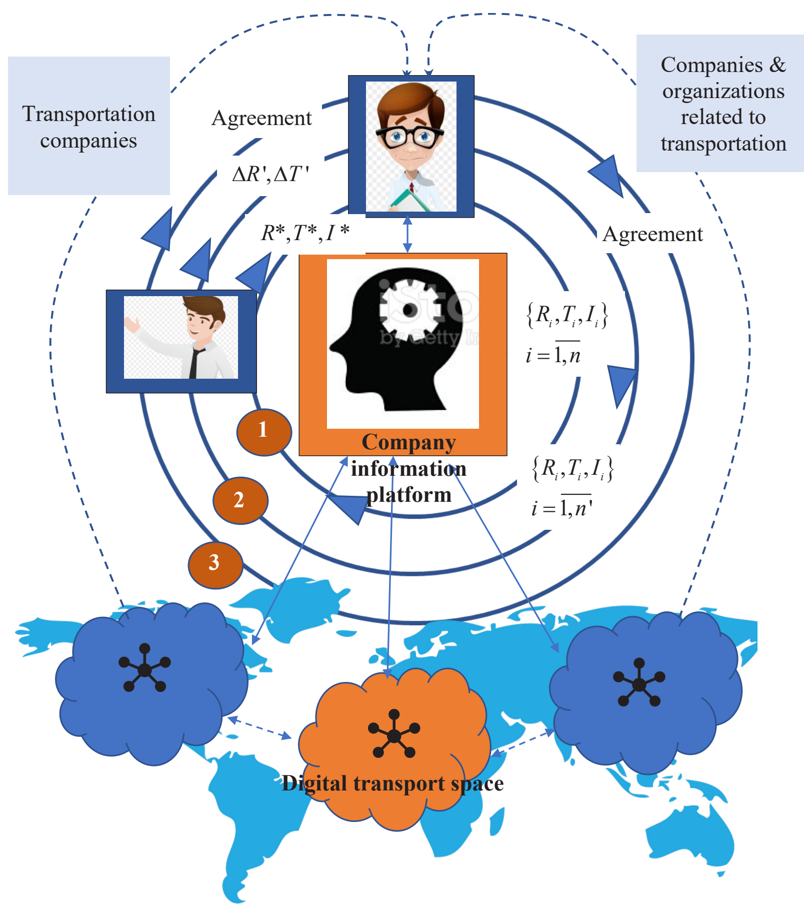


Fig. 12. Adjustment and coordination of the «compromise area» within the framework of the agile approach to the work of a multimodal operator with a cargo owner

But, in contrast to [18], in which the authors consider the delivery of goods within the framework of the project approach and project management office, in this work the emphasis is on the use of the area of compromise within the framework of agile cycles. This enables the operator to conduct activities in accordance with modern standards and implement an agile approach to working with cargo owners.

At each cycle, the customer (cargo owner) analyzes the area of compromise, taking into account the information provided by the operator. The shipper either agrees to the terms and conditions of delivery or adjusts the input data to further search for an option that will be accepted as «final and working». Of course, the implementation of the agile approach is possible only if the operator has access to the digital transport space – an information base on the market of transport services.

Therefore, the work of modern multimodal operators involves the use of a set of information sources and information platforms, including those developed specifically for a certain operator, which help form and allow analysis of options for the delivery of cargo in containers. This forms an information basis for the implementation and realization of an agile approach in the processes of coordinating certain deliveries with cargo owners, provided that the operator has multiple orders and the possibility of obtaining a synergistic effect.

6. Discussion of the definition and use of the area of compromise in the processes of organizing multimodal delivery

As a result of the study, the term «compromise area» was introduced, which reflects the numerical limits of product (project) parameters in the general case. For the transport domain under consideration, the «area of compromise» reflects the limits of the characteristics of multimodal delivery, which is the «product» for the multimodal operator (Fig. 3, 4).

The area of compromise is important for the practical implementation of the agile approach in any field because it is in the area of compromise that the search for solutions regarding the product (project) is carried out. Thus, existing algorithms and methods of finding solutions based on the agile approach (for example, [15]) will receive a numerical «base» for searching. «Compromise» is associated with the possibility of acceptance by the customer of some deviations from the initial values (numerical characteristics of the requirements) – Fig. 12. The formation of this area is related to a preliminary study of the relationships of product parameters, which can be performed using correlation-regression analysis (Fig. 5–8).

This analysis was carried out on a specific example of multimodal delivery and the practical aspects of determining and correcting the area of compromise were characterized (Fig. 10, 11), which demonstrated the applicability and efficiency of the concept of numerical determination of the area of compromise, and also formed a methodical approach to working with the area of compromise.

We have proposed a scheme for adjusting and harmonizing the «compromise area» within the framework of the agile approach (Fig. 12), unlike [18], in which the authors consider the delivery of goods within the framework of the project approach and the project management office, the emphasis is on the implementation of the agile approach to work multimodal operators.

Summing up, it should be noted that the proposed results, unlike existing approaches that determine the need for a compromise (for example, [16, 17]), but do not set the limits of this compromise, are aimed at determining these limits. The lack of similar studies and results is explained by the more widespread use of agile in the IT field, where it is quite difficult to find quantitative product characteristics, and even more so, the dependence of these characteristics. For the transport sector where the «product» has various quantitative characteristics, the implementation of this idea is possible, and it was achieved. Thus, the results of this study are intended for use in planning processes or organization based on the agile approach for the transport sector, or areas and projects where the product can be characterized by a set of interdependent characteristics. Limiting the use of the «compromise area» are products that have a numerical measure, which, for example, is not inherent in software products.

The shortcoming of this study is the lack of a theoretical generalization of the area of compromise since the main attention is paid to the practical aspects of the formation and use of the area of compromise. But eliminating this shortcoming is the essence of the continuation of our research and its advancement. It should also be noted that the development of the obtained results should be the construction of mathematical models for finding solutions within the framework of the compromise area, taking into account the information on all the operator's shipments.

7. Conclusions

1. The concept of «compromise area» has been introduced – an area in the space of «time-reliability-increase in time (reliability) – costs», within which there are solutions for multimodal delivery that satisfy the cargo owner's requirements for delivery (maximum delivery cost, maximum delivery time, as well as a possible increase in cost and delivery time), which are adjusted and agreed upon in the process of agile cycles. The compromise area involves the dependence of delivery costs on other characteristics, which was established using regression models.

The concept of formation of the compromise area as a space for balancing the interests of the customer (cargo owner) and the operator (executor) has been formed for further use within the framework of the agile approach.

2. Statistical studies of the compromise area were carried out on the example of a specific multimodal delivery. Corresponding regression models were built, the reliability of approximation is 0.76–0.88 for univariate models, 0.97 for multiple regression, which allows us to conclude about a sufficiently high degree of their correspondence to the original data. An analysis of the formation and adjustment of the compromise area for various conditions and requirements of the cargo owner was performed, which demonstrates the practical implementation of the idea of the formation of the compromise area.

3. A scheme for using the area of compromise and balancing the interests of the cargo owner and the multimodal operator by adjusting the limits of the area of compromise within the framework of agile cycles in the process of organizing delivery was built. Dana describes a practical implementation of an agile approach using the compromise area.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal,

authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

All data are available in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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