Intelligent system of invariant interactions automorphisms of the theory of symmetry for innovative transformations of a tourism product under extreme environmental influences

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Abstract

A solution to the urgent problem of modern internal tourism is proposed in order to preserve the dynamics of financial flows from the implementation of tourism flows in the context of unpredictable situations like pandemic outbreaks, wars, natural disasters, by constructing intelligent systems of invariant interactions of automorphisms of symmetry theory. The generalization of the Euclidean space to the class of economic indicators of internal tourism in the form of a four-dimensional space-time continuum is carried out. Based on the theory of symmetry, causal prediction and graph theory, the possibility of obtaining an intelligent system of invariant interactions of automorphisms of the theory of symmetry, adjusting the content of travel in the process of removing and introducing restrictions associated with uncertainties is investigated. Symmetric configurations of elements of invariant interactions of tourism services and a group of automorphisms that preserve the amount of funds invested in the implementation of a tourism product have been developed.

Keywords

automorphism, symmetry, causal forecasting, substitution effect, information technologies

1. Introduction

In conditions of limited movement due to the pandemic outbreaks, wars, natural disasters, the internal tourism and travel industry is in an extremely difficult situation. It becomes impossible to predict the development of the situation even in a short time interval. Despite a number of

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preventive measures and restrictive measures, the tourism and travel industry is developing in conditions of uncertainty and unpredictability of the influence of environmental factors, when neither the consumer of the tourism product, nor its manufacturer can predict in advance what consequences the choice of the appropriate alternative to the sale of the tourism product will have.

At the end of 2021, income from the tourism sector began to grow and gain momentum after the outbreak of the COVID-19 pandemic. But later, part of the reservations in the tourism sector were canceled in early 2022, when the tension between Ukraine and Russia escalated and a full-scale invasion of the aggressor country was launched. With the beginning of a full-scale war, the tourism industry found itself in the worst state in the entire history of the development of the Ukrainian tourism industry [1].

During the period of martial law, due to increased security measures and restrictions on movement, tourism and recreation facilities suffer. The work of these facilities is limited or suspended and visitors face difficulties. The peculiarities of recreation and operation of tourist facilities in different regions of Ukraine during the period of martial law directly depends on the specific circumstances of the declaration of martial law and the degree of its impact on the region [2]. At the same time, infrastructure facilities such as highways, bridges, railway tracks, railway stations, airports, runways were severely damaged. [3].

Assessment of direct and indirect losses and recovery needs of the Ukrainian economy (in the field of culture, tourism and sports), in monetary terms, as of June 13, 2022 is presented in Table 1 [3].

Table 1
Estimated losses (billion USD)

Type of property	Direct losses	Total indirect losses of the industry	The general need to restore the industry
Culture, tourism, sports	0.7	4.3	1.6

The reconstruction of damaged and destroyed objects of the cultural and tourist sphere will require investments, as it will be built taking into account the principle of "build back better" (as well as for other types of damaged objects - administrative buildings, housing, etc.), which requires compliance with modern standards [3].

Inflows of funds to local budgets from the tourism sector are significantly reduced. Thus, in the first half of 2022, the budget of the capital city of Kyiv received $0.89 million of tourist tax, and in the first half of 2021 this figure was $2.81 million. As of September 27, 2022, the budget of the capital of Ukraine receives $1.13 million from tourism [4].

According to the calculations of Ukrainian and international scientists, in the future Ukraine will need additional external financial assistance and its debt will probably have to be restructured to support reliable reconstruction and recovery, as well as to consolidate fiscal stability [1, 5, 6].

In wartime, especially during active hostilities, foreign tourism also suffers indirectly. The military conflict leads to deviations in long-haul flights between Europe and East Asia, which increases transportation costs. The global tourism industry could lose at least $14 billion in revenue if the war between Ukraine and Russia drags on [7, 8].

The complexity of ensuring financial flows of internal tourism with the uncertainty of the influence of external factors and their diversity prompts to look for means of their simultaneous modeling with the establishment of cause-and-effect relationships of factors both among themselves and with the output variable.

The presence of internal links between tourism and travel services in the structure of a tourism product is manifested in their symmetry in the service implementation. Symmetry is a vast topic, rooted in mathematics, allowing for the transition from the visual presented to abstract ideas of harmonic proportions. There are a number of works in which the concept of symmetry is

successfully used to solve various physical, chemical problems, problems in natural science and medicine. However, to solve economic and social problems, including tourism, this method has not previously been used.

The behavior of the output variable reflecting the financial flows of internal tourism is determined by a complex of cause-and-effect relationships between independent factors and the dependent variable. It is designed to highlight the most alternative paths of development from many different states. This forecasting feature can be used to develop a methodology for managing the preservation of financial flows of tourism in the face of sudden restrictions on the implementation of tourism and travel services caused by pandemic outbreaks, wars, natural disasters.

To the unresolved parts of the general problem of maintaining the dynamics of financial flows from the implementation of travel content in the event of unpredictable circumstances refers to the development of a model for maintaining financial flows of tourism in conditions of uncertainty and risk.

The main purpose of this work in building an intellectual system for maintaining the dynamics of financial flows is to try to link four important scientific results: symmetry of service consumption in the structure of the tourist product, causal forecasting based on the establishment of causal relationships, maximization of financial flows of domestic tourism based on graph theory and Ford-Falkerson algorithm, as well as economic aspects of the formation of tourism and tourist services. Practical realization of the development was carried out based on statistical processing of real data of Tour Plasa tourist company.

The aim of the work is to study the possibility of adjusting travel content in the implementation of tourism and travel services at the time of introduction or removal of restrictions, allowing to encode knowledge regarding causal and associative relationships for making managerial decisions on the development of internal tourism.

2. Literature Review

Establishment of limitations forces people to limit activities outside the home, as a result of which, the turnover of sales of tourism and travel services decreases sharply. Therefore, it is necessary to change the way of thinking when running a tourism and travel business through technology transformations.

Recently, a number of new mathematical models, methodological approaches, proposals and recommendations have appeared on the development and management of tourism in the short term [8-10] using digital technologies [11], causal forecasting [12], economic innovations [13,14]. The issues of syngony and automorphism in the theory of symmetry of single crystals and their solid solutions are considered in [15,16].

The possibilities of practical applications of the theory of symmetry and its fundamental laws are revealed in all the variety of problems to be solved. Thus, the fluctuation theorem on the exchange of information between subsystems evolving in time is considered in [17, 18]. Prediction of traffic of intelligent transport systems using the method of automatic parking and fuzzy logic control is considered in [19]. In [20], the accessibility of high-level urban hospitals for the elderly in Sinai, China was assessed. In [21], a method for making emergency decisions for regulating various situations based on game theory and perspective theory is proposed. In [22], the influence of plastic anisotropy on the distribution of stresses and strains is considered. In [23], an assessment was made of the properties of toxic products and their impact on the environment and humans.

It is promising to attract experimental methods based on the analysis of observation results, the receipt of new information about changes in the current situation and the establishment of cause-and-effect relationships between the factors that determine the change in the output variable. Causal forecasting is used to solve various technical problems: signal extraction against the background of interference [24], energy efficiency assessment [25], electrical loads [26], machine learning of product transactions [27], neurobiology [28]. The common problem of causal

forecasting is the establishment of a group of factors and the degree of their influence on the output variable. Identifying the most significant among them is the most difficult moment that hinders the introduction of methods of causal forecasting.

An analytical consideration of the optimization of resource allocation in a situation of uncertainty and unpredictability of the influence of external factors is used in graph theory, with the transport problem of the maximum flow under restrictions on the throughput is carried out using the Ford-Fulkerson algorithm [29]. In [30], an implementation of an algorithm for finding the maximum flow with the smallest number of iterations by the breadth-first search method is presented. In [31], the performance of the maximum flow on grid and random geometric graphs was investigated. In [32], combinatorial structures for weighted graphs with a low field volume were investigated by the same method. Combinatorial optimization using the Ford-Fulkerson algorithm is presented in [33].

As shown by a comprehensive analysis of publications on symmetry theory, causal forecasting, graph theory and algorithms for finding maximum flows in the network, such work is pioneering, priority and, to some extent, breakthrough. in the conditions of unpredictability and uncertainty of the influence of external factors, its development will ensure profit from the sale of a tourism product while maintaining consumer demands. Interest in the problem is growing over time.

3. Materials and Methods

The symmetry of objects in space represents changes in space itself, i.e. rotation or mirroring that does not change the object itself. Symmetry, in addition to the ratio of proportions, determines the type of consistency of individual parts of the system [34].

The use of symmetry to solve the problems of maximizing financial flows in the implementation of tourism and travel services in a uncertain circumstances can be based on the main property of the theory of symmetry, which is that some spatial figures can be obtained with a relatively large number of turns around any axis.

In mirror symmetry, the mapping S takes an arbitrary point G into its mirror image G '. A mapping is defined if a rule is established according to which each point G is associated with its image G → G '. Mirror symmetry expresses not only reflection but also rotation, i.e. rotation around the perpendicular axis.

A transform that rotates each point of a shape by the same angle around a specified center is a mirror-rotate transformation. Helical symmetry is carried out by turning at a certain angle around the axis and additional translation along this axis. Discrete symmetries of the second order work on a finite number of steps, which occurs when a stepwise transition to other types of services on specific days of using a tourism product. In a general sense, symmetry means the invariance of the structure of a mathematical object with respect to transformations.

Determination of a set of transformations that leave unchanged all structural relationships of the object, i.e. group G of its automorphisms has become a guiding principle of modern mathematics and physics, allowing deep penetration into the internal structure of an object as a whole and its parts. If there are similar studies and recommendations for mathematics and physics, then there are no such recommendations for the economy of modern tourism under the influence of uncertain circumstances. The space of symmetry elements that can be considered tourism and travel services v_i and time intervals, days of tourist travel t, forms the internal structure of the tourism product. Such space can be represented in the form of a table (table 2).

Table 2

Structure of the tourism product

Services	Price	Consumption intervals	Travel duration	Tourism product cost
$v_1, v_2, \dots, v_i$	$P_1, P_2, \dots, P_i$	$t_1, t_2, \dots, t_n$	T	P

To determine the symmetric configurations of the elements of invariant interactions, it is necessary to select a fixed element, the main tourism and travel service, which determines the attractiveness of a tourism product.

The space of services of a tourism product and their manifestations will be considered symmetric with respect to the plane passing through the axis of the main tourism and travel service.

The entire range of offered tourism and travel services during their implementation during the proposed trip with the transition from one service to another in consequence of restrictions related to war, pandemics, natural disasters forms a spatial object in which the pole is the source of S i.e. the amount of funds invested in the organization of a tourism product, and the other pole is the runoff T, i.e. their implementation in the face of uncertainty.

In the Ford-Fulkerson algorithm, the network is considered as a connected digraph, oriented in one direction from source to drain. The initial state of maximizing the financial flows of external tourism is the graph $G\ (V, E)$ with the capacity $G(u,v)$ and flow $f(u,v) = 0$ for edges from u and v.

The flow in the network is equal to the sum of the flows of all arcs incident to the flow of the graph.

The conservation of the flow when passing from source to drain can be written as:

$$O(mn\log u) \tag{1}$$

where $m = |E|$, $n = |V|$, $u = \max C_{ij}$

The formal description of Ford-Fulkerson algorithm is as follows: given a graph $G\ (V, E)$ with capacity $c\ (u, v)$ and flow $f\ (u, v) = 0$ for edges from u to v. It is necessary to find the maximum flow from source s to drain t. At each step of the algorithm, identical conditions are applied for all flows:

- $f\ (u, v) \leq c\ (u, v)$. i.e. the flow from u to v does not exceed the capacity.
- $f\ (u, v) = f\ (v, u)$.
- $\Sigma f\ (u, v) = 0 \longleftarrow\longrightarrow f_{in}\ (u) = f_{out}\ (u)$ for all nodes u except s and t i.e. the flow does not change as it passes through the node.
- the flow in the network is equal to the sum of the flows of all arcs incident to the flow of the graph.

The algorithm starts from zero flow, increasing it at each iteration until the arc of the network becomes saturated. Denoting the saturation of the digraph arc through $\Delta P = P_i - P_j$, where P_i – the cost of the main tourism and travel service, P_j – the cost of an additional service, we obtain an orthonormal basis for maintaining the financial flow of tourism in conditions of uncertainty.

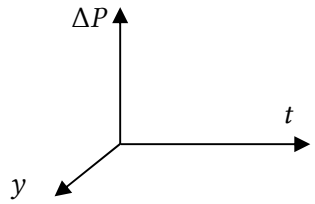

Figure 1: Orthonormal basis for maintaining the financial flow of tourism in conditions of uncertainty

The analysis of statistical reporting before the onset of uncertain circumstances made it possible to determine the weights of the tourist network digraph arcs by experimental estimation, which are presented in Table 3.

As a material for the study, we used the results of statistical processing of the data of the travel company Tour Plasa before the onset of the war in Ukraine, please, check Table 3.

Table 3
Tourism consumption statistics

Type of tourism	Vacation at sea	Cultural tourism	Backpacking	Religious tourism	Gastronomic tourism
Symbol	v_1	v_2	v_3	v_4	v_5
Arc weight,%	37	22	13	11	17

Travel duration in days is selected as network nodes. Usually it is a week, so the number of nodes is 7. The network of sales of a tourism product is shown in Figure 2.

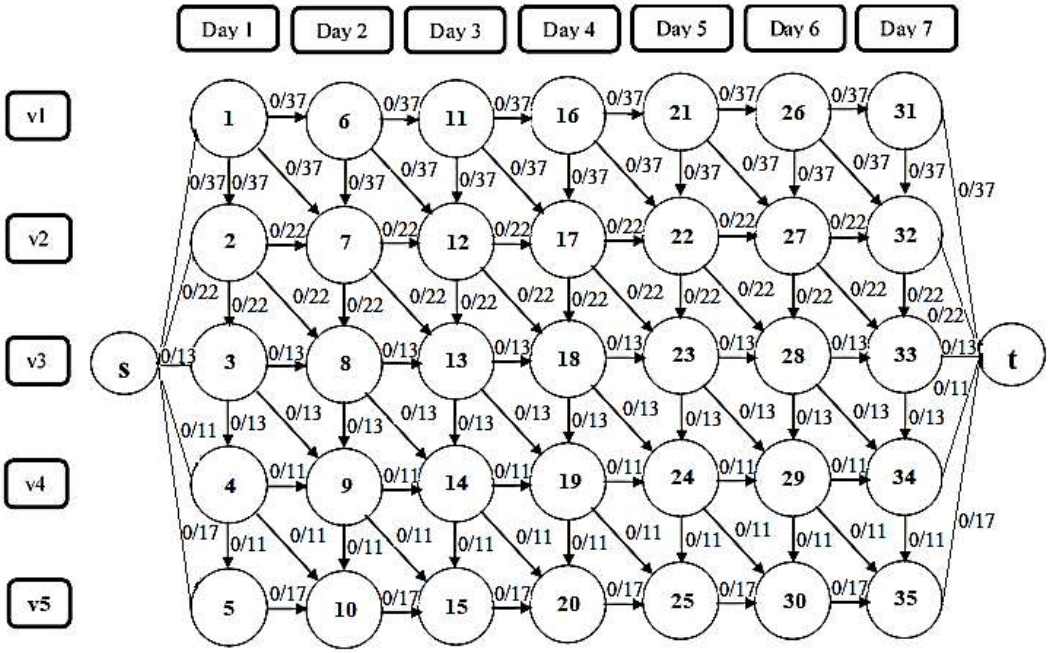

Figure 2: Initialization of arcs in the network of the digraph of tourism and travel services

The occupancy of the days of stay with the possibility of participating in the services offered is presented in columns 1-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35.

When the algorithm is running, the flow should not exceed the bandwidth of the network edges $f(u,v) \le C(u,v)$. It is symmetrical about the axis passing through its middle $f(u,v) = f(v,u)$. For all nodes u except S and T, the flow does not change when passing through the node

$$\sum f(u,v) = v \leftrightarrow f_{in}(u) = f_{out}(u) \tag{2}$$

According to [40], the mathematical expression of the Euclidean space is expressed in terms of points and vectors. The connection between them is determined by the fact that each two points A and B corresponds to a single vector $\overline{A}B$, and to each point A and vector "a" there is a single point B such that $\overline{AB}$ = a. In addition, at any points A, B and C

$$\overrightarrow{\mathbf{AB}} + \overrightarrow{\mathbf{BC}} = \overrightarrow{\mathbf{AC}} \tag{3}$$

Line AB is defined as the set of all points M such that

$$\overrightarrow{\mathbf{OM}} = \overrightarrow{\mathbf{OA}} + \lambda \overrightarrow{\mathbf{AB}} \tag{4}$$

where O, A and B – fixed points, λ – arbitrary number.

The plane ABC is defined as a set of points M such that

$$\overrightarrow{\mathbf{OM}} = \overrightarrow{\mathbf{OA}} + \lambda\overrightarrow{\mathbf{AB}} + \mu\overrightarrow{\mathbf{AC}} \tag{5}$$

where O, A, B and C – fixed points, λ and μ – arbitrary numbers.

For two vectors "a" and "b" their dot product must satisfy the properties:

- communicativeness $ab = ba$,
- linearity

$$(\lambda_1 a_1 + \lambda_2 a_2)b = \lambda_1(a_1 b) + \lambda_2(a_2 b) \tag{6}$$

- positive definiteness

$$a^2 = a \quad a > 0 \tag{7}$$

In this work, we generalize the Euclidean space to the class of financial and economic indicators of internal tourism in the uncertain circumstances in the form of a four-dimensional space-time continuum. At the same time, points of space elements express tourism and travel services that are part of a tourism product v_i, and the vectors indicate the location of consumers of a tourism product at a given point and their displacement on the path of consumption by days of travel, while additional tourism and travel services are filled with other elements that increase the attractiveness of additional services while maintaining financial flows.

4. Methodology

Representing the movement of financial flows in the form of travel in time of tourism and travel services that form the structure of a tourism product, one can try to define a group of automorphisms, i.e. a group of elements that carry out transformations, providing profit from the sale of a tourism product under unpredictable external influences. At the same time, the number of all offered services in the structure of the tourism product remains unchanged throughout the trip, and only the moments and duration of their use change, i.e. internal structure of a tourism product.

The interaction of the services offered in the process of implementing a tourism product can be presented in the form of successive iterations over the days of the proposed trip, starting with the main service, which determines the priority of tourists' preferences in choosing a region of country or place of stay, and a subsequent series of nearest, replacing, additional neighboring services, as well as a number support services more distant from the main service.

Separately, we should dwell on the formation of tourism and travel services in the proposed tourism product intended for its implementation in the conditions of uncertain circumstances, since a simple unreasonable selection of them can lead to significant financial losses associated with the termination of travel, which is equally unacceptable to both manufacturers and consumers of the tourism product.

A fundamental powerful tool for understanding how changing economic conditions affect the prices of production of services offered is the analysis of supply and demand.

The transformation of the basic patterns for the formation of demand and supply of tourism and travel services during a uncertain circumstances is shown on Figure 3.

The demand curve D shows how many services consumers are willing to purchase depending on the price. The supply curve S shows how the number of services offered varies depending on its price. Curves S and D intersect at the equilibrium point. Supply and demand curves move over time as external conditions change. Changing external conditions shift the supply and demand curves to the S 'and D' positions.

The same reasoning is true for the market for two tourism and travel services (Figure 4).

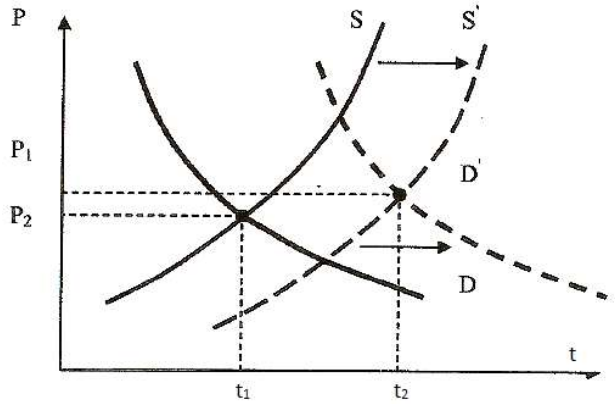

Figure 3: Influence of changes in external conditions on the formation of demand and supply of one tourism and travel service

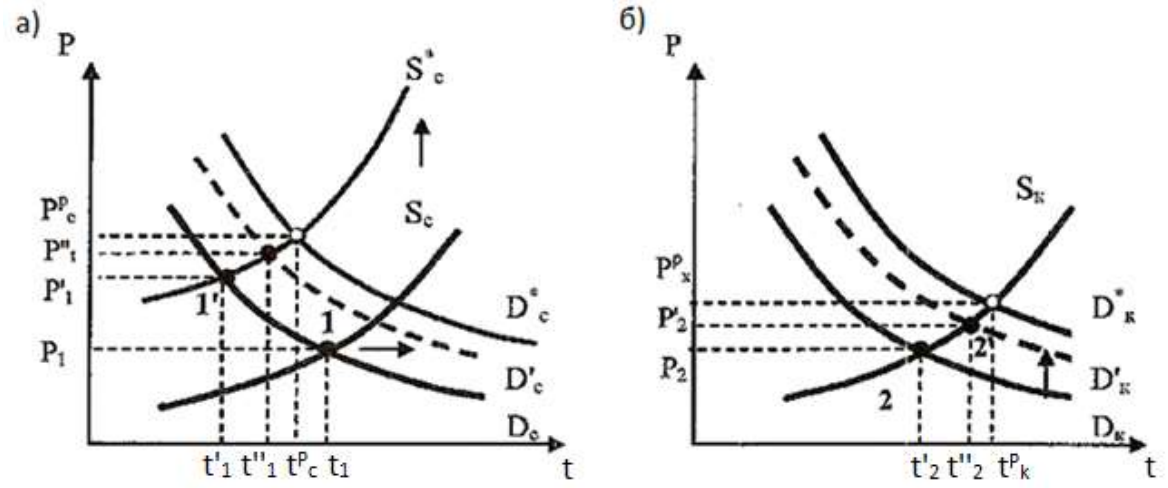

Figure 4: The impact of changes in external conditions on the formation of demand and supply of two tourism and travel services: a) termination of the implementation of the main service, b) transition to an additional service

The primary service market is initially at the intersection of the curves S_c and D_c and is determined by the price P_1 and service implementation time t_1 (point 1 in Figure 4a). If the external conditions change caused by the possible termination of the implementation of the main service as a result of uncertain circumstances, the time of its consumption will decrease from t_1 to t_1' (point 1 'in Fig. 4 (a)), which forces producers to shift the supply curve from the position S_C to the position S_C^* to maintain financial flows from the sale of this service at the same level. When switching to an additional service (Fig. 4 (b)), the equilibrium point will also be at the intersection of the curves S_k and D_k is already determined by the new price P_2, service implementation time t_2, other services.

The interaction markets of the two services that make up the tourism product are interdependent, i.e. conditions for the implementation of one service affect prices, consumption volumes and the attractiveness of another. The services offered that are the parts of the tourism product must be the substitutes, i.e. to complement each other.

Another necessary condition for the formation of a package of tourism and travel services in the restrictions related to war, pandemics, natural disasters, in addition to the fact that they should be substitutes, there is the observance of the conditions of complementarity, when an increase in the price of one of them will lead to an increase in demand for the other.

Information on the development of the tourism and travel services market is contained in the ratio of internal and external destabilizing factors. While internal factors can be controlled, external factors must be considered.

After determining the composition of tourism and travel services in the structure of a tourism product, it is equally important to determine the sequence of their use. The priority of the use of tourism and travel services in the context of uncertain circumstances, while ensuring the possibility of switching from one service to another due to restrictions related to war, pandemics, natural disasters, should be based on the causal relationship of factors that determine the attractiveness of the entire trip.

The presence of cause-and-effect relationships between the offered tourism and travel services v_i is the basis for causal forecasting of the preservation of financial flows during the implementation of a tourism product $\hat{y}$. The entire system of causal forecasting exists in time:

$$\hat{y} = f(v_1(t), v_2(t) \ldots v_n(t)) \tag{8}$$

The complex use of causal forecasting together with the Ford-Fulkerson algorithm makes it possible to assess the contribution of a specific tourism and travel service i at a fixed moment of its use j to the total profit from the sale of a tourism product

$$A = \left\| C_{ij} \right\| \cdot \left\| \alpha_{ij} \right\|^{\mathrm{T}} \tag{9}$$

where A – financial result of use of the i tourism and travel services, C_{ij} – monetary terms of all components of the i tourism and travel services, α_{ij} – the magnitude of the direction of movement of financial flows when they move from 0 to t.

The direction of movement of financial flows can be estimated by the values of the missing information I included in the entropy formula H [19].

$$H = \frac{I}{n} = -\sum_{i=1}^{n} P_i \log_2 P_i \tag{10}$$

where P_i – the probability of a random event occurring.

The implementation of tourism and travel services and their ranking can be represented by reproducing possible mappings.

The frequency of the circuits and their composition impose restrictions on the intervals of consumption of tourism and travel services due to unexpected external disturbances. Since the sale of a tourism product after its acquisition occurs in the direction of increasing, the intervals of time intervals and the direction of movement of the main service are displayed in the direction of increasing processes occurring. The interaction of nearby and neighboring tourism and travel services is based on the symmetry of periodically repeated contours, taking into account a time shift based on feedback from previous visitors of this complex of services.

A diagram of possible interactions of tourism and travel services in the structure of a tourism product is shown in Figure 5.

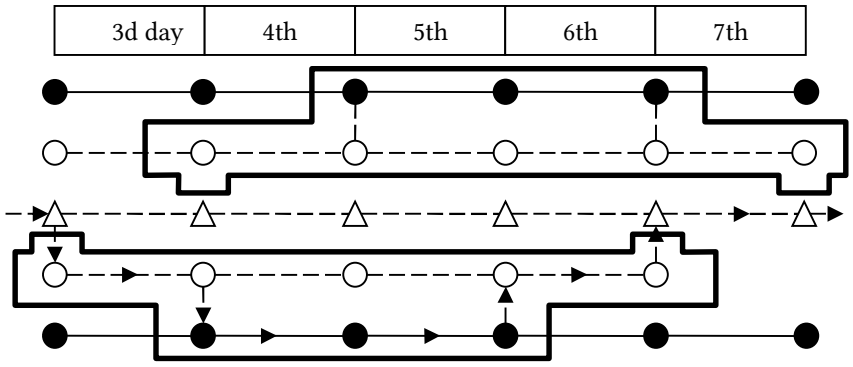

Figure 5: Scheme of interaction of tourism and travel services in the structure of a tourism product: Δ – main service, ○ – additional service, ● – support service

The arrows indicate the path of the tourist route. The symmetrical configuration shown at the top of Figure 5 is the orthogonal finite transform of mirror, translation, and rotational symmetry.

The figure limiting the area of possible changes in Fig. 5 has rotational symmetry, since it goes over into itself at all turns around a fixed axis.

The description of the space of possible implementations of tourism and travel services during restrictions related to war, pandemics, natural disasters can be performed taking into account the congruence of the figures. Mappings of the space S, for which one is inverse to the other, represent two one-to-one transformations. A transformation that preserves the structure of the space for the implementation of tourism and travel services in the context of uncertain circumstances can be considered an automorphism (Figure 6).

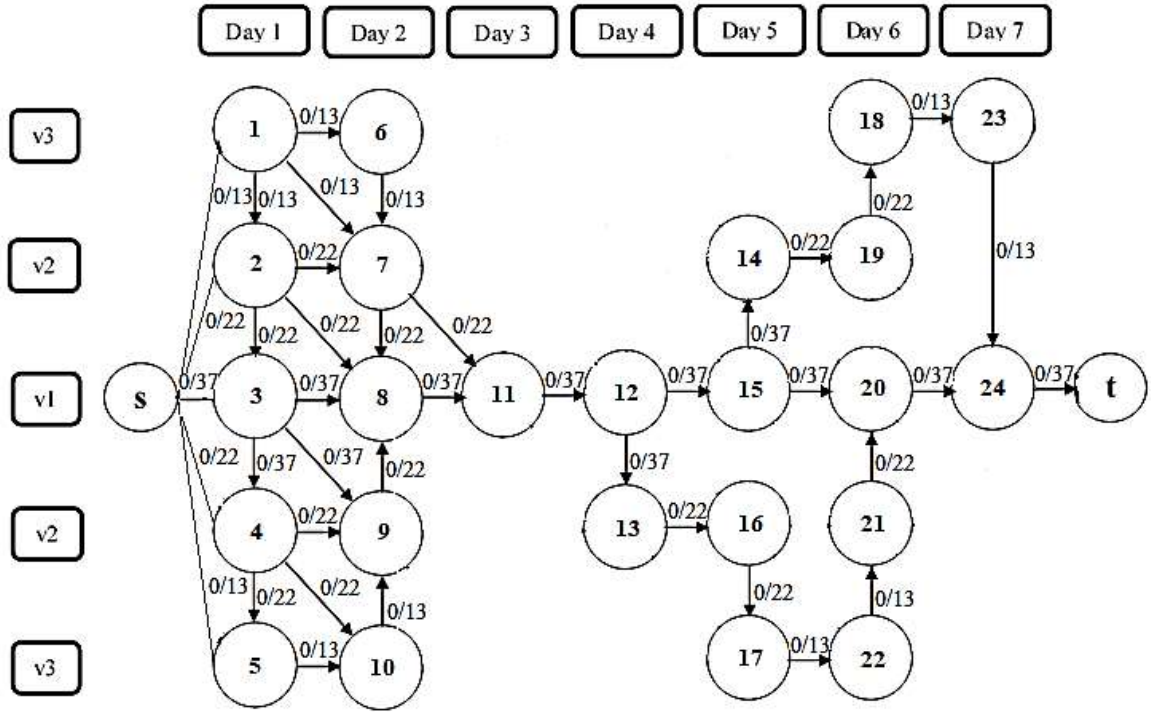

Figure 6: Algorithm for finding the maximum tourism flow in the modified network

Automorphism transforms the amount of financial costs for the purchase of a package of tourism and travel services into a function of their movement during the time they are on a trip to generate and save profits depending on unpredictable restrictions related to war, pandemics, natural disasters.

In set theory, an arbitrary permutation of elements is an automorphism. In the network of tourism and travel services and the days of their implementation, when developing routes for their passage, the number of automorphisms is equal to the number of iterations, i.e. steps of the path.
The sequence of modeling the structure, synchronized with the conditions for the implementation of tourism and travel services during the restrictions is shown in Figure 7.

During restrictions it is necessary to create some preferences in the consumption of services that increase the interest of consumers in the transition to another tourism and travel service in the form of an increase in service, laying new routes, organizing additional meals, etc. At the same time, care should be taken to ensure that the financial costs associated with an increase in the cost of additional services do not exceed the cost of the main service. Combinatorics of symmetric configurations and their transformations are possible due to pressure from external conditions and reactions to these changes. In conditions of uncertainty in the consumption of tourism and travel services, one should not rely on the stability of their consumption. Tourism and travel services need to be differentiated according to the degree of their attractiveness to consumers.

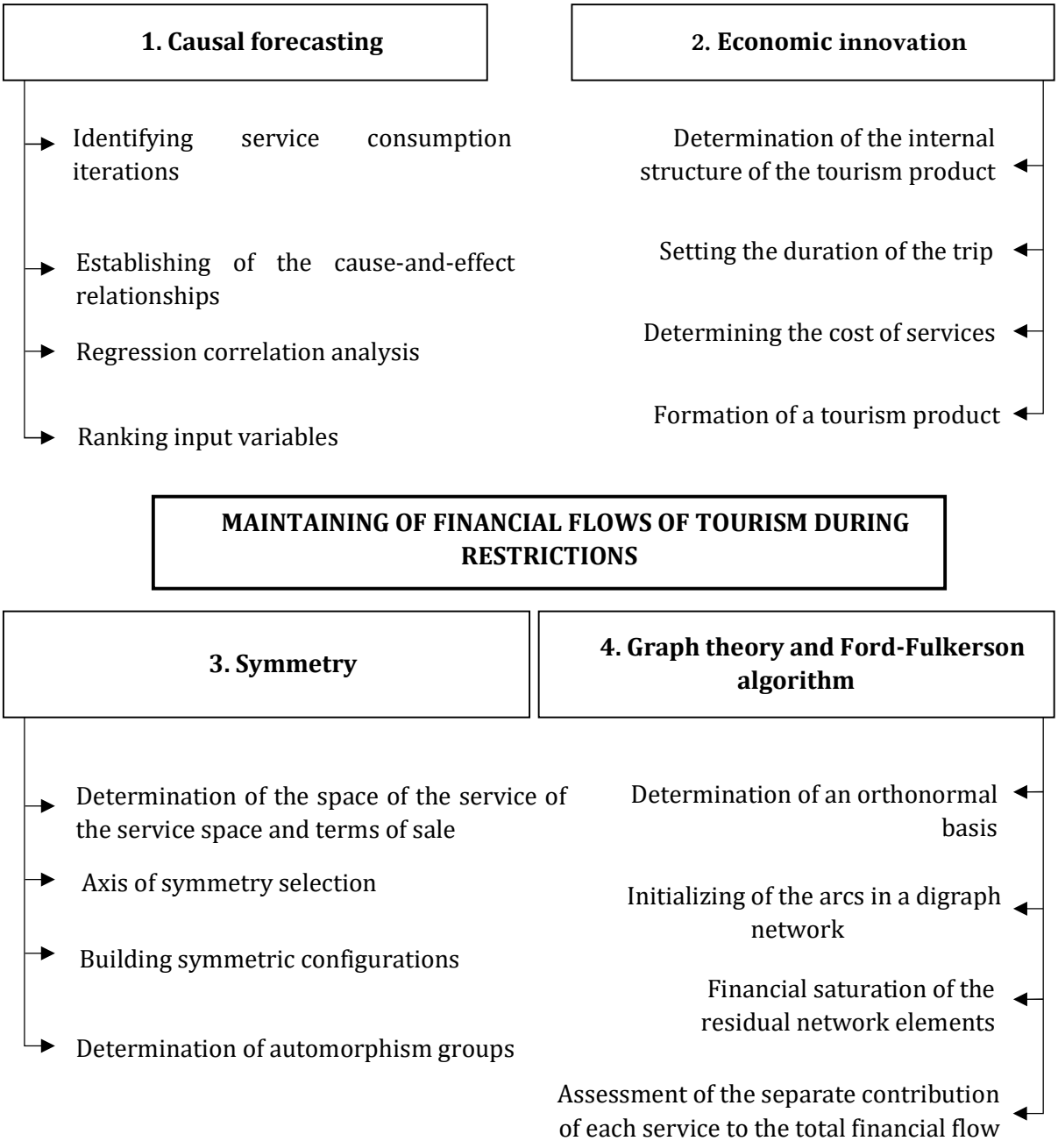

Figure 7: Methodology for maintaining financial flows in the face of uncertainty and risk

So, with the general main tourism and travel service of visiting sea rezorts in summer, the forced transition to mountain hiking trails for tourists of retirement age is not very attractive. The repeated visit to the tasting rooms looks just as unattractive.

5. Results and Discussion

The art of keeping profit from the implementation of travel content in the face of uncertainty about the impact of the external environment lies in the introduction of iterations of the stepwise use of basic tourism and travel services with the transition in case of restrictions related to war, pandemics, natural disasters to additional and auxiliary ones.

Examples of possible combinatorics of symmetric configurations ensuring the mutual interest of manufacturers of consumers of a tourism product are shown in Figures 8-13.

The main service of the v_1 tourism product is offered: sea rest, sun, beach, diving, jet skiing and catamarans. Tour duration is 7 days. Visiting museums, cultural centers, fairs, cathedrals, shops is

offered as an additional service v_2, which is inferior to the main one in priority of preferences according to consumer reviews. The next in priority of preferences will be v_3 services, which we refer to as support service: hiking, mountain tourism, familiarization with local attractions, architectural monuments, historical and cultural heritage. A separate group of v_4 services is represented by exotic tours, visits to tasting rooms and peculiarities of national cuisine.

The implementation of the services offered in the context of uncertain circumstances has made its own adjustments. On the first day of our stay there was a worsening of the weather. Due to the stormy sea, the main tourism and travel service v_1 was replaced with an additional v_2, associated with visiting museums and cultural centers. On the second day, the weather did not improve and therefore the acquaintance with the monuments of history and architecture continued. On the third day, the still bad weather for a seaside holiday turned out to be acceptable for the transition to the new tourism and travel service v_3, associated with walking sightseeing walks and excursions. In order not to depend on the vagaries of nature, the fourth day was devoted to visiting religious monuments, temples - v_4. On the fifth, sixth and seventh days of the trip, the weather improved, and the tourists were happy to spend them on the sea.

The scheme of interaction of tourism and travel services in the considered example is shown in Figures 8, 9.

Building of another contour of symmetric configurations is carried out for the same tourism and travel services, but implemented in different conditions of environmental influence. It started raining on the third day of the trip, limiting the consumption of the v_1 service, replacing it with the use of the v_2 service associated with visiting museums. On the fourth day, a lockdown was announced due to coronavirus outbreaks and the exclusion of mass events. The forced transition to the v_3 service is associated with individual tours on the fifth day of travel. The end of the tour was in good weather and the lifting of restrictions related to the pandemic.

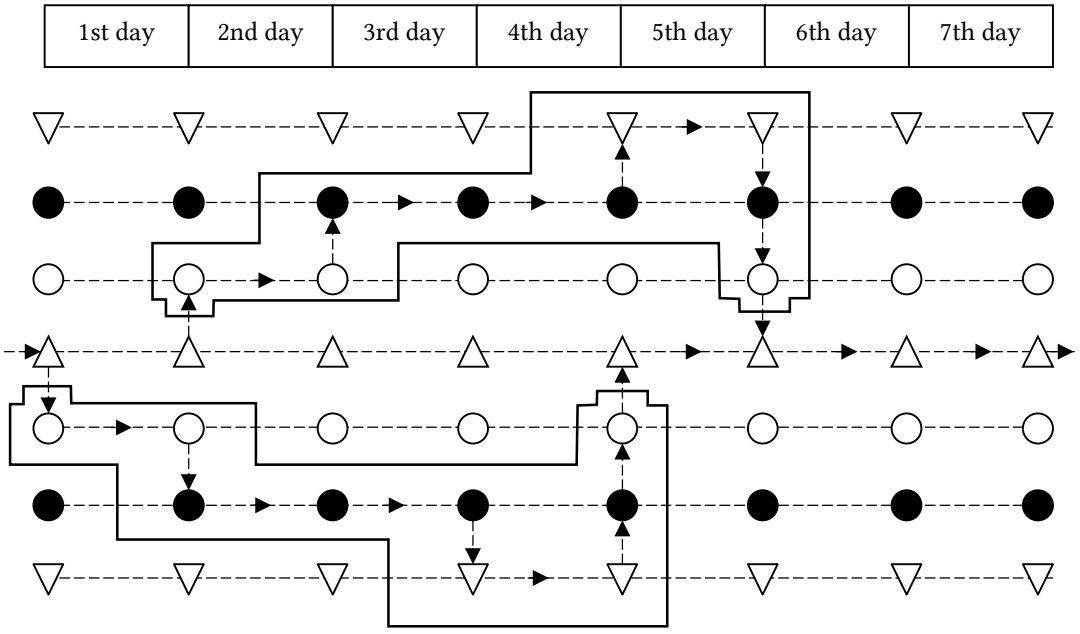

Figure 8: Diagram of possible interactions of tourism and travel services in the structure of a tourism product

A characteristic feature of the considered examples is the identity of the initial conditions for the sale of tourism products on the first and second days of travel. This is necessary to ensure the identity of the routes by subsequent groups of tourists, whose stay is shifted by one day. When these requirements are met, symmetric configurations of the elements of invariant interactions of tourism and travel services save the amount of funds for the implementation of the tourism product.

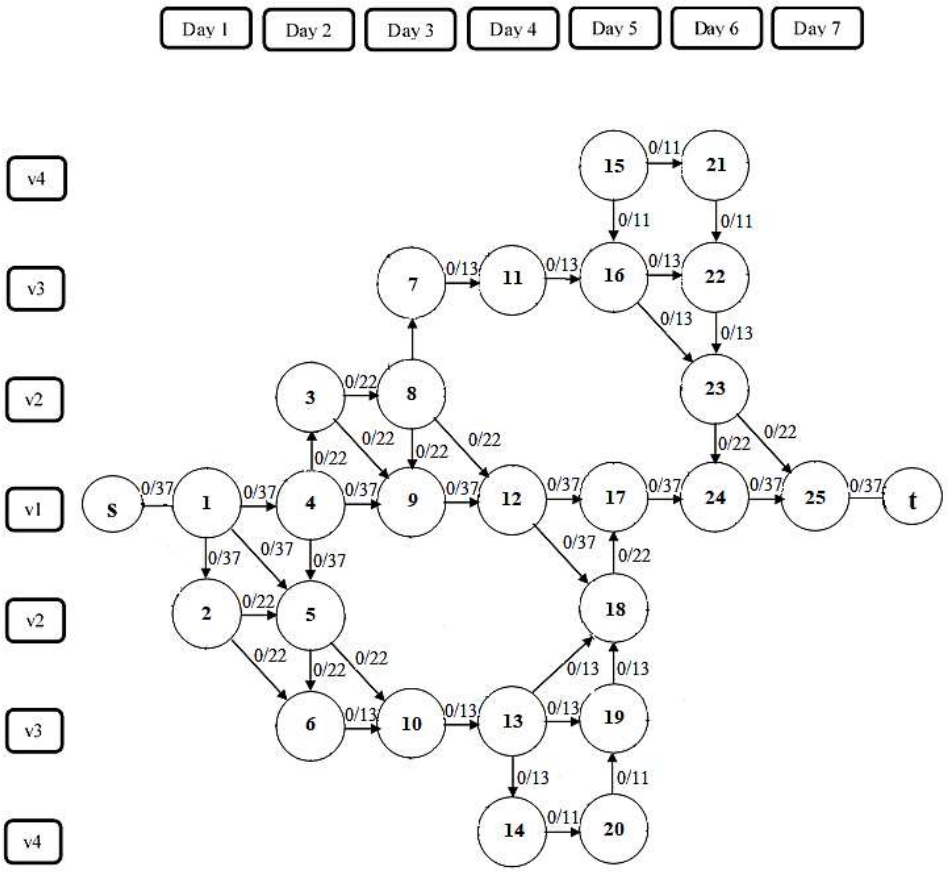

Figure 9: Algorithm for finding the maximum tourism flow in the modified network (Example No.1)

The scheme of interaction of tourism and travel services in the considered example is shown in Figures 10, 11.

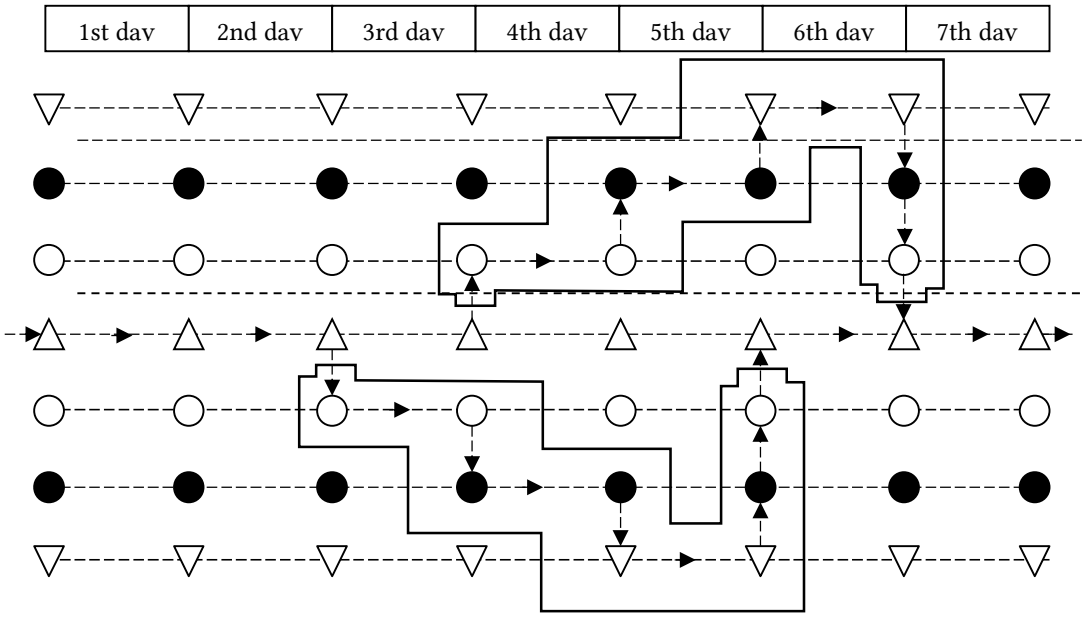

Figure 10: Scheme of possible interactions of tourism and travel services in the structure of a tourism product

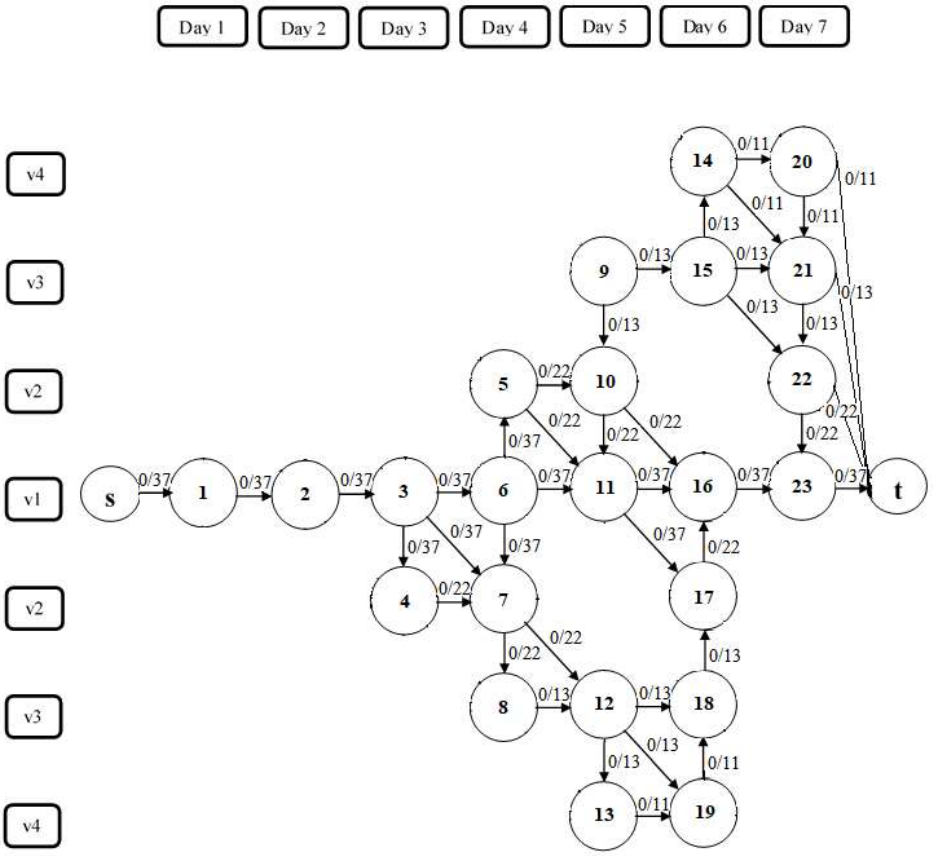

Figure 11: Algorithm for finding the maximum tourism flow in the modified network (Example No.2)

Conclusion

1. Development and implementation of practical recommendations for creation of an intelligent support system maintaining financial flows of internal tourism in the face of uncertainty caused by limited travel associated with the restrictions related to war, pandemics, natural disasters is a priority breakthrough task of the modern tourism economy, the urgency of solving which requires concentration of efforts to implement the indicated direction in world practice.
2. The difficulty of ensuring financial flows of internal tourism with the creating an intelligent system of necessity of the influence of external factors is manifested in the need for simultaneous modeling of the structure and conditions for the sale of tourism products. A intelligent system for maintaining financial flows for the complex use of tools, the theory of symmetry, economic innovations of causal forecasting and the Ford-Fulkerson algorithm has been developed, which allows to evaluate the effectiveness of its use on specific examples.
3. To enable the transition from one service to another during restrictions related to war, pandemics, natural disasters, the services offered must be substitutes, i.e. complement each other. In addition, the services offered must ensure the condition of complementarity, when an increase in the price of one of them leads to an increase in demand for others.
4. Based on the formation of cause-and-effect relationships between the offered tourism and travel services and the preferences of consumers, the priority of their use is scientifically substantiated intelligent system for maintaining financial flows to preserve financial flows of internal tourism in conditions of uncertainty and risk.
5. In the event of unpredictable restrictions, ensuring the financial sustainability of internal tourism can be achieved through the use of symmetric configurations of elements of interaction of tourism and travel services and a group of automorphisms, which, in combination with the Ford-

Fulkerson algorithm, save the amount of funds for the implementation of a tourism product while meeting the needs of tourists.

6. The novelty of the proposed approach to the creation of an intelligent system for maintaining financial flows of internal tourism in the context of restrictions related to war, pandemics, natural disasters is the use of the connection between management theory and methods of transforming complex structures by introducing iterations of the stepwise transition of tourism and travel services in the process of their implementation.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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