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## MODELLING OF INNOVATIVE AND INVESTMENT PROCESSES IN RESORT CITIES AND DESTINATIONS

*The innovative development of resort cities and territories is a crucial factor in their competitiveness, economic growth and efficient use of recreational potential. In the context of digitalization and the global transformation of investment flow management, the implementation of modern models based on the principles of the platform economy is necessary for the automation of business processes, optimization of tourist flows and the creation of an effective innovation environment.*

*Development and substantiation of theoretical and methodological approaches to modeling innovation and investment processes in resort cities and destinations, analysis of the role of digital platforms in the modernization of recreational infrastructure and improving the level of services and identification of patterns of innovation adaptation in resort and recreational systems based on a diffusion model.*

*Theoretical and methodological approaches to modeling innovation and investment processes in resort cities and destinations based on the principles of the platform economy are substantiated. The role of digital platforms in the modernization of recreational infrastructure and improving the level of services, in particular, through the implementation of smart solutions for managing tourist flows, optimizing resource use and ensuring sustainable economic growth, is determined. A diffusion model of innovation dissemination in resort and recreational systems is proposed, which takes into account the peculiarities of innovation adaptation in the context of digital transformation and globalization. It is revealed that digital technologies and investment mechanisms, in particular, the platform economy, create prerequisites for the sustainable development of the sanatorium and resort sphere, contributing to its integration into the global tourism market.*

*The research results can be used to develop strategies for the development of resort areas, improve investment policies and implement innovative technologies in the recreational economy. The proposed theoretical and methodological approaches and the model can become the basis for making informed management decisions regarding the innovative development of resort cities and destinations in the context of digitalization and globalization.*

**Keywords:** cities and destinations, investments, innovations, resort, recreation, digitalization, model, platform economy.

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## МОДЕЛЮВАННЯ ІННОВАЦІЙНО-ІНВЕСТИЦІЙНИХ ПРОЦЕСІВ У КУРОРТНИХ МІСТАХ ТА ТЕРИТОРІЯХ

*Інноваційний розвиток курортних міст та територій є вирішальним фактором їх конкурентоспроможності, економічного зростання та ефективного використання рекреаційного потенціалу. В умовах цифровізації та глобальної трансформації управління інвестиційними потоками, впровадження сучасних моделей, заснованих на принципах платформної економіки, є необхідним для автоматизації бізнес-процесів, оптимізації туристичних потоків та створення ефективного інноваційного середовища.*

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*Розробка та обґрунтування теоретико-методичних підходів до моделювання інноваційно-інвестиційних процесів у курортних містах та територіях, аналіз ролі цифрових платформ у модернізації рекреаційної інфраструктури та підвищенні рівня послуг та визначення закономірностей адаптації інновацій у курортно-рекреаційних системах на основі дифузійної моделі.*

*Обґрунтовано теоретико-методичні підходи до моделювання інноваційно-інвестиційних процесів у курортних містах та територіях на засадах платформної економіки. Визначено роль цифрових платформ у модернізації рекреаційної інфраструктури та підвищенні рівня послуг, зокрема, шляхом впровадження smart-рішень для управління туристичними потоками, оптимізації використання ресурсів та забезпечення сталого економічного зростання. Запропоновано дифузійну модель поширення інновацій у курортно-рекреаційних системах, яка враховує особливості адаптації інновацій в умовах цифрової трансформації та глобалізації. Виявлено, що цифрові технології та інвестиційні механізми, зокрема, платформна економіка, створюють передумови для сталого розвитку санаторно-курортної сфери, сприяючи її інтеграції у світовий туристичний ринок.*

*Результати дослідження можуть бути використані для розробки стратегій розвитку курортних територій, вдосконалення інвестиційної політики та впровадження інноваційних технологій у рекреаційну економіку. Запропоновані теоретико-методичні підходи та модель можуть стати основою для прийняття обґрунтованих управлінських рішень щодо інноваційного розвитку курортних міст та територій в умовах цифровізації та глобалізації.*

**Ключові слова:** міста та території, інвестиції, інновації, курорт, рекреація, цифровізація, модель, платформна економіка.

## INTRODUCTION

The innovative development of resort cities and destinations is a key factor in ensuring their competitiveness and sustainable economic growth. In the context of global digitalization, effective management of investment flows and the implementation of innovative solutions have become priority tasks for the development of the recreational sector. The resort economy, as an integral part of the tourism and recreation sector, requires modern management models that consider the specifics of territorial development, investor needs, and digital opportunities. The platform economy opens new prospects for integrating innovative services, automating business processes, and forming effective management solutions in the field of resort tourism.

Modelling innovation and investment processes allows for assessing the impact of digital technologies on the development of resort cities and destinations and forecasting the effectiveness of smart solutions. Creating a favourable investment environment facilitates the modernization of recreational infrastructure and ensures sustainable economic growth. The implementation of digital platforms enables the optimization of tourist flow management, enhances service quality, and ensures the environmental safety of regions. The use of modern economic and mathematical models provides a comprehensive analysis of innovation and investment processes and supports the development of effective growth strategies.

Research on these aspects is essential for forming scientifically grounded approaches to managing resort cities and destinations. The findings of this study can be utilized to improve investment policies, advance digital technologies, and enhance the competitiveness of recreational regions.

## LITERATURE REVIEW

The study of the development of resort cities and destinations involves examining various models of tourism destination evolution, considering innovation and investment factors. The study [1] proposes a novel approach to modelling resort development, emphasizing investment flows and innovative solutions. Institutional changes and crisis phenomena affecting entrepreneurial activity in the recreational sector are analysed in [2], highlighting the significance of effective public policy for attracting investments to resort areas. The relevance of supporting small and medium-sized enterprises as a crucial factor in the economic growth of resort cities is discussed in [3], which underscores the necessity of fostering innovative entrepreneurship in the context of digitalization. The importance of human capital for developing innovative management models in the recreational sector is explored in [4], with a focus on the digitalization of educational processes. The utilization of the innovation potential of enterprises in the recreational economy and platform-based business models is examined in [5], demonstrating the role of digital technologies in stimulating economic growth.

The digital transformation of the resort cities and destinations economy and the specifics of innovation-investment processes in the recreational sector are addressed in [6], which emphasizes the role of digital platforms in the modernization of the industry. The potential for modelling "smart tourism" in resort cities is explored in [7], analysing the impact of digital tools on the efficient management of tourist flows. Similarly, [8] discusses the formation of a smart industry as a driver of the competitiveness of resort cities and destinations. The development of business models in the context of the digital economy and the resort sector is analysed in [9], forming the basis for designing effective strategies for investment process management. The interconnection between the sanatorium-resort complex, preventive medicine, and investments in territorial development is discussed in [10]. Study [11] focuses on the socio-economic factors influencing the evolution of the sanatorium-resort sector in Ukraine, providing insights for forecasting its future development.

The innovative aspects of transitioning to a circular economy in the hotel sector of resort cities and destinations are examined in [12], demonstrating the importance of sustainable resource management. The study of interregional cooperation in innovative processes in the tourism sector in [13] underscores the significance of

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collaboration among cities and destinations in stimulating investments. The optimization of managerial decision-making in recreational enterprises through digital technologies and economic-mathematical models is explored in [14], contributing to the effective governance of resort cities and destinations. The development of predictive models for assessing the growth of tourism systems is presented in [15], aiding in the strategic planning of investments in resort cities. Project management as a mechanism for ensuring the resilience of the hospitality industry is examined in [17], highlighting the adaptation of business models to contemporary challenges in resort tourism.

### **THE PURPOSE OF THE STUDY**

The aim of the study is to develop and substantiate theoretical and methodological approaches to modelling innovation and investment processes in resort cities and destinations. Analysis of the role of digital platforms in the modernization of recreational infrastructure and improving the level of services. Identification of patterns of innovation adaptation in resort and recreational systems based on a diffusion model.

### **RESULTS**

In the modern resort cities and destinations economy, the role of innovation has significantly increased. Innovations are increasingly becoming key drivers of post-war economic recovery. The growing importance of innovations is determined, first, by the very nature of market relations and, second, by the necessity of profound qualitative transformations in Ukraine's post-war resort and tourism sector to transition towards a trajectory of sustainable growth. Without the application of innovations, it is practically impossible to create competitive products that possess a high degree of scientific intensity and novelty. Thus, in the market-based resort and recreational economy, innovations serve as an effective tool of competitive struggle, as they lead to the creation of new demands, cost reduction, increased investment inflows, and enhanced reputation of producers introducing new products. Furthermore, innovations facilitate the discovery and capture of new markets, including international ones. In other words, innovations should be regarded as an integral part of a competitive market, as they have historically contributed to and continue to enhance the competitiveness of both the resort and recreational product and the national resort and tourism sector as a whole.

One of the fundamental models of innovation is the diffusion model of its dissemination. According to this model, the spread of innovations depends on both the number of firms that have already implemented them and the number of firms that have not yet adopted them. However, the limitation of the diffusion model in describing markets is linked to the coexistence of technologies with varying levels of efficiency across different economic sectors. The distribution curves of production capacities in any given sector, when examined at different points in time, demonstrate similar patterns. This observation suggests the universality of the "spatial" distribution curve of technologies and its stability (invariance) over time.

It is important to note that the capacity for self-organization is a crucial characteristic of complex resort and recreational systems. This property implies the ability to autonomously structure the internal organization of the system, manifested through the establishment of long-range correlations between its elements – thus increasing the rigidity and range of interconnections. According to the principle of internal resource optimization, a resort system strives to achieve an equilibrium state with the highest possible level of disorganization, which is dependent on external influences that the system must withstand. Consequently, the stronger the external influences, the more interconnected the elements of the resort and recreational system must become, leading to a higher level of self-organization. Under the impact of external anti-entropic forces, the process of self-organization strengthens structural connections within the system, increasing their range and rigidity. This, in turn, generates flows of negative entropy for its elements. These elements either enhance their own organizational complexity or degrade, contributing to an increase in entropy. Once the system reaches the maximum rigidity of its interconnections, it attains the state of self-organized criticality. In this state, the system becomes highly sensitive to all external and internal influences, meaning that even minor fluctuations may trigger a bifurcation process, leading to the collapse of the existing structure, followed by the initiation of a new self-organization cycle.

The emergence of fluctuations that give rise to self-organization is caused by the intersection of multiple chaotic systems. External fluctuations arise due to negative entropic interactions from macro-systems, while internal fluctuations can be induced by deterministic chaos, which, resonating through the rigid connections of the resort and recreational system's elements, propagates to higher levels. Through these rigid structural connections, such fluctuations intensify and transition to higher levels of economic development.

At the core of self-organization lies the resort and recreational complexes' drive to ensure a diversity of responses that corresponds to the variety of external influences, allowing the system to implement its chosen strategy for achieving objectives. The increase in internal entropy is facilitated by the positive effects of scale and the internal interconnection of different types of resort and recreational activities, which helps reduce resource expenditures needed to maintain the effectiveness of the external strategy. Consequently, the fundamental components of resort and recreational systems' functioning are optimized. It can be argued that the adaptive behaviour of a resort and recreational system – its structure and management – is formed at the intersection of two types of fluctuations: internal innovation variability and external market dynamics. This is precisely the manifestation of the intersection of multiple chaotic systems, at the boundary of which self-organization emerges.

Innovation, as a distinct form of chaos, can serve as both a catalyst and a mechanism for transitioning to one of the possible development trajectories that align with the internal tendencies of the resort and recreational system, ensuring its qualitative transformation. This highlights the crucial role and constructive significance of innovation in initiating self-organization processes and preparing the system for various developmental scenarios. Innovation, as a type of chaos, acts as a factor that guides nonlinear systems toward their inherent attractor structures.

Since innovations introduce an element of chaos relative to the existing resort and recreational system, their implementation triggers self-organization processes aimed at integrating the new elements into the system's structure. To accelerate adaptation, the recreational system generates corresponding internal innovations, increasing the complexity of interconnections among elements and altering the system's structure. In the initial phase of self-organization, to maintain system stability, the number of its responses (internal innovations) must match the number of external signals, which are determined by market fluctuations. The system constructs a structure in which each external influence corresponds to an element capable of generating internal innovations and influencing the system's structural transformation.

In the subsequent phase, the resort and recreational system evolves toward a more organized state, achieved through the hierarchical arrangement of elements: order parameters are established, a principle of subordination is introduced, and effective clustering of homogeneous internal innovations takes place. This approach enables adaptation with minimal structural changes and, consequently, with minimal costs. In other words, this phase marks the adaptation of the resort and recreational system. The system remains in a state of stable disequilibrium, where endogenous innovations become critical for rapid adaptation and self-organization.

The resort and recreational system selectively responds to exogenous innovations, enforcing strict control over their penetration and accepting only those influences that align with its intrinsic nature – any others may exert negative effects, potentially leading to chaotic scenarios. Once nonlinear systems reach a certain level of internal resilience, they become active agents in structuring the external environment in accordance with their inherent nature and the existing market landscape. At this stage, it is essential to develop an appropriate management paradigm that defines relevant objectives and activates adequate internal mechanisms for the development of the resort and recreational system. Thus, the property of innovativeness can be viewed as a disruption of the conventional order of the recreational system's functioning. Order can be aggressive, seeking to suppress any manifestations of novelty within the system, including innovations as a form of chaos. This phenomenon may lead to contradictions, conflicts, and economic failures that accompany the evolution of complex resort and recreational systems.

The processes occurring in the market environment have a different nature. For a transitional economy undergoing systemic transformation, the following characteristics are typical: qualitative and quantitative changes in components (some become deformed, others disappear, and new ones emerge); multiplicity of states that differ qualitatively; and nonlinearity in development trajectories due to rapid state transitions. During transformation, the inertia of various components and the market environment varies, indicating that the duration of prevailing trends differs significantly.

The subjective components of the market environment are also prone to change: shifts occur in the needs of economic agents, along with changes in their interests, motives, stimulus-response mechanisms, and behaviour. This has led to increased chaos, misalignment, spontaneity in interconnections, and heightened cyclical fluctuations in the transitional market economy. Thus, the external market environment can be viewed as a synthesis of spontaneous market evolution and cyclical as well as chaotic conjunctural changes.

The above considerations suggest that the functioning of the resort and recreational system under conditions of intersecting deterministic chaos is characterized by significant particularities. The influence of both innovation-driven and external market chaos on the resort and recreational economy leads to a deformation of its fundamental nature. The chaotic component of the system intensifies significantly, and its cyclicity undergoes substantial modifications, particularly in terms of phase distortions. The instability of the resort and recreational economy in conditions of uncertainty and a perpetual crisis pushes the system into a bifurcation development mode, characterized by frequent shifts in direction. Consequently, anomalies emerge in the system's behaviour, including the effects of mixing and the emergence of hyperchaos.

Let us now consider one of the scenarios that arises in the innovative activities of the resort and recreational system under the conditions of intersecting deterministic chaos, based on the following model

$$\begin{aligned}\frac{dx}{dt} &= kx + y - xS, \\ \frac{dy}{dt} &= -x, \\ \frac{dS}{dt} &= -\varepsilon S + \varepsilon R(x, y)(x + y)^n,\end{aligned}$$

$$R(x) = \begin{cases} 1, (x, y) > 0, \\ 0, (x, y) \leq 0 \end{cases}$$

where  $X$  - production of the traditional resort and recreational product.

$k$  - parameter accounting for the growth in product production  $X$ .

$y$  - production of the innovative resort and recreational product.

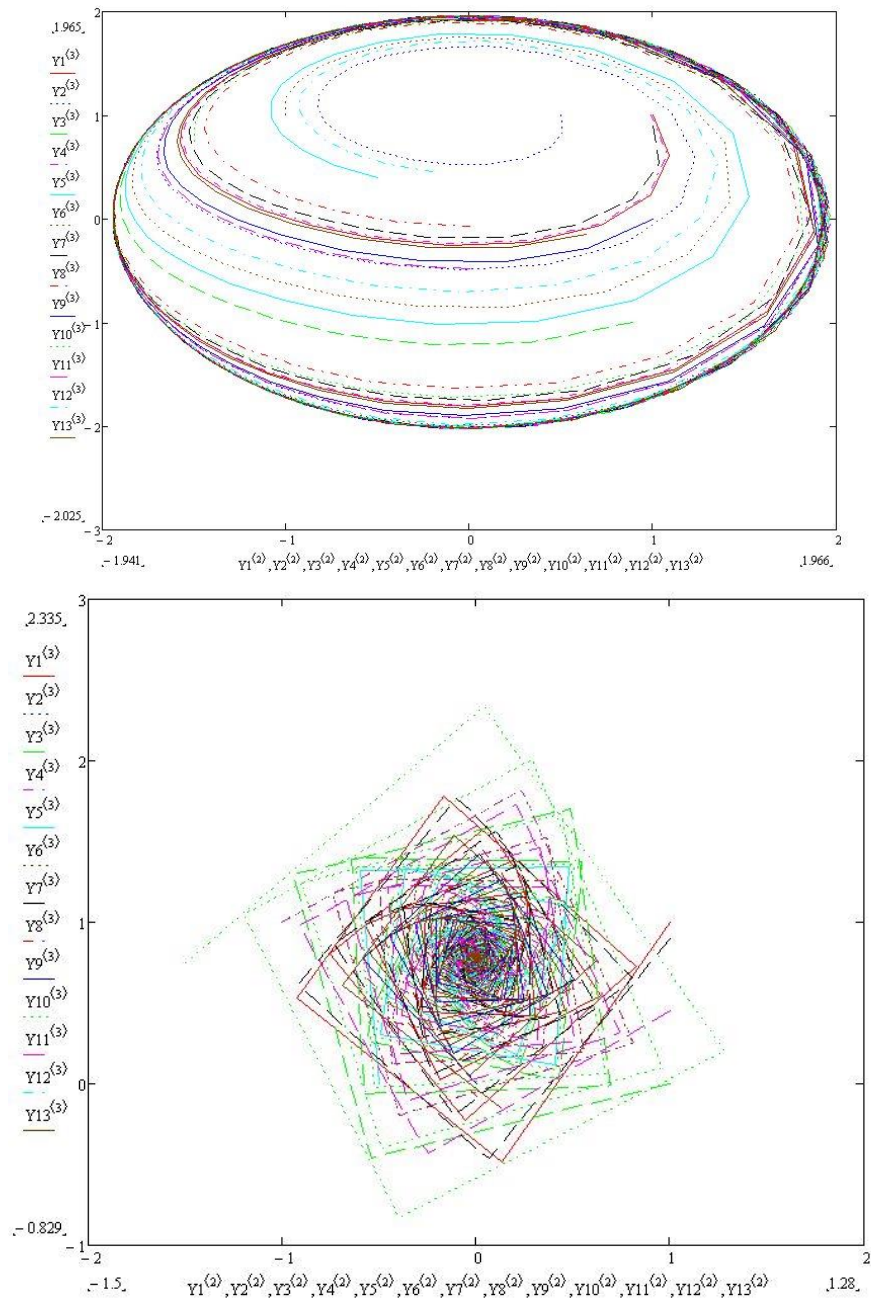
$S$  - market fluctuations in demand for resort and recreational products.

$\varepsilon$  - demand inertia parameter.

$R(x)$  - market fluctuation indicator.

$n > (3/2)te^{-ut}$  - transition zone at the edge of chaos.

The results of the computer simulation are presented in Fig. 1.



**Fig. 1. Mixing of phase trajectories under conditions of intersection of deterministic chaos**

Source: Calculated and constructed by the authors

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Let's introduce the following definition: a mapping  $f : X \rightarrow X$  is said to exhibit topological mixing if, for any two non-empty open sets  $U, V \subset X$ , there exists a positive integer  $N = N(U, V)$  such that for every  $n > N$ , the intersection  $f^n(U) \cap V \neq \emptyset$ .

This implies that for any given non-empty open set  $\theta > 0$  and any initial open set  $U$ , all sufficiently large iterations  $U$  become  $\theta$ -dense in the phase space.

The unpredictability of the behaviour of the resort and recreational system in conditions of intersecting deterministic chaos is due to its high sensitivity to small changes in initial conditions. This implies that it is necessary not only to analyse a single initial point but to examine an entire initial volume of states, which may evolve in different directions over time.

The instability arising during the system's development creates the potential for a sudden transition to a qualitatively new state. Such a transition can be interpreted as the system's response to external or internal perturbations, aimed at compensating for them. However, instead of returning to its previous state, the system forms a new, more complex, and structured organization. Thus, the concept of "development through instability" suggests that stability is not achieved by maintaining equilibrium but through self-organization, self-regulation, and adaptive transformations that lead the system to a new level of stability.

In this context, stability is understood not as a static equilibrium but as a dynamic property of open systems capable of adapting to changing environmental conditions. Through these mechanisms, the resort and recreational system can effectively function under conditions of innovation and market variability, transforming chaos into a driving force for its development.

## CONCLUSIONS

Thus, the study of the behaviour of the resort and recreational system under conditions of innovation and market variability allows us to draw the following conclusions:

The analysis of the role of innovations in shaping the innovation-investment concept of economic development in the resort and recreational sector highlights the significance of management influence. In conditions of instability, management can push the system toward one of the development paths favourable to it, initiating the process of self-organization. Therefore, the crucial role of management during periods of instability and crises is to effectively harness chaos and guide the system toward an innovative trajectory of development.

A key task is the modelling of innovation chaos development processes as a means to maximize the socio-economic benefits for both the state and the market from newly created innovations. In existing national innovation systems, chaos modelling can enable researchers to uncover alternative strategic development directions that remain hidden during stable periods. These alternatives can facilitate the achievement of significant economic, scientific, and social objectives. This approach allows for the simulation of multiple development trajectories for a nation's, region's, or industry's innovation system. As demonstrated, chaos can, in some cases, lead to transformative changes and, in others, to destructive outcomes. Its ultimate impact on the resort and recreational system is determined by the state and development of its internal innovation environment, as well as the influence of external market conditions.

From the perspective of nonequilibrium dynamics, system behaviour and development are interpreted as a sequence of transitions through hierarchical structures of increasing complexity. The transition to a new level of functioning progresses from chaos to order through instability. In nonequilibrium situations, order can emerge only in the presence of external flows that keep the system far from equilibrium. In the absence of such flows, similar situations lead to dissipative structural degradation, energy or information dissipation, and, consequently, system regression toward equilibrium. The interaction with the environment creates potential opportunities for the emergence of unstable states, followed by the formation of a new, more structured order.

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