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ORGANIZATIONAL RESILIENCE OF LOGISTICS SYSTEMS IN A CONFLICT ENVIRONMENT: GAME THEORETICAL AND ADAPTIVE APPROACH

Mariia Hryhorak, Daria Novosolova. «Organizational resilience of logistics systems in a conflict environment: game theoretical and adaptive approach». *The article examines the challenges of ensuring the organizational resilience of logistics systems within an increasingly turbulent environment, characterized by military risks, global supply chain disruptions, infrastructural constraints, and high uncertainty of market parameters. It is substantiated that traditional logistics management approaches, which focus primarily on static efficiency metrics, are insufficient for adequately reflecting the dynamics of crisis processes and internal coordination gaps. Within the scope of this study, organizational resilience is conceptualized as an integral dynamic property of a logistics system that determines its capacity for predicting, localizing, and neutralizing destructive impacts, as well as restoring operational functionality following crisis shocks. The key groups of factors shaping resilience are systematized, including structural-organizational, information-analytical, socio-behavioral, resource-economic, and external-environmental determinants. A structural mechanism for ensuring organizational resilience is proposed, based on the integration of digital monitoring, predictive analytics, game theory, and adaptive management. Particular attention is dedicated to the behavioral component of the logistics system as a source of hidden coordination risks and a driver of systemic instability. A KPI-driven approach to resilience assessment is formalized, and a mathematical model is developed to evaluate the synergetic effects of interaction among logistics system participants, recovery dynamics, and the balance of incentives in a conflicting environment. Additionally, a game-theoretic coordination model between administration and personnel is introduced, demonstrating the advantages of cooperative strategies and* *adaptive incentives over directive management methods. The economic substantiation confirms the efficacy of the proposed mechanism, specifically regarding the reduction of system recovery time, minimization of losses from internal conflicts, and enhancement of the return on investment (ROI) in resilience assurance. The findings indicate the expediency of transitioning toward a proactive logistics management model focused on preemptive risk detection and the dynamic balancing of managerial decisions. Consequently, the proposed approach allows for viewing the logistics system as a self-regulating adaptive loop, wherein digital analytics, behavioral factors, and managerial mechanisms are integrated into a unified architecture for ensuring organizational resilience.*

***Keywords**: logistics systems, risk management, adaptive management, organizational resilience, dynamic modeling, KPI-driven model, predictive analytics

Марія Григорак, Дар'я Новосьолова. «Організаційна резильєнтність логістичних систем в умовах конфліктного середовища: теоретико-ігровий та адаптивний підхід». *У статті розглянуто проблематику забезпечення організаційної резильєнтності логістичних систем в умовах зростаючої турбулентності зовнішнього середовища, що характеризується воєнними ризиками, порушенням глобальних ланцюгів постачання, інфраструктурними обмеженнями та високим рівнем невизначеності ринкових параметрів. Обґрунтовано, що традиційні підходи до управління логістичними системами, орієнтовані переважно на статичні показники ефективності, є недостатніми для адекватного відображення динаміки кризових процесів і внутрішніх координаційних розривів. У межах дослідження концептуалізовано організаційну резильєнтність як інтегральну динамічну властивість логістичної системи, що визначає її здатність до прогнозування, локалізації та нейтралізації деструктивних впливів, а також до відновлення операційної функціональності після кризових шоків. Систематизовано ключові групи чинників формування резильєнтності, зокрема структурно-організаційні, інформаційно-аналітичні, соціально-поведінкові, ресурсно-економічні та зовнішньо-середовищні детермінанти. Запропоновано структурний механізм забезпечення організаційної резильєнтності, що базується на інтеграції цифрового моніторингу, предиктивної аналітики, теорії ігор та адаптивного управління. Особливу увагу приділено поведінковому компоненту логістичної системи як джерелу прихованих координаційних ризиків і фактору формування системної нестабільності. Формалізовано KPI-driven підхід до оцінювання резильєнтності та розроблено математичну модель, що дозволяє оцінювати синергетичні ефекти взаємодії учасників логістичної системи, динаміку відновлення та баланс стимулів у конфліктному середовищі. Додатково запропоновано ігрову модель координації між адміністрацією та персоналом, яка демонструє переваги кооперативних стратегій та адаптивного стимулювання порівняно з директивними методами управління. Економічне обґрунтування підтверджує ефективність запропонованого механізму, зокрема щодо скорочення часу відновлення системи, зменшення втрат від внутрішніх конфліктів та підвищення окупності інвестицій у забезпечення стійкості. Отримані результати свідчать про доцільність переходу до проактивної моделі управління логістичними системами, орієнтованої на превентивне виявлення ризиків і динамічне балансування управлінських рішень. Таким чином, запропонований підхід дозволяє розглядати логістичну систему як саморегульований адаптивний контур, у якому цифрова аналітика, поведінкові фактори та управлінські механізми інтегровані в єдину архітектуру забезпечення організаційної резильєнтності.*

Ключові слова: логістичні системи, управління ризиками, адаптивне управління, організаційна резильєнтність, динамічне моделювання, предиктивна аналітика, KPI-driven модель

Introduction. Modern logistics systems operate within an increasingly turbulent environment characterized by a combination of military risks, global supply chain disruptions, infrastructural constraints, and high volatility of market parameters. For Ukraine, these factors are shifting into a state of particular intensity, as the logistics sector simultaneously serves to ensure economic resilience, sustain import-export flows, and adapt to critical external shocks. Under such conditions, traditional performance management approaches – relying predominantly on static productivity and cost metrics – demonstrate a limited capacity to adequately reflect the dynamics of crisis processes.

One of the pivotal challenges in contemporary logistics management is the rise of internal organizational instability resulting from a high degree of interdependence among human resources, digital information systems, and physical material flows. In this environment, even localized coordination failures can rapidly escalate into systemic disruptions, leading to a loss of operational synchronization, extended logistics cycle times, and a decline in the overall reliability of supply chains.

This emphasizes the urgent need for a paradigm shift from reactive management models toward proactive and adaptive approaches capable of ensuring systemic resilience against unpredictable impacts. In this context, the concept of organizational resilience gains paramount importance as an integral property of a logistics system, reflecting its capacity not only to withstand destructive influences but also to adapt, restore functionality, and maintain operational continuity under crisis conditions.

Literature Review and Research Gaps. The concept of organizational and supply chain resilience represents one of the pivotal trajectories in contemporary research within logistics and supply chain management. In academic literature, resilience is predominantly defined as a system's capacity to anticipate, withstand, adapt to, and recover from disruptive impacts while maintaining an acceptable level of operational efficiency. A significant body of research focuses on analyzing the consequences of global crisis events (such as COVID-19, geopolitical conflicts, and transport route disruptions), which have demonstrated the critical vulnerability of modern globalized supply chains to cascading failures and domino effects [1; 2].

Within the scope of existing approaches, several major streams of resilience research have emerged. The first stream is linked to risk management and disruption source identification, where the emphasis is placed on risk classification, vulnerability assessment, and scenario modeling for logistics network disruptions [3; 4; 5]. The second stream focuses on developing operational strategies to enhance resilience, specifically through flexibility, resource redundancy, supplier diversification, and increasing the adaptability of logistics processes [6; 7; 8]. The third stream encompasses quantitative resilience modeling utilizing stochastic programming, robust optimization, and network analysis methods [9; 10; 11].

A distinct body of literature is dedicated to the integration of digital technologies into resilience assurance [12; 13; 14]. In particular, approaches leveraging digital twins, big data, machine learning, and predictive analytics are actively expanding, allowing for improved disruption forecasting accuracy and reduced response times to crisis events [15; 16; 17]. Concurrently, a research trajectory centered on knowledge graphs and network analytics is forming, which enables the detection of critical nodes within logistics systems and models risk propagation across complex, multi-tiered structures [18; 19].

Recent studies also demonstrate a growing interest in combining resilience with game theory and behavioral decision-making models [20; 21]. Specifically, researchers examine mechanisms of cooperation and competition among supply chain participants, as well as the impact of strategic interaction on systemic stability under uncertainty [22; 23]. However, these approaches mostly remain isolated and are not integrated into a unified managerial architecture [24; 25; 26; 27].

Despite the active evolution of research in this domain, existing approaches frequently remain fragmented, as they fail to sufficiently account for the simultaneous interaction of the social, informational, and operational components of logistics systems. While an analysis of academic literature indicates substantial progress in studying the resilience of logistics systems, it simultaneously reveals the absence of a holistic, integrative model that combines digital analytics, behavioral factors, a KPI framework, and game-theoretic mechanisms into a unified organizational resilience management system. This justifies the expediency of developing the mechanism proposed in this study, which enables a transition from a fragmented analysis of individual stability aspects to a comprehensive, KPI-driven, and dynamically managed approach to ensuring the resilience of logistics systems.

The objective of this study is to advance the conceptual and methodological foundations of the organizational resilience of logistics systems and to construct an integrated mechanism for its assurance based on a combination of predictive analytics, game theory, and adaptive management. Particular attention is dedicated to formalizing a KPI-driven approach and developing a mathematical model that allows for evaluating resilience dynamics, identifying critical points of systemic instability, and determining optimal managerial strategies under uncertainty.

Achieving this objective involves addressing the following tasks: (1) systematizing approaches to interpreting organizational resilience within logistics systems; (2) identifying the key groups of factors shaping its formation; (3) developing a structural model of the resilience assurance mechanism; (4) formalizing a KPI-driven mathematical model; (5) substantiating the efficacy of the proposed approach through an analysis of economic and operational effects.

The proposed approach allows for viewing the logistics system as an adaptive loop with self-regulating behavior, wherein internal coordination processes, information analytics, and incentive management mechanisms form a unified architecture for resilience assurance. This establishes a foundation for transitioning to a new class of managerial models focused not only on efficiency but also on the system's capacity for rapid recovery and the maintenance of functional integrity under conditions of prolonged instability.

Basic material and results.

In the conflict-prone environment characteristic of Ukraine's contemporary logistics sector, an organization's capacity to identify potential destabilization points before they transform into large-scale operational losses gains paramount importance. The specificity of modern logistics systems lies in the high interdependence among the human factor, digital communications, and the continuity of material flows. Under such conditions, even localized manifestations of social tension or intra-organizational conflicts can rapidly propagate through the interconnected network, inducing coordination failures, transport delays, desynchronization between departments, and a reduced capacity of the operator to adapt to external shocks.

Consequently, ensuring organizational resilience has emerged as a key trajectory for the development of modern logistics systems, serving as a prerequisite for maintaining operational continuity under highly turbulent environmental conditions. Concurrently, the intensive application of this concept in academic research necessitates its refinement and conceptualization, particularly within the context of conflict, risk, and adaptation process management.

The theoretical foundation of this study is anchored in the provisions of the ISO 22316:2017 standard on organizational resilience, which defines the principles for building resilient organizations, the attributes that enable these principles to be realized, and the management activities aimed at assessing and enhancing organizational performance. The standard is universal and applicable to organizations of any size, type, or sector. According to its tenets, resilience is viewed as a strategic organizational attribute formed through a combination of effective risk management, sound business practices, and the capacity to adapt to changing external environments. Furthermore, it emphasizes the absence of a one-size-fits-all mechanism for its attainment, as the level of resilience is determined by a confluence of interrelated organizational properties and managerial processes.

At the same time, it is expedient to differentiate between the concepts of "stability" and "resilience", which are frequently used as synonyms in Ukrainian scientific discourse. While stability is traditionally associated with a system's capacity to maintain predefined performance parameters under external perturbations, resilience reflects its dynamic capability to adapt to changes, restructure internal coordination mechanisms, and restore functionality following crisis events. Thus, resilience implies not merely resistance to negative impacts, but the active transformation of the system in alignment with new operational conditions.

For logistics systems, this approach is of critical significance, as modern supply chains operate under constant uncertainty, and external risks rapidly transform into internal organizational gaps. Under these conditions, ensuring resilience transcends the boundaries of maintaining adequate material-technical supply or financial stability, shifting into the domain of managing personnel interaction, information flows, decision-making mechanisms, and coordination processes.

Within the scope of this study, organizational resilience is conceptualized as an integral functional property of a logistics system, characterizing its capacity to:

– anticipate potential destabilizing impacts;

– timely localize internal gaps and conflict interactions;

– adaptively restructure coordination mechanisms;

– minimize losses of operational integrity;

– ensure accelerated recovery following crisis shocks.

Consequently, the organizational resilience of a logistics system represents an integrated adaptive capacity of an organization to anticipate potential destabilizing impacts, localize internal gaps and conflicts, restructure coordination mechanisms, maintain operational integrity, and ensure accelerated recovery and subsequent development in the wake of crisis events. This approach aligns with the contemporary understanding of resilience as the capacity for anticipation, response, adaptation, and organizational transformation under uncertainty. This implies that organizational resilience does not act as an isolated management function, but rather as an integral characteristic of the logistics system's operational quality, determining its ability to maintain business continuity in an uncertain and conflict-prone environment.

Crucial to this discussion is the differentiation among the categories of "stability", "adaptability", "resilience", and "organizational viability", which reflect distinct levels of system response to destructive impacts (fig. 1).

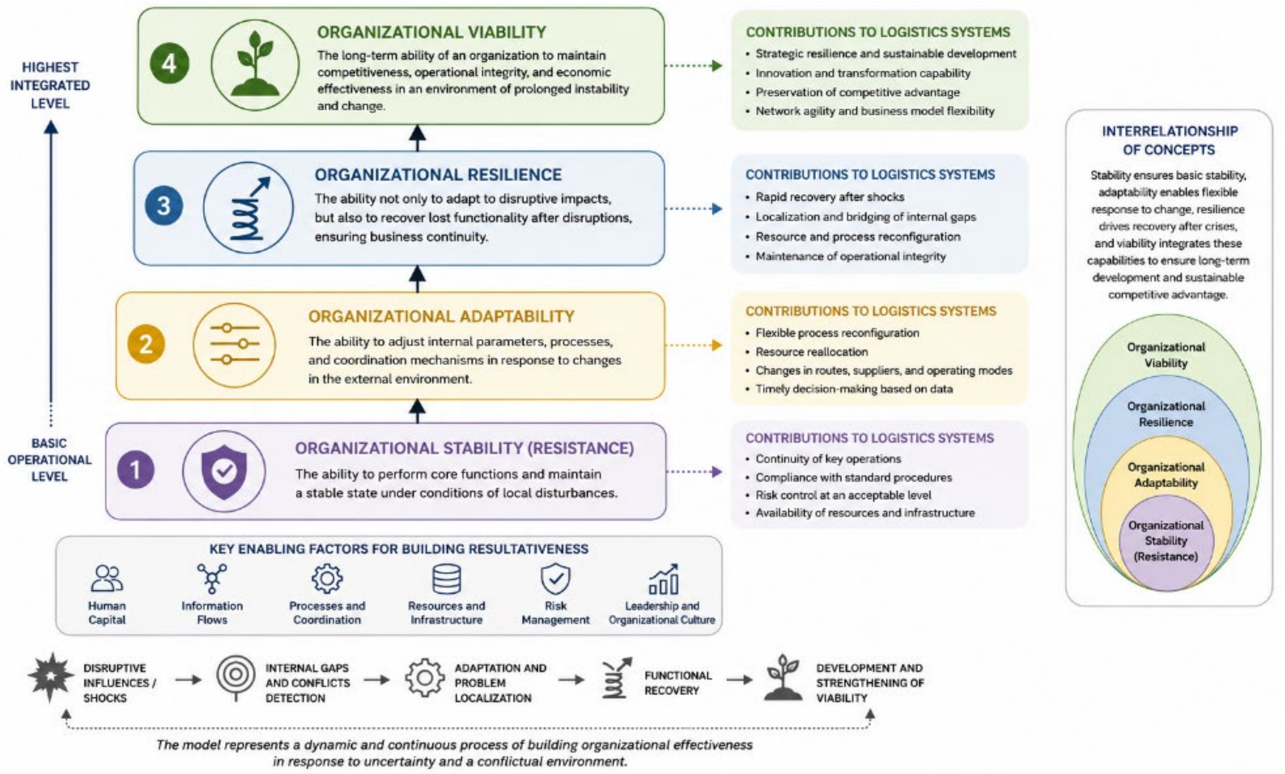

Figure 1 – Graphical representation of the interrelationships among concepts related to organizational resilience

Sourse: compiled by the authors based on ISO and [28-31].

According to the presented framework, operational stability serves as the baseline level, characterizing the capacity to maintain the execution of core functions in the presence of localized perturbations. The subsequent level is adaptability, defined as the capability to alter internal performance parameters in alignment with environmental shifts. Building upon adaptability is resilience, which converges the capacity for adjustment with the ability to recover lost functions following crisis impacts. The highest integral level is organizational viability, which characterizes the long-term capacity of a logistics system to sustain competitiveness, operational integrity, and economic efficiency under conditions of prolonged instability. Within this hierarchy, resilience acts as the critical nexus connecting short-term operational stability with the long-term viability of the system.

The formation of the organizational resilience of logistics systems depends upon a complex of interrelated factors, which are expediently classified into functional groups, as illustrated in figure 2.

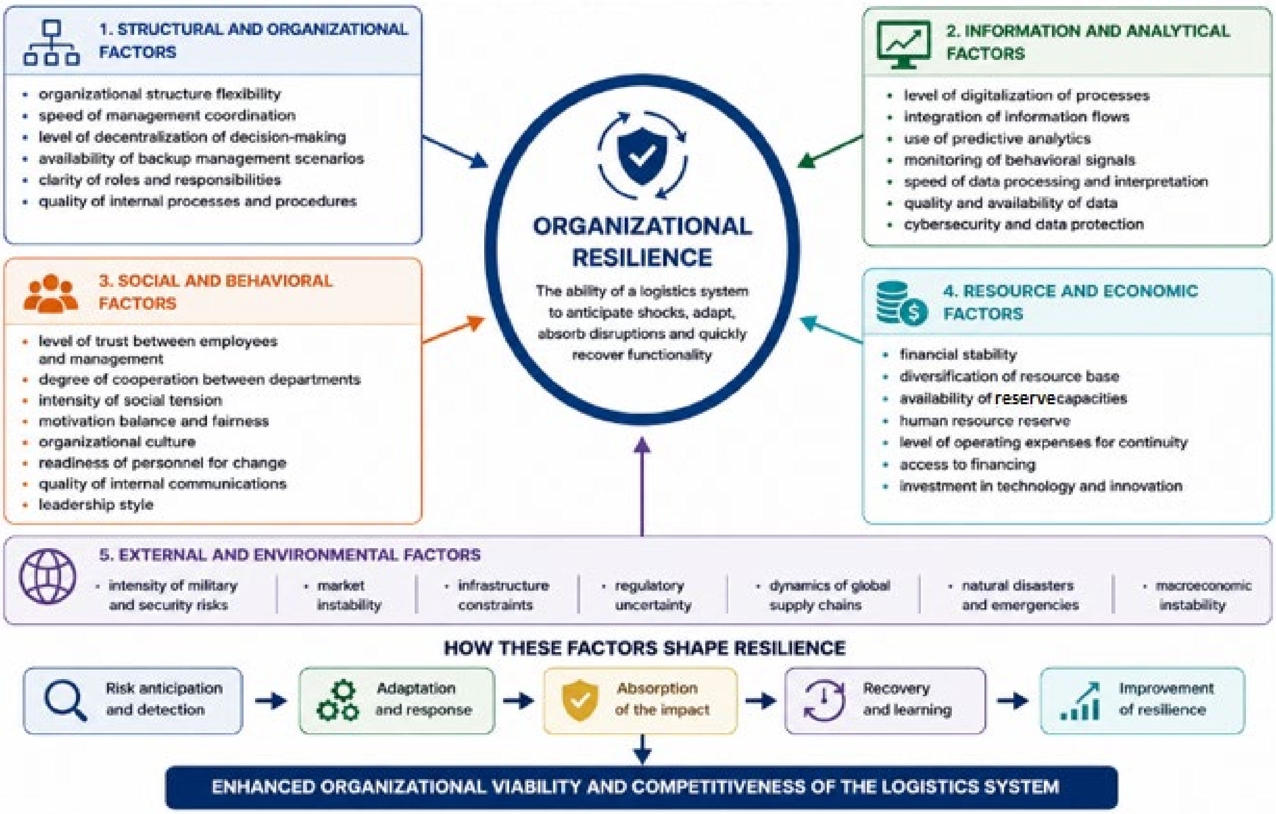

Figure 2 – Classification of factors influencing the organizational resilience of a logistics system

Source: developed by the author.

The first group comprises structural-organizational factors, which include organizational structure flexibility, the velocity of managerial coordination, the degree of decision-making decentralization, and the availability of contingency management scenarios. The cumulative impact of these factors determines the logistics system's capacity to respond promptly to destabilizing impacts without compromising controllability or functional integrity.

The second group includes information-analytical factors, where the level of business process digitalization, information flow integration, the deployment of predictive analytics tools, capabilities for monitoring behavioral signals, and data processing and interpretation speed are of paramount importance. Under the digital transformation of the logistics sector, informational adaptability increasingly dictates an organization's capacity for self-diagnostics, early-stage threat identification, and the formulation of preemptive managerial responses.

The third group is formed by socio-behavioral factors, specifically the level of trust between personnel and management, the degree of cross-functional cooperation, the intensity of social tension, motivational alignment, organizational culture characteristics, and employee readiness for change. For logistics systems, this group is critical, as the human factor frequently serves as the source of hidden conflicts and functional gaps capable of significantly disrupting operational continuity.

The fourth group consists of resource-economic factors, including the enterprise's financial stability, resource base diversification, the availability of reserve capacities, workforce redundancy, and the capability to fund business continuity measures. Insufficient resource allocation substantially constrains the system's adaptive potential and its capacity to recover from crisis impacts.

The fifth group comprises external-environmental factors, reflecting the nature and intensity of external pressures on the logistics system. These encompass military risks, market volatility, infrastructural constraints, regulatory uncertainty, and the transformation of global supply chains. This group of factors defines the baseline environmental turbulence to which the organization must continuously adapt.

However, the mere presence of favorable factors does not guarantee a high level of organizational resilience. The decisive element is the capacity to integrate them into a holistic management mechanism that ensures timely threat identification, internal gap localization, adaptive process restructuring, and the accelerated recovery of the system's functional capacity.

Consequently, the proposed mechanism for ensuring the organizational resilience of a logistics system is built upon the convergence of digital analytics, behavioral forecasting, and adaptive management. Its functional logic lies in the sequential transformation of internal and external environmental state data into a system of managerial decisions directed at preventing destructive processes, minimizing internal organizational gaps, and shortening recovery times following crisis events.

Conceptually, this mechanism is operationalized through six interconnected functional blocks that form a closed-loop adaptive management system. This configuration ensures the timely identification, localization, and resolution of intra-organizational conflicts, thereby sustaining the required level of logistics system organizational resilience within highly uncertain and turbulent environments (fig. 3).

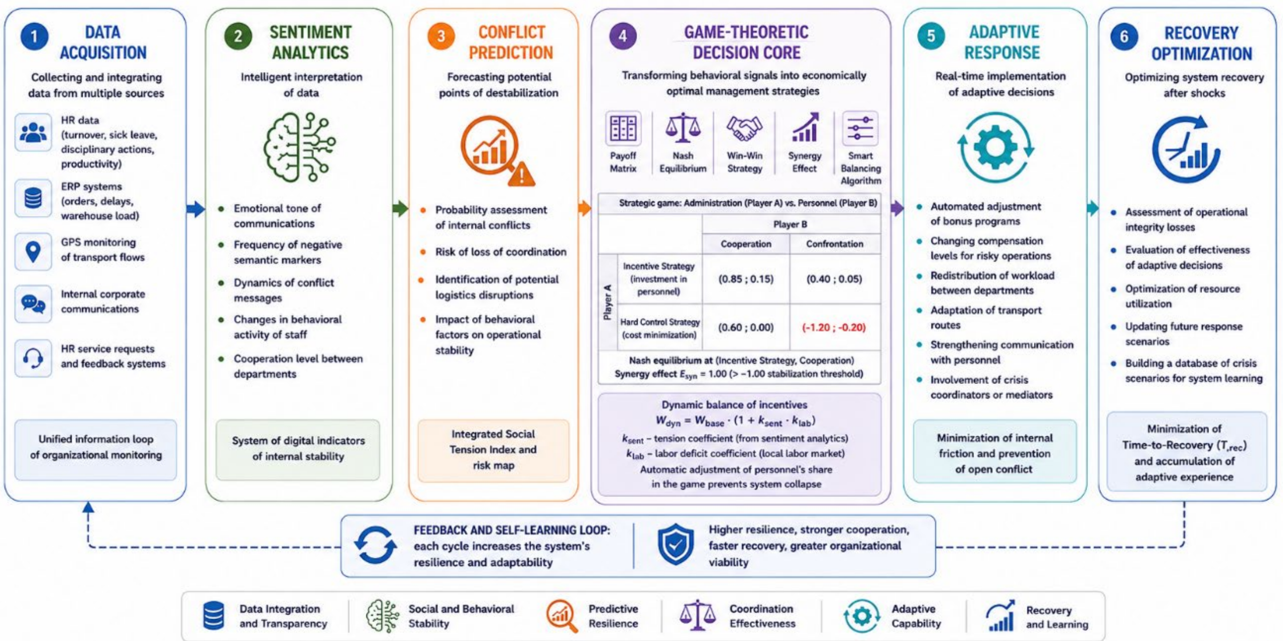

Figure 3 – Structure of the organizational resilience assurance mechanism

Source: developed by the author.

The proposed mechanism fundamentally diverges from traditional crisis management approaches because it is oriented not merely toward responding to the aftermath of destructive events, but primarily toward their early detection and prevention. While classical risk management models predominantly focus on the material-technical or financial-economic parameters of an enterprise's operations, the proposed approach integrates behavioral, informational, and coordination aspects of organizational interaction. Consequently, organizational resilience is viewed not as a static parameter of stability, but as a dynamic capacity of the logistics system for forecasting, adaptation, recovery, and subsequent development under uncertainty.

A pivotal feature of this mechanism is the implementation of the adaptive feedback principle. The outcomes of each managerial response cycle generate an updated information baseline for subsequent analysis and decision-making, thereby enabling an organizational self-learning effect. As a result, the system accumulates experiential data regarding typical destabilization scenarios, the efficacy of applied managerial interventions, and personnel behavioral patterns under crisis-induced strain. This enhances risk forecasting accuracy, refines coordination mechanisms, and shortens reaction times to potential threats.

Under conditions of military and economic instability, the mechanism's capacity to ensure alignment between operational continuity and the organization's social stability gains paramount importance. The operational reality of logistics enterprises demonstrates that the efficacy of adaptation to external shocks heavily depends on the level of internal coordination, information exchange velocity, and trust among logistics process participants. Within this context, conflict transcends its socio-psychological definition to acquire economic and managerial substance, transforming into an operational risk factor that directly impacts the continuity of material flows, the velocity of logistics operations, and service reliability levels.

A significant advantage of the proposed approach is the capability to transition from a reactive to a proactive management model. Combining digital monitoring tools, predictive analytics, and adaptive coordination enables the identification of potential destabilization sources before they escalate into a systemic crisis. This guarantees not only the minimization of operational integrity losses but also the maintenance of the required functional resilience under prolonged external environmental turbulence.

The deployment of game-theoretic tools for analyzing conflict interactions among logistics system participants carries distinct importance. Formalizing the interests of specific stakeholder groups allows for the timely identification of potential conflicts, the evaluation of alternative managerial decision impacts, and the generation of incentives for cooperative behavior. Consequently, conflict is viewed not merely as a source of threats, but as an informational signal indicating hidden organizational imbalances, the remediation of which strengthens systemic resilience.

Thus, in contemporary environments, organizational resilience transforms into a strategic resource for a logistics enterprise, ensuring the preservation of functional integrity, adaptability, and competitiveness within a highly uncertain environment. Implementing the proposed mechanism enables the integration of digital analytics, behavioral forecasting, game-theoretic conflict analysis tools, and adaptive management into a unified system for the preemptive assurance of a logistics operator's organizational viability.

However, the efficacy of the proposed organizational resilience assurance mechanism cannot be evaluated solely through the description of its structural elements or functional logic. The practical value of the mechanism is determined by its capacity to deliver measurable results in the form of enhanced adaptability, shortened crisis response times, minimized operational losses, and the maintenance of logistics process continuity. Consequently, it is necessary to establish a system of quantitative and qualitative metrics to evaluate the organizational resilience level and monitor its dynamics.

The complexity of evaluating organizational resilience stem from its multidimensional nature. Unlike traditional logistics performance metrics, resilience encompasses not only system outputs, but also its capacity to forecast risks, adapt to changes, localize internal gaps, and restore functionality following crisis impacts. Therefore, its assessment is best served by a Key Performance Indicators (KPI) framework that reflects the distinct facets of a logistics operator's organizational, informational, social, and economic resilience.

Given the functional structure of the proposed mechanism and the identified groups of organizational resilience factors, the KPI system must be structured according to a multi-tiered indicator grouping principle. This approach enables a comprehensive assessment of the current resilience level while isolating bottleneck areas that require managerial intervention. Within this study, it is expedient to delineate several interconnected KPI groups, each characterizing a distinct component of logistics system organizational resilience (table 1).

Table 1 – System of key performance indicators of organizational resilience of the logistics system

Mechanism Block	Organizational Resilience KPI Group	Key Indicators	Characteristics of Indicators
Data Acquisition	KPIs of Information Integration and Transparency	Data Integration Level (DIL); Data Completeness Ratio (DCR); Real-Time Visibility Index (RTVI); Information Latency Time (ILT)	Characterize the completeness, velocity, and quality of incoming information into the monitoring system. They reflect the logistics system's capacity to construct a unified digital control loop and ensure continuous tracking of the organizational state.
Sentiment Analytics	KPIs of Socio-Behavioral Stability	Employee Sentiment Index (ESI); Conflict Frequency Rate (CFR); Cooperation Intensity Score (CIS); Organizational Stress Level (OSL)	Evaluate the level of internal social tension, the emotional state of personnel, the intensity of conflict communications, and the degree of cross-functional cooperation. They enable the transformation of behavioral processes into formalized managerial parameters.
Conflict Prediction	KPIs of Predictive Resilience	Conflict Prediction Accuracy (CPA); Early Warning Detection Rate (EWDR); Coordination Risk Index (CRI); Social Tension Index (STI)	Characterize the system's capacity to forecast potential conflicts, coordination failures, and logistics gaps. They facilitate the transition from reactive to preventive management.
Game-Theoretic Coordination	KPIs of Coordination Efficiency	Coordination Efficiency Index (CEI); Cooperative Stability Ratio (CSR); Win-Win Strategy Adoption Rate (WSAR); Decision Alignment Index (DAI)	Reflect the efficacy of interaction among logistics system participants, the level of cooperation, and the consistency of managerial decisions. They allow for the evaluation of the economic viability of cooperative strategies.
Adaptive Response	KPIs of System Adaptability	Adaptive Response Time (ART); Operational Flexibility Index (OFI); Dynamic Resource Reallocation Speed (DRRS); Adaptive Decision Efficiency (ADE)	Characterize the velocity, flexibility, and efficacy of adaptive responses to destabilizing impacts. They reflect the system's capacity to alter operational parameters in real time.
Recovery Optimization	KPIs of Recovery and Self-Learning	Time-to-Recovery (Trec); Operational Recovery Ratio (ORR); Recovery Resource Efficiency (RRE); Crisis Learning Index (CLI)	Evaluate the rate of functional recovery within the logistics system, the efficiency of resource deployment under crisis conditions, and the system's capacity to accumulate adaptive experience to enhance future resilience.

Source: developed by the author.

The proposed framework of organizational resilience KPIs establishes a foundation for transition to mathematical modeling, transforming a heterogeneous collective of qualitative and quantitative indicators into a structured analytical system. Whereas the KPIs function to operationalize and monitor distinct constituents of organizational resilience—process robustness, adaptability, recovery velocity, informational sensitivity, and coordination efficiency—the mathematical model integrates these vectors into a unified system for evaluation, analysis, and forecasting.

Within this formalization, each key indicator can be mathematically modeled as a state variable or a functional parameter whose value is determined by environmental stressors and managerial control actions. This approach enables not only the assessment of the current state of organizational resilience but also the analysis of its trajectory, the derivation of critical thresholds, and the algorithmic simulation of logistics system behavior under diverse scenario variants.

Integrating the KPI framework with game-theoretic instruments carries particular significance, as it incorporates the behavioral decisions of logistics process participants into the system's aggregate resilience level. Consequently, the key performance indicators transcend passive monitoring to serve as arguments within the utility and payoff functions of distinct stakeholder groups. This shift allows for the evaluation of both technical-economic consequences and behavioral effects tied to the degrees of cooperation, conflict intensity, and readiness for joint crisis response.

Accordingly, it is expedient to transition from static, expert-elicited assessments to a KPI-driven payoff matrix formulation, wherein the strategic outcomes of participant interactions are endogenously determined by the actual state of the logistics system's organizational resilience. Under this paradigm, each player's payoff function becomes dynamic, depending explicitly on metric values that characterize participant cooperation levels, social tension intensity, process adaptability, post-shock recovery velocity, and information exchange efficiency.

Consequently, shifts in KPI vectors induce structural transformations within the payoff matrix, altering the Nash equilibria and the nature of strategic interaction among the logistics system participants. This allows the game-theoretic model to function not merely for ex-post conflict analysis, but as a predictive tool to evaluate alternative managerial interventions and select strategies that maximize the integral organizational resilience level.

To quantitatively evaluate the efficacy of the proposed mechanism, it is appropriate to formulate an integral organizational resilience index, R, which reflects the logistics system's capacity to preserve its functional potential under destabilizing impacts and ensure timely post-crisis recovery. In a formalized, simplified layout, this relationship can be mathematically specified as a function of resource potential retention and systemic recovery velocity:

$$\boldsymbol{R} = \frac{\boldsymbol{E_{total}} - \boldsymbol{E_{conflict}}}{\boldsymbol{E_{total}}} * \frac{\boldsymbol{1}}{\boldsymbol{1} + \boldsymbol{T_{rec}}}$$

where E_{total} represents the aggregate resource potential of the logistics system; $E_{conflict}$ denotes resource losses induced by internal conflicts and coordination failures; T_{rec} is the time required to restore the system to its target functional performance baseline.

The specified structural equation reflects a systemic dependency wherein the organizational resilience level scales proportionally with the fraction of retained resource potential and inversely with recovery duration. Within the developed mechanism, achieving this optimization is driven by the early detection of behavioral risks, predictive analytics deployment, adaptive coordination, and the enforcement of win-win cooperative strategies among logistics process participants.

To visualize the advantages of the adaptive model over traditional command-and-control management, we analyze the organizational resilience trajectory presented in figure 4.

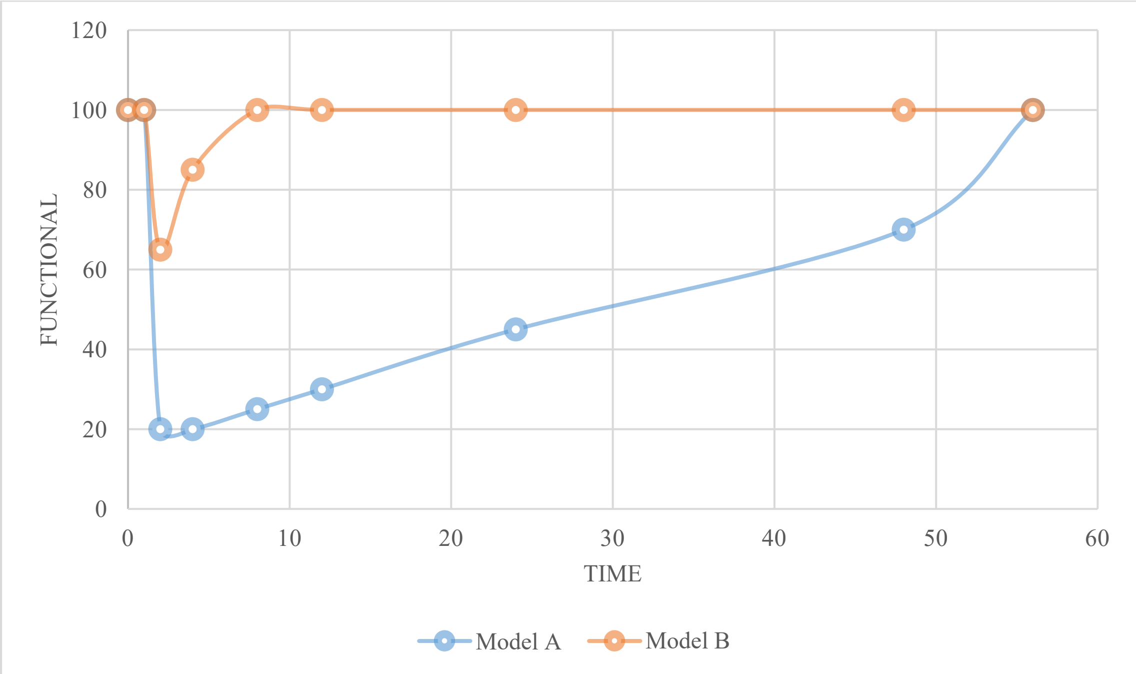

Figure 4 – Comparative dynamics of logistics system organizational resilience under external destructive impact

Source: developed by the author.

As demonstrated in fig. 4, the integration of predictive analytics and win-win strategies (Model B) allows not only for a 7-fold reduction in system recovery time from 56 to 8 hours, but also sustains operational functionality above 65% of the nominal level, whereas the traditional directive approach (Model A) results in a critical decline to 20%.

The efficacy of the proposed mechanism is further detailed through a comparative analysis of operational efficiency, summarized in table 2.

Table 2 – Comparative analysis of logistics models' operational efficiency in a conflict-prone environment

Indicator	Model A (Directive)	Model B (Adaptive)
Expenditures on preventive measures (E_{prev}), units	0	0.15
Direct losses from conflict ($E_{conflict}$), units	1.20	0.05
Time-to-Recovery (T_{rec}), hours	56	8
Resilience Index (R)	-0.0035	0.1055
ROI in resilience, %	—	760%

Source: calculated by the author.

The economic efficiency of the proposed mechanism is quantified via the return on investment (ROI) in resilience-building measures. The results demonstrate that each unit invested in predictive analytics and win-win mechanisms saves 7.6 units of potential losses, yielding a 760% ROI. This high profitability is explained by the adaptive model's capacity to prevent the "domino effect," where minor dysfunctions in logistics chains otherwise escalate into systemic operational stoppages. Thus, capital allocation toward digital monitoring and cooperative coordination serves as a strategic instrument to augment long-term organizational viability and competitiveness.

Discussion. The research findings allow for the formulation of several debatable propositions regarding the nature and measurement of organizational resilience in logistics systems.

First, the proposed approach shifts the emphasis from the traditional interpretation of resilience as the capacity for 'post-shock recovery' toward its conceptualization as a continuous process of preemptive management. This raises questions regarding the boundary between crisis management and a permanently operating system of adaptive control, wherein a crisis ceases to be a discrete event and is increasingly viewed as a manageable state of the system.

Second, while the KPI-driven formalization of resilience operationalizes a complex category, it simultaneously introduces the risk of reducing multidimensional socio-organizational processes to aggregated indicators. This highlights the problem of measurement validity for phenomena such as social tension, levels of cooperation, and behavioral signals within digital logistics systems.

Third, integrating game theory into the logistics resilience management mechanism opens a debate concerning the assumption of actor rationality. Under real-world conditions, the behavior of personnel and managerial entities may deviate from rational strategies due to information asymmetry, emotional factors, and institutional constraints, which subsequently compromises the stability of theoretically derived equilibrium states.

Fourth, the proposed model demonstrates a high degree of formalization regarding the interdependencies among cooperation, social tension, and system recovery speed. However, the problem of empirical parametric identification remains unresolved, particularly concerning the determination of stable KPI weight coefficients across diverse types of logistics systems.

Fifth, the utilization of integrated resilience metrics poses a challenge for cross-organizational comparability. Variations in digitalization levels, data cultures, and supply chain structures can significantly distort the interpretation of the derived values.

Conclusions. As a result of this study, the conceptual and methodological foundations of the organizational resilience of logistics systems have been advanced, and an integrated KPI-driven assurance mechanism has been proposed, combining the tools of predictive analytics, game theory, and adaptive management.

The synthesis of theoretical approaches revealed that existing resilience models are predominantly fragmented and fail to sufficiently account for the interaction among the socio-behavioral, informational, and operational components of logistics systems. Consequently, the study substantiates the expediency of transitioning toward integrated models that accurately reflect the systemic nature of organizational stability.

The key groups of factors shaping resilience have been identified, encompassing structural-organizational, information-analytical, socio-behavioral, resource-economic, and external-environmental determinants. It has been established that socio-behavioral and informational factors play a critical role in generating hidden coordination risks and latent systemic instability.

A structural model of the organizational resilience assurance mechanism has been developed, based on the integration of digital monitoring, predictive analytics, game-theoretic coordination, and adaptive management. The proposed architecture ensures the implementation of a closed-loop cycle for detecting, evaluating, and neutralizing crisis impacts within the logistics system.

A KPI-driven approach to resilience assessment has been formalized, and a corresponding mathematical framework has been introduced, allowing for the evaluation of synergetic effects, recovery dynamics, and the balance of incentives within the interaction system of logistics process participants.

The economic substantiation confirmed that implementing the proposed mechanism guarantees a reduction in losses stemming from conflict situations, shortens system recovery times, and enhances the return on investment (ROI) in resilience building, collectively driving the growth of logistics operators' operational efficiency.

Consequently, organizational resilience is viewed as an integral dynamic property of a logistics system, determining its capacity for adaptation, self-regulation, and the preservation of functional integrity under conditions of prolonged uncertainty and crisis impacts.

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