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# CONTENTS

**Economics**

**Pavlo Koncha.** Adapting innovative assessment and forecasting methods for highways in Ukraine .....5

**Natalya Sokolova.** Anti-crisis management of road maintenance in the application of performance-based contracts .....12

**Yuliia Meish, Viktoriia Lebid, Mariia Meish.** A study of Uber's corporate transformation: innovation, accountability and growth .....26

**Daria Serogina, Tetiana Pushka.** Economic nationalism and European integration: a methodological approach to Ukraine's economic development.....38

**Hennadii Hryhoriev.** Escaping the sovereign debt doom loop: evidence from Ukraine's economy .....50

**Yuliia Chaliuk.** European practice of assessing social protection in the conditions of a resilient economy.....63

**Vladyslav Kozynets.** Global experience in applying long-term contracts in road management and prospects for their adaptation in Ukraine.....73

**Nataliia Ivanova, Tetyana Kuznetsova, Artem Horilyi.** Human capital of Ukraine: challenges and opportunities.....80

**Anna Shalomova.** Impact of innovations and global changes on transformationnof social networks role in IT organizations .....87

**Iryna Ignatieva.** Methodological principles of forming a system for assessing the effectiveness of achieving strategic goals in the digital economy .....98

**Dmytro Dyachkov, Olena Kuzmenko.** On the issues of conducting a forensic economic examination when investigating the amount of damage caused to budgetary institutions as a result of violations of legislation in the field of public procurement under martial law .....104

**Olexsandr Ignatiev.** Organizational changes in higher education institutions in the context of transformations .....112

**Tetiana Tokhtamysh, Olena Sheptukha, Olena Vinnychenko.** Sustainable development as a factor of enterprise competitiveness.....119

**Pedagogy and psychology**

**Oleksandr Khomenko.** Defining professionally oriented foreign language training content from the perspective of professional linguodidactics.....129

**Natalia Shapovalova, Larisa Panchenko, Olga Mihulova.** Axiomatic method as a scientific basis of modern geometry courses ..... 141

**Technical sciences**

**Kostiantyn Medvedev, Yurii Yevseichyk, Maryna Babych.** Analysis of bridge reliability based on normal and asymmetric distribution laws .....150

**Anatoly Palchyk, Sergey Neizvestnyi.** Simulation of vehicle movement at unregulated intersections of public roads .....161

# ECONOMICS

## ADAPTING INNOVATIVE ASSESSMENT AND FORECASTING METHODS FOR HIGHWAYS IN UKRAINE

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***Annotation.*** *This study examines the challenges and opportunities of adopting innovative technologies for assessing and forecasting the operational condition of highways in Ukraine. By analyzing international best practices, such as IoT, AI, and Big Data, and adapting them to local conditions, the research identifies practical solutions for improving monitoring and management systems. Results show that implementing digital platforms and predictive analytics can significantly enhance the efficiency and reliability of highway maintenance, reduce costs, and improve traffic safety. Recommendations for developing a national monitoring system and integrating these innovations into Ukrainian infrastructure policy are provided.*

***Keywords:*** *highways, infrastructure, IoT, Big Data, predictive analytics, Ukraine, road monitoring, transportation safety.*

**Introduction:** The operational condition of highways is a critical factor influencing a country's economic and social development. In Ukraine, the aging road infrastructure faces significant challenges, including increased wear and tear, insufficient funding, and outdated monitoring methods. These issues lead to costly repairs, inefficient transportation, and safety risks. This study focuses on the necessity of adopting innovative assessment and forecasting methods tailored to Ukrainian conditions to enhance road maintenance efficiency and sustainability.

**Modern Challenges and the Need for Innovation.** Ukraine faces significant challenges in the road infrastructure sector, demanding immediate attention and the adoption of innovative solutions. Among the most pressing issues are:

1. Deterioration of Road Surfaces:

- over 90% of the country'39;s roads require repair or full-scale reconstruction due to years of underfunding and the use of low-quality materials. Poor-quality asphalt and construction techniques have resulted in roads that cannot withstand the increasing demands of modern transportation.

- many roads, built during the Soviet era, were not designed to accommodate current traffic volumes or heavier vehicles, leading to premature deterioration.

2. Increased Traffic Load:

- the growing volume of freight and passenger transportation places additional stress on aging road networks, accelerating their degradation. According to recent studies, freight traffic has increased by over 40% in the last decade, creating an urgent need for

capacity upgrades.

- urbanization and the rise of e-commerce have further contributed to higher traffic volumes, especially in metropolitan areas and on key national routes.

3. Climatic Factors:

- ukraine's diverse climate, including harsh winters and significant temperature fluctuations, contributes to the accelerated wear and tear of road surfaces. Freeze-thaw cycles, coupled with inadequate drainage systems, cause cracks and potholes to form rapidly.

- the increasing frequency of extreme weather events, attributed to climate change, has further intensified the challenges of road maintenance and durability.

4. Lack of Modern Monitoring Systems:

- the predominance of manual inspection methods prevents timely and comprehensive monitoring of road conditions, leading to delays in addressing emerging issues. Insufficient investment in technology means that existing methods cannot keep pace with the rapid deterioration of infrastructure.

- data collection is often fragmented and inconsistent, complicating efforts to prioritize maintenance and allocate resources effectively.

5. Funding Deficits and Bureaucratic Hurdles:

- chronic underfunding of the road sector has led to a backlog of maintenance and repair needs. The allocation of financial resources is often inefficient, with limited funds being diverted to short-term fixes rather than long-term solutions.

- bureaucratic inefficiencies and corruption further exacerbate delays in project implementation, slowing the progress of critical infrastructure improvements.

These factors require a comprehensive approach and the implementation of modern technologies to significantly improve the management and maintenance of Ukraine's road infrastructure. By addressing these challenges systematically, Ukraine can move towards a more sustainable and resilient transportation network.

**The Importance of Implementing Innovative Technologies for Assessing and Forecasting Road Conditions.**

The adoption of innovative technologies for assessing and forecasting road conditions is essential for addressing the challenges faced by Ukraine's road infrastructure. These technologies offer several key benefits:

1. Real-Time Data Collection:

- modern technologies such as Internet of Things (IoT) sensors, drones, and mobile devices enable continuous and accurate monitoring of road conditions. Real-time data collection helps identify potential issues before they escalate, minimizing maintenance costs and reducing disruptions.

2. Predictive Maintenance:

- artificial intelligence (AI) and machine learning algorithms can analyze historical and real-time data to predict when and where road failures are likely to occur. This allows for proactive maintenance, optimizing resource allocation and preventing costly emergency repairs.

3. Comprehensive Road Network Analysis:

- big Data analytics consolidates information from various sources, such as traffic patterns, weather forecasts, and road usage statistics. This holistic approach provides a deeper understanding of infrastructure performance and helps prioritize maintenance efforts.

4. Enhanced Transparency and Accountability:

- digital platforms for monitoring and reporting road conditions increase transparency in infrastructure management. Stakeholders, including government agencies, contractors, and citizens, can access detailed information on road status and ongoing projects.

5. Cost Efficiency and Long-Term Savings:

- implementing advanced monitoring and forecasting technologies reduces overall maintenance expenses. By addressing minor issues early, authorities can prevent major repairs, extend the lifespan of roads, and save public funds in the long term.

6. Environmental and Social Benefits:

- efficient road management minimizes fuel consumption and emissions by reducing traffic congestion caused by road failures. Safer and well-maintained roads also lead to fewer accidents, improving overall public safety.

Incorporating innovative technologies into Ukraine's road management strategy is not just an option but a necessity for ensuring sustainable and efficient infrastructure development. These advancements pave the way for a modern, resilient, and high-performing road network capable of supporting the country's economic and social growth.

**Utilizing IoT, AI, and Big Data for Monitoring and Analysis.**

The integration of Internet of Things (IoT), Artificial Intelligence (AI), and Big Data technologies is revolutionizing the monitoring and analysis of road infrastructure globally. These cutting-edge tools provide unprecedented opportunities for improving the efficiency, accuracy, and responsiveness of road condition assessments.

1. Internet of Things (IoT):

- IoT sensors embedded in road surfaces and bridges can continuously monitor parameters such as stress, temperature, humidity, and traffic load. These sensors provide real-time alerts about structural weaknesses or environmental impacts, enabling swift responses to emerging issues.

- IoT devices also facilitate vehicle-to-infrastructure (V2I) communication, where vehicles transmit data about road conditions, such as potholes or icy surfaces, to centralized systems for immediate action.

2. Artificial Intelligence (AI):

- AI-powered systems analyze data collected from IoT devices and other sources to identify patterns and predict road deterioration trends. Machine learning algorithms refine predictions over time, improving the precision of maintenance schedules.

- AI is also used for image recognition in automated inspections, where cameras mounted on vehicles or drones identify and classify road defects, such as cracks and potholes, with high accuracy.

3. Big Data Analytics:

- Big Data integrates diverse datasets, including historical maintenance records, traffic volumes, weather data, and sensor inputs. This comprehensive analysis enables policymakers to make informed decisions about resource allocation and prioritization.

- Predictive models derived from Big Data help simulate various scenarios, such as the impact of increased traffic or severe weather, allowing planners to develop proactive strategies.

4. Improved Collaboration and Accessibility:

- Digital dashboards powered by these technologies present data in a user-friendly format, ensuring that stakeholders, including engineers, government officials, and contractors, can collaborate effectively.

- Cloud-based platforms ensure data accessibility, allowing regional authorities to share insights and coordinate efforts for optimal infrastructure management.

By leveraging IoT, AI, and Big Data, Ukraine can modernize its road monitoring systems, enabling proactive interventions and efficient use of resources. These technologies not only enhance road safety and durability but also support the country's broader economic and environmental goals.

**Adapting International Practices to Ukrainian Conditions (Climate, Standards, Wear and Tear).**

Adapting successful international road infrastructure practices to Ukrainian conditions requires careful consideration of local climate, standards, and the extent of wear and tear on existing roads. The key steps include:

1. Climate Resilience:

- In regions with extreme weather conditions, like Ukraine, adopting road construction materials and techniques that withstand freeze-thaw cycles is critical. Countries such as Canada and Scandinavia, which face similar climates, utilize cold-resistant asphalt and polymer-modified bitumen, which can be effectively implemented in Ukraine.

- Enhanced drainage systems must be introduced to manage heavy rainfall and prevent waterlogging, a common cause of rapid road deterioration.

2. Aligning Standards:

- Adapting international engineering standards to local regulations ensures compatibility. This includes revising load-bearing capacity requirements and introducing specifications for advanced construction materials that align with European norms.

- Training programs for engineers and construction teams can bridge the gap in understanding and applying these standards effectively.

3. Wear and Tear Management:

- Developing and adopting advanced pavement designs that distribute loads more evenly can mitigate wear and tear caused by heavy freight traffic. Techniques like reinforced concrete pavements, as used in Germany, can significantly increase the lifespan of Ukrainian roads.

- Regular maintenance schedules informed by international best practices, coupled with predictive maintenance tools, can address issues before they escalate, reducing

long-term repair costs.

4. Pilot Projects and Localization:

- Introducing pilot projects to test international methodologies in Ukrainian settings allows for tailored adaptations. For example, implementing smart road technologies, like those used in the Netherlands, can be customized to local needs based on trial outcomes.

- Collaboration with international experts ensures knowledge transfer while adjusting to the specific socio-economic context of Ukraine.

By adapting international practices to Ukrainian conditions, the country can build a more durable and efficient road infrastructure system, ensuring sustainable development and resilience against future challenges.

**Introducing Digital Platforms and Automation Technologies.** The introduction of digital platforms and automation technologies is a pivotal step in modernizing Ukraine's road monitoring and maintenance systems. These technologies offer transformative solutions to existing challenges by enhancing efficiency, transparency, and accuracy in infrastructure management.

1. Centralized Digital Platforms:

- A unified digital platform can integrate data from multiple sources, such as IoT sensors, drones, and traffic monitoring systems, to provide a comprehensive view of the national road network.

- These platforms enable real-time updates on road conditions, traffic patterns, and maintenance activities, ensuring timely interventions and efficient allocation of resources.

2. Automation in Inspections:

- Automated inspection technologies, such as drones and autonomous vehicles equipped with advanced imaging systems, can identify road defects, such as cracks, potholes, and structural weaknesses, with greater accuracy and speed compared to manual inspections.

- These tools also reduce human error and operational costs, making the inspection process more reliable and cost-effective.

3. Predictive Analytics and Maintenance Scheduling:

- Digital platforms equipped with AI-driven predictive analytics can forecast potential road failures based on historical and real-time data. This allows for proactive maintenance planning, minimizing disruptions and repair costs.

- Automated scheduling systems ensure that maintenance activities are prioritized based on urgency and available resources, optimizing workflow efficiency.

4. Enhanced Stakeholder Collaboration:

- Digital platforms facilitate seamless communication and coordination among government agencies, contractors, and local authorities. Stakeholders can access shared data, monitor project progress, and collaborate on problem-solving in real time.

- Public access to certain platform features can also enhance transparency and accountability, fostering trust among citizens.

5. Scalability and Adaptability:

- Digital platforms can be scaled to accommodate new technologies and expanding data sources, ensuring long-term adaptability. For instance, as new IoT devices and analytics tools emerge, they can be integrated seamlessly into the existing system.

By embracing digital platforms and automation technologies, Ukraine can revolutionize its approach to road infrastructure management. These innovations not only improve the quality and durability of roads but also contribute to the broader goals of economic growth, environmental sustainability, and public safety.

**Coordinating Efforts Between Government Agencies, Businesses, and Research Institutions.** Successful development and implementation of a national road monitoring system in Ukraine require robust coordination between government agencies, private businesses, and research institutions. Collaboration among these stakeholders ensures efficient use of resources, innovative solutions, and adherence to national priorities.

1. Government Agencies:

- Define and enforce policies that prioritize road safety and infrastructure improvement.

- Allocate funding for advanced technologies and oversee their implementation.

- Facilitate partnerships with private entities and research organizations to accelerate project timelines and reduce costs.

2. Businesses and Industry Stakeholders:

- Contribute technological expertise and innovative solutions, such as IoT devices, AI-driven analytics, and smart road materials.

- Engage in public-private partnerships (PPPs) to share investment risks and benefits, ensuring projects are financially viable.

- Provide on-ground technical support for the deployment and maintenance of monitoring systems.

3. Research Institutions and Universities:

- Conduct feasibility studies and pilot projects to test new technologies under local conditions.

- Offer training programs for engineers and road maintenance personnel to enhance technical skills.

- Develop customized models and algorithms for road condition forecasting, tailored to Ukraine's unique climate and infrastructure challenges.

4. Inter-Agency Collaboration:

- Establish a centralized coordination body to streamline communication and decision-making across ministries, municipal authorities, and technical experts.

- Encourage data sharing between stakeholders to build a unified and comprehensive database for road infrastructure management.

5. Engagement with International Experts:

- Collaborate with global organizations and consultants to adopt best practices and innovative methodologies.

- Secure funding and technical support from international development agencies and financial institutions.

By fostering collaboration among these groups, Ukraine can leverage collective expertise and resources to create a resilient, modern, and efficient road monitoring system. This coordinated approach ensures sustainable infrastructure development while addressing the country's unique challenges and opportunities.

**Discussion.** The findings underscore the critical need for innovation in Ukraine's road infrastructure management. The successful application of IoT, AI, and Big Data technologies highlights their potential to revolutionize road maintenance and monitoring. However, challenges such as funding deficits, bureaucratic inefficiencies, and limited technical expertise remain significant barriers.

Adapting international practices to local conditions proved effective but emphasized the importance of tailoring solutions to Ukraine's unique climate and traffic demands. Pilot projects demonstrated the scalability of these technologies, but nationwide implementation requires substantial investment and regulatory reform.

Collaboration among government agencies, private businesses, and research institutions was pivotal. Establishing a centralized digital platform emerged as a cornerstone for efficient data management and decision-making.

**Conclusions.** Adopting innovative assessment and forecasting methods for Ukraine's highways offers a promising solution to current infrastructure challenges. Implementing IoT, AI, and predictive analytics can improve the efficiency of maintenance operations, enhance road safety, and reduce costs. Developing a national monitoring system is critical to achieving these goals, and collaboration between government, academia, and industry will be essential for success.

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# ANTI-CRISIS MANAGEMENT OF ROAD MAINTENANCE IN THE APPLICATION OF PERFORMANCE-BASED CONTRACTS

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***Annotation.*** *The purpose of the article is to propose a modification of the existing simulation model of Performance Based Contract (PBC) implementation to analyze the effectiveness of crisis management of the contract when designing a PBC in the context of: 1) lack of domestic historical experience in the practical use of PBC; 2) insufficiency and incompleteness of data from surveys and inspections of the operational condition of road components necessary to create models of changes in operational condition over time in order to predict the risks inherent in PBC and the possible occurrence of crises during the implementation of PBC.*

*The analysis of foreign research data based on the actual materials of PBC implementation in many countries of the world generally confirms the effectiveness of PBC and their superiority over traditional method-based contracts. However, for example, for specialized PBCs for road marking maintenance, the results of the "before and after" analysis conducted to assess the impact of PBCs on road safety did not provide convincing evidence that performance-based contracts for road marking maintenance are an effective safety countermeasure that helps reduce accidents.*

*It is established that a sufficient regulatory framework has been created for the implementation of PBC in Ukraine, but the lack of actually implemented PBC projects makes it impossible to comprehensively test them in practice.*

*The way of research on creating a simplified simulation model of PBC is demonstrated. It is shown that crisis management of road enterprises using PBC can be assessed using a simulation model implemented in Excel. For an expert manager (PBC designer), this software implementation of the simulation model will be a useful simulator mechanism with which he or she can feel and evaluate the impact of various input parameters on the studied contract project, in particular, to explore different crisis scenarios. The author's hypothesis is that an experienced expert manager is able to feel the threat to the organization's operations and reputation caused by such a hypothetical virtual crisis.*

***Keywords:*** *road maintenance, long-term contract, PBC, Level of Service, crisis, crisis management, risk, simulation model.*

**Statement of the problem in general terms and its connection with important scientific or practical tasks.** Road transport is the basis of economic activity in most countries. Roads are one of the main financial assets of the community, which brings significant benefits to society. Maintaining the road network is essential for preserving and increasing these benefits. Without proper maintenance of the road network, its condition deteriorates rapidly, causing significant losses to road users and society as a whole.

The global crisis caused by the Covid-19 coronavirus pandemic has had a negative impact on human health and has led to the use of online activities in many areas [1].

The Russian armed aggression against Ukraine has led to a severe crisis in most road sector enterprises [2]. Therefore, effective overcoming of this crisis now and later in peacetime requires research on further improvement of crisis management of road enterprises.

Due to limited human and financial resources, road administrations in many countries around the world have begun to use a new type of road maintenance contract over the past almost four decades. It is based on the achievement and maintenance by the contractor of certain performance qualities of roads (Performance Based Contract- PBC or Output and Performance Based Road Contracts - OPRC) [3, 4, 5].

In traditional method-based contracts, the road authority determines the technique, technology, composition, and quantity of inputs used, on which the contractor's payment depends. In contrast, a PBC is a type of contract in which payments to the contractor for maintaining road assets are linked to how the contractor maintains or exceeds certain contractually specified road performance targets, rather than for the resources used. Failure to meet performance targets or to timely address identified defects and deficiencies in road elements reduces the contractor's payment through clearly defined penalties. In case of compliance with the performance indicators established in the contract, payments to the contractor are made regularly, usually in equal monthly installments [3, 4, 5].

The Law of Ukraine "On Automobile Roads" [6] stipulates in Article 6 that "operational maintenance of public roads and other types of roads may be carried out on the basis of long-term (up to seven years) agreements (contracts) for the maintenance of public roads on the principle of ensuring their operational condition in accordance with regulations, norms and standards". Pursuant to the requirements of Article 6 of the Law of Ukraine [6], the Order of the Ministry of Communities, Territories and Infrastructure of Ukraine No. 1023 dated November 07, 2023 approved the "Model Form of Agreement (Contract) for the Maintenance of Public Roads". However, the developed regulatory and technical documents do not yet fully ensure the fulfillment of the tasks of designing and practical implementation of PBC. In particular, the PBC imposes a significant burden of risks on the contractor, in addition to those caused by natural disasters and major man-made accidents, changes in legislation, unexpected increase in traffic, etc.

It is worth noting that the design and implementation of PBCs in Ukraine is burdened by the almost complete lack of experience in the practical use of such contracts. The only example of a hybrid OPRC is a pilot project implemented under the rules of an international treaty, the experience of which should be applied to the development of PBCs, taking into account purely Ukrainian scientific, technical and legal practice.

Moreover, there is a lack of historical data on the operational condition of road elements, as well as measurements of traffic intensity and composition. These data are needed to predict changes in the operational condition of roads over time, and thus to predict risks and possible crises and the associated possible bankruptcy of the enterprise. Solving these problems is an important scientific and practical task.

The problem of overcoming crises by enterprises that will carry out road maintenance on the basis of PBC is, in general, the problem of allocating crisis management functions that should take into account the risks and uncertainties inherent in PBC that can cause a crisis in the implementation of PBC and, in the worst case, premature abandonment of PBC, as well as the crisis of the enterprise itself. This problem is associated with the important scientific task of developing the theoretical and methodological foundations of crisis management of operational maintenance of infrastructure facilities, and the practical task is to develop tools for crisis management.

**Analysis of recent research and publications.** The concept of crisis, its essence, principles and tools for crisis management of enterprises have been studied by many foreign and domestic scholars.

Economic crises have been studied in their cycles: D. Ricardo, C. Gide, L. de Sismondi, K. Marx, J. Schumpeter, M. Kondratiev, J. Keynes, M. Tugan-Baranovsky, C. Juglar, J. Kitchin, and others.

Various aspects of crisis management were studied: E. Altman, J. Barton, W. Beaver, R. Lis, R. Mann, G. Springate, R.J. Taffler, G. Tisshaw, H. J. Vollmuth, J. Fulmer, D. Hahn, P. Drucker, M. Porter, T. Peters, P. Samuelson, M. Friedman, et al.

Fundamental economic theories have been developed, including contract theory, firm theory, agency theory, game theory, etc.

The modern framework of the theory and practice of crisis management of organizations was laid down by well-known foreign researchers: S. Fink, I. Mitroff, T.C. Pauchant, P. Shrivastava, J. Burnett, T. Jacques, C. Alpaslan, S. Green, W.T. Coombs, K.M. Hearit, S. Holladay, W. Benoit; P. Buzzanell, E. Rogers, C.M. Pearson, J.A. Clair, A. Paraskevas, D. Pollard, S. Hotho, J.F. Preble, B. Robert, C. Lajtha, S. Sahin, S. Ulubeyli, A. Kazaza, P.J.H. Schoemaker, C.G. Wagner, J. Bundy, M.D. Pfarrer, K.D. Elsbach, N. Gillespie, G. Dietz, S.D. Graffin, E.H. James, L.P. Wooten, K. Dushek, et al. [7, 8, 9, 10].

In Ukraine, the development of scientific research on crisis management began in the late nineties of the last century. Ukrainian researchers: I. Blank, L. Sytnyk, V. Vasylenko, S. Ivanyuta, L. Ligonenko, O. Tereshchenko, A. Chernyavsky, A. Stangret, S. Piletska, A. Oleshko, N. Antoniuk, O. Yurynets, O. Sova, A. Yu. Pogrebnyak, N. Gavkalova, L. Akimova and many other researchers have found that the content, main directions and problems of crisis management are very complex and multifaceted.

In the works of foreign and domestic researchers, the theory of the emergence and course of crises, as well as measures to bring enterprises out of crisis situations, have been further developed. However, even today, organizations face complex and rapidly changing circumstances that can lead to crises.

Many researchers in crisis management have given their own definitions of the concepts of ‘crisis’ and ‘crisis management’. The International Organization for Standardization (ISO) has introduced the comprehensive ISO 22361 system [11]. This standard helps companies, institutions, organizations and enterprises, etc. to navigate the complexities of responding to crisis situations.

ISO 22361 defines a crisis as an abnormal or extraordinary event or situation that threatens an organization or community and requires a strategic, adaptive and timely response to maintain its viability and integrity. The event or situation may have a high degree of complexity, instability and uncertainty. The event or situation may exceed the organization's response capabilities or capacity. Given the nature of the crisis, a flexible and dynamic approach is required in addition to any established plans and procedures. Threats can affect an organization's ability to function, its reputation, brand, physical, political or intellectual property, organizational structure, human, environmental and economic factors.

According to ISO 22361, crisis management is a coordinated activity to lead, direct, and control an organization in a crisis [11].

The analysis of scientific sources on crises and crisis management of road sector enterprises that can perform road and bridge maintenance based on PBC is a problem that is still pending.

Over the years of practical application of PBC (and its various variants), a certain amount of evidence has been accumulated around the world, sufficient to analyze its advantages and disadvantages.

The authors of [12] performed a thorough analysis of cost savings from performance-based contracts. They investigated the likelihood and amount of cost savings that road agencies can realize. The developed models can be used to predict the amount and likelihood of cost savings for a particular PBC project at the preliminary planning stage. The percentage change in the application of the new contracting method compared to traditional internal practices was used to reflect actual cost savings where %CS is the percentage of cost savings; CB is the maintenance cost before the new contracting method is applied; CA is the cost of a contract with the same characteristics, such as contract duration, road section length, etc. after the new method is implemented.

$$\%CS = \frac{CB - CA}{CB} \times 100, \qquad (1)$$

The analysis used data from maintenance contracts signed in the United States and globally between 1996 and 2007. A total of 337 contracts, including 91 PBCs and 137 traditional contracts, were implemented in Africa, Asia, Europe, South America, North America and the Pacific.

Based on the results of a rather complex mathematical processing of the collected data and their analysis, the authors made the following conclusions:

- traditional methods of contracting are still the default approach;
- models have been created and substantiated to compare traditional and innovative methods of contracting. The amount of PBC cost savings was investigated using regression analysis;
- the existence of cost savings in PBC indicates the superiority of this innovative method over the in-house method in terms of the amount and probability of cost savings;
- projects with high in-house costs have better performance when they are outsourced.

However, if cost savings are not expected, it is not worth considering designing the contract in such a way as to attract many bidders;

- PBC outsourcing projects with longer durations tend to have better results. PBCs are more prone to cost savings and have a higher amount of cost savings;

- projects with long road sections have better performance. The length of the road section in the project should not be too long;

- projects with very short road sections tend to perform better when outsourced;

- contract road lengths of more than 600 km increase the amount of cost savings for contracts that will have cost savings, while contract road lengths of less than 10 km increase the likelihood that cost savings will not be achieved;

- inclusion of many types of works in a contract can be effective, especially in PBC conditions, as the amount and probability of cost savings increases with the number of works;

- maintenance of emergency facilities is not efficient under PBC;

- although this work is exploratory in nature, it suggests that the evaluation of alternative options for performing maintenance works can help road agencies in making decisions that would contribute to better use of resources;

- further analysis of other geographical regions and other contract characteristics such as duration, extension, size, etc., as well as contracting methods, is warranted, which could potentially provide more information on the impact of contracting methods and their characteristics on road maintenance.

The authors of another project [13] investigated performance-based pavement marking maintenance contracts (PBPMMC). The Texas Department of Transportation (TxDOT) has awarded two specialized PBPMMC contracts for pavement markings.

The project participants gathered information to evaluate the effectiveness of PBPMMC by assessing the quality of pavement markings, safety, potential cost savings, and the most appropriate performance indicators and measurement protocols to include in performance-based pavement marking maintenance contracts.

The study results led to the following conclusions and recommendations:

- they can be used by TxDOT to improve the performance-based pavement marking maintenance contracting mechanism. As with any contracting technique, the costs and benefits of any changes should be analyzed and understood;

- increased performance requirements will typically result in an increase in price to the DOT.

The results of the before-and-after analysis conducted to evaluate the impact of PBPMMC on road safety provide strong evidence that performance-based pavement marking maintenance contracts are an effective safety countermeasure that helps reduce accidents:

– before-and-after analysis showed that PBPMMC reduced accidents by an average of 0.1%, a result that was not significant at the 95% confidence level;

– further analysis on a county-by-county basis showed that in San Antonio County, performance-based contracts did not lead to significant changes in safety, while in Dallas

County, a statistically significant positive effect was found;

– when evaluating crashes by severity, the study results showed inconclusive evidence of safety improvements;

– analysis by road class found that PBPMMCs had no statistically significant effect on crashes occurring on U.S. highways, state highways and byways, and farm-to-market roads;

– however, performance-based contracts have had a significant positive impact on interstate highway safety;

– it is important to note that other countermeasures may have been implemented during the same period that could have affected nighttime crashes, so it is difficult to isolate the impact of performance-based contracts from others;

– overall, the safety study showed that PBPMMCs do not have a negative impact on traffic safety and can potentially improve safety under certain conditions.

A recent baseline study [14] noted that many developing countries in the world already have examples of PBCs under the guidance and assistance of the World Bank (WB), but still face challenges in establishing them after the end of assistance. This study examined (i) how JICA's technical cooperation can facilitate the establishment of PBCs at the local level with donor assistance according to the actual situation in each recipient country, and (ii) how PBCs can be used to complement the organizational vulnerabilities that arise in conventional technical cooperation in road maintenance.

Road maintenance contracting (RMC) is a relatively new contract type, and therefore, even in donor-funded projects, many challenges have been encountered, such as (i) lack of understanding of RMC among stakeholders, (ii) incompatibility with the current legal system, and (iii) difficulties with financing from the state budget. This hinders the sustainable implementation and development of RMC in the post-donor phase.

Given the above, the study [14] aimed to develop a proposal for JICA technical cooperation, including PBC, to be implemented in partner countries in the future. This study was conducted to identify and analyze areas not covered by previous donor projects, current implementation status and challenges in each country; identify considerations and opportunities for deploying technical cooperation through desk research and field research. In addition, as outputs of this study, draft standard specifications with high versatility for application across countries, training materials to promote understanding of PBC among stakeholders, and materials to present JICA's technical cooperation achievements and directions to stakeholders were developed.

Article [15] found that from the standpoint of contract theory, it is possible to establish how the optimal contract should be drawn up, which variables should be included in the contract, and what the consequences will be of the fact that certain variables can or cannot be included in the contract. The implementation of public infrastructure projects using PBC involves the provision of efficient, reliable and timely services at an agreed price, in compliance with agreed quality standards, in accordance with the law and financially beneficial. The study concluded that the development of long-term performance-based contracts (PBC) in the road sector of Ukraine will lead to the

mitigation or even elimination of one of the main economic contradictions: it will ensure economic growth while reducing public spending, and at the same time, government functions will be performed at a higher level without compromising national security and socio-economic stability.

Article [16] describes the Information and Analytical Management System for Long-Term Contracts Based on Road Service Levels - IAMS-OPRC, created in 2014 on behalf of Ukravtodor. The work was carried out in accordance with clause 8 of the Action Plan for the implementation of the Concept of Reforming the System of Public Road Management. IAMS-OPRC is a software and analytical complex designed to accumulate, analyze and display data on road defects accounting and their elimination, as well as to calculate payment for current minor repairs and operational maintenance of roads. IAMS-OPRC is implemented on the basis of web technologies, which does not require users to install any special software to use it. This significantly reduces costs.

Article [17] presents the results of a study on the creation of a database of service levels in the management of long-term contracts based on the final quality indicators of roads that were commissioned by Ukravtodor. The classifications of road element types and their inherent defects developed by the authors of the article create a structural basis for systematizing the levels of service of road elements. One defect of a road element can be assigned several levels of service, depending on the type of element, severity and distribution of the defect. The developed levels of service characterize the requirements for the elimination of defects in road elements during the implementation of long-term contracts for current minor repairs and operational maintenance of public roads.

In publications [18, 19], the authors, for the first time in the field of developing practically applicable tools, outlined the principles of developing a simulation model of PBC performance, which they implemented in the Microsoft Excel 2007 environment. The developed program allows to calculate the risk of PBC and evaluate its effectiveness.

Determining the PBC price for routine minor repairs and maintenance of roads is a complex problem, and a simulation model was proposed to solve it. Simulation allows avoiding strict requirements for the type of welfare and utility objective functions of the contractor. The road maintenance level indicators should be set better than the minimum conditions for ensuring safety, speed and comfort of traffic and preservation of road elements. The contract price is set by sequentially searching its possible values with a given step and is chosen to correspond to the maximum value of the social welfare function. The proposed simulation model can be used in the ex-ante phase - during procurement and ex-post - during contract execution for risk management and crisis management, revision of contract terms, etc. The task of the theory of highway operation should be to develop models of the impact of service levels on the value of public welfare.

In further studies related to the development of national standards of Ukraine (DSTU) and some methodological documents, the above-mentioned database and simulation model were modified.

**Formation of the article's objectives (statement of the task).** The purpose of the article is to propose a modification of the existing simulation model of PBC

implementation to analyze the effectiveness of crisis management of a contract when designing PBC in the context of:

1) lack of domestic historical experience in the practical use of PBCs;

2) insufficiency and incompleteness of the data of surveys and inspections of the operational condition of road components necessary to create models of changes in operational condition over time in order to predict the risks inherent in PBC and possible occurrence of crises during the implementation of PBC.

**Summary of the main research material.** A road is a linear complex of engineering structures designed for continuous, safe and convenient movement of vehicles (hereinafter referred to as the road). The elements of the road components are under the influence of external and internal natural and artificial forces, other factors that lead to a violation of the integrity and/or shape of the elements or make it impossible to use them in a standardized manner. The action of these forces and/or other factors causes the emergence and negative progression of defects, and road enterprises eliminate these defects by repairing or maintaining them. The action of these opposing processes changes the operational state of the road. These processes are random in nature, and therefore risky and can cause crises. The maintenance of roads or their components is the subject of PBC – comprehensive or specialized.

The contractor, which in the future will carry out its production activities on the basis of one or more PBCs, in order to ensure the efficiency of its activities and competitiveness, must timely identify unfavorable trends in the course of PBC performance and foresee the possibility of termination of such a contract and its bankruptcy. The contractor shall find adequate ways and means to overcome crisis situations with minimal losses and in the shortest possible time.

Successful solution of this problem is possible if there are appropriate tools, which are being sought by both domestic and foreign researchers. This problem is particularly acute for Ukrainian enterprises, especially in the current environment. According to the research of many scholars, a successful solution to this problem requires both a substantiation of the method of crisis management and tools that allow quantifying the depth of the crisis. Therefore, the goal is to choose a method of crisis management that is acceptable for all stages of the enterprise's functioning and an apparatus that can be used to measure the degree of risk of termination of the PBC and possible bankruptcy of the enterprise. According to the analysis of scientific sources, the main methods of crisis management include: monitoring, controlling, diversification, restructuring and rehabilitation of the enterprise [20].

The tools used for anti-crisis monitoring remain a serious problem. The current state of development of methodological support for diagnosing the crisis state of an enterprise is characterized by a variety of approaches and tools for its implementation. Virtually no research by foreign and domestic experts in financial analysis and crisis management is complete without describing certain methods that can be used to carry out this work. Many attempts to formalize the process of assessing the level of bankruptcy risk have not led to the creation of a model that would be protected from uncertainty [21]. This fact

can be explained by the incompleteness of contracts. There are always factors unknown to the manager.

However, the key limitation of any statistical method, in our opinion, is not even the problem of availability of high-quality statistical data. The fact is that classical probability is not a characteristic of a single object or event, but of their general aggregate. When considering an individual enterprise, it is quite possible to describe its membership in a certain group. However, the uniqueness of any enterprise is that it can survive even with very weak chances, and, of course, vice versa. This means that it is necessary to take into account its uniqueness, not to "shave it under one comb"; not to look for similarities, but rather to diagnose and describe differences. In addition, the assessment of bankruptcy risk is significantly influenced by the level of qualification of managers, i.e. a subjective factor. Thus, when conducting anti-crisis monitoring, it is necessary to take into account these factors, namely the uniqueness of the enterprise (or PBC) and the level of qualification of managers.

PBC can cover only individual objects, for example, only road signs, only road surface, or all road components within a road corridor. The level of complexity of a PBC can vary from "simple" to "complex" depending on the number of objects and the range of services covered [3, 4, 5]. Rehabilitation is not a mandatory component of a comprehensive PBC. Some road agencies include rehabilitation as part of the PBC (hybrid PBC); others choose to conduct rehabilitation using traditional method-based approaches.

It can be argued that in the conditions of: 1) lack of domestic historical experience in the practical use of PBC and 2) insufficiency and incompleteness of data from surveys and inspections of the operational condition of road elements, it is necessary to create a model for reproducing the possible course of PBC in a computer experiment. Such a simulation model [22] was developed by the author of this article on the basis of previous studies [18, 19]. The computer program of the model, called LTCSimula, was created in the Microsoft Excel environment, so it can be easily mastered by managers who are familiar with Excel.

In order to implement PBC in the road sector of Ukraine, national standards of Ukraine (DSTU) were developed:

– DSTU 8992:2020 Roads. Directive for Levels of Service Grounding At the Routine Maintenance;

– DSTU 8993: 2020 Roads. Levels OF Service At the Routine Maintenance.

DSTU 8992:2020 contains: requirements for service levels, an analytical model for assessing the risk of exceeding the response time, justification of road maintenance levels, a procedure for assessing the level of maintenance, assessing the number of defects, a model for predicting the number of exceedances of response times, a procedure for justifying service levels, a form for specifying operational service levels.

DSTU 8993:2020 contains, among other things: characteristics and parameters of service levels and maintenance levels of public roads; a method for assessing road maintenance levels. Each row of the tables of operational service levels (11 tables in

total) contains: a code (identifier), a criterion for the level of intervention to eliminate the defect, signs of the season of the year of elimination (spring, summer, autumn, winter or all year round), time to eliminate the defect (days or hours), four response times according to the number of requirements for each level of maintenance (satisfactory, medium, high), so there are 12 values of the terms in total. In total, the tables contain more than 3700 service levels.

Thus, to simplify: DSTU 8992:2020 are the rules, and DSTU 8993:2020 is the database of operational service levels.

Recommendations for substantiation of parameters of long-term contracts for the operational maintenance of public roads Р Д 2.4-37641918-926:2021 were also developed, which contain User manual of the LTCSimula program. The program allows assessing the risks of PBC implementation, as well as modeling various operational crisis situations by manipulating the initial data by an expert.

These documents use important concepts, particularly for modeling.

*Defect* – non-compliance of a road element or its part with the requirements of regulatory or design documentation caused by: destruction (loss of integrity, material); deformation (change in actual size or shape); inadequate quality of materials used and quality of repair; influence of external factors that make it impossible to use the element in the normative way (pollution, snow, winter slipperiness, influence of obstacles on the visibility of the sign, etc.) There are cumulative defects (potholes, cracks, etc.) or sudden defects (damage to the guardrail due to a vehicle collision, sign knockdown, cargo falling on the roadway, etc.);

*Operational Level Of Service* – a set of characteristics and parameters (criteria) established for each type of defect of a road element or its part: description of the defect and parameters of the level of intervention, season of the year of elimination, unit of measurement, response time;

*Maintenance Level* is a characteristic of a certain condition of an element, component, road section, a set of road sections, road network, which is determined by the timeliness, completeness and quality of defect elimination. Three standard levels of maintenance are used: satisfactory, medium, high and one non-standard level – unsatisfactory;

*Level Of Requirements* is the classification number of the road type depending on their value and average annual daily traffic intensity in the requirements for the operational condition of public roads according to DSTU 3587:2022 "Road Safety. ROADS. Requirements for operational condition":

1 - international and national with a traffic intensity of more than 7,000 vehicles per day;

2 - international and national roads with traffic intensity up to 7,000 vehicles per day;

2 - regional and territorial with a traffic volume of more than 3,000 vehicles per day;

3 - regional and territorial with traffic intensity up to 3,000 vehicles per day;

3 - regional with a traffic intensity of more than 1,000 vehicles per day;

4 - all others not included in (1-3);

*Regulatory response time* - a period of time (hours or days) specified by applicable regulations from the moment a defect is detected until it is eliminated.

*Actual response time* is the actual period of time from the moment the defect is detected (date, hour, minute) until the moment it is eliminated (date, hour, minute), minus the time of impossibility of performing work caused by adverse weather conditions and/or adverse technical and economic conditions.

LTCSimula contains the following worksheets:

– *LOS* is a table of operational service levels specification;

– *Template* - contains the title and "header" of the future spreadsheet and one row of sample data with the corresponding formulas for calculating the values of individual indicators;

– *Roads* - contains data on PBC road sections, some basic PBC parameters and controls for the program's operating modes;

– *Graphs* - contains the results of processing the simulation data obtained after launching the 'Simulation' mode and performing a specified number of runs of the simulation model of the PBC execution to assess the laws of distribution of the amounts of deductions from the monthly payment, the cost of performing works and services, and the contractor's profit;

– *Costs* – contains, among other things, a monthly schedule of the contractor's costs, adjusted to the year of the contract (net present value) with a discount factor adjusted for the forecasted inflation rate;

– *Penalties* – contains, among other things, a schedule of the net present value of deductions from payment to the contractor for accrued penalty points due to late elimination of defects;

– *Profit* – contains, among other things, a monthly schedule of the net present value of loss/gain;

– *Worksheets* – contain worksheets of source data. A worksheet is created automatically using one of the two modes available in the program (Fig. 1).

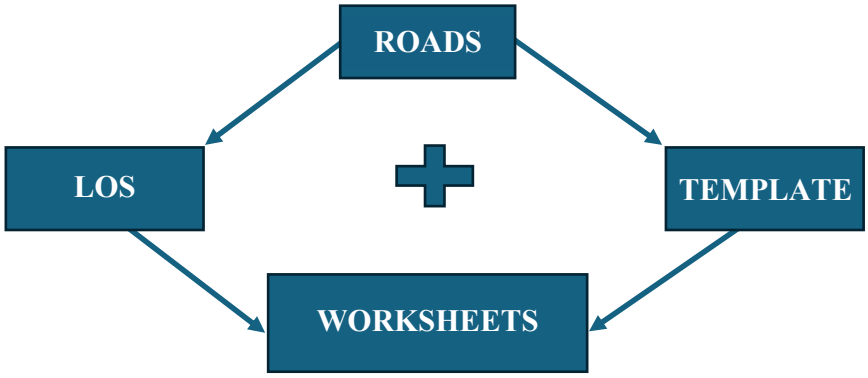


**Fig. 1. Scheme of worksheeta formation**
*Source: author's development*

Regardless of the level of complexity of the PBC, all data rows are left, and for

specialized PBCs, the estimated number of defects per season is set to a different value from zero only for those operational levels of the facility that are relevant to the specialization of the PBC (e.g., only for asphalt pavement or only for bridges, etc.).

After that, all the variables of the initial data are edited, regarding the values of which a decision needs to be made, namely the values of the parameters a, b, and c of the triangular laws of distribution of random coefficients: to the time of elimination, the number and cost (per case) of defects, and estimates of the expected values of the number (for a year or season). This stage of preparing the initial data is the most responsible and time-consuming. After receiving the results of the simulation modeling, the initial data can be adjusted and re-simulated.

Thus, the probabilistic nature of the PBC process is modeled by three random coefficients defined by triangular distribution laws, with three parameters (minimum, mode, maximum) set by the expert. These are the coefficient of advance/delay in defect elimination, the coefficient of increase in the cost of defect elimination, and the coefficient to the number of defect cases. The random duration and cost of eliminating one defect and the number of defect cases are determined by the product of the value of the base value and the corresponding coefficient obtained by the Monte Carlo method. The modeling algorithm is given in [22].

Due to the parameters of the triangular distribution laws, the expert, by setting higher values of the b parameter of these laws, as well as the basic values of response time, cost of defect elimination, and their average number, can get a virtual crisis after the simulation. In this case, all results will be recalculated and displayed. The hypothesis is that an experienced expert-manager is able to sense the threat to the organization's operations and reputation caused by such a hypothetical virtual crisis.

An important problem in monitoring the operational condition is the meticulous recording of the moments when defects occur and when they are eliminated, which means that there is a problem of the reliability and validity of the collected data and their registration. This problem is still awaiting resolution both in terms of theory and practice.

**Conclusions.** The analysis of foreign studies based on actual PBC implementation in many countries of the world generally confirms the effectiveness of PBC and their superiority over traditional method-based contracts. For specialized PBCs for road marking maintenance, the results of the “before and after” analysis conducted to assess the impact of PBCs on road safety did not provide convincing evidence that performance-based road marking maintenance contracts are an effective safety countermeasure that helps reduce accidents.

Only one pilot PBC (or, more precisely, OPRC) project has been implemented in Ukraine so far, funded by loans from international financial organizations, but its results, in our opinion, are not yet well known to a wide range of scholars.

It can be assumed that, with some exceptions, a sufficient regulatory framework has been created for the implementation of PBC in Ukraine, but the lack of actual PBC projects makes it impossible to comprehensively test them in practice.

Crisis management of road companies using PBC can be evaluated using the proposed LTCSimula simulation model, which is implemented using Excel. For the PBC expert manager – designer, this software implementation of the simulation model will be a useful simulator mechanism with which he or she can experience and evaluate the impact of various input parameters on the contract project under study, including exploring different crisis scenarios. The hypothesis is that an experienced expert manager is able to sense the threat to the organization's operations and reputation caused by such a hypothetical virtual crisis.

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# A STUDY OF UBER'S CORPORATE TRANSFORMATION: INNOVATION, ACCOUNTABILITY AND GROWTH

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***Annotation.*** *This article focuses on the organizational transformation of Uber Technologies in the period during which the company underwent significant changes in leadership, corporate culture, and strategic direction.*

*The evolution of Uber Technologies from 2016 to 2022 represents a critical case study in corporate transformation within the dynamic and competitive mobility services sector. This period was marked by pivotal internal and external catalysts that necessitated profound organizational changes. Internally, a leadership transition triggered by crises involving corporate governance and workplace ethics redefined the company's cultural paradigm. Externally, intensifying regulatory pressures, shifts in consumer expectations, and competitive forces reshaped Uber's strategic and operational focus.*

*The forcefield analysis applies to evaluate driving and restraining forces in Uber's transformation, highlighting the interplay between resistance to change and the strategies employed to mitigate it. Additionally, external disruptions like the COVID-19 pandemic necessitated adaptive measures to sustain operations while fostering a culture of safety, sustainability, and inclusivity. Key adaptations included the establishment of a reformed organizational culture prioritizing transparency, accountability, and inclusivity, alongside innovations in service diversification such as the introduction of shared mobility solutions and eco-friendly transport options.*

*This findings can be interesting to highlight the interplay between market dynamics and internal reform, highlighting how strategic leadership, stakeholder engagement, and adaptability can recalibrate an organization's trajectory in the face of multifaceted challenges. The findings contribute to broader discussions on corporate resilience, ethical governance, and innovation-driven growth in global platform-based businesses.*

***Keywords:*** *Uber Technologies, ride-hailing industry, workplace culture, innovation and diversification, forcefield analysis, corporate restructuring, transformational leadership, behavioral resistance, stakeholder engagement, strategic diversification, rebranding, labor dynamics.*

**Introduction.** The American company was founded in 2009 in San Francisco

as a startup under the name Uber Technologies, butswiftly became a prominent force within the taxi and delivery sector, establishing itself as a key player in the industry. The transformation of Uber from a traditional ride-hailing service to a multifaceted mobility company occurred over several years, with significant developments taking place from 2016 to 2022[1]. During this period Uber faced a myriad of challenges and opportunities.

The controversies around Uber`s policy have not only been a byproduct of its rapid expansion but also appeared from the controversial leadership of CEO Mr Kalanick. His tenure as CEO was marked by numerous manifestations of sexism within the organization and contentious disputes with company drivers regarding their working conditions [2]. These issues not only spottedUber's reputation but also raised serious questions about its corporate governance and ethical standards. However, a significant turn of events in 2017 was a change in management when Mr Kalanick stepped down, making way for Dara Khosrowshahi as CEO. This leadership transition was a pivotal moment for Uber, ushering in a new era characterized by a change in corporate culture and a commitment to resolving internal conflicts. Under Dara Khosrowshahi's leadership, Uber has embarked on a journey of organizational reform, prioritizing transparency, accountability and employee well-being to foster a healthier and more harmonic work environment.

As competition intensified and technology continued to evolve, the company recognised the need for strategic and cultural shifts to sustain its growth trajectory. This essay will critically analyze the transformative changes undertaken by Uber from 2016 to 2022, examining the drivers behind these changes, the implementation strategies employed, and the short-term and long-term outcomes evaluated. Drawing upon change management theories and literature, this analysis will delve into the triggers and nature of the changes initiated by Uber during the specified timeframe. It will explore the role of key stakeholders, the management of resistance to change, and the overarching objectives driving Uber's transformation initiatives. Additionally, the essay will assess the effectiveness of Uber's change management strategies in achieving its organizational goals and maintaining its position as a leader in the market.

Uber experienced a multitude of triggers which can be categorized into internal factors, originating from within the organization, and external factors, arising from the broader business environment.

**Objective of the study.** The rapid transformation of Uber Technologies from a ride-hailing startup to a global leader in the mobility sector highlights the need for a systematic understanding of corporate change mechanisms in the context of technological disruption, cultural shifts, and competitive market dynamics.A key focus is the impact of these transformations on Uber's organizational culture, ethical governance, and operational strategies. The objective is to critically evaluate the interplay of internal and external factors driving these changes, with particular attention to the role of leadership in addressing corporate scandals, fostering innovation, and sustaining competitive advantage. It seeks to explore how ethical governance and accountability were integrated into organizational practices to rebuild stakeholder trust and align the company with broader societal expectations. Special attention is given to Uber’s efforts to foster

inclusivity, transparency, and employee well-being within a previously contentious corporate environment.

The key goal is to evaluate the strategic diversification initiatives undertaken by Uber, such as the development of Uber Eats, Uber Freight, and its ventures into micromobility and sustainable transportation. By investigating Uber's adaptive strategies, research provides insights into effective change management practices and their implications for global businesses in evolving environments.

**The main part.**

**External triggers of change.** According toFigure 1 PESTEL analysis, there are some economic, sociocultural and environmental factors, which can be considered crucial for external changes for the company.

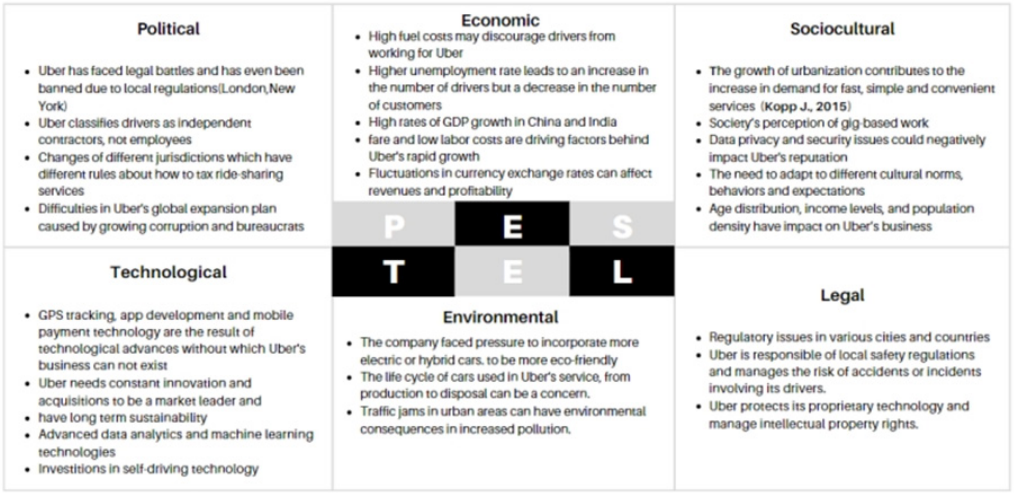


**Fig. 1. PESTEL analysis of Uber Company 2016-2022**

The movement Delete Uber became popular during 2016-2017 years, which caused a lot of social scandals and boycotts among customers not only in America but in other countries too. This movement caused losses of an estimated 200,000 users and helped Lyft rise in the App Store ratings[3]. Strong competition from rival ride-hailing companies, traditional taxi services, and emerging mobility providers exerted pressure on Uber to innovate, differentiate, and adapt its business model. Intense competition acted as an external trigger for change, compelling Uber to explore new markets, expand its services, improve customer experiences and provide new PR- campaigns. Compliance with evolving regulatory requirements and addressing legal challenges became imperative for Uber's sustainability and growth. Uber`s invested in sustainable technologies, providing new services such as Uber Pool which allows the sharing of a private car between different customers. This strategy was developed to reduce the company's emissions into the environment, as the issue of global warming began to emerge acutely, affecting the transition of consumer preferences to more eco-friendly transport.

Rapid changes in consumer preferences, behaviors, and expectations influenced Uber's product offerings, service delivery, and business strategies. Consumer demands for convenience, affordability, sustainability, and safety increased, driving external changes within Uber, and prompting the company to innovate and evolve its offerings to meet market demands. As the demand for clean energy products increased in 2018, Uber bought a company which made electric bicycles and created a collaboration with Lime – a company which provides motorized scooters for clients.

Such events as the COVID-19 pandemic had profound impacts on Uber's operations, revenue streams, and stakeholder perceptions. External shocks and socioeconomic trends acted as triggers for change, forcing Uber to adapt its business practices, priorities, and resource allocation strategies accordingly. During the COVID-19 pandemic, Uber lost 70% of its clients, so it was a huge problem for the company [4]. Uber implemented employment safeguards in response to the pandemic, which gives accountability for drivers' working conditions and showcases its ability to enhance them. It showed that Uber has the potential to enact similar measures beyond crises as well and that future changes are needed.

**Internal triggers of change.** The appointment of Dara Khosrowshahi as Uber`s CEO in 2017 marked a pivotal internal trigger for change within Uber. Uber faced a crisis during the period from 2016 to 2017 ranging from allegations of workplace and sexual harassment and discrimination to regulatory challenges and legal disputes. Khosrowshahi introduced an innovative set of cultural principles for the company, supplanting the earlier framework devised by Travis Kalanick. This updated set aims to foster a more inclusive and harmonious atmosphere within a corporate culture historically perceived as stringent and contentious. Internal feedback mechanisms, such as employee surveys, town hall meetings, and exit interviews, revealed widespread dissatisfaction among Uber employees regarding workplace culture, leadership, and the treatment of workers. When Susan Fowler posted her story on social networks, the situation got out of control and the need for changes became necessary for the existence of the company on the market as one of the key players.

The new cultural values prioritized positivity and flexibility, embracing traits like perseverance and embracing diversity. Khosrowshahi initiated efforts to enhance employee relations and issued apologies to countless staff members following the previous CEO's confrontational approach, which contributed to issues in London and the revocation of the company's license due to perceived shortcomings in corporate responsibility [5].

In 2018, the company implemented a comprehensive marketing strategy which included rebranding efforts and the development of new visual elements such as logos, iconography, and typography for roadside signage and navigation imagery. This initiative also involved actively managing customer feedback while carefully considering previous unsuccessful experiences, particularly in 2016.

**Driving forces.** It is important to delve into the driving and restraining forces for Uber`s transformation in order to assess the need for changes in both Uber's corporate

culture and its market positioning strategies. To carry out successful analysis, forces were distributed according to Lewin`s model [6] and the framework of forcefield analysis was used to show the correlation.

As shown in Figure 2, the driving forces are represented by thicker arrows, indicating their significant influence. At the same time, in certain areas, the restraining forces have longer arrows, highlighting their significant impact. This visual representation highlights the complex dynamics within an organization, revealing the urgent need for change along with the many enabling conditions for its implementation. However, it also highlights notable problems that could slow down change, such as financial losses, driver dissatisfaction and public criticism.

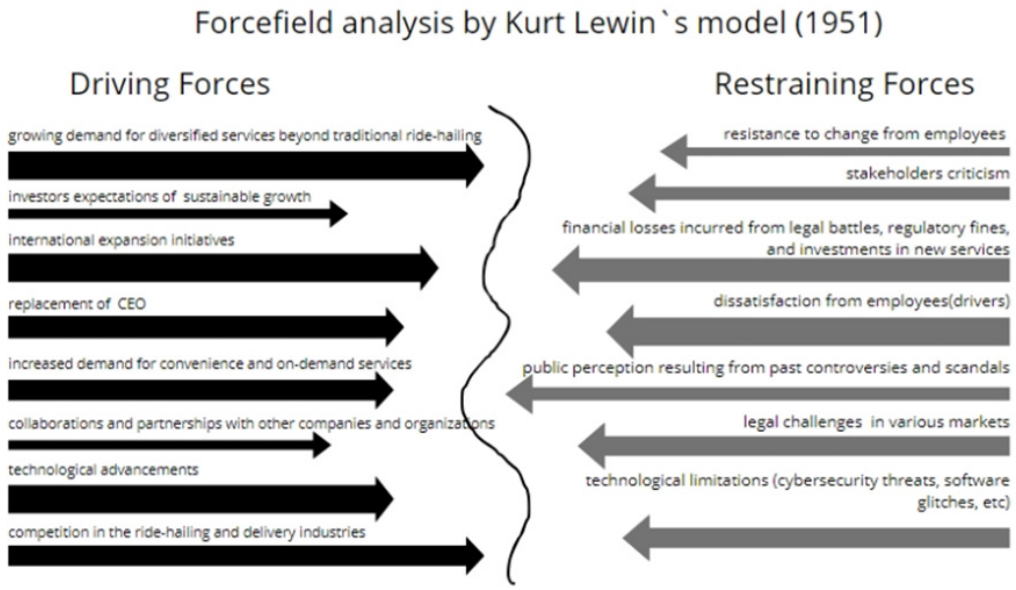


**Fig. 2. Forcefield analysis**

According to the Figure3 Uber experienced both soft and hard types of change during the period from 2016 to 2022. Soft changes primarily revolved around cultural shifts, leadership transitions, and internal organizational reforms aimed at improving workplace dynamics, fostering inclusivity, and enhancing employee satisfaction. On the other hand, hard changes encompassed strategic shifts, business model adaptations, and operational transformations aimed at diversifying service offerings, expanding into new markets, and addressing regulatory challenges. Therefore, it would be accurate to say that Uber experienced a combination of soft and hard changes during this period to adapt to evolving market dynamics, enhance organizational effectiveness, and ensure long-term sustainability.

**Implementation of Change.** According to R. Kanter`s works [7] it is important to figure out the role of the agent of change in Uber`s transformations. Kanter defines corporate entrepreneurs as individuals who exhibit entrepreneurial characteristics within

the established structures of a large organization.

*Table 1*

**Characteristics of change agent**

| Characteristic of change agent | |
|---|---|
| Vision | can identify opportunities for change and imagine new possibilities for the organization |
| Initiative | proactive and take ownership of change initiatives |
| Resourcefulness | adept at securing resources and building coalitions to support their ideas |
| Networking | build strong relationships across different departments and hierarchical levels |
| Risk-taking | willing to challenge the status quo and champion innovative ideas despite potential uncertainties |

Table 2 shows Kotter's model which offers a step-by-step approach to change management, providing clear guidance on the actions needed at each stage of the change process. This model can be used for an objective assessment of such complex changes as internal and external changes in the company. The model addresses various aspects of change, including creating a sense of urgency, building a guiding coalition, communicating the vision, empowering employees, and anchoring change in the organizational culture. While Kotter's model provides a structured framework, it also allows for flexibility and adaptation to fit the unique needs and circumstances of different organizations.

Kotter's model provides a granular framework with eight distinct steps, but it focuses mainly on leadership and communication whereas Lewin's three-phase model [6] offers a broader overview with a focus on the psychological aspects which influenced the change.

Lewin's three-phase model of change [6] can be used for analyzing the nature of change in Uber company. Lewin's model allows a methodical examine the factors that contribute to the initiation of change, the strategies used to implement it, and the mechanisms for introducing change into the organizational culture by dividing the path of change into three distinct phases - unfreezing, movement and refreezing. This model helps to acknowledge the natural human tendency to resist change. Recognizing resistance allows strategies to be developed to resolve problems, provide support during transition, and build support for desired changes.

Unfreezing.The unfreezing phase in Lewin's change model is the critical first step, where the stage is set for transformation. This phase looks like cracking the ice on a frozen lake, as it is compulsory to disrupt the current state before any movement can occur. This phase focuses on creating a sense of urgency for change. In Uber's case, mounting legal challenges, the public backlash on sexual and workplace harassment, and regulatory pressure highlighted the need to move away from its aggressive tactics

which the organization was famous for. The focus shifts to a clear understanding of why change is necessary for Uber. The negative impact of Kalanick's successful practices was too strong and the potential benefits of change became a solution. In 2017 Dara Khosrowshwahi stepped into the CEO role at Uber, inheriting a company facing a multitude of crises. Khosrowshahi wasted no time in demonstrating his dissatisfaction with the status quo. He embarked on a global apology tour, acknowledging the company's missteps and expressing a commitment to reform. Leaks of internal emails and reports highlighting safety issues became a catalyst for change. Khosrowshahi used these leaks to his advantage, publicly admitting to the company's shortcomings and using them as evidence of the need for a comprehensive restructuration. Khosrowshahi actively sought out data and stakeholder input to solidify the case for change. He commissioned independent safety audits, met with regulators and driver representatives, and conducted employee surveys. The results painted a clear picture: Uber's aggressive tactics were unsustainable and detrimental to its long-term success. The new CEO began to articulate a vision for a "New Uber," one focused on safety, regulatory compliance, and improved driver relations. The potential benefits of this approach, such as increased ridership, a more stable business environment, and a positive public image were undeniable. The appointment of a new CEO became the start of a transformative era for Uber, signaling a strategic shift aimed at reducing substantial losses and reclaiming market dominance lost to its U.S. competitor Lyft. At the same time, such type of calm leadership transition also paved the way for embracing innovative ideas, including the exploration of cutting-edge technologies such as airborne transportation solutions [8]. This clear vision, coupled with the weight of the collected data and stakeholder concerns, effectively created a sense of urgency within the company and paved the way for the moving stage of the transformation process.

Moving. The moving phase is a period of transitions where the actual transformation takes place [6]. It follows after the unfreezing phase, where the need for change is established, and precedes the refreezing phase, where the new behaviors and practices become solidified. The transitional phase, characterized by its dynamism and inherent challenges, serves as a pivotal period in organizational change. If organizations prioritize clear plans for putting changes into action, keep communication channels open, and make necessary adjustments along the way, it can boost chances of successfully navigating this period, reaching goals and implementing the changes.

The moving stage of Uber's transformation under Khosrowshahi involved a series of concrete actions aimed at translating the urgency for change into notable results. Uber introduced stricter background checks for drivers, implemented new technology features like in-app emergency buttons and ride tracking, and invested in driver safety training programs, revamped its complaint-handling process, ensuring swift and transparent responses to user safety concerns. Khosrowshahi adopted a more collaborative approach with regulators worldwide, focusing on establishing clear operating guidelines and addressing concerns about labor practices and insurance coverage. This shift in strategy which helped Uber navigate complex regulatory landscapes and avoid costly legal battles

can be adopted from Jason Colquitt's research of organizationalbehavior[9]. Prioritizing improving driver relations, Uber re-evaluated its commission structure to offer drivers more competitive pay and incentives [10] Additionally, Uber implemented features that provided drivers with greater flexibility in scheduling rides and reduced deadheading (driving without passengers). These changes aimed to create a more sustainable and rewarding work environment for drivers, a critical component of Uber's core business model.

*Table 2*

**Kotter`s 8-step Change Model**

| Kotter's 8-Step Change Model | | |
|---|---|---|
| **№** | **Step** | **Uber` s change** |
| 1 | Creation of urgency | Scandals with staff and drivers, problems with licenses, scandals on social networks, many court calls and the DeleteUber movement influenced the need to implement changes. As reputation declines, competition with other companies increases |
| 2 | Forming a powerful coalition | Uber has formed a strong leadership team under new CEO Dara Khosrowshahi to lead the change effort. This coalition consisted of key leaders and stakeholders committed to organizational change. |
| 3 | Creation of a vision for change | Khosrowshahi articulated a clear vision for Uber's future, emphasizing transparency, accountability, and a renewed focus on employee welfare. The strategy focused on diversifying service offerings, enhancing customer experiences, and fostering a positive workplace culture. |
| 4 | Communication of the change vision | Under calm and diplomatic leadership style of Dara Khosrowshahi Uber implemented extensive communication initiatives to ensure all employees understood the vision and strategic objectives. Town hall meetings, internal memos, and training sessions were utilized to disseminate information and garner employee buy-in **(Osman, 2023)**. |
| 5 | Empowering others to act on the vision | To empower employees to contribute to the change process, Uber encouraged innovation, collaboration, and autonomy at all levels of the organization. Cross-functional teams were established to tackle specific challenges and implement change initiatives **(Nickelsburg, 2017).** |
| 6 | Creation of short-term wins | Khosrowshahi apologized and paid compensation to dissatisfied consumers throughout 2017-2018, who had court hearings dating back to 2015. Encouraging change and creating new functional units has had success in increasing satisfaction for both drivers and passengers. |
| 7 | Build on and produce more change | Uber has innovated by diversifying its offerings beyond its core ride-sharing service to include food delivery (Uber Eats), freight logistics (Uber Freight), and a variety of other ventures.Performance metrics were established to monitor progress and identify areas for further improvement **(Osman, 2023)**. |
| 8 | Anchor the changes in corporate culture | The changes implemented at Uber are ingrained in the organization's culture and way of doing business. The companyimproved its market ratings despite a decline in 2019 and managed to stay afloat during the pandemic because of a new leadership style and implemention of innovational services(Uber Eats). |

As Ian Palmer explains [11], affects a widespread transformation within a company,

particularly in the case of a contentious organization like Uber, fatally facing internal resistance. With the change agent sourced externally and the previous one not removed from the board of directors, establishing a conducive environment and fostering confidence in the initiatives required considerable time and effort as shown in the Table 3. Internal resistance to change stemmed from individuals within Uber's ranks who were comfortable with the company's previous methods and reluctant to embrace new strategies. This resistance has manifested in various forms, such as skepticism, fear of the unknown, or concerns about a new leader.

*Table 3*

**Resistance to change**

| Internal Resistance | | External Resistance | |
|---|---|---|---|
| Employees | Accustomed to the old, aggressive approach have resisted the shift towards regulatory compliance and innovations | Regulators | At first steps regulators have initially viewed Uber with suspicion, given its past transgressions. Building trust and demonstrating a genuine commitment to compliance have been an ongoing challenge. |
| Managers | Who thrived in the fast-paced, growth-at-all-costs environment have struggled to adapt to a more collaborative and measured approach. They might have resisted new policies and struggled to implement them effectively within their teams who were not so happy to see new implement. | Competitors | Established players in the ride-hailing and food delivery markets viewed Uber's expansion efforts as a threat, potentially leading to increased competition and lobbying efforts against Uber's new ventures. |

Launched in 2014, Uber Eats gained significant traction during the moving phase. By leveraging its existing driver network and technological infrastructure, Uber offered a convenient food delivery service that competed with established players like Grubhub and DoorDash. This diversification not only provided additional revenue streams but also attracted new user segments, solidifying Uber's position in the broader transportation and on-demand delivery space.

In 2018, Uber introduced two significant innovations: Uber Freight, a platform designed to facilitate connections between businesses and truck drivers for cargo transportation, and Uber Jump, a pilot initiative offering dockless electric bike rental services in select cities. These endeavors were strategically implemented to capitalize on emerging trends in the logistics industry and address the rising demand for micromobility solutions within urban environments.

The period of moving in Uber not only addressed pressing issues but also laid the groundwork for solidifying the "New Uber" within the company culture, paving the way for the refreezing stage.

**Refreezing.** Table 4 describesthe final stage of Lewin's model, refreezing, which focuses on solidifying the changes and patterns implemented inside the organization. The goal is to ensure that new behaviors and practices become the new normal within the organization. In Uber's case, this meant ensuring safety, regulatory compliance, improved driver relations and innovative ideas became ingrained in the company culture. Such features as multi-factor authentication, ride checkup and emergency button implemented during the moving phase, have likely become standard practices through the refreezing stage. By integrating it into the core Uber experience, Uber reinforce safety as a top priority.

*Table 4*

**New patterns in Uber company**

| New patterns in organization | |
|---|---|
| Two-way rating system | Riders and drivers can rate each other, providing feedback on courtesy, cleanliness, and overall experience. The ratings incentivize positive behavior and impact access to future ride requests **(Uber, 2018)**. |
| In-app reporting tools | Drivers report safety concerns, disrespectful behavior and other issues directly through the app. |
| Safety reports | Publications of regular safety reports, detail incident rates, response times, and safety initiatives. Such initiatives creates a transparency and builds trust with riders and reinforces Uber's commitment to safety **(Hawkins, 2020).** |
| Community guidelines | Clear and available guidelines outline expectations for both riders and drivers, promoting a more predictable and respectful user experience. |

Efforts have been made to reinforce the importance of working with regulators, maintaining transparent operating guidelines, and prioritizing driver relationships as integral components of Uber's business model. The company has embraced a culture of innovation, which has led to the development of novel services like Uber Travel and the creation of a decision to make Uber Green for supporting eco-initiatives and sustainability.

**Evaluation of the change.** In Uber`s case, an external agent of change proved to be more effective than an internal one, as exemplified by Dara Khosrowshahi's tenure as CEO of Uber. His outsider perspective brought fresh insights into Uber's politics, fostering a culture of accountability and ethical business practices. Robert Iger in his work [12] presents a compelling narrative of leadership, innovation, and organizational transformation that correlates with Khosrowshahi`s leadership style after joining Uber. The response of Uber to its financial challenges in 2019 can be characterized by the implementation of cost-cutting measures and strategic partnerships which reflects a profound connection with the changes in organizational culture initiated under the leadership of the CEO. Khosrowshahi's tenure witnessed a strategic reorientation

towards fostering a culture of fiscal prudence, accountability, and adaptability within Uber. The adoption of cost-cutting measures signifies a departure from previous operational paradigms towards a more financially disciplined approach, emblematic of Khosrowshahi's commitment to sustainable growth and profitability. Uber diversified its portfolio beyond ride-hailing to include services such as Uber Eats and Uber Freight, leveraging its existing infrastructure and technology to enter new markets.

**Conclusions.** In conclusion, Uber's transformative journey from its aggressive past to a more tranquil and sustainable organizational culture has been driven by a combination of bottom-up and top-down changes orchestrated by a dynamic change agent Dara Khosrowshahi. By prioritizing transparency and safety for its workers, Uber has successfully implemented a new cultural paradigm that fosters innovation and collaboration. This shift not only reflects the company's commitment to addressing past challenges but also underscores its adaptability and resilience in navigating complex business environments. Today Uber continues to develop new practices, which emphasise fostering a culture of trust, accountability, and inclusivity will be essential in sustaining its growth and relevance in the ever-changing landscape of the ride-sharing industry. Uber's culture can be characterized by a dynamic blend of innovation, disruption, and customer-centricity, reflecting its commitment to driving positive change and delivering value to both customers and stakeholders. It means that Uber's cultural paradigm aligns with the «Orange» organizational type, emphasizing clear targets for middle management and shared decision-making authority, potentially centralized. This approach fosters growth and a shift towards prediction and control. As Uber evolves, it may incorporate traits of «Green» organizations, dispersing decision-making authority to frontline employees and promoting a culture of servant leadership.

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# ECONOMIC NATIONALISM AND EUROPEAN INTEGRATION: A METHODOLOGICAL APPROACH TO UKRAINE'S ECONOMIC DEVELOPMENT

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***Annotation.*** *This study explores the implications of economic nationalism, economic patriotism, and European integration on Ukraine's socio-economic development. By examining domestic initiatives and drawing parallels with successful global practices, the research identifies actionable strategies to foster economic resilience and sustainable growth. Additionally, the study evaluates three strategic scenarios for Ukraine – protectionism, a balanced approach, and market liberalization – highlighting their trade-offs and potential outcomes. The findings provide a comprehensive framework for policy design, emphasizing the optimal mix of strategies to support domestic industries while ensuring competitiveness in global markets.*

***Keywords:*** *economic nationalism, economic patriotism, European integration, Ukraine, socio-economic development.*

**Introduction.** In the contemporary globalized economy, Ukraine is positioned at a critical juncture, navigating the dual imperatives of economic recovery and deeper integration into the European Union (EU). The interplay of these objectives is further complicated by the impacts of ongoing military conflict, which have significantly reshaped the country's socio-economic priorities, disrupted industrial capacities, and placed heightened demands on both public and private sectors. Addressing these multifaceted challenges necessitates a comprehensive exploration of how economic nationalism, economic patriotism, and European integration can inform and shape Ukraine's economic policies to ensure sustainable growth while safeguarding its strategic economic interests.

Recent developments in Ukraine demonstrate a proactive approach to economic resilience, with notable initiatives aimed at stimulating domestic production and fostering economic patriotism. Programs such as the "National Cashback" initiative, which incentivizes the purchase of Ukrainian-made goods, and the broader "Made in Ukraine" campaign underscore efforts to strengthen local industries and reduce reliance on imports. Additionally, the promotion of industrial patriotism, particularly in strategic

sectors such as defense, agriculture, and energy, reflects a deliberate strategy to enhance economic sovereignty and fortify critical industries.

These domestic efforts align with international practices that have proven effective in other economies. Economic nationalism, exemplified by the United States' "Buy American Act" and India's "Atmanirbhar Bharat" initiative, highlights the utility of policies aimed at protecting and nurturing local industries through mechanisms such as trade barriers, targeted subsidies, and strategic incentives. Adapting such approaches, Ukraine could prioritize the development of key sectors, including agriculture and manufacturing, while ensuring alignment with international trade agreements to mitigate the risks of economic isolation.

Conversely, economic patriotism offers a balanced framework that prioritizes national industries within an open-market context. Nations such as France have demonstrated the effectiveness of safeguarding strategic sectors, such as telecommunications and energy, from foreign acquisitions while maintaining compliance with EU regulations. For Ukraine, such policies could focus on the development of high-growth sectors like information technology and renewable energy, leveraging domestic expertise while attracting foreign direct investment (FDI).

European integration provides an opportunity for Ukraine to modernize its economy and access the EU's single market, comprising over 450 million consumers. The experience of Poland serves as a salient example of how alignment with EU standards and the utilization of structural funds can facilitate infrastructure modernization, enhance competitiveness, and drive GDP growth. However, integration also imposes stringent regulatory requirements and necessitates significant economic adjustments, posing challenges for less competitive domestic industries.

This analysis underscores the importance of tailoring economic strategies to Ukraine's unique conditions, informed by global best practices and grounded in the need for both economic resilience and long-term growth. A balanced approach that combines elements of nationalism, patriotism, and integration may offer the most viable pathway for Ukraine's socio-economic development in a rapidly evolving global context.

**Literature Review.** Economic nationalism emphasizes the primacy of domestic industries through protective policies such as subsidies, tariffs, and restrictions on foreign ownership. Scholars argue that these measures are critical for fostering local capacity and achieving economic independence, particularly in times of crisis [1, 3].

Clift and Woll (2012) [3] analyze how European states have strategically deployed nationalist policies to protect critical industries, even within the constraints of open market systems. For instance, strategic subsidies in manufacturing and agriculture have been utilized to mitigate external competition and support local employment [6]. The United States' "Buy American Act" further illustrates the role of procurement policies in prioritizing local industries, particularly in sectors with high public investment [3].

In Ukraine, economic nationalism could serve as a viable strategy for protecting key industries, particularly agriculture and defense manufacturing, which are pivotal to national security. However, literature warns of the risks associated with prolonged

protectionism, including market inefficiencies and diminished competitiveness in international trade [2].

Economic patriotism offers a more flexible approach, prioritizing national economic interests while maintaining openness to global markets. This concept, as explored by Clift and Woll (2012) [3], encompasses measures that align domestic industrial policies with international trade norms, allowing states to safeguard strategic sectors without resorting to overt protectionism [6].

France provides a compelling example of economic patriotism, where targeted policies have protected industries such as telecommunications and energy from foreign takeovers while remaining compliant with EU regulations. This approach has enabled France to maintain control over critical sectors while leveraging global capital for growth [6].

Ukraine's "National Cashback" program aligns with this framework, incentivizing domestic consumption through financial rebates while promoting transparency and reducing the shadow economy [1, 3]. Such policies could be extended to strategic industries like renewable energy and IT, where Ukraine has significant growth potential.

European integration represents a comprehensive framework for modernization, offering access to the EU's single market and structural funds. Poland's experience serves as a benchmark, with EU membership facilitating infrastructure development, increased FDI inflows, and sustained GDP growth [4, 5].

However, integration is not without challenges. Studies highlight the economic and social costs of aligning domestic industries with EU standards, particularly for less competitive sectors. For example, Romania faced significant structural adjustments in agriculture and small-scale manufacturing during its accession process, underscoring the need for strategic planning and phased reforms [5].

For Ukraine, integration offers a pathway to diversify its trade partnerships and modernize regulatory frameworks. Yet, the literature emphasizes the importance of balancing these reforms with policies that protect vulnerable industries from immediate exposure to EU competition [4].

Ukraine's socio-economic policies reflect a blend of economic nationalism, patriotism, and integration. The Ministry of Economy has highlighted programs aimed at fostering industrial patriotism, particularly in defense and agriculture, as part of its broader strategy to enhance economic resilience [3]. Additionally, the "Made in Ukraine" initiative underscores efforts to stimulate domestic production while promoting national identity in global markets [1, 3].

Research by the Institute for Economic Forecasting further explores how Ukraine can leverage regional trade agreements and global trends to enhance its economic competitiveness. This requires a balanced approach that integrates domestic priorities with global opportunities, particularly in the context of ongoing geopolitical and economic uncertainties [2].

Nevertheless, integrating global best practices into Ukraine's socio-economic landscape remains a complex task, requiring tailored solutions that consider both immediate and long-term goals.

Despite the valuable insights provided by the literature, several unresolved questions remain. While economic nationalism can protect critical industries, how can Ukraine mitigate the risks of inefficiency and isolation associated with such policies? Economic patriotism offers a balanced approach, but what mechanisms can ensure its effective implementation in Ukraine's open-market context? Similarly, while European integration presents opportunities for modernization, what strategies can help Ukraine balance the demands of alignment with EU standards while protecting less competitive domestic sectors? These questions form the foundation of this study, guiding its analysis of how Ukraine can navigate these frameworks to achieve sustainable growth and resilience.

**Research Objective.** This study evaluates the implications of economic nationalism, patriotism, and European integration on Ukraine's economic trajectory. By analyzing domestic initiatives and drawing parallels with successful global practices, the research aims to offer actionable strategies for fostering economic resilience and growth.

This research investigates how Ukraine can balance different economic strategies to achieve sustainable growth and economic resilience. The study focuses on analyzing the effectiveness of approaches based on economic nationalism, economic patriotism, and European integration in influencing Ukraine's socio-economic development. Particular attention is given to their impacts on key indicators such as GDP growth, foreign direct investment, and industrial modernization. The research also examines global best practices, drawing insights from countries that have successfully implemented similar strategies, and explores how these approaches can be adapted to Ukraine's specific economic context and development priorities. Additionally, the study considers the optimal mix of policies needed to support domestic industries while ensuring competitiveness in global markets, emphasizing Ukraine's potential to leverage its unique resources and geographical position to maximize the benefits of these approaches.

**Methodology.** This study employs a mixed-methods approach to analyze the implications of economic nationalism, economic patriotism, and European integration for Ukraine's socio-economic development. The methodology is designed to evaluate these frameworks' impacts on key economic indicators and provide actionable recommendations for fostering resilience and growth. The analysis integrates qualitative and quantitative methods, drawing on global best practices and adapting them to Ukraine's specific context.

1. Research Design

The research is structured into two main components:

- Comparative Analysis: Evaluates the effectiveness of economic nationalism, patriotism, and European integration in achieving socio-economic objectives, using case studies from countries like the United States, France, and Poland.

- Scenario Analysis: Explores three potential economic strategies for Ukraine — protectionism, a balanced approach, and liberalization—assessing their trade-offs and outcomes.

2. Data Collection

The study utilizes secondary data from a variety of sources:

- Academic Literature: Articles and studies on economic frameworks, including Clift and Woll (2012) [3], Choudhury et al. (2024) [2], the Centre for European Reform (2024) [1], Medve-Bálint and Éltető (2024) [7], and Yue et al. (2024) [11], provide a comprehensive basis for analyzing the implications of economic nationalism, patriotism, and integration in diverse contexts.

- Policy Reports: Government publications, including Ukraine's Ministry of Economy reports, EU integration assessments, and international policy briefs.

- Economic Indicators: Data on GDP growth, FDI inflows, trade balances, and industrial output from organizations such as the World Bank [10], OECD [8], and Ukraine's State Statistics Service [9].

3. Evaluation Criteria

To ensure a consistent analysis, the study adopts the following evaluation criteria:

- Support for Domestic Industries: Measured by the level of subsidies, tax incentives, and programs aimed at fostering local production.

- Investment Attraction: Assessed by FDI inflows, their distribution across sectors, and their alignment with strategic economic priorities.

- Energy Independence: Evaluated based on the share of renewable energy, domestic production capacities, and dependence on energy imports.

- Regulatory Alignment: Examined through compliance with international trade agreements and alignment with EU standards.

4. Comparative Analysis

The study employs a comparative framework to analyze the effectiveness of economic frameworks in different contexts:

- Economic Nationalism: Case studies include the United States' "Buy American Act" and India's "Atmanirbhar Bharat" initiative, focusing on their impacts on industrial self-reliance and job creation.

- Economic Patriotism: France's policies on strategic sector protection serve as a model for balancing national interests with global market integration.

- European Integration: Poland's use of EU structural funds and its regulatory alignment illustrate the potential benefits and challenges of integration.

5. Scenario Analysis

The study models three potential scenarios for Ukraine's economic trajectory:

1. Protectionism: Prioritizes domestic industry protection through tariffs and subsidies, with high isolation risks.

2. Balanced Approach: Combines selective protectionism with regulatory alignment and strategic EU integration.

3. Liberalization: Emphasizes open markets and foreign investment attraction, with risks of social inequality and economic dependency.

Each scenario is analyzed against the evaluation criteria, focusing on trade-offs between growth, stability, and competitiveness.

6. Data Normalization and Aggregation

To facilitate comparison, the study normalizes quantitative data to a unified scale

(e.g., 0–10). Aggregated scores are calculated for each approach and scenario, enabling direct comparison of their relative effectiveness across evaluation criteria.

7. Visualization

The findings are presented through radar Charts: Comparative analysis of economic frameworks and scenario-based evaluations.

8. Limitations

The study acknowledges potential limitations, including reliance on secondary data, variability in economic conditions across case studies, and the challenges of directly extrapolating global practices to Ukraine's unique context. These limitations are addressed by incorporating expert insights and sensitivity analyses.

**Results and Visualizations.** This study evaluates economic nationalism, economic patriotism, and European integration in Ukraine's socio-economic development, incorporating insights from Poland, Hungary, the Czech Republic, Slovakia, China, India, and the United States. By analyzing these countries' strategies across criteria such as support for domestic industries, investment attraction, energy independence, and regulatory alignment, we establish a framework for policy development tailored to Ukraine's needs.

Poland exemplifies the successful integration of economic nationalism and European integration. Since joining the EU in 2004, Poland's GDP per capita has increased from 48% to 82% of the EU average (2024), accompanied by a drop in unemployment from 20% to 2.9%. These improvements are largely attributed to the strategic use of EU structural funds for infrastructure development and industrial modernization. Poland has also taken proactive measures to mitigate foreign influence by expanding its strategic company list to include sectors such as media and telecommunications (2024). This careful balance between integration and safeguarding domestic industries has enabled Poland to achieve rapid convergence with EU economic standards while maintaining national control over critical sectors.

Hungary's approach to economic nationalism involves selective state intervention, particularly in strategic industries such as energy and automotive manufacturing. The automotive sector contributes around 6% of Hungary's GDP, with additional contributions from suppliers amounting to 8–9% (2024). Government policies have focused on fostering national champions in pharmaceuticals and technology, emphasizing resilience and sovereignty. However, Hungary's economic strategy also underscores the importance of maintaining trade relationships to sustain growth. The country's reliance on foreign markets highlights the trade-offs between economic nationalism and external market access.

The Czech Republic takes a cautious approach to economic nationalism, with a focus on energy independence. Recent investments in renewable energy have reduced vulnerabilities associated with external energy dependence, aligning the country with EU energy standards. The Czech automotive industry, which has attracted significant foreign investment, exemplifies a balanced strategy that supports both local suppliers and foreign investors. This dual focus on fostering domestic industries while complying

with EU integration requirements provides valuable insights for Ukraine's efforts to modernize its economy.

Slovakia's economic strategy reflects its historical context of dependency and its transition toward industrial modernization. The country has effectively leveraged foreign investment in its automotive sector, which accounts for approximately 13% of GDP (2024), to build local industrial capacity. By balancing sovereignty with external partnerships, Slovakia has become a major player in Europe's automotive supply chain. However, challenges remain in reducing dependency on foreign actors and ensuring long-term competitiveness.

China's economic nationalism is defined by its industrial policies and global engagement. The "Made in China 2025" initiative focuses on reducing reliance on foreign technology and achieving dominance in high-tech industries such as semiconductors and renewable energy. Although China accounts for only 5% of global semiconductor manufacturing capacity (2024), the government has heavily invested in domestic innovation to close this gap. However, China's aggressive export strategy has led to trade tensions, highlighting the challenges of balancing domestic priorities with global integration. For Ukraine, adopting aspects of China's industrial strategy could accelerate growth in IT and advanced manufacturing.

India's Atmanirbhar Bharat (Self-Reliant India) initiative promotes self-reliance by incentivizing domestic manufacturing while maintaining integration into global value chains. The production-linked incentives (PLI) scheme has driven a 30% increase in electronics exports between 2021 and 2022. By 2023, electronics exports were expected to reach ₹1.76 lakh crore. This model illustrates how domestic production goals can coexist with global trade opportunities. For Ukraine, India's experience offers a framework for reducing dependency on imports while attracting foreign investment in strategic sectors like electronics and pharmaceuticals.

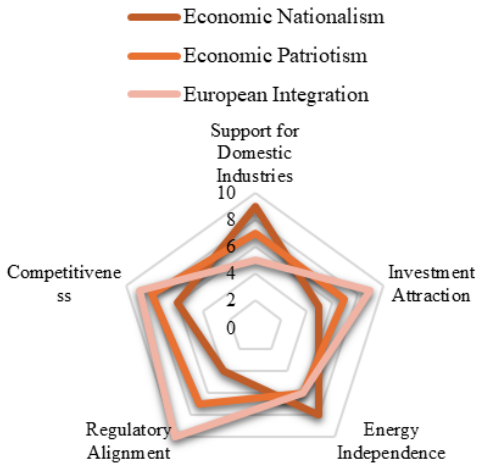
The United States provides a robust model of economic nationalism through policies such as the Inflation Reduction Act (IRA) and the Buy American Act. The IRA, introduced in 2022, allocated $369 billion in subsidies and tax incentives to support clean energy production, fostering the growth of domestic industries like solar panels, wind turbines, and electric vehicles. By 2024, 3.4 million Americans had benefited from $8.4 billion in tax credits for energy efficiency upgrades. The U.S. also employs the Committee on Foreign Investment in the United States (CFIUS) to protect strategic industries like semiconductors and telecommunications from foreign control. However, the U.S. model highlights trade-offs, including higher production costs and trade tensions, underscoring the need for careful policy design to ensure competitiveness.

The analysis of global practices provides valuable insights into the strengths and challenges of various economic frameworks. Poland demonstrates the advantages of leveraging EU resources while safeguarding key industries. Hungary highlights the potential and risks of state intervention in strategic sectors. The Czech Republic showcases a balanced approach to fostering energy independence and complying with EU standards. Slovakia illustrates the effective use of foreign investment to strengthen

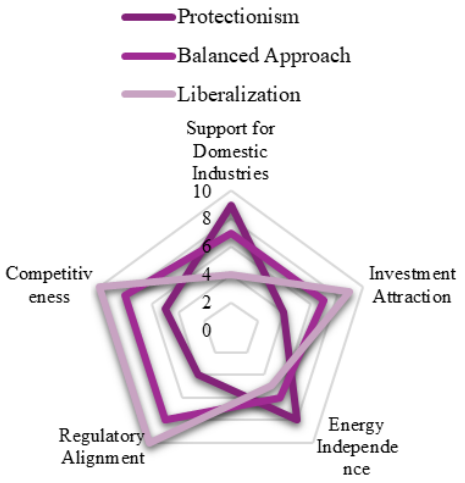
domestic industries. China emphasizes the importance of ambitious industrial policies in achieving global competitiveness. India illustrates how incentives can align domestic production with global trade integration. The United States demonstrates the effectiveness of targeted subsidies and industrial policies in fostering innovation and securing strategic sectors.

This comparative evaluation highlights distinct patterns across the key criteria. Economic nationalism excels in supporting domestic industries and achieving energy independence, as seen in China's "Made in China 2025" initiative and Hungary's focus on energy sovereignty. However, it often faces challenges in attracting foreign investment and aligning with international regulatory standards. Economic patriotism offers a middle ground, providing moderate support for domestic priorities while fostering global market engagement, exemplified by France's and India's strategic sector policies. European integration stands out in attracting investment and enhancing competitiveness through regulatory alignment, as demonstrated by Poland's and the Czech Republic's success within the EU framework.

For Ukraine, these findings emphasize the trade-offs inherent in each approach. Economic nationalism, while beneficial for energy independence and local industry, may limit Ukraine's access to foreign capital. Economic patriotism provides a pragmatic pathway to leverage domestic strengths while integrating selectively into global markets. European integration offers long-term benefits in market access and investment but requires significant structural adjustments.




**Radar Chart 1: Comparative Analysis of Economic Frameworks**




**Radar Chart 2: Scenario-Based Outcomes for Ukraine**

The radar charts illustrate these trade-offs and synergies. The first radar chart compares the performance of economic nationalism, economic patriotism, and European

integration across support for domestic industries, investment attraction, energy independence, regulatory alignment, and competitiveness. The second radar chart evaluates the scenario-based outcomes for Ukraine under three potential strategies: protectionism, a balanced approach, and liberalization. These visualizations provide a clear framework for understanding the implications of each approach and scenario, guiding strategic decision-making.

Radar Chart 1: Economic nationalism excels in supporting local industries and achieving energy independence (as seen in China and Hungary). However, it scores lower in regulatory alignment and competitiveness. Economic patriotism provides a balanced score across all criteria (France's model). European integration excels in regulatory alignment and investment attraction (Poland) but struggles with domestic industry protection.

Radar Chart 2: Scenario outcomes highlight that:

- Protectionism achieves high scores for domestic industry support but falters in investment attraction and regulatory alignment.

- Balanced approach offers consistent scores across criteria, balancing domestic priorities with global integration.

- Liberalization excels in investment attraction and competitiveness but lags in protecting domestic industries and energy independence.

The analysis of global practices reveals several recurring patterns that highlight the strengths and trade-offs of different economic strategies. Strong nationalist policies, such as those adopted by the U.S., China, and Hungary, provide significant short-term boosts by protecting domestic industries and fostering self-reliance. These policies enhance critical sectors like energy and manufacturing but often encounter challenges in attracting foreign investment and maintaining compliance with international trade standards.

Integration-focused policies, exemplified by Poland and the Czech Republic, demonstrate the long-term benefits of aligning with global markets. These strategies leverage trade and investment opportunities while ensuring regulatory modernization. However, such approaches demand extensive structural reforms and adjustments, which may place short-term strain on less competitive domestic industries.

Balanced models, such as India's mix of self-reliance and trade integration, illustrate the potential for gradual alignment with global markets while preserving national interests. India's production-linked incentives (PLI) programs, for example, attract foreign investment in strategic sectors like electronics and pharmaceuticals while fostering local enterprise growth.

For Ukraine, these insights suggest that a hybrid approach offers the most sustainable path forward. By combining elements of economic nationalism and European integration, Ukraine can craft a strategy that maximizes benefits while mitigating risks. Targeted subsidies should focus on strategic industries, including defense and energy, to strengthen critical infrastructure and ensure national security. Simultaneously, policies should prioritize integration into EU trade structures to leverage market access and attract foreign direct investment (FDI).

A careful balance must be maintained to avoid undermining local enterprise resilience. While foreign investment is essential for modernization, overly liberalized markets could harm domestic industries unable to compete with international players. Ukraine should adopt regulatory measures that ensure FDI aligns with national priorities, particularly in sectors like IT and agriculture.

Different economic strategies are likely to have varied impacts on Ukraine's regions, depending on their industrial strengths and resource availability.

Regions with strong agricultural bases, such as Vinnytsia, Kherson, and Poltava, would benefit most from targeted subsidies in farming technologies and export-oriented production.

IT hubs, including Kyiv, Lviv, and Kharkiv, could thrive with increased investment in digital infrastructure and skill development programs, fostering innovation and creating high-value jobs.

Energy independence initiatives would likely shift investments toward regions with renewable energy potential, such as wind farms in Zaporizhzhia and Mykolaiv or solar energy projects in Dnipro and Odesa.

Developing local energy infrastructure could reduce reliance on imported energy and boost regional economies by creating jobs and fostering local industry.

By tailoring these strategies to regional strengths, Ukraine can promote balanced economic growth while addressing local needs. A hybrid approach that considers both national and regional priorities will ensure resilience and inclusivity in Ukraine's economic transformation.

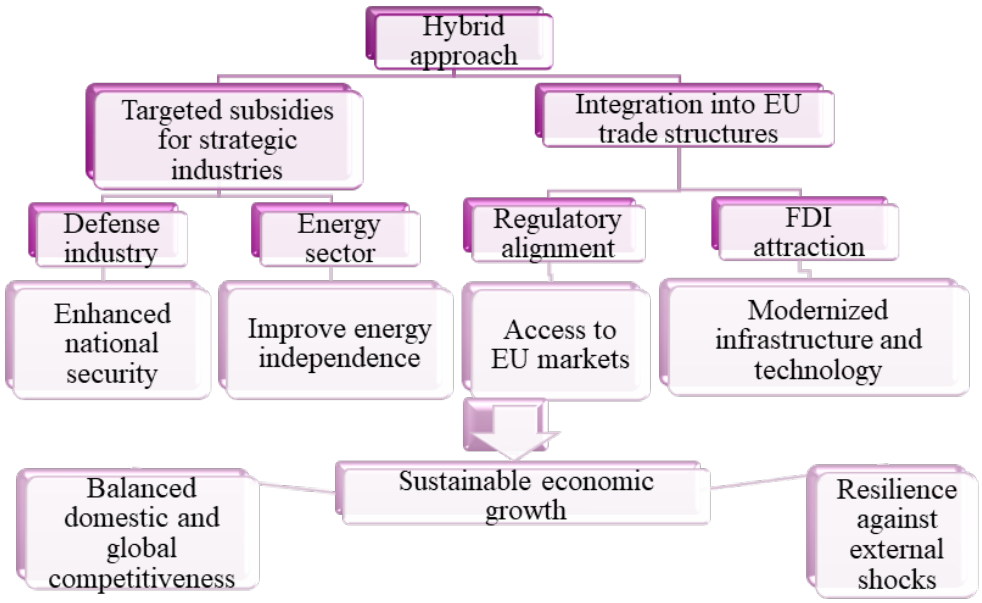
To effectively implement a hybrid approach, it is crucial to visualize how the combination of targeted subsidies and integration into EU trade structures can collectively foster sustainable growth. The flowchart below outlines the interconnected pathways of the hybrid strategy, demonstrating how support for strategic industries and regulatory alignment work together to achieve national and regional economic objectives.

The flowchart illustrates the dual impact of targeted subsidies and EU integration. By strengthening critical sectors like defense and energy through subsidies, Ukraine can enhance national security and energy independence. Simultaneously, aligning with EU trade structures and attracting FDI will modernize infrastructure, improve market access, and bolster competitiveness. This interconnected approach ensures that economic growth is not only sustainable but also inclusive, addressing both national and regional priorities. Adopting this framework allows Ukraine to balance domestic resilience with global integration, creating a robust foundation for long-term development.

The hybrid approach is not without challenges. Structural reforms required for EU integration may strain government capacity and resources, while efforts to bolster domestic industries may face resistance from global trade partners. Addressing these challenges requires a coordinated policy effort, strong institutional frameworks, and international support.

By aligning national priorities with global opportunities, Ukraine can create an economic strategy that is not only resilient but also inclusive. Targeted investments in

key sectors and regions, coupled with regulatory reforms and strategic partnerships, can drive sustainable growth, improve living standards, and position Ukraine as a competitive player in the global economy.




**Flowchart 1: Framework for Ukraine's hybrid economic strategy**

**Conclusions.** This study underscores that Ukraine's most viable economic strategy lies in a hybrid approach, blending elements of economic nationalism and European integration. Strong nationalist policies, as seen in the United States and China, offer short-term benefits for domestic industries and energy independence but risk limiting foreign investment. Conversely, integration-focused strategies, exemplified by Poland, provide long-term growth through market access and regulatory alignment, albeit with significant reform challenges.

A hybrid strategy enables Ukraine to leverage the strengths of both frameworks. Targeted subsidies for strategic sectors, such as defense and energy, can enhance national resilience, while integration into EU trade structures unlocks market opportunities and attracts foreign direct investment. This approach also addresses regional disparities, ensuring that policies benefit diverse sectors, from agriculture to IT.

By balancing domestic priorities with global engagement, Ukraine can foster sustainable growth, strengthen competitiveness, and build a resilient economy capable of meeting both national and international challenges.

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# ESCAPING THE SOVEREIGN DEBT DOOM LOOP: EVIDENCE FROM UKRAINE'S ECONOMY

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***Annotation.*** *In this scientific article, with the help of the method of simulation modeling, an attempt is made to identify the endogenous factors of the economy's exit from the debt trap. The problem of breaking the "doom loop" during the war and in the post-war period remains an insufficiently studied phenomenon due to the novelty of this phenomenon in the 21st century: the Ukrainian-Russian war is the first war of such a scale.*

*The result of writing a research paper is as follows: identification of patterns and mechanisms for overcoming exogenous negative economic shocks (debt burden) through endogenous factors of internal economic potential; construction of a macroeconomic model which allows to identify the scenario of debt burden on the country's economy under the conditions of its potential growth in export potential in wartime and post-war economy.*

***Keywords:*** *sovereign debt doom loop; system dynamics; economic growth and debt.*

**Introduction.** Sovereign debt doom loop is a relatively new phenomenon in the theory of sovereign debt, but it is gaining more and more scientific and practical importance. The world economy is experiencing a difficult period of significant growth of debt in relation to gross output "and expected to reach about 93 percent of global GDP by the end of 2024" [2]. Since Russian war invasion into Ukraine in February 2022 the level of sovereign debt has increased critically due to external borrowing from developed countries and international financial organizations, which allows to support the country's economy during war and macroeconomic instability. The economic growth of a country like Ukraine largely depends on its own export potential and relates to the possibility of entering the world financial markets for lending and export support. At the same time, external dependence on loans can lead to an increase in debts and difficulties in repayment of loans, which can create problems for the economic development of the country.

Thus, it is important to scientifically identify the factors that affect the balance of domestic and international trade for the country, but also the priority of endogenous economic development aimed at reducing dependence on external loans, because in the case of dependence, the country depends on external loans to maintain its export potential which may lead to an increase in the national debt of the country. External loans usually come in the form of loans or bonds that will need to be repaid in the future, which can lead to an increase in the country's debt burden.

The country's fiscal policy under the influence of the debt burden is under significant pressure, as the tax burden on economic entities increases (to strengthen the country's defense capability), which in turn leads to a fall in the level of consumer

spending, investment and production, which can negatively affect economic growth and employment in the country. In addition, rising taxes may also cause negative reactions from markets and investors. With the simultaneous growth of the external debt burden, this situation leads to an even greater increase in tax payments for debt service and to a decrease in the country's credit rating, which can complicate access to financing on international markets in the post-war period and worsen the country's financial stability and economic stability.

**Study analysis and problem statement.** The theory of sovereign debt makes it possible to provide a scientific explanation for the processes of accumulation and management of public external debt and its impact on macroeconomic stability and social well-being of the country.

The problem to be solved is the evolution of national welfare under the burden of external debt overhang. Excessive foreign debt indicates the resilience of the national economy in the event of external shocks, the ability to adapt in difficult economic conditions. The consequence of the existence of such debt resilience in the conditions of war can be a rapid economic rise of the economy of Ukraine after the end of the war with the corresponding breaking of the doom loop between the troubled national banking sector and sovereign debt.

Western European scientists are considered the founders of modern studies of the "sovereign debt doom loop" problem [6]. In [4,9] the relationship between banks' sovereign exposure and default incentive demonstrates a sovereign debt doom loop cycle, in which each element reinforces the influence of the others, ultimately threatening both national and international economic stability. From the point of view of system dynamics, a "self-reinforcing loop" appears, which means the following: a fall in economic indicators can lead to an increase in sovereign debt spreads and a fall in the country's sovereign ratings. As a result, the cost of borrowing on foreign markets increases, which will again lead to a drop in the economic indicators of the country's development and to possible economic crisis.

Certain aspects of the impact of the war on the growth of sovereign debt has been revealed in the article [10].

However, the issue of sovereign debt doom loop in wartime conditions is not sufficiently disclosed and needs to be studied carefully.

*The purpose of the study* is to investigate the long-term strategy of Ukraine's exit from the sovereign debt doom loop and to provide recommendations on possible improvement of the economic situation in the country while reducing the debt burden

*To achieve the research objective, the method of system dynamics simulation modeling was used,* using the principle "other things being equal", which allows to find the most important regularities in the development of the system. *Fit statistics methods were used to assess* how well a statistical model fits the observed data. Fit statistics provide a measurement of the goodness of fit of a model by comparing the model's predicted values to the actual observed values (reference mode). There are many measures we can use, such as correlation, r-squared, mean average error, and mean squared error. These

are part of behavioral tests in system dynamics and other statistical tools. We should focus on fit statistics, especially amplitude, mean, and phasing, using Theil inequality statistics to break down error into three parts.

**Study results.** According to the IMF, the national debt of Ukraine may exceed 105% in 2025, and in 2026 the dynamics of its growth will slow down somewhat [3]. Such growth has a critical negative impact on the stability of the national fiscal space, which may shrink to a critical limit soon. As of November 2024, the EU's strategic macro-financial support for Ukraine will play a crucial role in preventing such a critical contraction. At the same time, the negative dynamics of the growth of Ukraine's national debt may override such efforts (Fig. 1).


**Fig. 1. National debt of Ukraine (bln. USD)**
*Source: [11].*

According to the data in Figure 1, there is a stable trend towards the growth of the national debt. So, in 2019, the national debt amounted to 47.8 billion. US dollars, and in 2029 will reach 293.09 billion. US dollars (according to Statista forecasts). The critical increase in the national debt can be justified by complex factors, among which the military actions on the territory of Ukraine, caused by Russian military aggression and the economic crisis and instability because of such aggression, play a primary role.

Of particular concern is the extremely rapid growth of the national debt from 2022, which is again caused by Russian military aggression against Ukraine. The rapid exponential growth of loans and interest payments, in accordance with the law of the development of systemic phenomena, will be inhibited by the development of countercyclical processes due to the significant growth of GDP in the post-war and post-war periods, which is the subject of this study. A decisive role is played by the ability to maximize the mobilization of financial resources through the effective formation of

an institutional environment with the appropriate selection of tools and critical points of influence on the system to adjust fiscal rules.

**The process of modeling.** There are 5 steps of modelling, accepted in system dynamics science:

*Step 1. Definition of the issue.* The dynamic issue is formulated as: «Why the sovereign debt stock is increasing in Ukraine and is it possible to stabilize it in the long – run period of time? ».

*Step 2. Dynamic hypothesis formulation*

For this part of modelling, we construct a reference mode. The reference behavior reflects the pattern of the most characteristic and problematic variable (or group of variables) selected for analysis. The basic for analysis is the national debt in relation to the gross domestic product for 2013 – 2029 period.

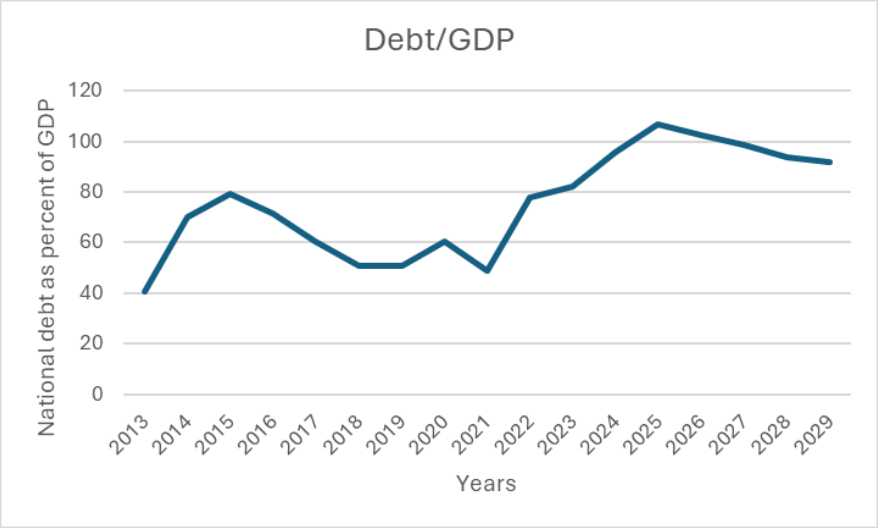


**Fig. 2. Ukraine: national debt in relation to GDP from 2013 to 2029**

*Source: [12]*

As the Figure 2 shows, the growth of the national debt to GDP will occur in the period until 2025, which roughly corresponds to various forecasts regarding the end of the war in Ukraine. After 2025, there could be a fall in debt related to the country's economic recovery with significant regaining of access to export markets lost during the war.

Figure 3 depicts a Reference Behavior Pattern for the issue (constructed in Stella Architect modelling tool), built on the base of Figure 2. As you can see, we extend the time period to 2040 for a better understanding of the processes of development of the economy of Ukraine in the post-war period. We suppose that debt/GDP ratio of Ukraine will increase again as OECD assume, that "in 2040 the global economy will be lower than in pre – COVID period" [7], which could have a negative impact on different

economies due to the highere level of external debt of individual countries around the world.

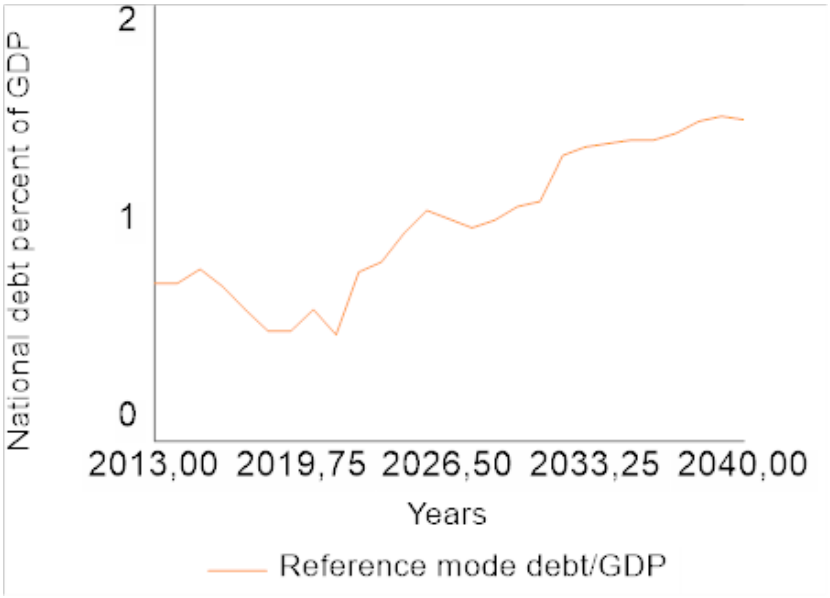


**Fig. 3. Reference Behavior Pattern**
*Source: author's development*

On Figure 3 the number 1 on vertical scale indicates 100% and number 2 – 200%

*Step 3. Constructing a model and formulating the hypothesis.*

On this step we initialize the model in steady – state, in which the inflows to the stock will equal to the outflows the outflows from the stock (Figure 4).

A hypothesis is visualized to explain reference behavior. In our case, it's a flow-generating process, so we build the co-flow model on the basis of [8, Chapter 9]. We will provide an explanation. Flows in system dynamics occur within a closed system in time. The creation of resource flows occurs with the help of the processes of generation of such flows. When we talk about creating a co-flow model, we mean developing a model that reflects the relationships between different flows within a system. The co-flow model allows us to understand how different flows are connected and how changes in one of them can affect other flows in the system. By studying the co-flow model, we can gain insight into system dynamics, identify feedback loops, and understand cause-and-effect relationships between different flows. This allows you to model the system's behavior over time and explore different scenarios to better understand how changes in one part of the system can affect the entire system.

The "starting point" model contains two stocks and one converter with relative measures: debt/GDP, economic growth rate and net export/GDP (the last one is also a stock, though presented in the form of converter). The interplay between the debt-to-

GDP ratio and the net export-to-GDP ratio may be represented as a feedback loop. The debt-to-GDP ratio indicates the total debt of a nation in relation to its gross domestic product, which serves as an indicator of economic performance. Meanwhile, the net export-to-GDP ratio reflects the balance of a country's exports and imports relative to its GDP.

When a nation experiences high debt levels compared to its GDP, it may face obligations that could deteriorate its economic stability. This situation may result in a decline in net exports, as the country may be unable to sustain high import levels, thereby diminishing its overall economic output and GDP. Such a reduction in net exports can lead to higher economic difficulties, potentially leading to an increase in the debt-to-GDP ratio.

On the other hand, the high level of net exports can stimulate GDP and economic expansion, enabling a country to manage its debt more effectively. This positive feedback loop can assist in achieving a sustainable equilibrium between debt levels and economic output.

The term "Growth rate" reveals how swiftly a country's debt is increasing or decreasing in comparison to its GDP.

The structure of the model also presents the stock of national external debt, which indicates the need to create the foundations of economic competition to stimulate the growth of export potential over time.

The growth of export potential to cover the negative burden from the debt burden should be 30% over a period of 20 years, since the critical debt burden on the economy exceeds the permissible 50% and equals around 100% of GDP [3]. The remaining 20% of the debt coverage should be due to the stimulation of endogenous potential and development and reparations from the Russian Federation to Ukraine, caused by military aggression.

The economic growth could not last forever. The average speed of export growth may cease to increase in 2030: according to ITR Economics "the next Great Depression will begin in 2030 and last well into 2036" [5]. It explains the cessation of exponential growth, based on export expansion and transition to the model of overshoot and collapse.

It is also worth noting that a significant simplification of the model is the establishment of the debt level as a constant that does not change over time.

We pointed out that foreign debt significantly inhibits economic growth in the long term, despite some stimulation of the national economy in the short term. Foreign debt puts pressure on the entire financial and economic system of the country and screens out weak economic players from the market. Inefficient enterprises or sectors of the economy are not always able to adapt to the new competitive environment. Under conditions of serious pressure from the external debt factor, such enterprises or sectors of the economy cannot withstand competitive changes and may be forced out of the market, which will lead to structural changes in the economy and possible economic growth.

Displacement of individual enterprises from the market occurs through the following mechanisms:

1. Increasing interest rates. The increase in external borrowing leads to higher interest rates and more expensive loans for private companies and the crowding out of uncompetitive companies.

"The National Bank of Ukraine has implemented a tight monetary policy" [1]. What implications will this have for Ukraine, which is currently at war?

A long-term high real interest rate can clearly have a negative impact on the Ukrainian economy, which will lead to a reduction in both investment (both domestic and foreign) and the level of consumption, which will lead to a decrease in economic potential and growth. In addition, credit risks for enterprises and individuals may increase, which may subsequently lead to an increase in the number of defaults and bankruptcies, as well as increase the risk of sovereign default because of the difficulty of accessing financing for enterprises of the national economy, a drop in the level of production and an increase in unemployment. In this case, two negative effects arise.

1. The effect of crowding out. When the external state debt increases, the purchase of shares of enterprises by investors may be replaced by government bonds, which leads to a decrease in available capital for private capital and complicates the creation of the economic potential of enterprises.

2. Endogenous macroeconomic shocks. Financial crises caused by the growth of external debt can lead to a reduction in investment and government orders for private enterprises and their displacement from the market.

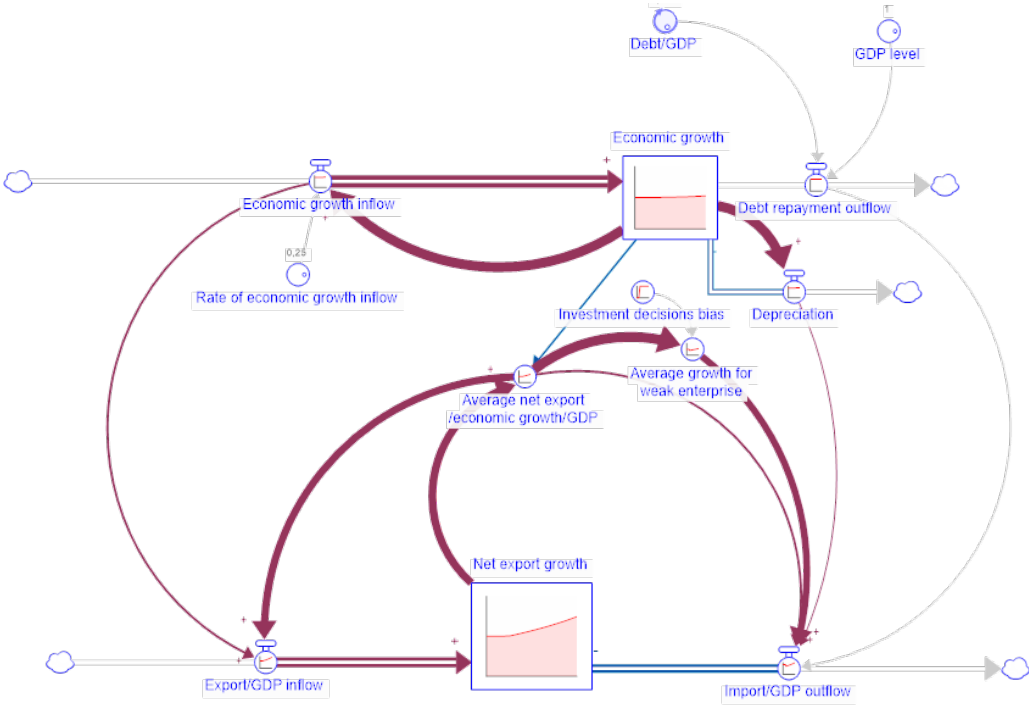


**Fig. 4. The first economic growth equilibrium model.**

We observe the steady state of economic growth at this point of analysis, though the fragile balanced state may be easily distorted by introducing some additional parameters.

The outflow of interest payments is partially contributing to the overall financial burden stemming from economic growth stocks. Companies are struggling to adjust to evolving market conditions, which hampers their ability to repay loans and subsequently invest in updating their capital assets, thereby hindering their competitiveness. Consequently, these companies risk falling behind more successful and efficient competitors in the marketplace.

The level of debt in the model is significantly lower than the level of economic growth. The latter should be sufficient to pay the former. At this stage, the debt level is set at -1, which is twice as low as the level 1 of economic growth. -1 indicates a decrease in the overall level of debt.

Interest payment outflow should be set at a level lower than economic growth - at the level of 0.05. Under these parameters, the inflow of economic growth will be equal to the outflow of economic growth and the economy will be in a steady state.

In the model, *the outflow of interest payments* is anticipated to place increased financial pressure on the economy, as these obligations must be met regardless of economic performance. This could lead to a situation where the income produced from economic expansion fails to counterbalance the interest payment outflow, jeopardizing economic stability and increasing the likelihood of falling into a debt trap. Additionally, the focus on servicing interest payments may exacerbate the challenges faced by weaker businesses, which might struggle to fulfill their financial obligations, ultimately leading to greater market consolidation and the removal of less efficient companies.

The key issue is to increase the export potential of the economic system to prevent it from falling into a new debt trap and crowding out inefficient enterprises from the market: weak, inefficient companies or industries are prone to being absorbed or displaced by stronger and more successful competitors. This can occur as a result of the processes of market consolidation, mergers and acquisitions, when large players absorb small players unable to compete on equal terms. We can integrate this logic by introducing a model variable that captures *average growth for weak enterprise,* separated from the *average interest payments outflow.*

In the proposed model, the parameter *investment decisions bias* is introduced. Regardless of the actual financial stability or attractiveness, investors prefer to invest in companies that, from their point of view, are the most attractive. This approach leads to the possibility that successful and innovative companies become "unnoticed" by potential investors. Thus, *investment decisions bias* leads to distortion of investment decisions and missing the opportunity to invest in little-known but promising companies.

Also, a new variable *average growth/weak enterprise* is introduced into the model, because of the activities of the inefficient enterprises described above. After the introduction of this variable, economic growth maintains its steady state with export growth. At the same time, after the possible expansion of the time horizon, exports will begin to significantly lag economic growth. This indicates the possibility of a gradual reorientation of the national economy to an internal (endogenous) type of economic development. If the planning horizon is increased to 18 years, the number of inefficient enterprises may increase significantly, by approximately 1.5. times This can be explained by the action of other factors that are not included in the model. We can assume that the

country pays insufficient attention to innovative renewal, which leads to a long-term deterioration of its economic condition.

As *net export growth* occurs, with the debt parameter unchanged, the number of inefficient enterprises should decrease. The graph with average growth per weak enterprises indicates that the number of inefficient enterprises initially remains unchanged (for about three years), after that it rapidly decreases by about 10%, after which it increases slightly and remains within the "steady state" during the entire studied time interval (Figure 5).

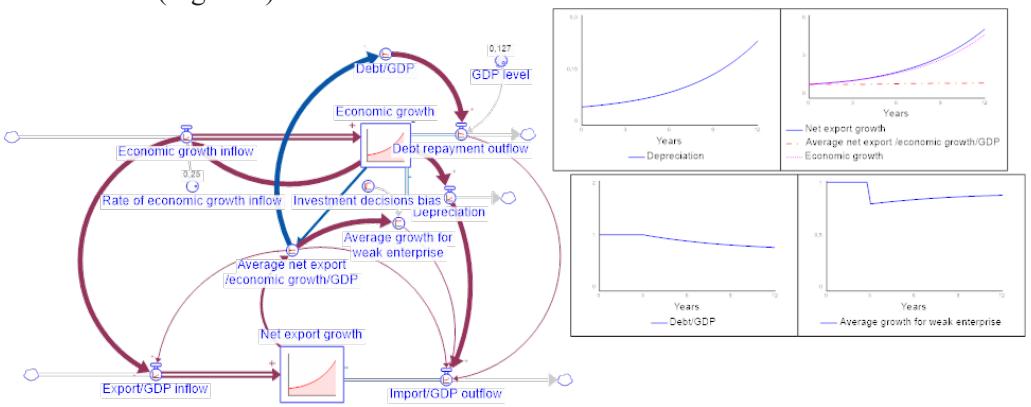


**Fig. 5. Model of exponential economic growth and exponential growth of exports**

This model is too optimistic, as it indicates exponential economic growth against the background of a fall in the debt/GDP outflow parameter. There is also a drop in the *debt repayment outflow* indicator that is unsatisfactory for this stage of the analysis.

The number of inefficient enterprises per unit of debt is decreasing and stabilizing thanks to the growth of export potential. The debt/GDP ratio is declining as export potential increases and the number of inefficient enterprises is relatively stable. A concern is the level of debt interest payments, which cannot be reduced despite economic growth.

*Final modelling part:*

To transform the above mentioned optimism into more realistic scenario we need to admit, that in the case of Ukraine its economy is completely depended on external loans, at least in the short run. While economic growth can be financed through external borrowing in the short term, over-reliance on external borrowing could create vulnerabilities that affect long-term growth and sustainability. These economies must strike a balance between borrowing and strengthening domestic economic strength to ensure that they do not become overly dependent on external financing. To present a realistic development scenario we are forced to replace the economic growth stock with debt/GDP to emphasize the fact that the main problem lies in the level of foreign debt, which does not allow the economy to achieve a high level of growth.

The following variables were added to the model: rate of economic growth was added to economic growth inflow (determines how quickly the economic growth inflow may occur) along with economic growth capacity (determines the highest sustainable rate of economic growth that a system can attain is determined by a range of factors, including available resources (including external financing), infrastructure, technological

advancements, and policy frameworks).

The variable *lack of investment* resources reflects the challenges posed by economies' ability to invest in growth-enhancing activities. Against the backdrop of existing debt levels, it becomes clear that economies must maintain a precarious balance between managing debt and creating an environment conducive to domestic and foreign investment. The variable *Investment climate* represents the overall attractiveness of an economy for investment and can affect the availability of financial resources to pay interest.

Compared to Figure 5, which shows the exponential growth of exports, Figure 6 shows a more moderate growth in exports.

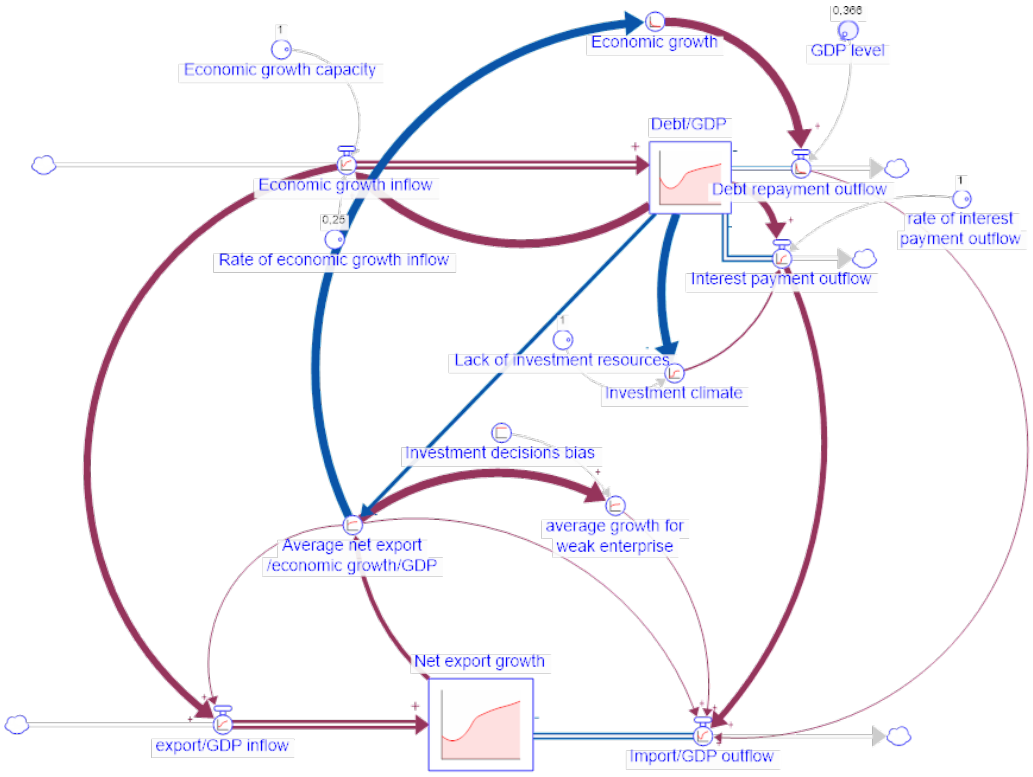


**Fig. 6. Final model of debt/GDP stock and moderate net export growth stock.**

*Step 4. Testing a model*

On this step we use fit statistics module in Stella Architect to test the model. Fit statistics (goodness of fit) is a behavioral reproduction test. It provides important quantitative metrics for evaluating model performance and ensures that the model's structure and parameters accurately represent the dynamics of the real system.

The way we want to approach it is to include fit statistics, paying attention to features of amplitude, mean and the phasing. Theil inequality statistics is a way to do that.

The question is how to obtain a reasonable fit between reference behaviour pattern (Figure 3) and simulated data (Figure 6). To do this we add the module called Debt/GDP

fit where we compare Reference mode debt/GDP with Debt/GDP (simulated value). The fit statistics module structure is presented on Figure 7 upper panel. On the Figure 7 lower panel we present the graphical results of goodness of goodness of fit results. The simulated behaviour and reference mode have the same general shape, though they don't match perfectly.

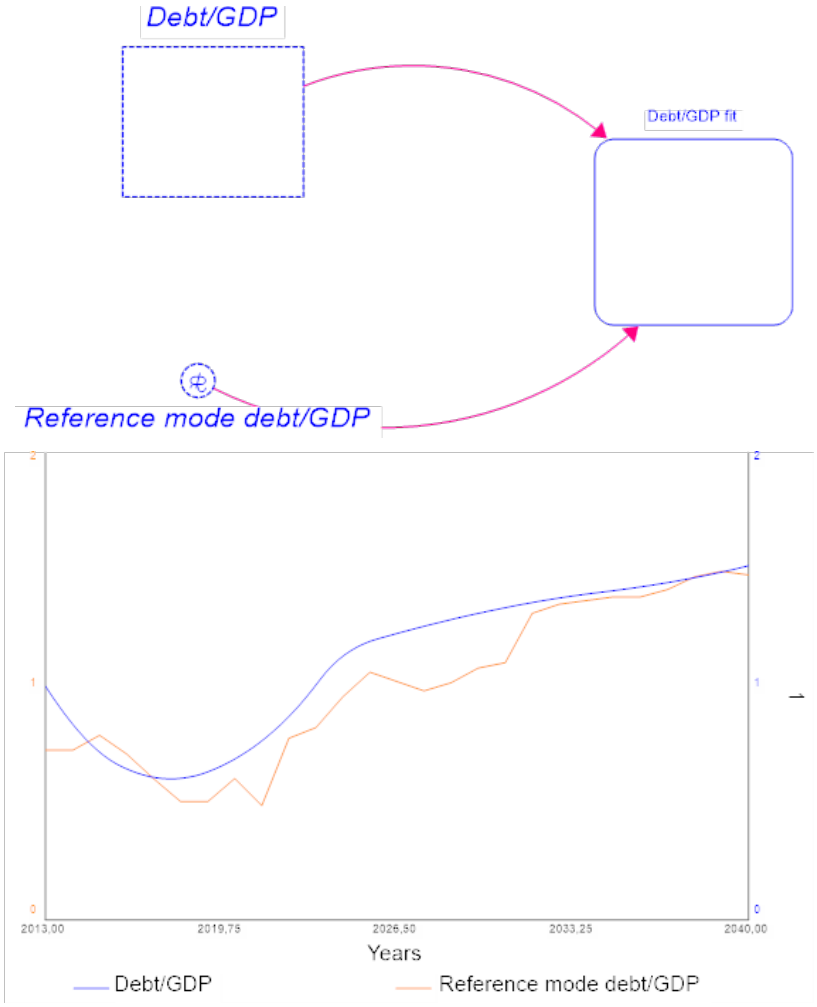


**Fig. 7. Fit statistics module and goodness of fit results.**

The actual fit statistics calculation is presented in Table 1. with the norm of correlation, R – squared; mean squared error (MSE) along with three inequality statistics: Um is looking for mean structure; Us as a measure of standard deviation amplitude; Uc a measure of phasing.

The results of testing are quite good with a correlation of 0,952 and R squared 0,907. The errors are decomposed, and we see that most of the errors are in mean structure (Um). Step 5. Policy design and evaluation.

*Table 1*

**Numeric goodness of fit results**

| | |
|---|---|
| Debt/GDP fit."Correlation.XsimXobs" | 0,952 |
| Debt/GDP fit.Rsquared | 0,907 |
| Debt/GDP fit.MSE | 0,0209 |
| Debt/GDP fit.Um | 0,529 |
| Debt/GDP fit.Us | 0,00611 |
| Debt/GDP fit.Uc | 0,464 |

We have chosen the following policies (leverage points to intervene in the dynamic structure with appropriate structure redesign) available for further research.

- Debt restructuring mechanism. Effective debt restructuring involves not only its postponement, but also managing the strategy of economic growth, considering the temporary reduction of the debt burden

- Economic growth strategies. We believe that in the long term, an import substitution strategy is important, in contrast to an effective short-term export promotion policy, which can create an endogenous boost to GDP growth and decrease sovereign debt level

- Macroprudential policy. Policies may be formulated to promote a more sustainable balance between public and private debt, potentially incorporating restrictions on the volume of short-term debt that can be issued.

- Partial (at least) debt writing off, which will lead to the release of economic resources for the post-war renewal of the economy

- Reduction of the tax burden in the post-war period, which allows the national economy of Ukraine to reduce the expenses of enterprises and increase their economic efficiency.

**Conclusions:**

- The sovereign debt doom loop underscores the relationship among escalating debt levels, economic metrics, and heightened borrowing expenses, especially in the context of wartime scenarios. For Ukraine, a continued dependence on external financing threatens to intensify its economic difficulties.

- Using the method of system dynamics, a model of partial equilibrium of the economic system has been built (equilibrium of economic growth against the background of export growth). It was theoretically approved that the national economy may simultaneously achieve economic growth steady state and export which contributes to sovereign debt relief.

- Goodness of fit results (Debt/GDP reference mode with Debt/GDP simulated model) have approved the reliability of modelling.

- Policy design and evaluation for assessing Ukraine's post-war potential growth driven by export potential and external borrowing effects has been provided.

- The practical implication of sovereign debt doom loop issue is to provide proactive actions to facilitate sovereign debt resilience and foster economic stability because of making recommendations for Ministry of Finance of Ukraine, National Bank of Ukraine

and other governmental institutions in their coordination with international financial institutions.

- Further research will be devoted to the implementation of the scenario approach to the above developed model of sovereign debt.

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# EUROPEAN PRACTICE OF ASSESSING SOCIAL PROTECTION IN THE CONDITIONS OF A RESILIENT ECONOMY

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***Annotation.*** *Analysis of approaches, indicators and criteria for determining the impact of Social services on the Global economy socialization revealed the need to improve existing methodological approaches with the need to shift emphasis to assessing the economic component and effects of the Social services provision both at the level of the Global economy and national economic systems. The study of methodological approaches to assessing Social protection of the population in Ukraine revealed a number of challenges both in the national methodology, established by law, and in alternative methods developed with the assistance of international and foreign institutions, in particular the European Commission. Ukraine needs to improve methodological approaches to the assessment of Social services, where special attention should be paid to establishing their impact on the socialization and resilience of global and National economies.*

***Keywords:*** *social protection, social security, resilient economy, socialization of the global economy, method of evaluating social services, social standards of the EU, indicators of the development of the social sphere.*

**Analysis of Recent Research and Publications.** Studying the experience of evaluating Social services makes it possible to claim that it is aimed more at evaluating the quality of providing the mentioned services and satisfying the social needs of consumers from receiving them, and the components of evaluating the effect of such services on the economy and resilience are of a secondary nature. Assessment of Social services mainly occurs at the level of state institutions, while non-state institutions can only evaluate any segment of social protection or their own activities.

Yu. V. Goremykina suggests using expert assessment of Social services, in which users and social workers serve as the experts. It is recommended that assessment be carried out at three levels: central level (state), territorial level (territorial unit) and social service level. The main groups of assessment parameters are: quality assessment of Social services provision; assessing the quality of receiving Social services; assessment of the provision of resources for the Social services provision [1, p. 123].

The study of Yu. V. Goremykina's methodological approach in assessing Social services makes it possible to point out the disadvantages of the mentioned process: the complexity of conducting the assessment due to its multi-level nature and the amount of information that requires processing; high level of subjectivity due to the emphasis only on expert assessment; insufficient detail of parameters and criteria for assessing Social services; the influence of Social services on the socialization of the national and Global

economy is not taken into account.

S. Shcherban, R. Sheiko, G. Levkina propose the assessment methodology that can be used for internal assessment of Social services, as well as the Social services provision in a certain territory or in the state as a whole.

Evaluation indicators are divided into three groups:

– For the social service (material and technical base; financing; working conditions; training / qualifications of personnel; psychological climate in the team; quantity, quality and efficiency of Social services provided; accessibility of Social services);

– For a separate territorial unit (level of satisfaction of users of Social services; market conditions for Social services; efficiency of meeting demand; compliance with legislative and regulatory requirements; program planning; efficiency of use of budget funds; reputation; cooperation and communication; awareness and transparency);

– For the state in general (meeting the needs for Social services; coverage with Social services; compliance with international norms and standards of social protection; awareness and transparency).

Institutions of central and local authorities, as well as public organizations, can conduct assessments using the proposed methodology. Methods of collecting information to evaluate Social services should be: mass survey; in-depth interview; focused group interview; observation; document analysis; tactics of qualitative research and the use of case studies (research tactics that involve a thorough analysis of a specific case, social group or organization through the use of qualitative research methods) [2, p. 10].

The methodology for assessing Social services, developed and proposed for use by S. Shcherban, R. Sheiko, G. Levkina, also has some shortcomings: the lack of clear criteria for assessing Social services; limited number of parameters for assessing social protection at the state level; insufficient consideration of the impact of Social services on the socialization of national and global economies; emphasis on state and municipal Social services; insufficient attention to the economic parameters of the Social services provision and the economic effects of consumption of such services.

The study of approaches, indicators and criteria for assessing Social services makes it possible to indicate that existing methodological developments require improvement with a shift in emphasis from assessing the quality of services to economic efficiency and influence on the socialization of global and National economies. This requires the development of new methodological approaches to assessing Social services and diagnosing such services at the global and national levels.

**Research results.** The most notable efforts to assess the impact of Social services on society, the quality of life of the population and economic systems in the countries of the European Union. Taking into account the de facto confederation approach to the formation of an interstate entity, the evaluation of Social services in the EU is carried out mainly at the level of individual countries that can actively use the achievements of other EU member states.

In France, quality standards and assessment tools are legally established, carried out by the Agency for the Assessment of Social services. However, the emphasis is on the

quality of their provision. Providers of Social services belonging to non-state institutions must establish accreditation, obtain certificates and periodically confirm them through the assessment procedure. Particular attention in the assessment of Social services is paid to the study of the professional skills and competencies of social workers. State and non-state institutions, service users and service personnel (social workers) of social institutions/services take part in the processes of improving methods for assessing Social services. Self-assessment and the involvement of independent experts in the assessment of Social services has limited application [3, p. 230].

Germany, at the federal and local levels, has legislated standards for the assessment of Social services (SGBXI), noting the assessment of Social services by state and municipal institutions. At the same time, the areas of verification and assessment are clearly demarcated between the relevant government institutions.

The country has developed the German Social Insurance Code, which defines the minimum parameters for assessing Social services: availability of services; communication with service recipients and between social service employees; working conditions of social workers; skills and competence of social workers Federal and local government institutions, non-state institutions, service users, and social workers take part in improving methods for assessing Social services. The assessment is mainly carried out comprehensively for individual providers/providers of Social services based on a scoring system (Pflegenoten). Service providers (self-assessment) and external experts also participate in the assessment of Social services, but such the assessment is not mandatory [3, p. 218].

In Poland, in the absence of special legislative support for regulating the assessment of Social services, only a few regulations are in force for certain types of Social services. At the same time, social service providers must have ISO certificates. The Quality Monitoring Center operates in the country, but it does not specialize in Social services. In Poland, there are no uniform parameters for assessing Social services. Mostly state institutions are involved in improving methods for assessing Social services, with little cooperation from non-state institutions. Service users and social workers are excluded from the process of assessing and improving Social services [3, p. 228].

Romania has introduced special standards for assessing Social services. For the Social services provision, a standard for assessing such services (EQRM) is in force and the accreditation procedure has been introduced. The following parameters are assessed:

• service availability; conditions for staff (social workers); qualifications and level of education of personnel. State and non-state institutions, as well as users of such services, take part in improving methods for assessing Social services (social workers are not involved in this process). Social service providers may, at their own discretion, conduct the internal assessment, but the information they receive as a result of the assessment has the right not to be made public [3, p. 219].

In Spain, criteria and procedures for assessing Social services are established at the legislative level. The assessment is mainly carried out by central authorities and local governments. Information on the results of the procedure is available to the

public and recipients of services and may become a basis for refusal to engage relevant organizations in the future in the Social services provision. The parameters for assessing Social services are mainly introduced by local governments and are quite different. The emphasis is made on the significance of assessing the working conditions of staff and the level of qualifications of social workers. Authorities of central government and local self-government, non-state institutions, including providers of Social services, users of services and their relatives, social workers take part in the processes of improving methods for assessing Social services [3, p. 228].

In Sweden, social service providers participate in tenders for their provision. Important in this process is the accreditation of social service providers and the assessment of activities for the previous period according to legally established criteria. Information on the evaluation of Social services is publicly available. Regulations are developed by the National Health and Welfare Board and assessed by the National Health and Welfare Office. The Open Comparison project operates in the country that makes it possibleers of such services and their relatives to be involved in the evaluation of Social services and their providers. The conclusion is drawn on the following parameters of Social services: ensuring quality of life (well-being, well-being); availability of services; personnel competence; continuity of service; conditions for the Social services provision; results of receiving Social services by consumers State and non-state institutions, as well as service users, take part in the process of improving methods for assessing Social services [3, p. 225].

The Swedish methodology for assessing Social services is based on compliance with five principles:

– Reducing the variability of the obtained indicators in relation to a certain standard;

– Obtaining certain planned effects of social and social protection;

– Achieving the declared strategic and tactical political goals (within the framework of social policy);

– Meeting the requirements of users and giving priority to their requirements in improving social protection;

– Formation of an appropriate organizational structure of the system for providing Social services [4, p. 38].

Considering that the assessment of Social services in Sweden is focused on studying their quality, there are three types of quality of such services:

• Structural quality concerns resources, personnel and their level of competence, the location of service delivery and the number of groups of people requiring social protection;

• Procedural quality includes the implementation of services - labor conditions, attitude towards clients, working climate;

• The quality of the results determines the goals of the organization (social service) and whether the results correspond to the official (stated, planned) objectives of social policy [5, p. 82].

In the UK (England and Scotland), the assessment of Social services occurs at the

level of government institutions - national verification authorities: in Great Britain - this is the Quality Care Commission, in Scotland - the Social Security Regulatory Commission. National social protection standards are applied and the “Best Value” approach is being implemented, in which local authorities, based on long-term population development forecasts, introduce changes to the social service delivery system to ensure sustainable and high-quality provision of such services. The assessment of Social services is carried out by local governments, with the emphasis on the following indicators: implementation of state social protection programs; management of public resources, as well as financial ones, provided to communities to solve the social problems of their inhabitants; responding to the social needs of communities and individual members; verification of social service providers. Social service providers shall be registered with government inspectorates that accredit their activities and issue social work licenses. Moreover, such verifications regularly (with or without notification) check social service providers. The key evaluation parameters are consistency of services; access to services; the resulting effects from the provision of services (negative or positive); training and competence of social workers; lack of people among social workers who were serving criminal sentences. In Great Britain, since 2008, a rating of the quality of Social services has been published. The maximum number of participants is involved in improving methods for assessing Social services: state authorities, local authorities, users and members of their families, customers of Social services, providers of Social services, social workers, independent experts [3, p. 228].

In England and Scotland the following indicators for assessing Social services are used:

– Improving the health and emotional well-being of people requiring social protection;

– Improving the quality of life (well-being, well-being);

– Positive contribution to social protection (individual, household, group of people, organization, enterprise);

– Selection of Social services and control over their provision;

– Elimination of discrimination in the Social services provision (freedom from discrimination);

– Economic well-being (increased income and decreased expenses, other types of economic benefits for people having social problems );

– Ensuring the protection of personal dignity and respect for human rights when providing services (applies to both service recipients and social workers) [6].

The Production of Welfare (POW) approach is used to evaluate Social services in the UK. According to this approach, the process of providing, consuming and obtaining results from the consumption of such services is distributed, and therefore they are assessed according to the following indicators: input resources (how much, how much they cost, when it is necessary to attract them); incoming components, but not resources (characteristics of the user, social service, social worker; competition between recipients and service providers, etc.); service parameters (availability, features, delivery schedules,

etc.); final results (short- and long-term results for the recipient, the provider of services, as well as other subjects of the system for the Social services provision) [7, p. 568].

Also in the UK, when assessing social services, the experience of the European Union and the UN in implementing the Performance and Accountability Framework (PAF) is taken into account, and other assessment methods are used.

The Baltic countries (Lithuania, Latvia, Estonia) are at the stage of reforming their system of providing Social services according to European Union standards, in which the key characteristics of services are quality and cost. The assessment of Social services is based on methodologies proposed by the European Foundation for Quality Management (EFF) and the European Foundation for Quality Management (EFQM). The main parameters of this methodology are as follows: leadership; staff; partnership; complexity; results orientation and continuous improvement; defining and implementing the vision, mission and values of the social service; long-term definition of quality goals; customer reviews; attraction of personnel and their competence; protection of fundamental rights and freedoms of service recipients; ensuring the beneficiary's right to self-determination; respect for ethics; providing support, expanding user capabilities; performance assessment [8, p. 167].

In addition to the national practice of assessing Social services, several common methods are used in the European Union. EU member countries can use the proposed methods without making changes or supplementing them in accordance with the peculiarities of the development of their own systems for the Social services provision.

In 1992, the European Foundation for Quality Management (EFF) developed the Social services Quality Assessment Model (EFQM). This model is focused on assessing the quality of Social services provision by Social services and contains the following indicators: organization of work and management in the social service; identifying and meeting consumer needs; quick response to changing consumer needs; building a dialogue with consumers; organizational effectiveness; the work of individual workers and personnel as a whole; the organization's potential and its implementation; quality culture in the organization The model is based on a combination of external audits and self-assessment and is aimed at improving the functioning of Social services, as well as the quality of Social services [9].

In EU member countries, the public service organization assessment model (BVM) is also used. The given model is aimed specifically at assessing the activities of state institutions, which include some Social services. The model has the following limitations: assessment of government institutions only; focus on assessing the work of Social services without taking into account the assessment of service to consumers of Social services.

The main areas of application of the BVM model:

1) Identification and study of the unique characteristics of government institutions, including Social services;

2) Searching for ways to improve the performance of state institutions, taking into account the peculiarities of the functioning of state-owned organizations;

3) Combination of different approaches to quality management in order to obtain better results;

4) Comparison of public sector organizations with private organizations or enterprises, including in the social sphere. The main groups of parameters to be assessed are input resources and flows, including costs; process and change management; key results of the work. The BVM model can be used both by regulatory authorities (assessment and monitoring of the activities of Social services) and directly by Social services (self-assessment) [10, p. 5-7].

In the European Union, the SERVQUAL methodology, developed in 1990 by V. Zeithaml, A. Parasuraman and L. Berry to assess production quality, is also used to evaluate Social services. Subsequently, business entities began to implement SERVQUAL in assessing the quality of services provided to clients.

The methodology is based on active interaction with consumers of services, which makes it possible to establish the level of quality of service provision by examining the satisfaction of their hopes for the consumption of the relevant service provided by a specific organization/enterprise. Assessments are made according to five parameters: perceptibility; reliability; responsibility; confidence; sensitivity. The limitations in using the SERVQUAL methodology to evaluate Social services are its emphasis only on quality; subjectivity through interaction with consumers; large volumes of information processing; the need to adapt to the conditions of the social sphere.

The most common methodology for assessing Social services in the European Union is the methodology developed by the Europethe quality Reference System (EQUASS). It is based on ensuring the ten leading principles of social work adopted in the EU: leadership, people, rights, ethics, partnership, participation, people-centred, complexity, results-oriented, continuous improvement. The main evaluation criteria in the methodology are: identification of key needs and expectations of users/consumers of Social services; processes for managing the development and Social services provision, as well as directly Social services (institutions, organizations, enterprises); responsibility management both at the level of Social services (institutions, organizations, enterprises) and individual workers (social workers); resource management, including financial; construction and implementation of processes and systems for measuring and analyzing data; level and quality of meeting the needs of users/consumers of Social services; system for continuous improvement of the quality of Social services.

The key limitation of the methodology is its focus on the quality of Social services provision. Social services (institutions, organizations, enterprises) can, based on the results of the verification according to the methodology, receive a certificate of conformity [11].

In the European Union, the evaluation of Social services uses the Performance and Accountability Framework (PAF), developed by the UN (The Central Emergency Response Fund, CERF). CERF mechanism is carried out to ensure more timely and reliable provision of humanitarian assistance to victims of natural disasters and armed conflicts. PAF aims to assess: timeliness of care; organization of assistance; use of the

financial and other resources; efficiency and effectiveness of care delivery; level of satisfaction of beneficiaries; absence of abuse in the provision of assistance and targeted use of provided resources.

The mechanism of efficiency and accountability makes it possible to build a transparent system for providing assistance (Social services) and formulate clear evaluation criteria without increasing bureaucratic procedures and the time required to provide assistance (Social services).

In Ukraine, there is a process of reforming the system of providing social services, which contributes to the emergence of different approaches to the assessment of such services, including within the framework of assessing the impact on the socialization of global and national economies. The assessment of social services is based on regulatory documents, the fundamental of which are the Methodological Recommendations for Monitoring and Evaluating the Quality of Social Services (12/27/2013).

The state methodology is designed to provide the quality assessment of social services provided by state and municipal social services, as well as other institutions (commercial and non-profit) that use budget funds.

The main assessment parameters are as follows: targeting and individual approach; effectiveness of service delivery; timeliness of social protection; availability; transparency of service provision; convenience for consumers of services; respect for persons in need of social protection; professionalism of social service employees.

Authorities monitoring the process of providing social services are recommended to use the following assessment methods: survey (questionnaire); monitoring the provision of social services; conversation with social workers; research of documentation, including complaints from users of social services.

The assessment is carried out on the basis of assigning points and using evaluation criteria for each of the parameters ("Good", "Satisfactory", "Unsatisfactory") as a percentage of the basic value of the parameters. The assessment is proposed to be carried out by local authorities (with the participation of service users and members of the public) and directly by social service providers (self-assessment) [12].

Critically examining the Methodological Recommendations for monitoring and assessing the quality of social services, a number of shortcomings in the proposed methodology were identified. There is no mandatory assessment of social services that provide social services without using public funds; insignificant participation of service recipients in the assessment procedure; emphasis only on the quality of service provision; lack of economic component of the assessment; performance indicators are not disclosed, including at the level of the national and global economic system.

Considering the complexity of the process of reforming the social protection system and the provision of social services in Ukraine, we note the presence of alternative methods for assessing social services, even those developed with the help of international organizations and foreign institutions.

With the help of the European Commission and the U LEAD program in Ukraine, Methodological recommendations for planning and organizing the provision of social

services were developed and proposed at the level of local communities, an important element of which is the methodology for assessing the provision of social services.

It was proposed to calculate the aggregate index of provision of social services to the population.

This contains the following indices (groups of parameters): provision of social services to children and families with children (13 assessment indicators); provision of alternative care services for orphans and children deprived of parental care (7 assessment indicators); provision of social services to older people (5 assessment indicators); provision of social services to persons with disabilities (7 assessment indicators); provision of adaptation and integration (reintegration) services (7 assessment indicators); environmental safety and provision of services to victims of violence (7 assessment indicators). The score is set from 0 (worst level) to 100 (best level) points. The share of parameters (indicators) and indices in the Aggregated Index is the same.

When examining the approach to assessing Social services proposed by the group of developers of the U LEAD program in Ukraine, one should point out its shortcomings:

• Insufficient attention is paid to the quality of service provision;

• Lack of deep disclosure of the economic aspects of the Social services provision;

• Influence of Social services on the socialization of the national and Global economy is not taken into account;

• Issue of assessing the effectiveness and efficiency of the Social services provision needs to be improved;

• Inadequate participation in the assessment of service users.

**Conclusions.** Analysis of approaches, indicators and criteria for determining the impact of Social services on the Global economy socialization revealed the need to improve existing methodological approaches with the need to shift emphasis to assessing the economic component and effects of the Social services provision both at the level of the Global economy and national economic systems.

Among the peculiarities of the quality assessment of the Social services provision in the European Union, the following should be highlighted:

– Development of the same fundamental rules for the provision and assessment of Social services;

– Emphasis on accreditation and licensing of social work and social workers, both state-owned and those working for private companies;

– Involvement in the assessment of quality standards, in particular from business activities;

– Variety of approaches, indicators and criteria for evaluation of Social services;

– Division of assessment by types of Social services (Social services for the elderly, homeless women, children, etc.);

– Constant improvement of the methodology and expansion of evaluation criteria with the emphasis on determining the quality and efficiency of the Social services provision;

– Critically insufficient attention to the assessment of the interaction of the system

of providing Social services with economic systems and the impact of Social services on the socialization of the economy.

The study of methodological approaches to assessing Social services in Ukraine revealed a number of challenges both in the national methodology, established by law, and in alternative methods developed with the assistance of international and foreign institutions, in particular the European Commission. Ukraine needs to improve methodological approaches to the assessment of Social services, where special attention should be paid to establishing their impact on the socialization and resilience of global and National economies.

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# GLOBAL EXPERIENCE IN APPLYING LONG-TERM CONTRACTS IN ROAD MANAGEMENT AND PROSPECTS FOR THEIR ADAPTATION IN UKRAINE

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***Annotation.*** *The aim of this article is to analyze the global experience in applying long-term contracts in road management and evaluate the prospects for their adaptation in Ukraine. Considering the current challenges faced by Ukrainian infrastructure, this study seeks to identify the most effective contract models that can be implemented to improve road quality, optimize costs, and enhance transparency in the road sector. In countries with well-developed road infrastructure, long-term contracts have become a crucial tool for ensuring quality construction, operation, and maintenance of roads. These contracts help reduce risks for public authorities by attracting private investments and increasing accountability among stakeholders. Ukraine, struggling with insufficient funding and outdated road management mechanisms, requires innovative approaches that could be adapted from international practices.*

***Keywords:*** *long-term contracts, road management, PPP (public-private partnership), road operation, global experience, adaptation, Ukraine.*

Long-term contracts in road management refer to agreements between public authorities and private entities aimed at ensuring the construction, maintenance, and operation of road infrastructure over an extended period, typically spanning 10 to 30 years. These contracts often integrate various forms of public-private partnerships (PPP), including Design-Build-Finance-Operate (DBFO) and Build-Operate-Transfer (BOT) models. The primary objective is to distribute risks and responsibilities effectively between the public and private sectors, ensuring sustainable infrastructure development [1].

The research methodology applied in this study is based on:

1. Literature Review: Analysis of global practices in long-term road management contracts from countries with successful implementation, such as the UK, Germany, and Brazil [2].
2. Comparative Analysis: Examination of similarities and differences in contractual frameworks between developed and developing countries.
3. Adaptation Framework: Exploration of how successful global models can be tailored to Ukraine's specific economic, legal, and infrastructural context [3].
4. Case Studies: Review of real-life examples of long-term contracts in road infrastructure to identify best practices and common challenges [4].

In developed nations, long-term contracts in road management have become a key element of sustainable infrastructure development. For example, the United Kingdom has successfully utilized DBFO (Design-Build-Finance-Operate) contracts for major

highways, allowing for cost-effective construction and long-term maintenance [1]. Similarly, Germany applies performance-based contracts, where private companies are incentivized to maintain road quality over an extended period [2]. These examples illustrate the benefits of long-term contracts in reducing lifecycle costs and ensuring infrastructure sustainability.

In countries like India and Brazil, long-term contracts have also been implemented, although with modifications to suit local needs. India's Hybrid Annuity Model (HAM) combines government funding with private investments, reducing financial risks for contractors while ensuring timely project execution [3]. Brazil employs Build-Operate-Transfer (BOT) contracts to attract investments in its vast road network, demonstrating the adaptability of these models in different economic contexts [4].

Public-Private Partnerships (PPP) are at the core of long-term contracts in road management. These arrangements allow governments to leverage private sector expertise and financing for infrastructure projects. For example, PPPs have been instrumental in European road projects funded by the European Investment Bank, emphasizing clear accountability and risk-sharing mechanisms [2]. While PPPs are well-established in developed economies, their successful implementation in developing countries often requires overcoming challenges such as weak regulatory frameworks and financial instability [1].

Benefits:

- cost Efficiency: Long-term contracts distribute costs over their duration, minimizing immediate financial strain;
- road Quality: Performance-based structures ensure consistent quality over time;
- risk Sharing: Responsibilities are divided between public and private sectors, reducing risks for both parties.

Challenges:

- financial Barriers: Significant initial investments can limit private sector involvement;
- regulatory Issues: Many countries lack the necessary legal frameworks for effective implementation;
- monitoring Requirements: Ensuring compliance over decades necessitates strong oversight mechanisms.

Ukraine's road infrastructure is characterized by significant challenges, including aging networks, inadequate funding, and insufficient maintenance. Nearly 90% of the country's roads are in unsatisfactory condition, with many requiring urgent repairs and modernization [1]. The introduction of the State Road Fund in 2018 was a positive step, but the financing gap remains substantial, hindering sustainable development [2].

At present, Ukraine relies predominantly on short-term contracts for road construction and maintenance. These contracts prioritize immediate fixes over long-term planning, leading to frequent repairs and increased lifecycle costs [2]. Furthermore, the absence of performance-based incentives limits accountability and results in subpar road quality [3].

The Ukrainian legal framework for long-term contracts and PPPs in road management is still underdeveloped. Key barriers include:

Legislative Gaps: The lack of comprehensive regulations for PPPs in road infrastructure.

- Institutional Weaknesses: Limited capacity within government agencies to design and monitor long-term agreements effectively

- Political Risks: Inconsistent government priorities and instability reduce the attractiveness of Ukraine's road sector to private investors [4].

Ukraine can leverage international expertise and build on its existing reforms to implement long-term contracts. Recommendations include:

- legal Reforms: Developing a regulatory framework tailored to PPPs and long-term road management contracts;

- capacity Building: Providing training for public officials on the negotiation, implementation, and monitoring of such contracts;

- international Partnerships: Collaborating with global institutions such as the World Bank and European Investment Bank to secure technical and financial support [5].

Ukraine can benefit from adapting successful international models of long-term contracts in road management. Two promising approaches include:

- performance-Based Contracts (PBC): In Germany, such contracts incentivize contractors to meet predefined performance standards, ensuring high-quality maintenance over the contract's duration. The UK employs similar mechanisms, where payments are tied to meeting service-level agreements (SLAs). These models can be adapted in Ukraine to address the inefficiencies of reactive, short-term repairs [2];

- hybrid Annuity Model (HAM): Successfully implemented in India, HAM integrates government funding with private investments, where the government covers a significant portion of the project cost during the construction phase. This model reduces financial risks for contractors while ensuring project delivery timelines. Given Ukraine's budgetary constraints, this approach offers a practical solution for large-scale infrastructure development [3].

Advantages of Long-Term Contracts for Ukraine:

1. Lifecycle Cost Savings: By focusing on long-term planning, contracts reduce frequent, costly repairs and optimize total expenditures over the asset's lifecycle [2].

2. Improved Road Quality: Performance incentives encourage contractors to maintain high standards in construction and maintenance, ensuring longer-lasting roads and fewer disruptions for users [4].

3. Attracting Foreign Investments: Predictable revenue streams and risk-sharing mechanisms inherent in long-term contracts make Ukraine's road sector more attractive to international investors [5].

4. Enhanced Accountability and Transparency: Long-term contracts establish clear roles and responsibilities, reducing risks of mismanagement and corruption often associated with short-term projects [4].

Challenges in Implementation: Despite the potential benefits, several challenges

may arise during the implementation of long-term contracts

1. Financial Barriers: Limited fiscal resources might restrict the scope of initial projects. International financial institutions, such as the World Bank and the European Investment Bank, can play a key role in providing funding and technical assistance [5].

2. Regulatory Gaps: Ukraine's existing legal framework does not fully address the requirements of long-term public-private partnerships. Comprehensive legislative reforms are needed to enable the effective implementation of such contracts [4].

3. Institutional Capacity: Government agencies require technical expertise and training to negotiate, monitor, and enforce long-term agreements effectively. Without this, contracts may fail to deliver intended outcomes [3].

4. Public Perception: Resistance from stakeholders, including the public and small contractors, may arise due to concerns over privatization and foreign involvement in road management.

Opportunities for Improvement:

1. Pilot Projects: Ukraine should begin with pilot programs in specific regions to demonstrate the feasibility and benefits of long-term contracts. This approach minimizes risks and builds public trust.

2. Legal and Institutional Reforms: Introducing PPP-specific legislation and strengthening institutional frameworks is critical for successful contract management. Collaboration with international organizations can help Ukraine design effective policies [2].

3. Capacity Building: Targeted training programs for government officials and stakeholders can enhance understanding and efficiency in managing these contracts.

4. Leveraging Technology: Advanced monitoring tools, such as real-time performance tracking and data analytics, can be integrated to ensure compliance with contract terms.

In India, the adoption of the HAM model enabled the construction of over 15,000 kilometers of highways in just five years. This success was driven by clear policy guidelines, financial incentives for contractors, and strong public-private collaboration [3]. Similarly, Brazil's use of BOT (Build-Operate-Transfer) contracts has significantly improved road quality while attracting billions in foreign investment. These examples highlight the potential for Ukraine to achieve similar results with the right strategic approach [5].

The successful adaptation of international practices requires a long-term vision that aligns with Ukraine's national development goals. Establishing a unified strategy for road management, supported by consistent political will and international partnerships, can transform Ukraine's infrastructure landscape and enhance economic growth.

Recommendations for Legislators and Market Participants For Legislators

1. Develop a Comprehensive Legal Framework:

- Enact laws specifically regulating long-term public-private partnership (PPP) contracts in road management.

- Include provisions for performance-based contracts, dispute resolution mechanisms,

and sustainability requirements [1].

2. Streamline Approval Processes:

- Simplify bureaucratic procedures for project approval and implementation to attract private sector participation.

- Establish centralized agencies responsible for overseeing long-term contracts and PPPs [2].

3. Ensure Financial Incentives:

- Offer tax benefits or guarantees to private companies participating in long-term contracts.

- Collaborate with international financial institutions to create low-interest financing mechanisms for road infrastructure projects [3].

4. Promote Transparency and Accountability:

- Mandate public disclosure of contract terms, project progress, and audit results.

- Use digital platforms to monitor and report the performance of contractors [4].

**For Market Participants (Private Sector and NGOs)**

1. Engage in Capacity Building:

• Invest in training programs to enhance technical expertise in managing long-term road projects.

• Partner with global firms to learn best practices in implementing PPPs and performance-based contracts [5].

2. Participate in Pilot Programs:

• Start with smaller, regional projects to build trust and demonstrate capabilities to public authorities.

• Showcase innovative solutions such as green construction methods and cost-saving technologies [2].

3. Advocate for Balanced Risk Sharing:

• Negotiate contracts that fairly distribute risks between public and private sectors.

• Ensure mechanisms for renegotiation in case of unforeseen circumstances, such as economic instability [1].

4. Adopt Sustainable Practices:

• Incorporate environmental considerations into road projects, such as reducing carbon emissions and utilizing renewable resources.

• Align project goals with international sustainability standards to attract funding from eco-conscious investors [4].

Key Findings on Adapting Global Practices to Ukraine.

The adaptation of global practices in long-term road management contracts offers significant potential to transform Ukraine's road infrastructure. Experiences from countries like Germany, the UK, India, and Brazil demonstrate that well-structured long-term contracts can improve road quality, reduce lifecycle costs, and attract private investments. For Ukraine, these lessons provide a framework for addressing its pressing infrastructure challenges [2].

Ukraine's reliance on short-term contracts has led to frequent repairs and inflated

costs due to a lack of long-term planning. Introducing performance-based long-term contracts could ensure sustained road quality and optimize expenditure. Performance incentives tied to specific service-level agreements, as practiced in Germany and the UK, could be directly adapted to meet Ukraine's needs. Moreover, these contracts help distribute financial and operational risks between public authorities and private contractors, fostering efficiency and accountability [4].

While global practices provide a strong foundation, implementing long-term contracts in Ukraine is not without challenges. Key obstacles include gaps in legislation, limited institutional capacity, and financial constraints. However, these can be addressed through targeted reforms and international collaboration. For instance, partnering with institutions such as the World Bank and the European Investment Bank could provide technical expertise and funding for pilot projects [5]. These partnerships have been effective in countries like Brazil, where Build-Operate-Transfer (BOT) contracts attracted substantial foreign investment for infrastructure development.

Additionally, a focus on sustainability presents opportunities for innovation. Long-term contracts could incorporate green technologies and environmentally friendly practices. For example, Japan has successfully integrated recycled materials into road construction through performance-based contracts, achieving both environmental and economic benefits [6]. Similarly, Scandinavian countries have adopted digital tools for real-time road monitoring, reducing maintenance costs and ensuring high-quality outcomes [7].

To ensure the successful adaptation of global practices, Ukraine must prioritize:

1. **Legislative Reforms:** Establishing a comprehensive framework for public-private partnerships tailored to road management needs.
2. **Capacity Building:** Training government officials to negotiate and oversee long-term contracts effectively.
3. **Sustainability Metrics:** Including environmental goals in contract frameworks to align with global trends and attract green investments [6].
4. **Pilot Projects:** Starting with smaller-scale implementations to demonstrate feasibility and gain public trust.

Adopting these measures would not only modernize Ukraine's road infrastructure but also create a model for sustainable, transparent, and efficient public-private collaboration. The successful integration of long-term contracts could serve as a catalyst for broader infrastructure improvements across the country, fostering economic growth and improving the quality of life for its citizens [8].

**Conclusions.** Long-term contracts in road management offer a unique opportunity for Ukraine to address its critical infrastructure challenges. By adopting proven international practices, such as performance-based contracts (PBC) and hybrid annuity models (HAM), the country can move toward a more sustainable and efficient road management system. These contracts have demonstrated success in countries like Germany, the UK, and India, where they have significantly reduced lifecycle costs and improved road quality. For Ukraine, these approaches provide a roadmap for addressing

inefficiencies in its existing short-term contracting system.

The adaptation of global models, however, requires overcoming several challenges. Key barriers include a lack of comprehensive legislation, insufficient institutional capacity, and limited financial resources. Without the necessary legal and regulatory framework, the implementation of long-term contracts may be delayed or inefficient. Furthermore, government agencies must develop expertise in negotiating, monitoring, and managing these contracts to ensure their success.

Collaboration with international organizations, such as the World Bank, European Investment Bank, and UNECE, will be crucial for Ukraine's progress. These institutions can provide technical expertise, funding, and access to global best practices. Moreover, starting with pilot projects in select regions will allow Ukraine to build public trust and test the feasibility of new contract models. Public-private partnerships (PPPs) should be designed with a clear division of risks and responsibilities, ensuring mutual benefits for all parties involved.

Incorporating sustainability into road management is another vital step. By aligning with global trends, such as using green technologies and adopting environmental performance metrics, Ukraine can enhance the appeal of its infrastructure projects to eco-conscious investors. Sustainable practices not only reduce environmental impact but also contribute to long-term cost savings and resilience.

In conclusion, long-term contracts are more than just a financial tool; they represent a strategy for comprehensive reform in Ukraine's road sector. With a clear vision, targeted reforms, and strong international partnerships, Ukraine can transform its road infrastructure into a model of quality, transparency, and innovation. This transformation will not only improve connectivity and road safety but also stimulate economic growth, attract foreign investments, and elevate the standard of living for all Ukrainians.

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# HUMAN CAPITAL OF UKRAINE: CHALLENGES AND OPPORTUNITIES

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***Annotation.*** *The global economic challenges caused by the full-scale war in Ukraine emphasize the need to develop human capital as a key factor in the success of companies and economic recovery. As studies have shown, in the conditions of martial law and post-war recovery in Ukraine, the introduction of digital technologies is becoming a key factor in the modernization and increase in the efficiency of the state economy.*

***Keywords:*** *human capital, post-war recovery, digital technologies.*

**Introduction.** The need for human capital development is driven by rapid changes in the global economy, technological progress and the growing importance of knowledge and innovation. For Ukraine, human capital development is particularly relevant because Russian military aggression against Ukraine negatively affects labor market trends and economic activity of enterprises. This leads to the loss of qualified workers and a decrease in the general level of productivity. In these conditions, the Ukrainian government faces the difficult task of finding opportunities to compensate for the loss of human capital and restore the competitiveness of the state. One of such opportunities is the development of digital technologies and the formation of a digital culture that will contribute to the digitalization of the Ukrainian economy.

**Analysis of studies and statement of the task.** It should be noted that as of now, a small number of publications and studies on the topic of human capital and the development of the digital economy in wartime have been published. However, these topics are beginning to be actively studied by domestic experts. Thus, issues of human capital in Ukraine in wartime and the assessment of human capital losses as a result of Russian aggression were studied by such Ukrainian researchers as M. Nalbandian, Yu. Zaloznova, N. Azmuk, O. Pishchulina and others. L. Prodanova, I. Yehorov, O. Nykyforuk, V. Vyshnevskyi, O. Harkushenko, N. Shapoval, M. Fedoseienko, O.

Hrybanovskyi, O. Tereshchenko and others devoted their works to justifying the need for digitalization of the Ukrainian economy.

Therefore, in the opinion of the authors, the issue of restoring human capital and developing the digital economy remains extremely relevant and strategically important.

The purpose of the article is to study the state of Ukrainian human capital during the full-scale Russian invasion and to justify the need for Ukrainian digitalization as a strategic direction for compensating for human capital losses.

To achieve the goal, the following methods were used: theoretical for analyzing scientific sources and assessing the role of human capital in economic activity; empirical for processing data and systematizing them and identifying the main factors of labor supply reduction; abstract-logical for formulating general conclusions and research results.

**Study results.** Analyzing the state of human capital in Ukraine, it is worth giving a definition of this economic category. The conducted studies showed that there is no generally accepted definition of the category "human capital", but many formulations contain the same important characteristics and signs of human capital. This allows us to state that human capital is a stock of knowledge, abilities and skills of a person regarding productive activity in various spheres of social life. Therefore, in further studies, analyzing the state of human capital in Ukraine and looking for ways to restore and develop it, we will have in mind exactly such a formulation.

In the modern economic environment, which is undergoing constant changes and transformations under the influence of scientific and technological progress and the phenomena of Industry 4.0-5.0, the role of human capital is becoming more and more important every year. The search for the most important factors of economic development and success is based largely on the human factor and its comprehensive development. It is human capital that plays a crucial role in economic reproduction, as it directly relates to the skills, knowledge and experience of the workforce, which contributes to the further success of the company. Investments in human capital lead to improved business performance by increasing productivity, generating creative solutions and developing innovations in the organization. Regarding the macroeconomic level, countries that prioritize the development of human capital have more chances and opportunities to achieve sustainable economic growth and gain a competitive advantage in the global market[1].

On the eve of the full-scale invasion, Ukraine was defined by its highly qualified, well-educated, creative and motivated human capital for effective work. According to the Global Talent Competitiveness Index (GTCI, 2021), Ukraine ranked 61st out of 155 countries. According to the integrated indicators, Ukraine ranked as follows: Enable – 85, Attract – 80, Grow – 57, Retain – 59, Vocational and Technical Skills – 69, Global Knowledge Skills – 39 [2].

The listed indicators are combined into two groups: the first four indicators assess the conditions, policies for the formation and promotion of talent development in the country; the last two are the result of the previous ones, the quality of talent. It should

be noted that despite the insufficiently favorable conditions for talent development, Ukraine had a high score on the indicator “global knowledge skills”. This indicator takes into account the workforce with higher education, scientists, professionals and senior managers, as well as the impact of talent on economic development [3].

Among the most well-known and successful international strategies for the development of human capital in countries around the world is the United Nations Human Development Program (UNHDP). This initiative, aimed at increasing human capital, expands the concept of development to include health, education, and living standards, rather than focusing solely on economic growth. The central indicator of the UNHDP is the Human Development Index (HDI), which ranks countries by life expectancy, education level, and per capita income [4].

As of 2024, HDI of Ukraine is 0.734 and ranks it to the states with high level human development (100th place among 193 countries) [5].

Thus, during the years of independence of Ukraine the HDI increased by 0.4%. However, due to the influence of pandemics, growth of population mortality level, full-scale invasion and decline economic activity in the country the gradual decrease of HDI value is observed.

According to the forum Human Capital UA, the migration of over 6 million Ukrainians has caused a reduction in the labor force by almost 22%. Such fluctuations in labor resources and a decrease in economic activity have led to a decrease in household incomes by 65%, of which 44% cannot meet their basic needs at all [6].

One of the main challenges that will affect the prospects for further economic development is the decline in human capital, in particular the reductionof labor potential, which is necessary for the country's post-war recovery.

Even before the full-scale invasion, Ukraine was facing a labor shortage. The problem of labor shortage was seen as a major factor holding back economic growth. But now the economic situation in the country has become even more difficult, which is due to the challenges and threats to development of Ukraine from a demographic point of view.

According to expert estimates, in 2023 the working-age population of Ukraine decreased by 39.2%, compared to 2021: from 17.4 million to 12.5 million, and in 2024-2032, according to forecast calculations, it may decrease to 11.7 million [7].

According to studies of the Ukrainian Institute for the Future, today 58.6% of the population in Ukraine is professionally inactive [8]. Demographic losses and occupation played a significant role (about 40% reduction in the labor force in 2023, compared to 2021), as well as a decrease in the economic activity of the population (due to possible difficulties in finding work for internally displaced persons, the need to care for other family members), an increase in the number of pensioners, and a lack of skills in demand on the labor market. The reduction in the labor force was widespread in all regions of Ukraine, but it is most noticeable in regions with active hostilities.

According to the Confederation of Employers of Ukraine, in 2022-2023, companies lost more than 781 thousand men: some were dismissed from their jobs, others were

mobilized, and otherswent to other places or transferred to unofficial work. At the same time, almost twice as many women left the labor market as men: up to 1.5 million: most of them went to other places with children or lost their jobs after the start of active hostilities. The labor market of Ukraine as a whole decreased by 2.23 million people[9]. If before the war there were 12.3 million official taxpayers, now there are just over 10 million.

According to research by OlhaPyshchulina, who is a leading expert on social and gender programs at the Razumkov Center, the main factors reducing the labor supply include: demographics, migration, labor shortages, and mobilization [10].

Demographic factors include, first of all, the decline in birth rates and the reduction in average life expectancy. The birth rate in Ukraine has fallen to the lowest levels among European countries. The birth rate is currently 0.7 (to maintain the population at a stable level, this rate should be 2.14). In addition, the birth rate will be significantly affected by the separation of families, which occurs as a result of mobilization or the fact that women have gone abroad and men have remained in Ukraine. As for the reduction in life expectancy, for men it is expected to decrease from 66.4 years to 57.3 years, and for women: from 76.2 years to 70.9 years [10].

One of the key risks for the economic development of Ukraine is the deepening of negative migration trends. Almost half of the reduction in the working-age population was provided by the departure of external migrants from the labor force. According to various estimates, from 6 to 8 million working-age people have left abroad, and the countries that have provided asylum to Ukrainian citizens will not always facilitate their return to Ukraine [11].

In 2023, the absolute majority of employers faced a shortage of personnel. This is exacerbated by the uneven recovery of the labor market both geographically and in industry terms. According to the results of a study of the labor market in Ukraine conducted by the European Business Association, three quarters of employers are experiencing a shortage of personnel in Ukraine: this was reported by 74% of respondents [12] (in autumn of 2023 the result was 55%).

Another factor leading to a shortage of personnel in the Ukrainian labor market is mobilization. The most important consequence for the labor market of the adoption of the Law “On Amendments to Certain Legislative Acts of Ukraine Regarding Certain Issues of Military Service, Mobilization, and Military Registration” [13] and the upcoming mobilization process is an increase in the labor shortage. In 2022, there was a shortage of women in Ukraine, as a significant part of Ukrainian refugees are women with children.

Now, companies that mainly use male labor: retail, manufacturing, construction, logistics, transportation, and agriculture are experiencing a shortage of workers [10].

Thus, Russian full-scale military invasion of Ukraine has led to enormous losses of human capital and the destruction of millions of jobs. The Ukrainian government faces a strategically important issue of compensating for the losses of human resources. Restoring Ukrainian human capital is a complex task and requires the combined efforts of the government, the community, and business.

As scientists note, in the conditions of martial law and post-war reconstruction of Ukraine, the introduction of digital technologies into the management practices of business entities is becoming a key factor in the modernization and increase in the efficiency of the state economy. The rapid and high-quality restoration of industrial and agricultural enterprises, social sphere and infrastructure facilities destroyed by military actions in the post-war period requires a radical modernization of the applied technologies and management approaches. Digital technologies are capable of optimizing and significantly accelerating the above processes. The integration of digital solutions into the management practices of business entities (of different levels, spheres, industries and forms of ownership) can become a determining factor in solving a number of strategic tasks: increasing labor productivity, optimizing resources, improving the quality of decision-making and ensuring the flexibility of business processes. Moreover, the digitalization of management corresponds to modern global trends and can significantly increase the investment attractiveness of Ukraine. In the context of post-war recovery, the introduction of digital technologies into management practices becomes a necessary condition for ensuring accelerated socio-economic development and successful integration of Ukraine into the global digital economy [14].

The results of the analysis of theoretical and applied scientific research [15,16], as well as leading world practices [17] allow us to state that the following digital technologies may be relevant for the post-war recovery of Ukraine: cloud technologies, big data processing technologies (BigData), artificial intelligence (AI) and machine learning, Internet of Things (IoT), blockchain, digital twins, digital platforms.

In the work “Digital Technologies in Management Practices of Ukrainian Economic Recovery in the Post-War Period”Prodanova L.V. notes the key areas of application of digital technologies [14]. Cloud technologies (a model of providing wide and convenient network access to a shared pool of computing resources that can be quickly provided and released with minimal management costs or appeals to the provider) are suitable for rapid restoration and scaling of IT infrastructure of business entities, in particular without significant capital investments, which is important in the conditions of limited resources of the post-war period. Cloud technologies provide data availability and the possibility of remote work, which is also important in critical and unstable conditions of business recovery [14].

Big data processing technologies (a set of approaches, tools and methods for processing large amounts of structured and unstructured data to obtain results that can be perceived by a person) can ensure informed decision-making, optimization of business processes and forecasting of market trends. In the context of economic recovery, this will contribute to the effective allocation of resources and accelerated adaptation to changing conditions. The use of artificial intelligence (intelligent machines capable of performing tasks that usually require human intelligence, and the results of their “training”) allows you to automate cyclical and standardized processes, increase the efficiency of operations and improve customer service, which contributes to the restoration of production, optimization of logistics and personalization of services. The

Internet of Things (a network of physical objects equipped with electronics, software, sensors and network connectivity that allows these objects to collect and exchange data) can affect the following processes: the creation of "smart" enterprises, optimization of resource use and increased production efficiency. In the context of post-war reconstruction, such technology is especially important for implementing the principles of sustainable development and energy efficiency in the activities of business entities. Blockchain technologies can ensure transparency and security of transactions, which is especially important for restoring the trust of investors and partners from abroad. Digital twins (virtual copies of physical objects, processes or systems that allow modeling and optimizing their operation in real time), in the context of the restoration of the Ukrainian economy, will be especially useful for: optimizing production processes, predicting potential problems and preventing failures in the operation of various systems, testing new strategies and scenarios without risk to real assets, increasing the efficiency of infrastructure and resource management. Digital platforms (technological solutions that ensure the interaction of various market participants in a single digital space) in the context of the post-war restoration of the Ukrainian economy can play a key role in solving the following tasks: creating new business models and new markets; ensuring coordinated interaction between the business sector, government structures and civil society; promoting the development of small and medium-sized businesses; increasing the transparency and efficiency of economic processes [14].

**Conclusions.** Human capital is the main source of economic development of the country. In the conditions of the ongoing full-scale war and significant losses of labor resources, the development of human capital is strategically important. The government of Ukraine faces difficult tasks in returning citizens to their homeland and building an effective system for the development of human capital. Studies show that it will not be possible to return all citizens of Ukraine and the longer the war lasts, the higher the percentage of non-returns will be as people adapt to life abroad.

Thus, the efforts of the government of Ukraine should be aimed at creating a favorable environment for the return of citizens and building an effective system for the development of human capital. One of the extremely important factors in solving these tasks is the formation of a digital economy in Ukraine.

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# IMPACT OF INNOVATIONS AND GLOBAL CHANGES ON TRANSFORMATIONNOF SOCIAL NETWORKS ROLE IN IT ORGANIZATIONS

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***Annotation.*** *The article examines the impact of innovations and global changes on social networks in IT companies. The following three key factors are considered: the COVID-19 pandemic, the war in Ukraine and the active implementation of artificial intelligence tools in the working environment of IT organizations. The analysis shows how such changes are transforming the structure and functions of social networks as well as affecting employee interaction, information diffusion, knowledge sharing, and corporate culture. The author emphasizes the need to adapt management strategies to maintain the social connectivity of employees in order to increase productivity in remote work and digital transformation.*

***Keywords:*** *innovation, technology, artificial intelligence, AI tools, social networks, organizational social network, AI social node, organization management, IT organization, organizational culture, innovative culture, team performance, human resources management, remote work, Ukrainian labor market.*

**Introduction.** When analyzing the society through the lens of innovative technology development, we should note that throughout history, a chain of successive innovations has significantly changed the foundations of our civilization. Such historical innovations would include mastering the fire, creating the first stone tools, developing the speech and writing, using the steam power and electricity, cultivating methods to transmit information over long distances, inventing the first computers, harnessing the nuclear energy, making advances in biotechnology and genetic engineering, etc. Each innovation served as a tool to address complex social and economic challenges. However, it would raise an important question: have these innovations always positively impacted our progress? When examining the society development periods over time, we could observe that introducing new technologies has contributed to the craftsmanship decline due to mass production, increased the unemployment rate due to expanding automation technologies, diminished personal interactions because of the social communication platforms rise, generated confidentiality and private data protection issues, aggravated social inequality across societies, degraded the quality of education, shifted the labor culture, as well as reduced the influence of religious and moral values. The above-mentioned phenomena have resulted from technological globalization of the modern society, which impacts not only the technological landscape, but also the social processes, organizations, groups, etc. Therefore, it is crucial to study the transformation changes taking place through introducing the innovation technologies. Since the interplay between the innovations, technologies and the context may lead to the emergence of new behavior models, social

norms, and economic relationships.

**Analysis of studies and publications.** Currently, many scientific studies analyze the impact of innovations on societal development. Such prominent scholars as M. Kondratieva, S. Kuznetsova, G. Mensha, M. Tugan-Baranovsky, P. Sorokin, B. Twissa, J. Schumpeter, E. Rogers, R. Solow, K. Christensen, R. Nelson, M. Castells, K. Freeman, and others have made notable contributions. These scholars have both outlined a theoretical framework and shown how innovations shape new social, economic, and cultural environments. For instance, J. Schumpeter, known for his theory of creative destruction, argued that innovations and technological progress alter traditional economic and social structures eliminating outdated technologies and creating new production relationships. Though the process may lead to economic disruptions and job losses in the short term, it ultimately stimulates economic growth, increases productivity, and improves living standards [3]. Creative destruction is the foundation of capitalist progress, driving dynamic renewal in the economy. Despite being published in 1942, Schumpeter's insights regarding the impact of innovation on society remain relevant today.

The scientist E. Rogers, who originated the diffusion of innovations model, made just as important contribution to understanding of the impact of innovations on society. Rogers identified several groups that adopt innovations at different rates, such as innovators, early followers, early majority, late majority, and laggards. The diffusion of innovations occurs through social networks and depends on factors such as the relative advantage of the innovation, its compatibility with existing values, complexity, trialability, and the observability of results from using the innovation [17]. Rogers' theory enables us to understand how and why people accept or reject innovations, which is crucial to successfully implement new ideas in society.

M. Castells, a Spanish sociologist, developed the concept of the information society, highlighting the pivotal role of information technologies in transforming the economy, culture, and social structures. His theory describes the shift from an industrial society to an information society, where information becomes the primary resource rather than material assets. Castells emphasizes that global information and communication networks are altering the nature of work, creating new forms of social interaction, and increasing inequality between those who have access to information and those who do not. His theory explores how the Internet and digital technologies serve as foundations for globalization and new models of social development [8].

As we would notice, the research conducted by the scholars provides valuable insights into how innovations influence economic and social processes, reshaping the foundational aspects of society's operations.

Since the author explores the effects of innovative technologies and global changes on social networks, it is essential to actively consider the core theories and concepts that explain the interaction between social structures and innovations.

In sociology, notable scholars such as M. Granovetter, R. Burt, M. Castells, D. Watts, S. Milgram, L. Freeman, J. Coleman, N. Christakis and others have focused on

social networks and studied how these networks are formed, function, and impact on social and economic transformations in society. Moreover, the scholars also explore the role of social connections in information diffusion, building trust, and maintaining corporate culture, among other topics. For example, R. Burt, a world-renowned scholar, examined the influence of social networks on generating ideas and social capital. His central hypothesis suggests that individuals who occupy intermediary positions between groups, known as "structural holes," are more likely to generate valuable ideas. Those who hold such positions in a social network and relate to different groups are called brokers. Brokers enhance their knowledge by accessing diverse perspectives and practices, which ultimately form the basis of their social capital [1].

The equally prominent scientist M. Granovetter introduced the concept of the "strength of weak ties" and presented those weak ties, such as acquaintances or distant colleagues, can be more valuable for accessing new information and opportunities than strong ties, which include close friends or family. As long as people within our immediate social circle often share the same resources and information, while acquaintances from different social groups can provide fresh ideas and connections [4]. Granovetter's research can be useful in understanding how establishing and maintaining diverse social ties, as they facilitate access to new ideas, resources, and opportunities. Additionally, these ties can play a significant role in fostering innovation within organizations and enhancing teamwork effectiveness.

The "small world" theory proposed by D. Watts suggests that any two individuals in an extensive social network can be connected through relatively few intermediaries. This idea is often illustrated by the concept of six degrees of separation, assuming that, on average, six people connect any two strangers in the world [22]. The small world theory is instrumental in explaining how information and ideas can spread quickly within large social networks and it can be applied across various fields, including sociology, biology, computer science, and marketing.

These and other research works have laid the groundwork to identify and analyze major social relations patterns in the relationships network. However, most of the studies were conducted between the 1960s and 2000s, when people did not have access to technology to the extent that they do today. Therefore, social networks were largely considered by scientists in a context largely unaffected by modern digital technologies and automation as we face these days. For this reason, the author of the article would like to highlight that a gap in knowledge about social networks was discovered. Accordingly, it emphasizes the relevance and necessity to research the impact of innovative technologies on the traditional role of social networks, considering the circumstances in which this influence occurs. To effectively explore this impact of innovative technologies within an organization's social network, we must clarify some key concepts, namely network, social network, technology, innovation, remote work, information technologies, Internet search engines, artificial intelligence and AI social node.

The term "network" refers to a collection of elements consisting of nodes and edges illustrating the connections between these nodes [15]. Nodes represent people,

organizations, biological structures, and other units. In various scholarly works, the term "nodes" may be interchangeable with "actors."

Many systems are now recognized for their ability to form networks. Notable examples include the Internet, social communication platforms, organizational networks, corruption networks, terrorist networks, neural networks, citation networks between articles, etc. However, the author of the article would still be focused specifically on the social network within an organization.

According to Wasserman, Stanley, Faust, and Katherine (1994), the concept of a "social network", or a "social graph", refers to a social structure consisting of the node sets, such as individuals or organizations, as well as the dyadic ties and other social interactions between these nodes [21]. Social networks enable organizations to effectively share knowledge, diffusion of information, generate new ideas and approaches, as well as to solve work-related problems. Through social network analysis, organizational leaders can closely examine the structure and dynamics of social interactions within their organization or groups. A comprehensive understanding of the social networks the properties can create opportunities to optimize management systems and enhance innovation within the organization.

The concept of "technology" arises from intellectual activity and encompasses organized scientific knowledge and technical and organizational and other decisions related to the list, timing, procedures, and sequence of executing operations involved in producing, selling, and storing products and providing services [10].

The concept of "innovation" refers to newly created (applied) and (or) improved competitive technologies, products or services, as well as organizational and technical solutions of a production, administrative, commercial or other nature, which significantly improve the structure and quality of production and (or) the social sphere [11].

The term of "remote work" describes a type of work in a remote mode and can be defined as a form of organization and/or performance of work using information technology, in the context of an employment contract/employment relationship, when work that can be performed on the employer's premises is regularly performed outside such premises [19].

The term of "information technology" refers to a collection of methods, production processes, as well as software and hardware tools integrated into a technological framework enabling to collect, store, process, output, and disseminate information in order to reduce the labor intensity of information resources while increasing reliability and efficiency [23].

The term "Internet search engine" refers to a web-based tool that allows users to search for information on the Internet by entering keywords or phrases. It retrieves relevant websites, documents, and other resources based on the user's query [18].

The term "artificial intelligence" refers to the capability of computers and other machines to exhibit or replicate intelligent behavior similar to that of humans. It is also the field of study focused on this concept. Additionally, the term describes software designed to perform tasks or achieve outcomes that were once believed to necessitate

human intelligence, particularly by using machine learning to extrapolate from large data sets [16].

Also, the article's author wants to introduce a new concept - AI social node or AI social actor, which describes an artificial intelligence node integrated into an organization's social network. AI social node serves as a knowledge resource that streamlines the process of information and solutions retrieval by providing insights, information, and recommendations upon request, replacing traditional knowledge sharing and idea generation among team members. However, it is necessary to note that the AI social node does not participate independently in knowledge and information diffusion within an organization. It indirectly contributes to the information flow by providing essential knowledge or information that can be shared and applied by other network participants. This concept is in the research and development phase.

The positive impact of integrating innovative technologies into the work processes of IT organizations is well established, as it is well known that implementing these technologies optimizes labor by automating routine tasks, boosting team productivity, speeding up task completion, and introducing new people and organizational management methods. Therefore, the author of the article proposes to consider the following hypothetical statements:

**Remote work and the geographical separation of employees** may cause distancing among team members, decrease the number of personal contacts, and propel the feeling of social isolation in individuals. These social and psychological factors can change the organizational social network by influencing its structure, density, centralization, network size, information exchange speed, employees' level of involvement and trust, knowledge exchange and ideas generation, intensity and frequency of communications in the organization, as well as efficiency in socializing new employees, mutual support among employees, and company's corporate and innovative culture.

**Applying innovative technologies** can transform the traditional role of social networks by influencing their structure, density, centralization, network size, information exchange speed, level of employee engagement and trust, knowledge sharing and idea generation, the intensity and frequency of communications in company, level of trust and mutual support among employees, as well as the corporate and innovative culture of the organization. As employees increasingly turn to online resources and artificial intelligence tools for assistance, the number of interpersonal interactions may decrease, reducing the need for obtaining information and sharing knowledge through the organization's social ties.

To investigate this issue, the author utilizes methods of analysis from recent scientific literature and publications, as well as statistical and socio-psychological data analyses.

**Presentation of the basic material.** The author examines three key transformations that have affected and reshaped Ukrainian IT companies for the past five years.

*The First Transformation.* In 2020, Ukraine and the rest of the world faced the COVID-19 pandemic, economic recession, and various social challenges. According to the statistic data analysis conducted by researchers O. I. Kariy, L. I. Galkiv, and A. Y.

Tsapulych in 2021, the IT industry began to optimize its operating costs, halt external hiring, rotates available resources between projects, and implements anti-crisis programs.

Approximately 36% of Ukrainian IT organizations reduced staff expenses, 40.5% of them cut administrative expenses by opting out of office rentals, 10.2% of companies implemented technical optimizations, and 5.1% of entities adopted other anti-crisis measures. Notably, only 20.4% of organizations managed to continue their operations as previously. Consequently, the corporate work culture and the employee behavior patterns have been evolving. In December 2020, 84% of employees fully transitioned to remote work, and by the end of the year, only 2% returned to working exclusively in the office [6]. These changes have affected several aspects: 1) how employees and management interact is evolving, with new approaches to time management, communication, and planning being introduced, 2) the primary mode of communication and collaboration between employees has shifted from physical meetings to online platforms such as Zoom, Microsoft Teams, Skype, Google Meet, and various messaging apps, 3) organizational management is allocating more resources to developing and implementing strategies to maintain the employees' engagement.

Collectively, all these factors begin to impact and alter the organizational social network and the social connections between employees. For instance, research into the impacts of the pandemic and enforced isolation on the social relations structure and the feeling of loneliness has revealed a decrease in the size and density of social networks among respondents, which has sharpened the feelings of loneliness. Individuals with fewer than five close relationships were found to be particularly vulnerable. Face-to-face communication with close friends and family reduced feelings of loneliness, while digital means of communication were less effective [9].

In the study examining the impact of social and organizational connectedness on employees' well-being during the COVID-19 pandemic, Brown, A., & Leite, A. C. (2022) highlighted the importance of maintaining social connections during remote work. The study also demonstrated that implementing strategies to foster organizational identification, social engagement, support, and communication was crucial to preserve a healthy psychological and social environment, which significantly influenced the team's perception of remote working under the forced isolation circumstanced.

This raises the question of how an organization's management system should look like to enable the social network to retain its essential properties required to facilitate communication, knowledge and information exchange, establish and maintain professional relationships, support innovation and idea sharing, strengthen the corporate culture and the company innovation culture, enhance employee engagement and motivation, facilitate the new employees adaptation, and encourage collaboration among different team members.

*The Second Transformation.* In February 2022, a full-scale war in Ukraine began due to the Russian invasion, leading to significant changes in the labor market as a result of both internal and external migration of Ukrainians. It is on the record that, during the first weeks of the war, approximately a million of working-age individuals

left the country. According to analysis held by Vynnychuk R.O. (2022), the number of job vacancies decreased by 34.17%, while responses to the vacancies fell by 17.8%; the ratio of reactions per vacancy increased by 25.48% compared to the pre-war period. Additionally, the number of remote job openings and opportunities abroad has also risen, mainly due to relocation of IT professionals both within the country and internationally [20]. Remote work has become an integral part of the new reality for many Ukrainian industries. On one hand, such a shift has surely allowed companies to continue operations despite the war and changes in employee locations. On the other hand, employees are facing more social and psychological challenges than during the pandemic.

Up until today, most IT companies in Ukraine have adopted remote or, less frequently, hybrid work formats. Remote work is becoming an increasingly common and widespread mode, enabling the employees to remain productive in an unstable environment and adapt their work processes to new realities. However, this shift raises new social and psychological challenges of utmost importance and those must be addressed promptly. For example, in their study of the psychological aspects of remote work, Y. Kaimanova and N. Riabokon (2024) highlight the emergence of issues such as social isolation, blurred boundaries between work and personal time, deterioration of mental health, reduced social interaction, etc. They also put an accent on the fact that while virtual communication and online meetings can partially compensate for the lack of physical social support, the absence of face-to-face interactions remains a significant problem [7]. All of these factors contribute to an increased risk of stress and burnout, presenting challenges for IT companies in maintaining productivity and ensuring their employees' mental well-being. Ultimately, all these issues directly impact the efficiency of the entire organization's team.

Based on the analyzed data, the author concludes that remote work can impact a company's social network. A decrease in personal interactions between employees alters the nature of social ties, making them less dense and more formal. This shift also affects the speed at which information and knowledge are exchanged, influences the generation of new ideas, and reduces the intensity and frequency of communication among employees. Additionally, remote work can hinder the adaptation of new employees, as socialization in a virtual environment is often less effective.

*The third transformation*. These days, the global IT market is experiencing significant changes due to rapid technological advancement. Innovative technologies are increasingly defining and shaping new approaches to business operations, management systems, labor productivity, and the sustainable development of organizations and enhancing their competitiveness. Presently, integrating artificial intelligence into workplace culture is becoming one of vital elements of the new transformation, fundamentally altering business practices and interaction patterns with employees and customers.

John McCarthy at the Dartmouth Conference first introduced the term “artificial intelligence” in 1956 [14]. Since then, artificial intelligence has evolved significantly, progressing from early theoretical models to powerful technologies capable of automating

complex processes and supporting human activities. Yet, its widespread use has only emerged in recent years.

In November 2022, OpenAI launched its new product online – the ChatGPT platform to quickly and essentially transform workflow automation, communication, and information retrieval approaches. The product went viral, spreading rapidly across the United States, Europe, and Asia. Within five days of its release, the number of its users surpassed one million. ChatGPT began to significantly alter various domain of human activities, including customer service, healthcare, education, content creation, business, etc. [12]. The world is entering the "Age of Artificial Intelligence", which extends beyond global markets and the ChatGPT platform. Alternative and equally powerful tools, such as GitHub Copilot, Google Gemini, Midjourney, DALL-E 2, Stable Diffusion, and Claude, are emerging on the market at a rapid pace.

In 2023, Microsoft launched a new tool called Microsoft Copilot. The tool utilizes the GPT-4 language model from OpenAI and is integrated into various applications such as Word, Excel, PowerPoint, Outlook, Teams, and business solutions. It aims to help users automate routine tasks and analyze large amounts of data [13]. Simultaneously, a number of other products is increasingly incorporating artificial intelligence into their functionalities. Notable examples include project management systems like Asana, Trello, Jira, Monday.com, Wrike, etc., as well as CRM systems similar to Salesforce and HubSpot. Data analysis platforms like Tableau and Power BI, writing assistants like Grammarly, and HR systems such as Workday are also implementing AI features.

Ukrainian IT organizations are actively integrating artificial intelligence into their workflows, demonstrating a rapid adaptation to new technologies. This trend shows that the impact of AI transcends geographical boundaries and is spreading equally in countries where digital technologies and AI-based services are prevalent.

The analysis on the artificial intelligence use by Ukrainian IT professionals reveals significant growth since its introduction. A survey conducted in 2023 showed that 53% of employees actively used AI to solve work tasks. In 2024, the number increased up to 85%. The use of chatbots is exceptionally high: 41% of employees reported using these tools daily or several times a week, while 32% used AI for work several times a month. Additionally, 12% reported rare usage, and 15% did not use AI. The primary purposes to apply AI tools include searching for information seeking advice, and finding various solutions with 83% of respondents, writing text (50%), writing code (44%), detecting errors (34%), translating texts (29%), brainstorming new or creative ideas (25%), and creating marketing materials (8%). As it turned out, most Ukrainian professionals view AI as positively impacting their work processes, with only 6% expressing concern about potential job loss due to the introduction of AI tools [5].

Many users highlight the positive effects of AI tools on optimizing work processes and boosting productivity. However, this study focuses on exploring the impact of the tools on sociological processes within organizations. The author notes that according to the survey conducted by the DOU IT community, it was revealed that 83% of IT professionals utilize artificial intelligence to seek information, advice, and various

solutions. Correspondingly, the statistic indicates a shift in employees' behavior regarding knowledge and information exchange. Thus, artificial intelligence is increasingly becoming the primary source for quick access to information, replacing traditional person-to-person communication. The author attributes these changes in employees' behavior to several factors: 1) instant access to information being essential for prompt problem-solving, 2) rapid resolution of issues in time-sensitive situations, 3) search and generation of ideas, 4) objective answers are accessible and free from the biases that may arise during interactions with colleagues, 5) integrating concepts from different fields to foster the development of new approaches, 6) assuring confidentiality for users who may not feel comfortable discussing work tasks with colleagues, 7) access to a broad range of knowledge and expertise that may not be available within the organization, 8) the convenience to operate asynchronously, etc.

The author emphasizes the changing behavior of users in searching for information online. Traditionally, search engines like Google, Yahoo, and Bing have been the primary tools for information retrieval. However, the author suggests that these platforms may gradually lose their prominence due to the rapid advancement of innovative artificial intelligence technologies. Several factors contribute to the shift in user behavior: 1) presently, searching for information has become more complicated as the Internet is inundated with vast data, 2) users often feel overwhelmed and struggle to process the information available, 3) the multitude of sources requires users to analyze them independently, 4) finding information demands significant effort to select relevant sources, and 5) search ads, banner ads, pop-ups, and notifications frequently divert users' attention. As a result, in the future, information search may increasingly rely on artificial intelligence. Therefore, AI offers quick access to structured information and can synthesize answers from multiple sources. Consequently, artificial intelligence could take over the role of a conscious information search, effectively acting as a consultant for users.

Thus, applying innovative technologies can alter the traditional role of social networks, affecting their structure, density, centralization, network size, information exchange speed, employee engagement, knowledge sharing, idea generation, intensity and frequency of communications, level of trust, and mutual support among employees, as well as the corporate and innovative culture of the organization. As employees increasingly turn to artificial intelligence tools for assistance, there is a noticeable reduction in interpersonal interactions and a decreased reliance on social ties for obtaining information and sharing knowledge. This is how artificial intelligence is embedded into an organization's social network and becomes its AI social node.

Accordingly, the research and analysis of recent transformations allow the author to conclude that the remote format of work and the introduction of innovative technologies can affect the organization's social network. Given the transformative influence, modern IT companies should implement new approaches and strategies to the management system of the organization to ensure a high degree of productivity and competitiveness of the organization.

**Conclusions.** Innovations have been reshaping society starting from ancient times, long before the of computers, internet technologies, and artificial intelligence in the workplace. Applying innovations have transformed not only the global economy, but it significantly altered the traditional role of social networks within organizations.

Analysis of recent studies and scientific publications highlights the effects of remote work and the integration of innovative technologies on organizational social networks. These changes contribute to a decrease in employees' social connectedness, a reduction in the size of social networks, and alterations in their network structure and features, which complicates the development of informal communication among employees, hinders the rapid exchange of information and knowledge, and reduces the intensity and frequency of interactions among colleagues, etc. Consequently, these factors can challenge maintaining effective social relationships within an organization. In addition, the integration of artificial intelligence into the social network and organization environment has been noted, suggesting the need to introduce a new concept as an AI social node and further study this process.

Though remote work and introducing innovative technologies offer organizations certain advantages, such as increased employee productivity and optimized routine processes, they also change the traditional role of social networks, which is crucial for enterprise efficiency. Therefore, modern IT organizations should adapt their management systems and implement strategies that optimize work formats and enhance employee interaction. They should also consider social and psychological factors when integrating new technologies into the workplace and develop programs that foster teamwork competencies in a remote work environment.

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# METHODOLOGICAL PRINCIPLES OF FORMING A SYSTEM FOR ASSESSING THE EFFECTIVENESS OF ACHIEVING STRATEGIC GOALS IN THE DIGITAL ECONOMY

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***Annotation.*** *The initial prerequisite for any meaningful activity is goals. Only their presence and clear awareness allow to organize the actions of an individual or an organization, direct them to achieve a certain result, encourage improvement, self-development, learning, and determine the search for the best ways and means of activity. The goal-setting process is of particular importance today in the context of forming motivational mechanisms for development and establishing effective management principles for modern business entities in the context of digitalization of business and society. Quite often, it is economic indicators that are a prerequisite for the formation of the general goals of business entities and serve as indicators of the effectiveness of achieving goals. The basis of this approach is the well-known concepts of classical economists, in particular, A. Marshall in his fundamental work "Principles of Economic Science" notes that the progress of economic theory is due to the fact that "money serves as a fairly tolerable measure of the driving force of most of the motives that shape the way of life of a person" [1]. This economic approach has been used for quite a long time in management science, as the determining measure of the success of managers was measured through financial results. It is the achievement of a certain financial result, certain financial parameters that was an indicator of the success and efficiency of the business entity. However, in the context of modern organizations in the VUCA, SPOD, DEST and BANI World, there is a need to solve a scientific problem - to find tools that would allow assessing the effectiveness of management at different levels of management and monitoring intermediate results with the possibility of making corrective actions at different stages of implementation of strategic goals. Therefore, the main objective of the study and the article is to highlight the experience of using a tool for assessing management effectiveness based on the priority of strategic goals. The study was based on the use of: the method of comparison, generalization - to clarify and formalize the essence of the concept, graphoanalytical method - to provide clarity of the material and schematic representation of a number of theoretical and practical provisions of the study.*

***Keywords:*** *management system, enterprise, changes, goal setting, potential, digital economy, strategy.*

**Introduction.** The complexity of the current external environment creates the impression that it is unnecessary to focus on goals, and therefore to formulate and set them. This approach gives us a myopic view of the dangers and opportunities emanating from the external environment. The process of formulating and setting goals for enterprises is complex but necessary. Formal goal setting creates advantages for all businesses, large, medium and small, whether they are just starting out or have an established business. Goals force the management of enterprises to think about the future from the standpoint

of an objective assessment of their capabilities. Therefore, the article is devoted to solving methodological problems of evaluating the effectiveness of goal setting and using the tool in the process of assessing the effectiveness of managers' activities in achieving the strategic goals of an economic entity.

**Results and their analysis.** A study of the methodological principles and practices used by various business entities in formulating their business goals, in particular, in determining the strategic development framework, has made it possible to identify that one of the problems in forming a block of strategic goals is the prioritization of goals. The need to solve this problem is traditionally associated with the limited investment resources available to business entities and the inability to implement all strategic programs. Thus, there is a problem of choosing strategic areas of activity, which cannot be solved without focusing on the target block in general and on the prioritization of goals in particular.

The problem of prioritizing goals remains, but it can be viewed from a different perspective. Since the task of forming a target block is central to system analysis, regardless of the field of application, it is interesting to learn from the experience of solving it in other industries and interpret the results obtained in relation to production systems.

At first glance, prioritization of any objects (economic, technical, social, etc.) seems to be a rather simple task with more technical difficulties. But nowadays, technical difficulties in the digitalization of business entities' processes have been practically overcome, which cannot be said about methodological support. When solving practical problems, they are either ignored or incorrectly bypassed. In this regard, this issue requires more detailed consideration. First of all, let us formulate these methodological problems:

1. Can the established prioritization of goals be unified for different business entities?
2. Is it possible to unify the established priority of goals for one entity for a long period?
3. Will the priority for goals that have a strategic orientation remain the same for operational planning purposes?
4 If the priority of strategic planning goals is not transferred to the goals of operational planning, how should they relate to each other?

The conducted research on the specifics of the analysis of industrial enterprises and the peculiarities of forming strategies of the regions of Ukraine made it possible to develop and propose methodological principles for establishing the priority of the enterprise's goals in order to further use the results of the assessment in the analysis of the system's performance as a whole. In order to be able to apply the prioritization of goals in further analysis, the term priority is used with a slightly different interpretation. In this case, the priority will reflect not the contribution to the achievement of the global goal, but the priority of the local goal. This task does not require measurement on the scale of relations, which is associated with rather serious methodological difficulties,

but allows to limit oneself to the rank scale. This procedure for prioritizing goals is not formalized and requires the use of expert opinion. There are many techniques for obtaining an expert assessment using an ordinal scale, but the most organic in relation to the expert is the method of pairwise comparisons [2,3]. When using the method of pairwise comparisons, the expert must compare all the goals in pairs in terms of the order of their implementation and for each pair make a judgment about the advantages of one goal on the specified basis, or their equivalence. The symbols <,>,= may be used. At the next stage, the results of the expert's judgment should be processed and the goals should be ranked. The results can be processed by building a “preference graph” or in tabular form using the coefficients aij .

*Table 1*

**General view of the pairwise comparison matrix**

| i / j | $G_1$ | $G_2$ | $G_3$ | $G_4$ | $G_5$ | ∑ |
|---|---|---|---|---|---|---|
| $G_1$ | 1 | 2 | 2 | 2 | 2 | 9 |
| $G_2$ | 0 | 1 | 2 | 2 | 2 | 7 |
| $G_3$ | 0 | 0 | 1 | 1 | 1 | 2 |
| $G_4$ | 0 | 0 | 1 | 1 | 0 | 2 |
| $G_5$ | 0 | 0 | 2 | 2 | 1 | 5 |

When processing the results of the examination in tabular form - based on the primary expert information in the form of pairwise comparisons and the above indicators aij, a square matrix is built and calculated by rows of the matrix, which allows you to build a ranked series. Higher priority goals have a higher value. After establishing the priority of the goals, the expert group divides them into goals of the first, second and third order. It is recommended that the beginning of the ranked series be attributed to the first-order goals, the end of the series to the third-order goals, and the middle to the second-order goals. The main task of experts is to determine the boundaries of the beginning and end of each group. The results of this work will be needed when moving from strategic benchmarks to tactical objectives. The next stage of assessing the achievability of the company's goals based on the study of the priority of goals is based on the use of the geometric summation method. The essence of the method is as follows: for the selected

group of indicators, a graph is drawn in the form of a square (Fig.1), each side of which is a measuring scale for fixing the value of a particular indicator for a certain period of time. For the practical construction of the graph, the ratio of the criterion to be evaluated to the indicator is quite important. For example, there are indicators in the company's activities that have a ratio of the higher the value, the better (labor productivity), and on the other hand, there are indicators "the lower the better" (unit costs per unit of production). This must be taken into account when orienting the measurement scales in the chart. In each period of time when the efficiency of the system's goal setting is measured, its total score is a point on the graph that moves when the values of at least one indicator change. In order to organize the movement of the point and provide the possibility of analysis, one of the corners of the graph is selected and fixed, in relation to which the movement of the point will be regarded as an increase in the efficiency of goal setting and system functioning (in Fig. 1, this corner has a "+" sign).

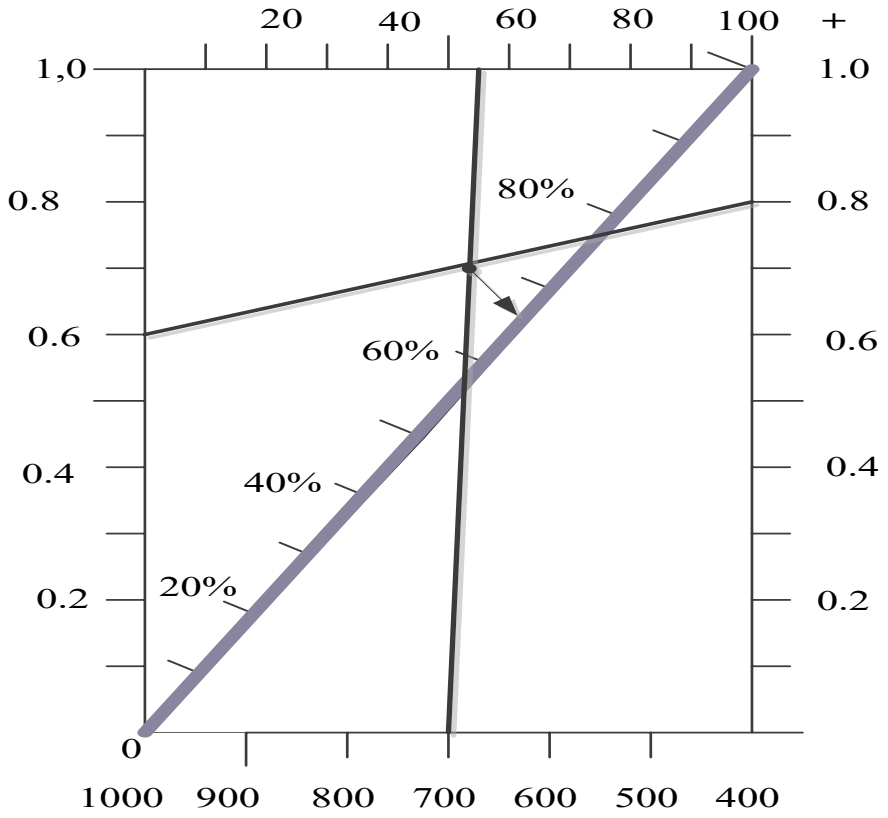


**Fig. 1. Conditional matrix for assessing the effectiveness of achieving the goals of a certain priority level of business entities**

Fixing the angle on the graph allows you to correctly orient the measurement scales for specific indicators. The indicators can be assigned to the sides of the square in any way.

This method has a number of advantages, but in terms of practical use of the method, there are a number of problems that need to be addressed. First of all, it is the problem of the number of indicators. The methodology of the methodical approach involves the use of four indicators. What if there are fewer or more? If the number of indicators decreases, it is suggested to duplicate indicators on opposite sides of the square. For example, if there are 3 indicators, then it is possible to consider the opposite sides 1-2 and 1-3; if there are two indicators, it is possible to duplicate two indicators 1-2, 1-2. If there are much more indicators, it is suggested to divide them into groups and build a corresponding graph for each group separately. In this case, the field of each graph is divided into several evaluation zones. There is no limit to the number of such zones (for example, 5 zones in Figure 1). In order to aggregate the indicators, another summary graph is built, the sides of which are measurement scales for groups of indicators. Groups of indicators are randomly assigned to the sides of the graph. Each side is divided into evaluation zones. The performance score obtained on the respective group graph is transferred to the linear scale of the summary graph, focusing on its position relative to the boundaries of the evaluation zones on the group graph. Then, geometric summation is performed by finding the point of intersection of the lines on the summarizing graph.

The next problem that requires further analysis is the use and comparison of the priority of goals to determine the company's strategies. As it was established earlier, the priority of the goals of the strategic plan may differ from the priority of the goals of the current moment. Moreover, this difference may concern only the first-order goals. For example, unforeseen, sharp changes in the requirements of the external environment require the priority implementation of several second- and third-order goals. As a result of the procedure for restructuring the company's goals, these goals will be added to the first-order group. Moreover, in this group, they will be the highest priority, since they require priority implementation. The very structure of goals and their prioritization is a guide to action for the formation of the strategic set of the enterprise. At the time of forming the strategic set, all strategic guidelines can be divided into groups depending on their belonging to a particular goal of the enterprise. Subsequently, in accordance with the distribution of strategic guidelines by objectives, they, like the objectives, can be classified as first-, second-, and third-order.

**Conclusions.** Testing the proposed methodological tool allows us to draw the following conclusions. Since the methodological recommendations are based on the capabilities of the square, it is rational to group goals into groups of four indicators. But this is not always possible if there are many goals. In this case, there will be much more iterations and more attention should be paid to prioritizing strategic goals. When prioritizing, it is important to realize the level of goal achievement and to avoid formalizing this process. Because the priority will affect the overall performance analysis. Thus, the goals of the 1st level of priority, which is often not the case in practice, are achieved at the level of 30-40%, while simpler tasks of operational activities have an indicator of 70-80%. In general, such results for a business entity will have an average level of performance. But will this solve the strategic objectives and will the implementation of

the entity's strategy be effective? Of course, it is the goals of the first level of priority that are important for the owners and key stakeholders. Another situation that arises is when there are fewer than four groups of indicators. Then you need to decide on one side of the square. The practice of applying the methodological recommendations proves that it is logical to use indicators of the 1st priority level goals on opposite sides of the square. After all, this group of goals is the most important. Therefore, its double use will allow to increase the level of influence on the resulting indicator.

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# ON THE ISSUES OF CONDUCTING A FORENSIC ECONOMIC EXAMINATION WHEN INVESTIGATING THE AMOUNT OF DAMAGE CAUSED TO BUDGETARY INSTITUTIONS AS A RESULT OF VIOLATIONS OF LEGISLATION IN THE FIELD OF PUBLIC PROCUREMENT UNDER MARTIAL LAW

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***Annotation.*** *Currently, under martial law, the organization of public procurement based on a transparent and competitive approach to the acquisition of goods, works and services is becoming an important element of national economic management. For Ukraine today, transparent, efficient and fair public procurement is an engine of economic growth that creates new opportunities for businesses and jobs for the population. For Ukraine today, it has become a topical issue not only for the economy but also for the functioning of society as a whole.*

*This article deals with a specific issue that arises in the course of forensic economic examination to determine the damages incurred by budgetary institutions as a result of changes in the essential terms (price) in contracts concluded as a result of procurement procedures.*

***Keywords:*** *budgetary funds, public procurement, overpricing, losses.*

**Formulation of the problem.** Currently, our country is in conditions it has never experienced before. Given the fact that the treacherous large-scale invasion of Ukrainian land by Russian invaders on the morning of February 24, 2022, divided our usual life into "Before" and "After", the war requires resources and mobilization of the entire society. The consequences of the armed conflict taking place in Ukraine are felt in various spheres of human activity, the functioning of enterprises, society and the state as a whole.

The invasion of Ukraine by the Russian invaders has changed approaches to the main components of the economy, including public procurement. The martial law regime has made its own adjustments to public procurement in Ukraine, the legislation is changing rapidly, and the circumstances of its application are sometimes changing even faster. In wartime, all the same prohibitions apply as in peacetime: it is forbidden to steal, it is forbidden to abuse, it is forbidden to spend scarce resources inefficiently. In

these circumstances, the issue of liability for financial violations committed in wartime becomes more relevant than ever.

It should be noted that different liabilities are possible in the field of public procurement, namely:

- commercial and legal (i.e., liability is stipulated in the procurement contract or a contract concluded without the use of an electronic procurement system);
- civil liability (liability for non-contractual damage, including damage caused by increased authority or abuse of office);
- disciplinary (liability under the employment contract, the Labor Code of Ukraine or a disciplinary statute);
- administrative (liability under the Code of Ukraine on Administrative Offenses);
- criminal (liability under the Criminal Code of Ukraine).

Business operation of public sector entities in the field of public procurement always attract public attention, as they often involve contracts worth millions of dollars.

**Analysis of recent research and publications.** Simakova-Yefremian E. is studying the issue of reforming forensic expert activity and the need to improve the legislation of Ukraine on forensic expert activity [4]. Pirig V. I. studies the use of special knowledge in pre-trial investigation [5, 6]. Vasylynchuk V. I., Slyvenko V. R. Study the Improvement of Criminal Liability for Crimes in the Field of Public Procurement [14].

**Setting the purpose and objectives of the study** – is to highlight problematic issues in conducting forensic economic examinations to establish damages to budgetary institutions by changing the essential terms (price) of concluded contracts based on the results of public procurement procedures.

**The main research material.** According to information provided by the Ministry of Economy of Ukraine, despite Russia's full-scale war against Ukraine, the total number of completed procurements in the Prozorro public procurement system in 2022 amounted to 2.8 million contracts worth UAH 484 million. At the same time, the number of competitive procurements last year was about 160 thousand, and the amount of concluded agreements was UAH 198 million.

The total number of customers in 2022 was about 30 thousand, of which 16 thousand announced competitive procurement. The total number of bidders was about 181 thousand, and 33 thousand participants took part in competitive bidding.

The top 5 procurements of 2022 are as follows: food - 25 thousand; construction works - 23 thousand; medical equipment - 20 thousand; petroleum products - 15 thousand; agricultural products - 8 thousand [17].

Also, according to the Ministry of Economy of Ukraine, in the public procurement system in 2023, the volume of procurement conducted through the Prozorro system tripled to UAH 480 billion compared to last year [18].

The Law of Ukraine "On Public Procurement" dated 25.12.2015 No. 922-VIII [1] defines the list of institutions authorized to exercise control in the field of public procurement, namely: the central executive body implementing the state policy in the field of treasury services for budget funds, the Accounting Chamber of Ukraine, the Antimonopoly

Committee of Ukraine, the central executive body implementing the state policy in the field of state financial control and public control. The above-mentioned institutions exercise control in the field of public procurement each within the limits of their powers defined by the Constitution and laws of Ukraine (Table 1).

*Table 1*

**Subjects of control in the field of public procurement**

| Subjects of control in the field of public procurement |
|---|
| *Accounting Chamber of Ukraine* (preliminary analysis of the annual report on the functioning of the public procurement system and summarizing the results of control in the field of procurement) |
| *The Antimonopoly Committee of Ukraine* (as an appeal body in the field of public procurement, establishes a Commission (commissions) for consideration of compliaints about violations of legislation in the field of public procurement) |
| *THE State Treasury Service of Ukraine* (prior to making payment under the procurement contract, checks the availability of the annual plan, procurement contract, report on the results of the procurement using the electronic procurement system, which confirm the procurement procedure/simplified procurement and the results of which the procurement contractwas concluded) |
| *The State Audit Service of Ukraine* (implements state financial control through monitoring and verification of procurement) |
| *Banks* (when making payments under procurement contracts, they check the availability of the procurement report by reviewing it in the electronic procurement system) |
| *Public control* (analysis and monitoring of information posted in the electronic procurement system, informing the authorities authorized to exercise control about the detected signs of violations) |

*Source: developed by the authors*

The State Audit Service of Ukraine (hereinafter referred to as SASU or the State Audit Service) is the central executive body that implements the state policy in the field of state financial control and exercises control in the field of public procurement. Pursuant to Article 5 of the Law of Ukraine "On the Basic Principles of State Financial Control in Ukraine", control over compliance with procurement legislation is exercised by monitoring procurement in accordance with the procedure established by the Law of Ukraine "On Public Procurement", conducting procurement audits, as well as during state financial audit and inspection.

The existence of offenses in the field of public procurement is confirmed by the results of their inspections and monitoring conducted by the State Audit Service of Ukraine. Thus, according to the State Audit Service of Ukraine, in January- December 2023, 395 inspections and almost 12.2 thousand procurement monitoring were conducted. Based

on the results of procurement monitoring, the State Audit Service prevented violations during the reporting period, including by canceling tenders worth more than UAH 7.4 billion and terminating contracts worth almost UAH 12.4 billion. In addition, according to the State Audit Service. 102 pretrial investigations were initiated by law enforcement agencies as a result of monitoring compliance with procurement legislation [1].

In the process of public procurement, one of the main criteria for assessing its efficiency and an indicator of achieving savings is the price. That is why price changes in the course of the procurement contract are subject to special attention of controlling and law enforcement authorities. It should be noted that offenses established by the state financial control body based on the results of control measures in the field of public procurement often become the basis for the appointment of a forensic economic examination in criminal proceedings.

During pre-trial investigations, law enforcement agencies are increasingly raising the issue of misappropriation of budget funds by officials of budgetary institutions in the course of public procurement through fictitious companies, purchase of goods, works, services at "inflated prices", as well as determining the amount of damage based on the results of procurement as a result of additional agreements on price changes, namely its increase per unit of goods. It is noteworthy that the main qualifying factor in the plots of investigations in economic criminal proceedings in all law enforcement agencies without exception is the concept of procurement at an "inflated price" and violation of the principle of maximum economy, efficiency and proportionality.

In their activities, law enforcement agencies assess the actions taken by the perpetrator to cause the negative consequences. For example, whether the head of the procuring entity foresaw the possibility of damage to the enterprise or the local community when signing additional agreements to increase the price. According to law enforcement agencies, the head of the procuring entity should take this into account, check prices and determine all possible risks, possible savings and efficiency of using funds for a particular procurement.

However, it should be noted that the current legislation of Ukraine does not contain the phrase "inflated prices". Similarly, there are no such legal concepts as: "fair price", "permitted markup", etc., neither in the Criminal Code of Ukraine, nor in the Resolution of the Cabinet of Ministers of Ukraine "On Approval of Peculiarities of Public Procurement of Goods, Works and Services for Customers Provided for by the Law of Ukraine "On Public Procurement" for the Period of Martial Law in Ukraine and within 90 days from the date of its termination or cancellation", nor in the special Law of Ukraine "On Public Procurement". The latter contains only definitions of the terms "expected value", "abnormally low price" and "reduced price" [2,3]. In addition, it should be noted that currently in Ukraine, the State Service of Ukraine on Food Safety and Consumer Protection exercises state supervision (control) in the field of pricing only for socially important products, gasoline and diesel fuel.

Therefore, in the course of court proceedings concerning the use of budgetary funds under contracts concluded as a result of public procurement, situations arise when, in order to establish certain circumstances of the case or facts, it is necessary to obtain

information relating to special knowledge and cannot be obtained except by addressing a list of questions to an expert institution or expert.

Specialized knowledge, according to E. B. Simakova-Yefremian, includes "professional knowledge and skills in the field of science, technology, art, craft, etc. that are necessary to clarify issues that arise during the investigation and trial of specific cases" [4]. I. V. Pirig in his scientific work clarifies that this is the knowledge that "is not professional for an investigator, prosecutor, investigating judge, judge, etc.", i.e., is beyond legal knowledge. Special economic knowledge, according to V. V. Fedchyshina, is the knowledge, skills, abilities and practical experience of persons knowledgeable in the field of economics on issues that reflect the current level of development of economic science, objects, phenomena and processes [5,6]. At the same time, it should be noted that the expert economist's special knowledge goes beyond clarifying legal issues (part 1. Article 242 of the CPC of Ukraine) and assessing the legality of procedures regulated by regulatory legal acts, as well as assessing the actions (inaction) of officials [9].

Despite the above, the initiators of the appointment of a forensic economic examination often raise questions related to public procurement, for example: "Is it documented that the customer "...." violated the principle of maximum economy, efficiency and proportionality when it concluded the additional agreement No. _ of _ to the Procurement Agreement No. _ of _ with LLC "....." regarding the change in the price per unit (namely, the increase in the price per unit), which led to damage. If so, what is the amount of damage caused to the budgetary institution as a result of changes in essential terms, in particular, the price in the contract concluded as a result of the procurement procedure?"

It is worth noting that the principle of maximum economy, efficiency and proportionality is one of the procurement principles set forth in Article 3 of the Law of Ukraine "On Public Procurement". This principle is unconditional and reflects the regularities of legal relations arising in the field of public procurement [10]. At the same time, the legislation relating to public procurement in Ukraine still lacks a clear definition of the terms "maximum economy", "efficiency" and "proportionality", in particular, and does not define the indicators of economy and efficiency criteria.

In addition, according to the information provided in the Accounting Chamber's report for 2022, the Ministry of Economy of Ukraine (which is the authorized body for state policy in the field of public procurement) has not developed and approved a methodology for comprehensive economic analysis of the efficiency of public procurement [11]. The analysis conducted by the Accounting Chamber showed that the Report of the Ministry of Economy does not contain sufficient information on the validity of the savings indicator, which it defines as the difference between the expected cost of procurement and the most economically advantageous offer. Therefore, it can be concluded that the lack of a methodology for calculating the savings, efficiency and proportionality of public procurement does not allow for a forensic economic examination to document the amount of losses caused by non-compliance with public procurement principles by public sector entities.

Pursuant to Article 224(2) of the Commercial Code of Ukraine, "losses are defined

as expenses incurred by the managed party, loss or damage to its property, as well as income not received by it that the managed party would have received in case of proper fulfillment of the obligation or before the rules of economic activity were observed by the other party" [12]. Also, according to part 1 of Article 225 of the Commercial Code of Ukraine, it is determined that "the losses to be reimbursed by the person who committed the economic offense include: the cost of lost, damaged or destroyed property, determined in accordance with the requirements of the law; additional costs (penalties paid to other entities, the cost of additional work, additional materials, etc. According to the provisions of the Commercial Code of Ukraine, a loss on procurement transactions occurs in case of violation by a participant of economic relations of its obligations under the procurement contract, taking into account the requirements of part 5 of Article 41 of the Law "On Public Procurement" [10] and for certain customers, paragraph 19 of the CMU Resolution No. 1178 [10, 13].

According to V. I. Vasylynchuk and V. R. Slyvenko, the biggest problem in determining damages in case of violations of legislation in the field of public procurement is the lack of a unified methodology for calculating such damages by executive authorities implementing state policy in the field of state financial control [14]. This, according to scientists, makes it impossible to effectively compensate for the identified losses.

Unlike auditors and inspectors, who establish facts, expert economists, within the scope of their competence, conduct research on data that has been established during audits, inspections and monitoring. Expert economists provide conclusions only on the basis of documents confirming business transactions, in accordance with the requirements of the current legislation governing the documentation and reporting of certain transactions, including public procurement. In addition, "conducting audit actions (determination by expert economists of any economic indicators without prior documentary checks of financial and economic activities by the subject of control) does not belong to the tasks of economic expertise" and is not provided for by the requirements of the last paragraph of clause 1.1 of section III of Instruction No. 53/5 [15]. Therefore, the appointment and conduct of a forensic economic examination is a process of interaction between experts and the initiators of an economic study.

When conducting forensic economic examinations, the expert shall take into account the following conditions:

- the material damage (losses) to the budgetary institution must be established by the body whose main tasks and functions include financial control over compliance with the public procurement legislation;

- documentary evidence of damages for unjustified transfer of funds may be made taking into account the conclusions of other types of examinations.

Therefore, taking into account the amendments and the lack of a methodology for determining damages in the field of public procurement, the following questions may be asked by the initiators of a forensic economic examination:

- Are the conclusions stated in the inspection report of the supervisory authority (number, date) regarding the overstatement of the volume of public procurement (name

of goods, works, services) by the amount of (specify the amount) compared to the terms of the contract (number, date) concluded as a result of competitive bidding confirmed by documents?

- Are the conclusions of the inspection report of the supervisory authority (number, date) regarding the unjustified transfer of budget funds in the amount of (specify the amount) documented, taking into account the conclusions of other types of examinations?

Law enforcement agencies should be provided with documentary evidence to support the calculation of the amount of damages caused by additional agreements to procurement contracts that increase the price of a unit of goods during the economic examination:

- an audit (inspection) report that establishes a violation of tender legislation, including documents used by auditors (inspectors) in the course of state financial control;
- conclusions of other types of expertise, which establish an overstatement of the price per unit of goods;
- a court decision to invalidate additional agreements;
- primary and accounting documents containing information on business transactions.

**Conclusions.** Therefore, the familiarity of the forensic authorities with the procedural capabilities of forensic economic examination, the subject of its research, as well as the competence of experts affects the correctness of the question posed to the expert economist, and thus the completeness of the economic research, its quality and timing [16].

As practice shows, inefficient use of budgetary (public) funds in the field of public procurement leads to significant losses to the state, territorial communities and associations of territorial communities. Therefore, in order to minimize the risks associated with violation of procurement procedures and inefficient and ineffective use of funds, it is proposed to develop and approve a methodology for conducting forensic economic examinations of business transactions related to fluctuations in unit prices in the context of contracts concluded as a result of public procurement. In particular, it is necessary to define the procedure for conducting such an economic examination, the documents that may be the subject of the examination, and the methods that may be used. It is the development of such scientific and methodological approaches that is a promising area for further research on the economical and efficient use of budget funds in the field of public procurement.

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# ORGANIZATIONAL CHANGES IN HIGHER EDUCATION INSTITUTIONS IN THE CONTEXT OF TRANSFORMATIONS

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***Annotation.*** *At the beginning of the 21st century, information and knowledge are becoming a qualitatively new factor of production, which is fundamentally different from the traditional factors of land, capital and labor. While the industrial revolution created industrial technology and machinery, which led to an increase in labor productivity, the scientific and technological revolution of the late twentieth century turned information and knowledge into a new factor of production that increases the efficiency of both production and service provision. Such an economic model is the economic system of those countries where the information sector occupies a prominent place in the structure of the economy and has a decisive impact on the functioning of all other areas of activity through the use of highly skilled intellectual labor, investment in the development of information resources, creation of new information, knowledge as the main product of production activity. Today, against the backdrop of intensive development of the latest information technologies, the processes of economic transformation are unfolding, forming a new economic and social reality that Ukraine cannot ignore, since transformation processes, their adequate perception and participation of our country in these processes will determine Ukraine's place in the global economy of the twenty-first century. In this regard, at the present stage, much attention is being paid to the study of the transformation of the governance system. This interest is also largely due to the intensification of information and integration processes in the economy, transnationalization of production activities, increased risks, and decreased profitability of many business segments. Education is of particular importance in this transformation. The search for new organizational forms for higher education institutions (HEIs) in Ukraine is an urgent process that requires finding effective solutions.*

*The study was based on the use of: method of comparison, generalization - to clarify and formalize the essence of the concept, graphoanalytical method - to provide clarity of the material and schematic representation of a number of theoretical and practical provisions of the study.*

***Keywords:*** *organizational change, educational institutions, transformation, bifurcation, transformation, motivation for change, strategy, change strategy, management system, adaptation, change potential.*

**Introduction.** The article analyzes the peculiarities of organizational changes required by higher education institutions in Ukraine, in particular under the influence of the development of the digital economy. The current situation in the economic environment of Ukraine requires comprehension and development of certain management and economic tools to adapt higher education institutions to new conditions. The article outlines the main directions of transformational changes in higher education institutions due to the impact of war and COVID.

**Results and their analysis.** In order to determine the directions of organizational

changes required by Ukrainian higher education institutions, it is worth investigating the importance of higher education for the economy and its role in the development of society. It is necessary to consider the world experience of the existence and transformation of universities as one of the most sustainable institutions of modern society. The first university is considered to be the University of Bologna, founded in the middle of the XII century. Thus, the university is about 850 years old, but if we take into account, for example, its prototypes, such as the medical school in Salermo, then its age will exceed a millennium [1, 2].

When universities appeared and spread throughout Europe, there was no state as we know it today.

The organization of the first universities of the 12th and 13th centuries reveals characteristic elements of the workshop structure or specific features of the oldest medieval associations.

The first university corporations could exist as associations of teachers or as associations of teachers and students.

At the oldest university in Europe, the University of Bologna, this corporation united only students, who elected their own leader, the dean, to whom professors were subordinate. The professors were elected by students for a certain period of time and received a fee from the funds collected by the dean from students. In addition, the elected professors were obliged not to teach anywhere but Bologna.

The University of Bologna was one of the most democratic institutions in Europe and became a source of free thinking, which was of great concern to the church of the time. In 1563, Bologna became part of the Papal State, and the Catholic Church tightened its control over the university and proclaimed the thesis: “knowledge is a gift from God, and therefore, the sale of knowledge is a form of sacred trade.” Therefore, the church condemned the collection of money to pay teachers and established professors' salaries, mostly in the form of land plots.

It is worth considering the historical background of the transformation of universities in different eras. Each era created its own type of education:

The Middle Ages created “labor education” - learning professions directly in the course of labor activity, the era of industrial society (17th century) created a classroom system of “academic education” - training in professions in isolation from direct production in special educational institutions (academies, institutes, universities). Management in these institutions was based on the principles of linear-functional and goal-oriented structures. “Industrial education” was fully aligned with the requirements of production and the labor market, and was focused on mastering various professional skills typical of the era of knowledge-skill reproductive activity.

At the turn of the eighteenth and nineteenth centuries, two main university models emerged: the French university, managed and controlled by the state (here, the key was state regulatory instruments, not science), and the Humboldt University, endowed with broad autonomy and combining teaching and research functions. The organizational structure of this university was based on the principles of linear-functional structures and

the principles of goal setting and value orientation. The logic of Wilhelm Humboldt's reasoning is as follows: the state that maintains a university, for its own benefit, should give it full autonomy in research and teaching. This is necessary because the university corporation is engaged in the search for scientific truth, and without freedom, such a search is impossible. Without autonomy from the university, it is impossible to achieve progress in knowledge, which means that such a university will not be able to solve the pragmatic tasks for which the state takes it under its care.

At the turn of the XX-XXI centuries, it became clear that Humbolt University did not fully meet the requirements of the emerging era of globalization, the new technological order and the market economy. Humboldt State University was poorly connected in terms of organizational and substantive partnerships with industry and business, did not understand the need for commercialization of science and education, and failed to meet the demands of society and individuals for personalized scientific and educational services.

Modern universities in the world: classical, technical, research universities are innovative structures that actively use innovations in their activities, make changes in the style of their activities in order to take a more promising position in the present and future, while maintaining traditional academic values.

In an innovative university, research is aimed at obtaining new knowledge, educational activities are aimed at using this knowledge in the educational process to train highly qualified specialists, and innovative activities are aimed at commercializing knowledge, i.e. commercially effective use of new knowledge.

At the current stage of development of the post-industrial society, education is becoming a purposeful, continuous (throughout active life) activity of an individual focused on using the educational system and the educational environment for self-improvement, meeting individual educational needs and obtaining a specialty necessary for the socio-economic development of society. Solving these problems requires a new approach to the organization and management of the university.

In the context of the modification of the educational and scientific system of Ukrainian higher education institutions, there is a transition to a new organizational structure, which can be characterized as a transition from a rigid organizational structure to a flexible one - an adaptive network structure. In its essence, the adaptive network structure is the development of the organizational structure in relation to post-industrial education and characterizes the transition from rigid structuring of activities to destructuring, and a new term for such a destructured structure appears in socio-economic theory - adaptive network.

A comparison of the properties of the hierarchical organization structure of higher education institutions and the adaptive network structure is presented in Table 1.

It should be noted that designing a higher education institution on the principles of adaptation and network organizational structure allows to present an innovative higher education institution as a set of interconnected and complementary structural units of educational, scientific, and innovation complexes within the institution, as well as coordinated by the institution independent, associative or under complex agreements

with it related research, design, development, research and production, financial, small and medium-sized innovative production and service enterprises and institutions, other organizations, agents, and other organizations.

*Table 1*

**Properties of the hierarchical organization structure of higher education institutions and the adaptation-network structure**

| Main properties | Hierarchical organizational structure | Adaptation and network organizational structure |
|---|---|---|
| Design features | Strict rules | Flexible approaches |
| Stability of the organizational structure | Hierarchical division of labor to improve the efficiency of labor organization and management | Developing competencies and implementing effective human capital management technologies |
| Stability of the organizational structure | Stable linear-functional structures with elements of divisional or matrix structures | Temporary project, matrix, network structures |
| Features of interconnections in the organizational structure | Administrative establishment and regulation of relationships. Limited levels of interaction, usually determined by the organizational structure and occurring between higher and lower levels and several functional units | Voluntary nature of network connections and contractual form of their regulation. Multiple levels of interaction depending on the needs of participants |
| Features of the management entity | One manager, clear hierarchical subordination | Plurality of leaders. A leader in a network organization is any participant who: 1) is a carrier of a resource (financial, production, intellectual, communicative, expert, etc.) of another resource that is relevant and important for the network at a given time; 2) is ready to use his/her resource to achieve common goals of the network |
| Peculiarities of the distribution of powers | Distribution of powers on the basis of regulatory documents in accordance with contracts, regulations | Expert power of the leader |
| Goals of designing an organizational structure | Individual interests of the staff subordinated to the general interests of the HEI | The overall goal of the network organization is based on the individual interest of each network member, which is unattainable outside the network (for example, in the use of common intellectual resources) |

*Source: compiled by the author on the basis of [2,3,4]*

It should be noted that designing a higher education institution on the principles of adaptation and network organizational structure allows to present an innovative higher education institution as a set of interconnected and complementary structural units of educational, scientific, and innovation complexes within the institution, as well as coordinated by the institution independent, associative or under complex agreements

with it related research, design, development, research and production, financial, small and medium-sized innovative production and service enterprises and institutions, other organizations, agents, and other organizations.

They ensure the process of comprehensive, interconnected, mutually coordinated and simultaneous implementation of educational activities based on innovation and development of innovation activities in all areas of the HEI for the development, creation, modification, operation, sale or transfer of innovative products and coordinate interaction with government, industry, and business.

On the one hand, an innovative HEI can be characterized as a system of social activity that implements purposeful activities of people focused on the production of final products and services to meet the needs of society, as well as value-oriented activities aimed at transforming the HEIs themselves and developing their creative potential. On the other hand, an innovative higher education institution in the modern socio-economic system is, by necessity, a subject of market relations, operating in the conditions of formation and development of specialized domestic and international markets.

According to the above, it seems adequate to describe an innovative university as a holistic, value-oriented system. This is what determines the directions of organizational changes required by the management system of the HEI.

It is logical to study the goal- and value-oriented systems as the basis for the formation of the organizational structure (Table 2). The purposeful nature of the formation of the management system of a higher education institution requires strict management, and the management system is designed as a purposefully functioning structure capable of solving problem situations under certain external conditions and given resources. The end product of the management activities of such an organizational system is a **decision** that prescribes the required behavior of the HEI. Purposeful organizational management structures are usually determined by hierarchical schemes depending on the degree of centralization of management and its nature: linear, functional, linear-functional.

Activities within a purposeful system always act as a given rational (optimized) behavior of the higher education institution, necessary and sufficient to achieve the set goals. The leading relations in the process of activity here are subject-object relations. Therefore, in systems of this class, individual characteristics and originality of elements are leveled, activities aimed at achieving goals are distributed and any other activities are suppressed, the own goals of the subjects of activity are ignored, their activity, social activity and initiative are limited [7].

The formation of a management system in value-based systems, on the other hand, can be characterized as soft management and self-governance (reflective management). The management tools used are of the nature of personal influence of subjects on the objects of management, which is dominated not by the transfer of information and norms of behavior, but by communication, collegial discussion, justification, and cooperation in achieving a conscious consensus of the objects of management in choosing areas of activity.

The peculiarities of managing the life of value-based systems are ensured by highly

developed intra-system self-governance, the creation of collegial and collective bodies. Self-governance is a characteristic feature of value-based systems that ensures the harmony of collective activity with personal mechanisms of creativity. The governing bodies of value-oriented systems, unlike goal-oriented systems, do not develop decisions, but rather a mission, goals, regulations, expert opinions, charters, memoranda, reviews, etc., the implementation of which involves the creative approach of the executors, as well as the freedom to choose the forms and methods of solving the tasks set by these documents.

*Table 2*

**Comparison of HEI management as a holistic, value-based system**

| Properties | Properties | Properties |
|---|---|---|
| Nature of the final product/service | Nature of the final product/service | Nature of the final product/service |
| Subjects of activity | Subjects of activity | Subjects of activity |
| Facilities | Facilities | Facilities |
| Subjects of activity | Subjects of activity | Subjects of activity |
| Technologies of activity | Technologies of activity | Technologies of activity |
| The main driving forces | The main driving forces | The main driving forces |
| The main features of management | The main features of management | The main features of management |

*Source: compiled by the author on the basis of [5,6,7]*

**Conclusions.** Thus, the problems of formation and development of a higher education institution as a subject of domestic and foreign specialized markets of educational services, intellectual labor, scientific products, real estate, consulting services, and financial markets introduce significant features of management of an innovative higher education institution.

And the formation of a higher education institution as a subject of market relations is not limited to a single act of making a relevant decision, but is a rather long, multifaceted and systematically organized process that involves a significant restructuring of all areas of activity of the higher education institution, changes in socio-economic and professional research and educational relations in the scientific environment, as well as the formation of new relationships between the higher education institution and external institutions. Successful implementation of the announced changes requires awareness of the need for organizational changes and adaptation of existing adaptation and network structures to the specifics of the activities and transformation of Ukrainian HEIs.

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# SUSTAINABLE DEVELOPMENT AS A FACTOR OF ENTERPRISE COMPETITIVENESS

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***Annotation.*** *The article defines the relationship between sustainable development and competitiveness of enterprises. Integration of the principles of sustainable development into various business strategies of enterprises will increase their competitiveness by optimizing costs, creating innovative solutions and promoting social advancement.*

***Keywords:*** *sustainable development, enterprise, Sustainable Development Goals, competitiveness, business strategies.*

**Introduction.** In the difficult economic conditions currently prevailing in Ukraine, the problem of competitiveness is relevant for enterprises of any industry. Therefore, one of the primary and most important tasks of state policy is to increase the competitiveness of the national economy. Competitiveness means not only the ability of an enterprise to survive in the market, but also affects its ability to innovate, create jobs and make a significant contribution to the country's socio-economic development. That is why modern enterprises are increasingly focused on sustainable development policy and achieving its goals. Competitiveness and sustainable development are closely interrelated concepts that determine the success of economic development in modern society [10].

Sustainable development is designed to meet the needs of modern society and is aimed at preserving natural resources, environmental sustainability and social justice. These are its main components. As for competitiveness, it requires efficient and, at the same time, rational use of all resources by enterprises, introduction of innovative technologies, improvement of product quality and increase in productivity.

Competitiveness is a factor that helps to realize the Sustainable Development Goals. It ensures that the products of national producers have a proper place in the domestic and foreign markets. That is why it is advisable to introduce the concept of competitiveness into public policy, the implementation of which can bring Ukraine, its regions and industries to the forefront of the world.

**Literature review.** Ukraine, like other UN member states, joined the global process of ensuring sustainable development after the adoption of the UN Sustainable Development Summit in September 2015. It was held as part of the 70th session of the UN General Assembly in New York. The outcome document "Transforming our world: the 2030 Agenda for Sustainable Development" was approved there, which approved 17 sustainable development goals and 169 targets by 2030. They are aimed at overcoming poverty and hunger, protecting the environment, and ensuring peace and prosperity for all people in the world. Nine years have passed since their implementation. During this time, Ukraine has developed national targets for achieving the Sustainable Development Goals and indicators of their achievement, introduced a system of annual monitoring of their achievement, and prepared the first Voluntary National Review of their achievement, which does not include information on the contribution of business [7].

"Leave no one behind" is a fundamental principle of the Sustainable Development Goals [8].

According to the second annual expert study of the level of integration of the UN Sustainable Development Goals into the business strategy and development strategy of Ukraine - the Sustainable Development Index - conducted by the European Business Association [5], 96% of businesses in their activities are guided by the Sustainable Development Goals in 2022, which corresponds to the level of 2021.

**Aims and objectives of the study.** The purpose of the article is to study the relationship between sustainable development and competitiveness of enterprises based on its Goals.

To achieve this goal, the following tasks were set and solved:

- identified the main areas of sustainable business development in Ukraine;
- analyzed the current state of implementation of the Sustainable Development Goals;
- identified sources of increasing the competitiveness of enterprises based on the concepts of sustainable development;
- the relationship between enterprise competitiveness and sustainable development was investigated, and its directions were identified.

**Research methods.** During martial law, Ukrainian business focused on the social component of sustainable development. Thus, the main areas of sustainable business development in Ukraine under martial law were

- support for employees and their families in relocation, payment of salaries during forced downtime, payment of compensation to families of those injured in the hostilities (97%);
- support for the military in the Armed Forces of Ukraine and the Territorial Defense Forces (84%);
- providing humanitarian support to internally displaced persons (69%);
- assistance to medical institutions (66%) [2].

Sustainable development defines the path the company is following and covers several aspects:

- how the company operates from a business perspective. It is about building a team

and using resources within the company;

- the client dimension, i.e., which clients the company works with and which it prioritizes, how it sees its client base in the near future
- what projects the company is implementing.

The history of sustainability projects is interesting because the company always receives more than it gives. This ensures its competitiveness in the market [8].

Fig. 1 shows the top 4 areas of sustainable development in 2022.

Fig. 1 shows the most relevant areas of sustainable development, namely the social component and the percentage of respondents.

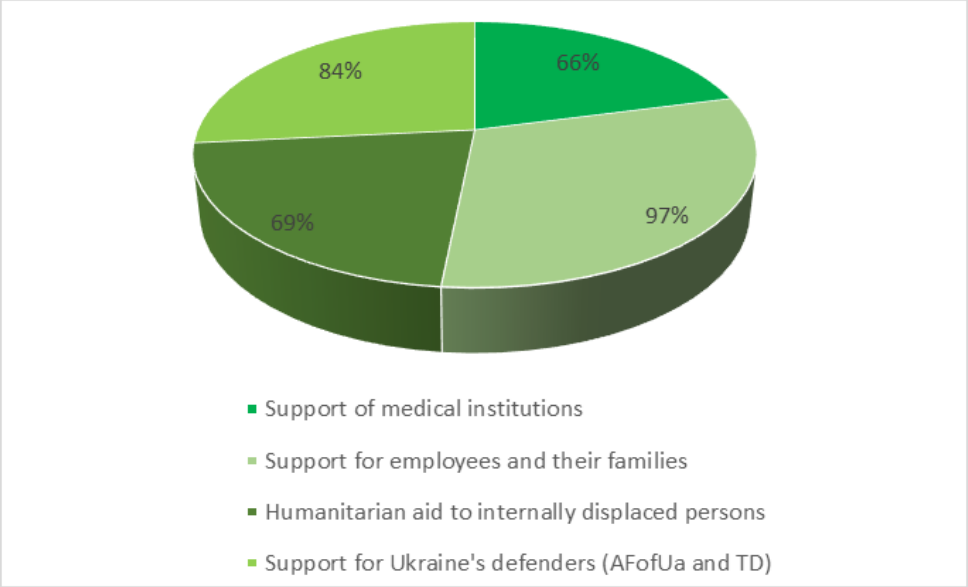


**Fig. 1. Top 4 areas of sustainable development in 2022**

*Based on [5]*

At the end of 2022, the main Sustainable Development Goals for business in Ukraine were:

- 1 - overcoming poverty;
- 16 - peace, justice and strong institutions;
- 2 - overcoming hunger;
- 3 - good health and longevity.

For comparison, the main Sustainable Business Development Goals in the world in 2022 were:

- 8 - decent work and economic growth;
- 13 - mitigating the effects of climate change;
- 12 - responsible consumption and production;
- 7 - affordable and clean energy;
- 9 - industry, innovation and infrastructure [5; 9].

As we can see, there is a huge difference in the priorities of Ukraine and the world. This is primarily due to the martial law that was introduced in our country in 2022 and continues to this day.

The assessment of the business contribution to the Sustainable Development Goals is conducted to identify achievements and challenges in integrating the Sustainable Development Goals into the strategy and practice of domestic companies, as well as to develop recommendations for strengthening the role of Ukrainian business in achieving the Sustainable Development Goals.

Achieving the Sustainable Development Goals requires the unification of government, business, and society. The private sector plays a significant role in implementing the 2030 Agenda for Sustainable Development [11]. However, to be successful, businesses need to operate in a developed society. Therefore, it is about a profitable, sustainable and long-term partnership between business and society.

Two main indicators are used to measure progress towards the Sustainable Development Goals: the current status index and the expected progress index. The definition of the indices answers two questions:

1. Current status index: What progress has been made since 2015?
2. Expected progress index: How likely is it that the goals will be achieved by 2030?

The Expected Progress Index measures the gap between the projected value of an indicator and the specified target value. Both indices are constructed at the sub-indicator level (series, disaggregation, or subcomponent of an indicator) and can be aggregated at the indicator, target, and goal levels if desired. In this analysis, the current state index is presented at the target level (snapshot), and the expected progress index is presented at the target level (panel) [2].

In Fig. 2 shows the integral value of the Sustainable Development Index of Ukraine in 2021-2022.

As can be seen from Fig. 2, the highest value of the Sustainable Development Index of Ukraine for the period under review was in business. In 2022, the index value was 3.8 points, which is higher than in 2021 (3.6 points). Overall, there is a positive trend in other areas: environmental, social, and economic.

In 2022, the integral value of the Sustainable Development Index of Ukraine was 3.5 out of 5, which is 0.23 points higher than in 2021.

According to 2022 data, 74% of enterprises kept the number of employees engaged in sustainable development projects at the pre-war level. This confirms the relevance and importance of this area of research. In particular:

- 5% of enterprises do not have a separate department or employees engaged in sustainable development projects;
- 10% of enterprises have increased the number of employees in the relevant departments, mainly in information technology and telecommunications;
- 11% of companies reduced the number of employees in the relevant departments.

The main barriers that prevent companies from implementing sustainable development projects (Fig. 3).

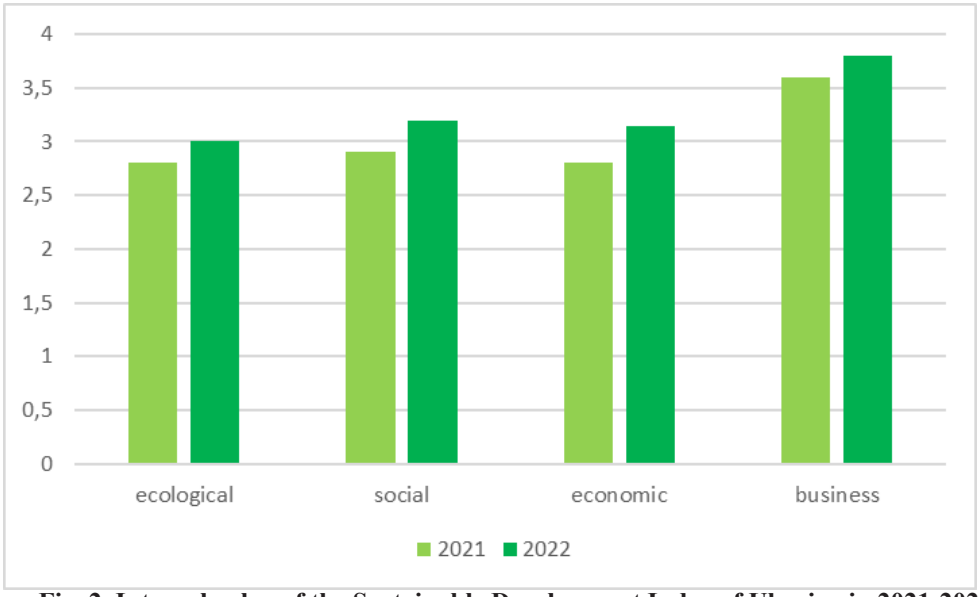


**Fig. 2. Integral value of the Sustainable Development Index of Ukraine in 2021-2022**
*Based on [5]*

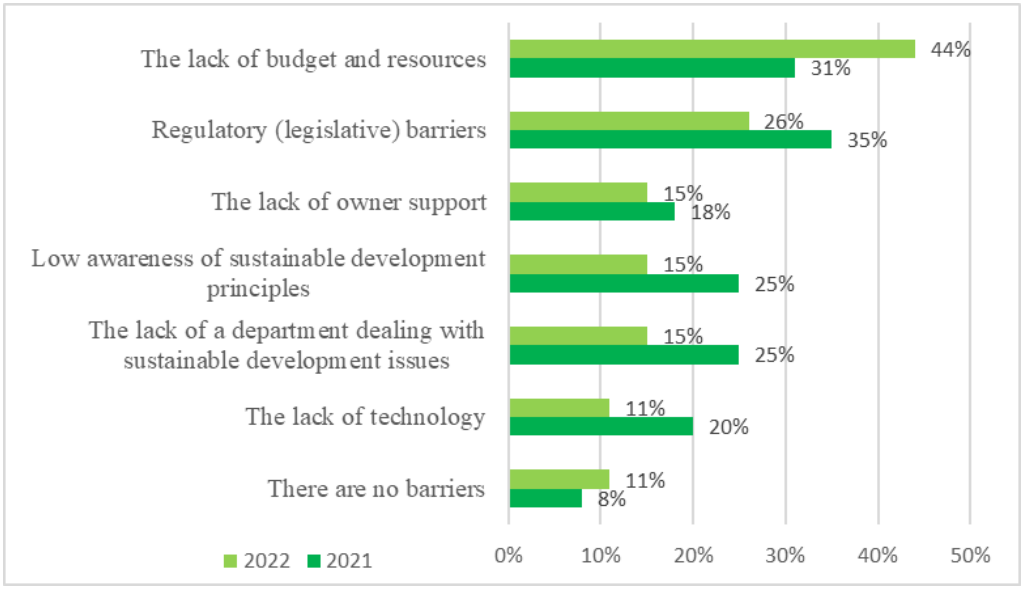


**Fig. 3. Barriers that prevent domestic enterprises from implementing sustainable development projects**
*Based on [5]*

According to experts, the implementation of the Sustainable Development Goals in Ukraine during the post-war recovery will be facilitated by:

1. Grants and targeted non-repayable assistance from international organizations.

2. Comprehensive support (financial, organizational, advisory and informational) for innovative projects.

3. Tax benefits.

4. Regulatory changes.

That is why businesses should focus on achieving the Sustainable Development Goals.

**The main part.** Sources of increasing the competitiveness of enterprises through the use of sustainable development concepts are:

- staff motivation;
- investment attractiveness through greater transparency;
- tax and other preferences;
- better relations with local authorities;
- customer loyalty [6].

Today, traditional methods of creating competitive advantages require new tools that contain "socially oriented components" and help strengthen relations between the enterprise, the government and society. This will help to develop and strengthen long-term relationships with consumers, attract highly qualified personnel, receive support from the state, and increase competitiveness. One of such tools may be the management of enterprise competitiveness on the basis of sustainable development, which implies the responsibility and participation of the enterprise in solving various problems, including social and environmental problems.

It is advisable to define the links between the Sustainable Development Goals and the concept of sustainable competitiveness of enterprises in accordance with three categories of competitiveness that are closely interrelated. These include economic, social and environmental competitiveness (Table 1).

*Table 1*

**Main categories of competitiveness**

| Category | Characteristic |
|---|---|
| Economic competitiveness | Reflects the ability of an enterprise, industry or country to compete effectively in global markets due to high productivity, innovation activity, developed infrastructure, efficient use of resources and other factors that determine economic success. |
| Environmental competitiveness | Reflects the ability of a system to compete in the marketplace through environmental benefits. This means that a company, industry or country can sell high-quality products and provide high-quality services that meet the requirements of sustainable development and gain competitive advantage through these advantages. |
| Social competitiveness | Reflects the ability of a system to compete in the marketplace through social goods. This means that an enterprise, industry or country can sell high quality products and provide quality services that meet social and consumer needs, and gain competitive advantage. |

*Source: compiled by the author*

Enterprise competitiveness management is a complex process based on the principles of comprehensiveness and systematicity. It is aimed at systematically updating and developing the competitive advantages of the enterprise. This process takes into account the impact of external factors, as well as the need to optimize profits to ensure a sustainable position in the market [1; 3].

The main purpose of enterprise competitiveness management is to ensure a sustainable competitive position of the enterprise in the market, increase the level of profitability, improve the quality of products and services, reduce costs, improve the marketing strategy, increase investment, etc. Managing the company's competitiveness allows it to maintain and strengthen its market position, ensure its development and growth, and respond to changes in the market and competitive environment.

The subject of enterprise competitiveness management is its management and staff involved in the development and implementation of competitiveness management strategies and tactics. The object of enterprise competitiveness management is the enterprise itself, its products and services, business processes and structural and business units that need to be optimized and adapted to achieve and maintain competitive advantages in the market.

Both internal and external factors influence the process of managing the company's competitiveness. The internal factors include the organizational and legal form of the enterprise, its structure, level of scientific and technological development, social potential, innovation potential, available resources, psychological climate, sales policy, etc. External factors include the production, scientific, technical and social environment.

Enterprise competitiveness management involves analyzing and managing all these factors to ensure competitive advantages and achieve success in the market. Based on the analysis of the factors of influence, the company's strategies are formed to ensure that its competitive advantages are enhanced. Strategies may include such measures as improving product quality, expanding product range, reducing costs, improving production processes, improving existing marketing strategies, etc. Enterprise competitiveness management is an ongoing and future-oriented process that requires monitoring and evaluation of the results of the implemented measures and mandatory adjustments to the strategy if necessary.

Successful functioning of an enterprise in a changing business environment while maintaining environmental, social and economic stability should be ensured by competitiveness management strategies based on sustainable development.

The main directions of such strategies are:

1. Environmental sustainability: companies that strive for sustainable development focus on reducing the impact of their activities on the environment. They introduce environmental standards and efficient technologies to reduce energy consumption, use renewable energy sources, and practice efficient resource use and waste management.

2. Social responsibility: the competitiveness of an enterprise also depends on the management's relations with employees, customers, consumers, suppliers, intermediaries, partners and society as a whole. Businesses must adhere to high labor standards, ensure

the safety and health of employees, create jobs with adequate remuneration, adhere to ethical standards in their interactions with customers and consumers, and actively participate in the development of local communities.

3. Supply chain management: sustainability requires consideration of the entire supply chain. Businesses must work with suppliers to ensure high quality materials, compliance with social and environmental standards, and effective risk management. It is important to establish partnerships, promote innovation and ensure transparency throughout the supply chain.

It should be noted that sustainability-oriented competitiveness management strategies are individualized and should take into account the specifics of the enterprise, its industry and context. The optimal strategy will include a balance between economic, environmental and social goals, while ensuring long-term stability and success of the enterprise in the global competitive environment. Sustainable development has a positive impact on the company's competitiveness because it is based on ensuring a balance between the economic, social and environmental aspects of the company's activities. This allows it to maintain and increase the level of competitiveness in the long term, as the company becomes more resistant to changes in the external environment, ensures an increase in the level of trust of consumers and other stakeholders, and also allows to reduce the risks associated with changes in legislation and regulations that may significantly affect the company's activities.

Enterprise competitiveness management in general and enterprise competitiveness management based on sustainable development in particular represent two different approaches to business management. The former focuses on how an enterprise can be more efficient in producing goods or services in the marketplace than its competitors. This process may include strategies to reduce costs, improve product quality, increase profitability, increase innovation, etc.

On the other hand, managing the competitiveness of an enterprise on the basis of sustainable development also includes social and environmental aspects of business management. This approach assumes that a business should act not only in its own interests but also take into account the impact of its activities on people and the environment. Therefore, the main difference between these two approaches is that managing the competitiveness of an enterprise on the basis of sustainable development implies that the success of an enterprise depends not only on its financial results, but also on how it affects the social and environmental spheres. This approach helps to improve the company's reputation, increase trust among consumers and investors, and ensure sustainable development not only of the company itself but also of society as a whole.

Summarizing the above, we should summarize the importance of implementing the Sustainable Development Goals for domestic enterprises as an important indicator of competitiveness:

- enterprises that directed their sustainable development programs to support the state primarily focused on addressing social issues;
- the budgets of enterprises that were directed to the implementation of sustainable

development projects increased several times;

- despite the martial law, the number of enterprises that saw obstacles in their implementation of the Sustainable Development Goals has decreased;

- businesses have improved their assessment of the government's efforts to implement the Sustainable Development Goals in the National Recovery Plan;

- the 2022 Sustainable Development Goals prioritized by businesses are in line with the goals of developing countries, so in effect, business has begun to perform the function of the state.

**Conclusions.** The interconnection of sustainable development and competitiveness of enterprises is manifested in the complementarity of these categories. This reflects the need of modern society to take into account economic, environmental and social aspects in its activities. Integration of the principles of sustainable development into various business strategies of enterprises allows to increase their competitiveness by optimizing costs, creating innovative solutions and promoting social advancement.

Thus, the synergy between competitiveness and sustainable development is a strategically important area for achieving success in today's business environment. Competitiveness is an important factor in the implementation of the Sustainable Development Goals, as the ability to compete both in the domestic and global markets encourages enterprises to introduce innovative technologies, replace existing production technologies with more environmentally friendly ones, and increases the company's productivity and profit level.

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# PEDAGOGY AND PSYCHOLOGY

## DEFINING PROFESSIONALLY ORIENTED FOREIGN LANGUAGE TRAINING CONTENT FROM THE PERSPECTIVE OF PROFESSIONAL LINGUODIDACTICS

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***Annotation.*** *This article defines the content of professionally oriented foreign language training and outlines its component structure. It highlights the training's linguistic, psychological, methodological, cultural, and extralinguistic components and proposes a variable three-level model for organizing this content. The study clarifies that the integration of interdisciplinary approaches and the fostering of learner autonomy result in the development of comprehensive foreign language professional competence.*

***Keywords:*** *professional linguodidactics, professionally oriented foreign language training, three-level content model.*

**Introduction.** The article is relevant because of the need to reform foreign language training for students of non-linguistic specialities. A successful course of this process can ensure the formation of professional linguodidactics as an innovative, independent branch of pedagogical science in Ukraine. Our previous publications have substantiated the need for its development and presented the theoretical and methodological principles of modern professional linguodidactics we have formulated.

We have emphasized that professional linguodidactics, as an interdisciplinary branch of pedagogical science, deals with strategies for forming a specialist's professional foreign language personality capable of engaging in professional communication within a multicultural environment. Its development in Ukraine is driven by the objective social needs of economists, engineers, lawyers, and scientists to master foreign languages as a means of international exchange of professional information and experience.

In searching for a theoretical and methodological basis for the foreign language training of future specialists, we considered an interdisciplinary approach to forming professional competence as a systemic factor in professionally oriented foreign language training. This interdisciplinary approach enables the transfer of research methods from one scientific discipline to another, forming binary interdisciplinary disciplines. In the context of professionally oriented foreign language training, professional linguodidactics serves as such an interdisciplinary scientific discipline, as it integrates the task of forming a specialist's professional competence (intersecting with professional pedagogy) within the process of foreign language training (encompassing aspects of linguodidactics).

**Literature Review.** The transformation of foreign language training into a means of mastering a profession necessitates a corresponding adjustment in the content of professionally oriented foreign language education. This study aims to identify the main factors in constructing content to form a professional linguistic personality that aligns with the requirements of continuous professional education. We also seek to harmonize this content with the linguistic-professional educational environment, essential for mastering professional foreign language communicative competence — the first step toward developing a professional linguistic personality.

The issues of educational content and the search for ways to update it have been explored by many domestic and foreign scholars, including O. Ovcharuk, A. Khutorskyi, N. Balovsyak, A. Dudynska, A. Kuzminskyi, V. Kraevskyi, I. Lerner, R. Owen, N. McClennen, and M. Pashia. Studies focusing on the content of professional foreign language teaching have been conducted by Ukrainian and international researchers such as N. Mykytenko, N. Rubel, G. Skurativska, O. Tarnopolsky and S. Kozhushko, Lasagabaster, D, B. Dahlhaus, B. Henriksen, and B. Hufeisen, Ruiz de Zarobe, Y., Sierra, J., M., Gallardo del Puerto, F.

The literature analysis demonstrates that educational content is a variable category that must be constantly updated. It depends on society's socio-economic state, the level of development of science and culture, societal demands, the personal needs of future specialists, and the country's prospects for further development. A new paradigm of education, new strategic goals, and an orientation toward learning outcomes also lead to profound changes in educational content.

According to Kremin (2003), it is necessary to "develop a mechanism for systematically updating the content of education by developing science and acquiring new knowledge by humanity. Moreover, ensuring a holistic vision of the world around the individual through a system of individual subjects and the organic inclusion of universal human activities, particularly one's own, is becoming increasingly urgent" [1].

In light of the above, the content of professionally oriented foreign language training for students—especially those in non-linguistic specialities—and its component composition also require updating. Therefore, we will first clearly define what we mean by the concept of educational content in general and the content of professionally oriented foreign language training in particular. In other words, we present the results of our research that are relevant to the tasks set, ensuring the fulfillment of the article's purpose.

**The purpose of the article.** This article aims to reveal the content of professionally oriented foreign language training from the standpoint of professional linguodidactics, as this represents its crucial issue. The content closely relates to society's demand for a new social and professional specialist type. This goal is achieved by accomplishing the following tasks: 1) to define the concept of "content of professionally oriented foreign language training" from the point of view of professional linguodidactics; 2) to outline the component structure of the content; 3) to develop a model of its implementation.

To achieve the aim of the study, the following research *methods* were used: *analysis*

*and synthesis of data and provisions* contained in the professional literature from various fields of science (pedagogy, vocational pedagogy, psychology, linguistics, foreign language teaching methods) in the works of Ukrainian and foreign scholars; *interpretive and analytical method,* which made it possible to compare the organization, functioning, development of the system of foreign language training and the system of professionally oriented foreign language teaching on an interdisciplinary basis; *methods of pedagogical diagnostics* - conversation, a survey of students and teachers to determine value orientations, needs of modern students, the attitude of teachers to the modernization of foreign language training.

**Results and Discussion.** It should be noted that there is no unanimity in defining the concept of "educational content" in the analyzed professional sources, except for the common viewpoint that content is a variable and constantly evolving category. Based on this understanding, we consider it appropriate to provide a working definition of content from the standpoint of V. Lugovyi's cultural and information theory of education [4], which aligns with the modern information society, is its product and meets the goals of our study.

In our view, the content of education is an organized and structured body of information—researched and formalized into an academic discipline—that encompasses knowledge about the surrounding world and the individual's place within it. This content is subject to assimilation and is continuously updated by the development of society and science, contributing to forming a future specialist's personal, value-based, and professional qualities.

Regarding the content of professionally oriented foreign language training and generalizing the opinions of other researchers [5; 6, 7], we believe that it is a selected portion from the entire array of information resulting from the achievements of modern science, which is fundamental to becoming a specialist. It considers the prospects of professional activity and interaction in the intercultural professional space, focusing on forming the general and professional culture of the future specialist and contributing to the development of personal, value-based, and professional qualities.

The current changes in social life necessitate specifying the content of professionally oriented foreign language training, particularly its component composition. This composition depends primarily on the requirements set for the content of foreign language training in the modern, information-rich, globalized society. Therefore, based on the analysis of professional sources and our research, we suggest that the content of professionally oriented foreign language training should:

1) *Meet qualification requirements:* Align with the qualification requirements of the future specialty in foreign languages, that is, the requirements for professionalism.

2) *Ensure competency formation:* Ensure the formation of professional intercultural and foreign language information and communication competencies. This will enable language training that meets the European standardized level of foreign language proficiency, thereby contributing to the internationalization of knowledge.

3) *Promote learner-centeredness:* Ensure that foreign language training is learner-

centred and stimulates the student's active role. This fosters independence, decision-making abilities in specific situations, and responsibility for outcomes.

4) *Encourage ethical orientation:* Promote orientation towards the moral, ethical, professional, and universal values of a professional, multicultural, globalized environment, thus fostering a professional culture.

5) *Support continuous development:* Encourage the development of a need for continuous self-education, linguistic self-improvement, and self-realization and self-development.

6) *Be flexible and adaptable:* Remain flexible and open to updating and adaptation to specific conditions.

7) *Allow for redundancy:* Feature a certain level of redundancy to create natural conditions for implementing a differentiated and individual approach to students.

8) *Offer choices:* Provide opportunities for choice, individual progression, and self-assessment of results.

9) *Integrate knowledge smoothly:* Structure the course so that each element allows for a seamless integration of new information with existing knowledge during the collaborative efforts of the teacher and the student, encompassing both practical methods and creative experiences.

10) *Reflect interdisciplinary interaction.*

The requirements for educational content and a focus on final learning outcomes manifested through possessing specific competencies justify discussing the multi-component nature of professionally oriented foreign language training. The component structure of such training is determined by its specificity, which is inherent in its very name.

Following other researchers [6,7,8], we understand professionally oriented training as instruction that considers students' needs in learning a foreign language dictated by the specifics of their future profession. This approach involves combining the mastery of a foreign language for a specific speciality with knowledge of the culture — exceptionally professional culture—of other peoples and countries, information culture, acquisition of values (moral, ethical, professional, socio-cultural), development of personal qualities, and acquisition of special skills and abilities in intercultural professional communication, all based on professional and linguistic knowledge. The essence of professionally oriented foreign language training lies in its integration with specialized disciplines to obtain additional professional knowledge and to form professionally significant personal qualities—in other words, to form foreign language professional communicative competence [7].

The characteristics of professionally oriented foreign language training imply a duality in the component structure of its content. On one hand, it is determined by the content of foreign language training; on the other, by the content of future professional activity. It means that all components of the content must be interconnected and interdependent. Considering the above, and after studying and generalizing the views of scholars on the component structure of the content of education, foreign language

teaching, and professionally oriented foreign language training, we will determine the components of the content of professionally oriented foreign language training. Due to space limitations, we will focus on only some of them.

We start from the premise that we must teach students professional foreign language communication for implementation in a multicultural, globalized information society. Communication is, first and foremost, the exchange of information due to subject interaction. According to the cultural-information theory of education, socio-cultural information has five types: knowledge, values, dialogisms (consensus), projects, and artistic images [4]. Thus, communication is the exchange of various types of information. Accordingly, the component composition of the content of foreign language training should ensure the exchange of this information.

Since the exchange of information occurs between the subjects of the communication process, we consider it legitimate to include intersubjective interaction in the component composition. Intersubjective interaction, or subject-subject interaction—the relationships between individuals—occurs through dialogue. As a result of such interaction, forms of culture are transmitted as sources of socio-cultural information and vital experience—that is, specific subject content.

Learning foreign languages is constructed as a model of real communication, preserving all its main parameters: motivation, situational context, and the mandatory presence of the speech addressee, regardless of the type of speech involved—oral or written. It involves areas of activity and communication, topics, problems, and situations in which the objective content of communication is transmitted (what to talk about, listen to, read, and write). This is optional (extralinguistic) information - thinking and thoughts. Thoughts arise and develop in continuous connection with speech. The more deeply a particular thought is contemplated, the more clearly it is expressed in oral or written language. Conversely, the more polished the verbal formulation of a thought, the clearer it becomes.

It should be noted that a person has already formed their figurative picture of the world based on their native language. When learning a foreign language, one is compelled to adjust this image, as learning is a creative activity resulting in the accumulation of new information about the foreign language — its structure and means of expression. In this context, mastering a foreign language without a language environment—that is, without an environment where it is spoken—requires the creation of imaginary communication situations equivalent to real ones, the introduction of role-playing and business games, and similar methods. This stimulates the development of imagination.

Imagination is closely related to creativity. The implementation of professional tasks is only possible with creative imagination. Creative imagination is an integral attribute of a creative specialist, enabling them to restructure themselves and their activities in accordance with rapidly changing conditions. Combining the learning process with developing intelligence, creative potential, and creative imagination is necessary to prepare such a specialist. In practice, this is achieved by creating a real-life system of interdisciplinary interaction, which involves unifying certain sections of different

disciplines based on a mutually agreed set of topics. According to our assumption, such unification opens the way to creating joint interdisciplinary projects. Professional foreign language projects with a problem-based presentation of material—which involves searching for ways to solve issues—encourage reflection and independent information gathering, thereby developing creative potential and creative imagination. On the one hand, without imagination and flexibility of thinking — the essential qualities of a modern specialist — and without professional foreign language skills, presenting an original project and defending one's point of view seems problematic. Considering the above, it is appropriate to include imagination as a content component of professionally oriented foreign language training, viewing it as the next sphere of spiritual and mental life after thinking.

The content components also include knowledge. Regarding foreign language training, knowledge in the professional literature is considered:

1) As knowledge about ways of working with language and speech material, and as methods of activity for mastering the competent formation of skills and, we add, abilities, since we also consider skills as one of the components of the content of education.
2) As socio-cultural knowledge — linguistic and cultural studies
3) As special/professional knowledge — knowledge of professional culture, culture of professional communication, and professional expertise

Accordingly, we mean knowledge of the phonetics, vocabulary, and grammar of the language being studied, as well as ways of working with them, including comparing the meanings of linguistic units in native and foreign languages; knowledge of speech material (samples of speech at the level of text, supra-phrasal units, phrases, formulas of speech etiquette/business etiquette) that express specific communicative intentions; knowledge of language units that reflect the conceptual differences between the native and foreign languages, and so on.

Socio-cultural knowledge involves understanding the national and psychological characteristics of representatives of the linguistic culture being studied; knowledge of the characteristics of professional/production culture (for example, in economic specialties, knowledge of national business practices); knowledge of various models of social behavior in these linguistic and professional communities; awareness of factors that can hinder intercultural communication—particularly in the business sphere—and means of overcoming communication difficulties; background knowledge, i.e., knowledge of realities, cinema, idiomatic expressions, aphorisms, etc., which reflect national-cultural specifics compared with verbal and non-verbal signs of the native culture; knowledge of stereotypes (socio-cultural, ethno-cultural, content and organization of communication, exceptionally professional, choice of speech and language forms) of speech and non-speech behavior (etiquette/business etiquette) in native and foreign professional languages.

As for the methods of activity that will contribute to the conscious formation of skills and their transition into abilities, based on the analysis of scientific sources, these include activities aimed at evaluating and interpreting the phenomena of another linguistic/

professional culture within its parameters; evaluating and interpreting the phenomena of the native culture/profession from the perspective of another; understanding the foreign language reality/social and professional environment; conducting a comprehensive analysis of the phenomena being studied through the integration of knowledge from various disciplines; commenting on linguistic and speech units that are marked by socio-cultural specificity and using them in speech; and building communicative strategies of speech and non-speech behavior by the conditions of communication, particularly professional.

We emphasize that the methods of activity in the foreign language professional sphere are primarily aimed at forming the ability to integrate special knowledge from various (main and related) disciplines to obtain a holistic picture of the world's professional/production culture and to act within it using verbal and nonverbal means of a foreign language. All of the above, in a comprehensive manner, will contribute to the formation of a multicultural linguistic professional personality.

Following Lugovyi (2011), we consider it necessary to reflect the individual's needs in the component structure of professionally oriented foreign language training. Without delving into a detailed analysis of this concept, we note that, according to Maslow's Hierarchy of Needs, there is a connection between an individual's need for self-improvement and the desire to self-actualize — to become who they can be and to do what they are intended for—which aligns with personal development.

The need for self-improvement should also inform the content of professionally oriented foreign language training. For a future specialist to master the competencies we have previously defined—professional foreign language communicative competence, professional intercultural competence, and foreign language professional information and communication competence [2, p. 209]—the content of foreign language training should evoke in them the desire for self-improvement and self-development, and the aspiration to become a proficient specialist. It should engage them in activities to master professional foreign language communication, involve them in a global professional culture, and present the foreign language as a means to master their profession better. It should satisfy their informational and spiritual needs—to become an erudite and cultured person—and equip them with appropriate experience (skills and abilities in foreign language communication) to realize these needs, promoting the development of the ability to evaluate their results.

Since needs are the deepest motivators and factors in activity, the content of foreign language training that reflects the individual's needs also catalyses the student's active engagement in mastering professional foreign language communication. We outlined the students' needs based on our vision of the problem, which crystallized during our research. However, as the connections of future specialists with their environment expand, it is logical to assume that the range of their needs also expands. Therefore, it seems appropriate in the process of further work to use empirical methods (observation, conversations with students) to determine whether the needs we identified correspond to the real needs of students and to make appropriate changes to the component composition

of the content of foreign language training.

The multi-component structure of professionally oriented foreign language training content should be reflected primarily in educational materials and textbooks. We will focus separately on the components that determine the content in the context of interdisciplinary integration. As noted earlier, the essence of professionally oriented foreign language training lies in its integration with specialized disciplines. Therefore, its content should aim to form the linguistic personality of the future specialist within the context of interdisciplinary integration—the essence of which is that each cognitive and professional problem is inherently multidisciplinary and requires solutions from the perspectives of related disciplines, followed by the unification of disciplinary solutions into a holistic picture (Shemet, 2004). The content should be subordinated to forming professional foreign language communicative competence and professional intercultural competence in the future specialist. Considering them equal and inseparable, we distinguish a variable (professional) component and an invariant (intercultural) component within professional foreign language competence. The professional component, in turn, is divided into general professional communication, business communication, scientific communication, and language for specific purposes [2, pp. 225–226].

General professional communication encompasses the abilities and competencies required for professional communication in the learner's specific field of specialization. These include implementing the exchange of professional information in a foreign language and independently searching, accumulating, and expanding professionally significant information through natural communication with native speakers and by utilizing information and computer technologies.

Business communication focuses on conducting professional dialogues in occupational contexts. Professional interests in this domain may involve scientific research, participation in business conferences and meetings, writing and reviewing abstracts, summaries, and articles, and delivering and understanding oral presentations. Such activities are indicative of scientific communication.

Language training tailored to a specific specialty is one way to shape the future specialist's professional competence in fields such as economics, marketing, finance, or management.

The intercultural invariant component encompasses linguistic, cultural, and communicative skills and abilities. The following traditional content components support its formation:

- **Linguistic component:** Language and speech materials
- **Psychological component:** Developing the skills and abilities necessary for effective foreign language use
- **Methodological component:** Mastering rational learning techniques
- **Cultural component:** Acquiring knowledge in the context of various cultures
- **Extralinguistic component:**

a) areas of communication (extralinguistic background) that influence the selection of language, speech means, and speech behavior

b) communication situations that define the specific conditions under which communicants interact

c) topics that serve as the informational basis of communication

Under modern conditions, the professional and intercultural components can only be fully realized by developing the appropriate educational and computer literacy skills. Equipped with such an expanded range of components, the content of professionally oriented foreign language training can be integrated into a linguistic-professional educational environment. This environment comprises the conditions necessary for forming foreign language professional competence, including linguistic-cultural and professional extralinguistic elements that support interdisciplinary integration and subject-subject interaction. It also involves educational and methodological materials—such as textbooks and manuals—that serve to implement the content. Among these resources, the foreign language course program tailored to a specific specialty occupies a central position.

In this way, the content of professionally oriented foreign language training is expressed through the formation of components within the linguistic-professional educational environment and the development of variable programs that meet international foreign language proficiency standards and general requirements for continuous professional education. Considering all these aspects, a variable model of the content of professionally oriented foreign language training emerges. This model reflects the progression from mastering foreign language communication skills in professional situations to achieving specialization-specific language competence.


**Fig 1. A Variable Model of the Content of Professionally Oriented Foreign Language Training**

**The first** level (general) encompasses communication in social and everyday contexts, as well as in socio-cultural and general professional domains. At this level, the content should broadly reflect the nature of the chosen profession. For instance, texts should be presented in appropriate professional genres, include relevant information, and feature communicatively significant situations.

The second level focuses on mastering business communication within the professional sphere. Taking the economist's profession as an example, it includes a broad range of specialties that can be grouped into two categories (Badadze et al., 2006):

1. Specialties dealing primarily with quantitative data—accountant, analyst, auditor, economist-mathematician, economist-planner.
2. Specialties dealing primarily with interpersonal relations—manager, marketer, entrepreneur, financier.

For the first category, written communication is predominant. Specialists must be adept at producing and understanding business letters, legal and social documentation (contracts, agreements), various types of supporting documents, protocols, reports, acts, certificates, analytical documents, and business plans. Thus, an economist must thoroughly master a specific official business style in the target language, recognizing that the rules of professional communication in one's native language do not automatically apply to foreign languages. Acquiring and comparing the official business style of a foreign language with that of the native language not only enhances proficiency but also fosters an appreciation of the culture of written communication. Effective interaction in today's globalized labor market is practically unattainable without these skills-particularly in conducting business correspondence.

Moreover, all specialists must cultivate a culture of oral communication and mastery of official and business written communication regardless of category. The first and second levels are essential for achieving professional, communicative competence in a foreign language.

The third level focuses on mastering scientific communication and language use specific to one's specialty within educational, cognitive, and professional contexts. We associate the implementation of this level with the learner's personal needs and capacities, as integrated into the content structure. The inherent drive for self-improvement, engagement with global professional culture, and recognition of the foreign language as a tool for professional growth—including becoming more erudite and cultured—stimulates progression to the third level.

Accordingly, this third level of the POIP content model should be variable, accommodating those who aim to:

1. Master only selected professional specialties in a foreign language,
2. Master their entire specialty in a foreign language, or
3. Develop expertise in scientific communication.

Integrative programs must be developed in line with these distinct categories of learners.

Thus, professionally oriented foreign language training has diversified content. It

considers students' needs and abilities and offers programs that enable each learner to attain a professional level aligned with their unique requirements and potential. The content across all levels is non-linear, allowing for the rotation of language and speech materials and their integration with humanities-based and specialized disciplines within a given thematic situation or topic.

The variable nature of the content and programs makes it possible to:

- Ensure transparency in professionally oriented foreign language training.
- Design tiered courses focused on general/intercultural, business communication, and language for specific purposes.
- Plan personalized learning trajectories for individual students and groups.
- Encourage deeper language study through independent work, supplementary courses, and related activities.
- Enable learners to shape their path within the foreign language educational environment.
- Enhance student autonomy and foster self-directed learning.

By student autonomy, we refer to learners' willingness and ability to take responsibility for their learning activities, including independently planning, organizing, adjusting, and evaluating their progress.

**Conclusions.** The findings of this study, which include defining the concept of "content of professionally oriented foreign language training," specifying its component structure, and developing a variable model that reflects the progression from general foreign language communication to specialized language mastery, contribute to forming foreign language professional competence in future specialists. This work represents a valuable contribution to developing modern professional linguistic didactics.

This research's scientific novelty lies in its attempt to specify the content of professionally oriented foreign language training for students in non-linguistic faculties from the perspective of professional linguistic didactics. By aligning this content with contemporary social demands and the abilities and needs of future specialists, the study aims to enhance their professional success in a global, multilingual, and multicultural environment.

The theoretical value of this work is evident in its development of a level-variable model that encompasses all content components and supports the formation of foreign language professional competence by individual learner needs and abilities.

The study's practical significance lies in its underlying ideas, which can be applied to professionally oriented foreign language training in higher education settings. These ideas can also be integrated into methodological seminars for teachers, serve as a foundation for further scholarly research, and be incorporated into monographs, textbooks on modern professional linguistic didactics, and specialized courses for students of foreign language faculties and linguistic universities.

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# AXIOMATIC METHOD AS A SCIENTIFIC BASIS OF MODERN GEOMETRY COURSES

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***Annotation.*** *The article reveals the essence and substantiates the expediency of using the axiomatic method of constructing geometry, both Euclidean and non-Euclidean, in institutions of higher education. The expediency of using the axiomatic method as a logical basis for constructing a geometry course is analyzed. Different approaches to building the axiomatics of Euclidean geometry are analyzed. Different systems of substantiation of Euclidean geometry are described. The problems of constructing a geometric theory based on the axiomatic method are studied. The specifics of the application of the axiomatic method in the study of Euclidean geometry in institutions of higher and secondary education are described. The main methodical aspects of these processes and the improved scientific principles of teaching geometry in institutions of higher and secondary education are revealed.*

***Keywords:*** *geometry, basics of geometry, Euclidean geometry, axiomatic method of construction of geometry, educational process, learning, scientific approach, logical basis.*

**Problem statement.** The purpose of the article is to, with the help of available sources, scientific and methodical literature, own experience, reveal the essence and justify the expediency of using the axiomatic method of constructing geometry, both Euclidean and non-Euclidean. To analyze different approaches to building the axiomatics of Euclidean geometry. To describe the specifics of the application of the axiomatic method in the study of Euclidean geometry in institutions of higher and secondary education. To reveal the main methodical aspects of these processes and to improve the scientific principles of teaching geometry in institutions of higher and secondary education.

**Presenting main material.** The axiomatic method is a way of building a scientific theory, where the basis of the theory is based on some initial propositions, which are called the axioms of the theory, and all other statements of the theory are obtained as logical consequences of the axioms.

The axiomatic or deductive method is one of the main methods of building a scientific theory. Its application assumes that a rigorous scientific construction of any

mathematical theory must satisfy the following requirements:

1. Any statement must be among the list of axioms or rigorously proven on the basis of axioms and previously formulated and proven theorems.
2. Any concept must be either among the main ones or defined with the help of the main and previously defined concepts.

The axiomatic method is that:

1. *The main concepts* are listed and named.
2. Certain laws are formulated that express the properties of these basic concepts (*axioms*).
3. A number of concepts are formulated that are not included in the list of basic concepts, which we mean using basic concepts and axioms (*definitions*). A definition is a sentence in which the content of a new concept is revealed with the help of already known concepts and their properties [3].
4. A number of statements are formulated, which we prove using the rules of logic and previously proven statements (*theorems*).

**The interpretation** of basic concepts is giving them a certain content, building models of a certain theory. In order for a system of axioms to serve as a scientific justification for a certain theory, three requirements must be met:

1. Consistency or compatibility of the system of axioms.
2. Independence or minimality of the axiom system.
3. Completeness or categoricalness of the system of axioms.

A scientific theory that satisfies these requirements is *a meaningful axiomatic theor* [20].*y.*

A system of axioms is called consistent if there are no two contradictory statements in the list of its axioms and in the list of its consequences (theorems). The requirement of non-contradiction is proven by building its model on the basis of that scientific theory, the non-contradiction of which we have previously established.

There are arithmetic, algebraic, geometric, physical, chemical, economic, astronomical, architectural, optical, biological, space, virtual and real models. In geometry, we very often use the arithmetic model, taking advantage of the fact that the arithmetic of the real numbers is consistent. In particular, each geometric object is assigned an ordered set of real numbers called its *coordinates.* This makes it possible to determine the position of a point or body using numbers and to use the coordinate method when proving theorems, statements and solving problems.

The requirement of *independence* is that the list of axioms does not include such a statement that is a consequence of others. Let us have a system of axioms $\sum a_1,a_2,...a_i,\ldots,a_k$. Let's choose axiom $a_i$ and prove that it is not a consequence of all other axioms. We will reject this axiom of $a_i$ and introduce a statement that is opposite in content to $a_i$. We will get a new system: $\sum' a_1,a_2,...\bar{a}_i,\ldots,a_k$. And we will prove that it is consistent. If as a result we got that the system of axioms $\sum'$ is consistent, it means that axiom $a_i$ is not a consequence of all other axioms, because if axiom $a_i$ was a consequence, then in the theory that was built on the system of axioms $\sum'$, two contradictory statements would

hold and it would not be consistent. From here we can conclude that axiom $a_i$ is not a consequence of all other axioms of the system of axioms Σ.

The requirement of *completeness* is that, given a certain system of axioms, we must say precisely about any statement whether it is true or false. The requirement of completeness is proved by establishing an isomorphism between two different models of the corresponding axiom system. A system of axioms will be *categorical* if all its interpretations are isomorphic. That is, the categorical requirement of the axiom system is stronger. The categorical nature of the axiom system implies its completeness, but not vice versa [20].

In contrast to substantive axiomatic theories, there are *formal* axiomatic theories in which the rules of logical deduction are introduced.

Consider Gödel's incompleteness theorem (1931). Let us have a consistent or compatible system of axioms $\sum a_1, a_2, ...a_i, \ldots, a_k.$, on which the formal theory T(Σ) is built.

**Gödel's incompleteness theorem.** *In any non-contradictory (compatible) formal system with minimal arithmetic possibilities (addition, multiplication, generality quantifier, existence quantifier), there will be a formally undecidable statement.*

That is, a true statement formulated in terms of the theory under consideration, which cannot be proven on the basis of the formal system under consideration. Thus, it cannot be deduced as a logical consequence of the system of axioms Σ under consideration, nor can its negative statement be derived on the basis of this system of axioms Σ.

A consistent system of axioms Σ is said to be complete if, in the theory T(Σ) built on the basis of this system of axioms Σ, any statement formulated in terms of the considered theory T(Σ) can either be proved or disproved, that is, a negative statement can be proved.

Thus, the completeness requirement is that, given the complete system of axioms Σ, we can prove the truth or falsity of any statement formulated in terms of the theory T(Σ). Therefore, true statements are fulfilled in every model (in all models) of a given system of axioms Σ, false statements are not fulfilled in any of its models, and formally unsolvable statements are fulfilled only in some models of the system of axioms Σ, but there are such models of this system axioms of Σ in which they do not hold. If a theory consists only of true and false statements, then it is complete.

In our time, axiomatic theories, which are based on set-theoretic concepts, which allow the basic concepts of the axiomatic theory to be given a certain set-theoretic interpretation in the form of sets and some relations between their elements, are strongly developing. For this interpretation of geometric objects, it is necessary to use the concept of mathematical structure.

*A mathematical structure* is an axiomatic theory whose axioms are expressed in terms of set theory. A mathematical structure can be defined by the assignment of one or more sets of relations, assigned to them, and a certain system of axioms that express the properties of these relations.

Therefore, in the axiomatic presentation of a certain geometry, the concept of mathematical structure and theory is used quite widely and requires detailed study.

A mathematical structure can be defined by specifying one or more basic sets:

$M_1, M_2,\ldots,M_p,$ the elements of which are connected by basic relations: $\rho_1, \rho_2, \ldots,\rho_n$. The properties of these relations are expressed in axioms: $a_1, a_2, \ldots,a_k$. The set of all axioms $\sum a_1,a_2,\ldots a_i,\ldots,a_k$ is called *a system of axioms of a mathematical structure.*

Mathematical structures are denoted as follows:

$$S = (M_1, M_2, \ldots, M_p, \rho_1, \rho_2, \ldots,\rho_n) + \sum a_1,a_2,\ldots a_i, \ldots,a_k$$

Among the basic sets, some are *basic*, the other part of the sets, which is not included in the selected list, is called *auxiliary.*

Examples of reference notes on this topic can be found in the publication [17]

To understand the construction of geometry using the concept of mathematical structure, it is advisable to give an example of the construction of Euclidean geometry based on *Hermann Weyl's* axiomatics. This axiomatics is also called *point-vector* axiomatics, since the main undefined concepts in it are points and vectors.

In the system of G. Weil's axioms, there are two main concepts: a point and a vector. The relations *"adding vectors", "multiplying a vector by a number", "scalar product of vectors"* and *"subtracting a vector from a point"* are called basic relations. The sets of all points and vectors are denoted by the symbols *T* and *V*, respectively. Weyl's axiomatics consists of five groups.

The axioms of the first and second groups allow us to define the concept of a vector space. A *vector space* over the field of real numbers is the set *V*, for the elements (vectors) of which the operations of adding vectors and multiplying a vector by a real number are defined so that the requirements of the first and second groups of axioms are met.

Using the concept of mathematical structure, the following definition of vector space can be given. *A vector space* is a mathematical structure $(V, \varphi_1, \varphi_2)$ with a basis set *V* and operations $\varphi_1, \varphi_2,$ for which the requirements of the first and second groups of axioms are fulfilled.

A vector space in which the operation of the scalar product of vectors is defined in such a way that the requirements of the axioms of the first, second, and fourth groups of axioms are met is called *a Euclidean space.* Or the Euclidean space is a mathematical structure $(V, \varphi_1,, \varphi_2, \varphi_3))$ with a basis set *V* and operations $\varphi_1,, \varphi_2, \varphi_3$, for which the requirements of the first, second, and fourth groups of axioms are fulfilled.

Two axiom systems Σ and Σ′ are called *equivalen*t if the theories built on the basis of these axiom systems coincide, i.e. T(Σ)=T(Σ′).

The formation of students' skills in building models of various axiomatics, checking the fulfillment of requirements for the system of axioms contributes and sets them up for understanding the scientific construction of geometric knowledge and facts. The need not only to state or verify, but strictly scientific proof of the facts of both Euclidean and non-Euclidean geometries, requires students to have a thorough theoretical and practical basis for further professional activity.

Therefore, the creation and use of reference notes, where the information necessary for learning the educational material is concisely presented in the form of diagrams, figures, tables, diagrams, color correspondences, etc., is urgent and expedient, especially in the conditions of distance learning [17, p.83].

The reference outline is a visual structural and logical diagram, which is used to present the educational material in a condensed form.

The pedagogical feature of the reference synopsis is that the educational material is offered in the form of a compact structural and logical scheme that is quickly remembered, has the form of a system of didactic blocks with the content of the educational material encoded in it.

The didactic essence of the reference synopsis is determined with the help of keywords or phrases, abbreviations, pictures, graphs, formulas, conventional signs or other means of coding, which allow you to quickly learn and reproduce the content of the studied material.

The psychological essence of the reference synopsis consists in the intensification of the educational and cognitive activity of students by creating favorable conditions for the effective course of the processes of perception, memorization and reproduction of large in volume and integral in nature arrays of educational information.

The reference synopsis is easily reproduced, which allows you to create a situation of success in learning, in addition, such material reflects the connections not only between course topics, but also between different educational disciplines, that is, it provides interdisciplinary connections, which greatly contributes to the development of the individual's thinking and its comprehensive development.

The significance of reference notes, which are both a means of visualization and a means of systematizing acquired knowledge, and a means of intensification of the educational process, is determined by time.

An example of one of the supporting notes in teaching the axiomatic method to students of mathematical specialties of the Faculty of Mathematics, Informatics and Physics of Mykhailo Dragomanov State University of Ukraine, namely, when checking the fulfillment of three requirements for the axiom system, can be found in our publication [17, p.83-86]. Reference notes as one of the means of learning the system of axioms D. Hilbert of Euclidean geometry can be seen in our publication [18].

**Problems of constructing a geometric theory based on the axiomatic method.**

Questions arise in geometry:

- can we build the same geometric theory, having different initial, basic, undefined concepts and relations?

− can we build different geometric theories, having different initial, basic, undefined concepts and relations?

- can we build the same geometric theory, having the same initial, basic, undefined concepts and relations, but formulating different systems of axioms?

In order to answer these questions, we will consider various axiomatic approaches to the construction of Euclidean geometry.

The axiomatic justification of geometry was first given by D. Hilbert in 1899, already after non-Euclidean geometry, namely hyperbolic geometry, was discovered.

Hilbert's axiomatics contains 20 axioms, they describe 8 main objects: 3 main concepts (point, line, plane) and 5 main relations (incidence, belonging or combination,

the relation "lie between" or the relation of order, congruence, continuity, parallelism).

Hilbert's system of axioms of Euclidean geometry consists of 5 groups that describe basic relations.

The first group: axioms of incidence, belonging or conjunction, which describe the relation of incidence of points and a line, a line and a plane, points and a plane.

Group II: axioms of order, which describe the basic relation "lie between"" associated with points incident to a line.

Group III: axioms of congruence, which describe congruence relations for segments, angles, triangles.

IV group: axioms of continuity, which describe the property of continuity of the location of points on a straight line.

Group V consists of only one axiom, namely, the axiom of parallelism: through point A, which does not belong to line a, in the plane defined by point A and line a, no more than one line can be drawn that does not intersect line a.

It is interesting that neither Hilbert's axiom of parallelism nor Lobachevsky's axiom of parallelism contains the word parallel. They only indicate the number of straight lines that pass through a given point and do not cross a given straight line.

At present, in secondary education institutions, the congruence relation is not considered, but the equality relation is introduced, so let's pay attention to the question of the equivalence of the congruence and equality relations. To do this, we will consider the concept of motion and show the connection between the relations of motion and congruence. The transformation of a set of points in space is called a movement if it translates two arbitrary points $A$ and $B$ into points $A'$ and $B'$ so that $A'B'=AB$. Considering the axioms of motion and studying the properties of equal figures, we can come to the conclusion that the relation of motion and congruence are equivalent. That is, in Hilbert's axiomatics, the third group, that is, the axioms of congruence, can be replaced by the axioms of motion.

The first Saccheri-Legendre theorem is very interesting: *The sum of the interior angles of a triangle cannot be greater than the sum of two right angles.* and the second Saccheri-Legendre theorem: *If there is at least one triangle on a plane whose sum of interior angles is equal to two straight lines, then every triangle of this plane has a sum of interior angles equal to two straight lines. If there is a triangle on the plane, the sum of the interior angles of which is less than two straight lines, then every triangle of this plane has the sum of the interior angles, less than two straight lines.*

The introduction of the definition of the defect of a triangle as a value equal to the difference between 1800 and the sum of the internal angles of a triangle is a kind of marker for determining the type of geometry, namely: if the defect of a triangle is zero, then we have Euclidean geometry, if it is greater than zero, we have hyperbolic geometry.

The system of consequences arising only from axioms I-IV of groups of Hilbert's system of axioms is called *absolute geometry*. And it is a common part of Euclidean and hyperbolic geometries.

Having a system of axioms D. Hilbert, Euclidean geometry can be strictly

scientifically constructed.

The work of D. Hilbert's Fundamentals of Geometry played an important role in the development of geometry. The modern axiomatic method and the theory of mathematical structures in the modern sense originate from it.

Friedrich Schur replaced David Hilbert's axioms of congruence with axioms of motion, which describe the properties of motion — the mapping of points, lines, and planes into points, lines, and planes, respectively. Both groups of axioms of both systems perform the same task, defining the same concepts in different ways.

Hilbert's axioms of congruence determine congruence relations directly, axioms of motion — through consequences.

In 1904, the American mathematician O. Veblen gives the construction of Euclidean geometry on the basis of "metric" axiomatics. His research was continued by another American mathematician R. L. Moore in 1908. But the most widespread of the "metric" axiomatics was the system of axioms of the American mathematician J. Birkhoff, who presented a system of planimetry axioms based on the use of a scale ruler and a protractor. The main concepts in the system are the concepts of "distance", "angle measure", "point", "line". This is a system of four axioms of Euclidean geometry. The concept of a real number is used in the formulation of the axioms. Therefore, Birkhoff's axiomatics resembles the introduction of Euclidean geometry using a model.

George Birkhoff was involved in writing a school textbook using this system of axioms. This system influenced the system of axioms developed by the School Mathematics Study Group for the American school.

In the textbook O. IN. Pogorelov adopted a modification of Birkhoff's axiomatics. The initial concepts in the system of axioms are: "point", "line", "plane", "belonging", "lie between", "length of a segment", "degree measure of an angle". The axioms of planimetry are divided into six groups: axioms of belonging; axioms of mutual location of points on a straight line and on a plane; axioms of measuring segments and angles; axioms of setting segments and angles; axioms of equality of triangles; axiom of parallels. This system of axioms, with some changes, became the basis of a school geometry textbook.

**Conclusions.** In institutions of higher education, both Euclidean and non-Euclidean geometries are constructed using the axiomatic method. The logical foundations of geometry are the foundations of geometry, which must meet the requirements of logic.

Thus, we can build the same geometric theory, having different starting, basic, undefined concepts and relations. Such a theory is Euclidean geometry, examples of various axiomatics of which are considered in the work.

We can also build different geometric theories, having different initial, basic, undefined concepts and relations. Examples of such theories are spherical geometry, elliptic geometry, Galilean geometry.

We cannot build the same geometric theory, having the same initial, basic, undefined concepts and relations, but having formulated different systems of axioms. Such an example is Euclidean geometry and hyperbolic geometry, projective geometry.

In order not to violate the principle of continuity and consistency in education, we

consider it expedient to build a geometry course in secondary education institutions using the axiomatic method. And from the very beginning of teaching geometry, use the axiomatic method as the basis for structuring students' thinking. The use of the principles of continuity and systematicity in education gradually gives good results not only when studying geometry, but also for studying other disciplines, as it teaches to structure the material, to see the logical structure of the relevant discipline. Otherwise, it will not be a construction of geometry, but a story about geometry.

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# TECHNICAL SCIENCES

## ANALYSIS OF BRIDGE RELIABILITY BASED ON NORMAL AND ASYMMETRIC DISTRIBUTION LAWS

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***Annotation.*** *In modern calculations of structural reliability, it is traditionally assumed that the distribution laws of random variables, such as material resistance and load effects, obey the normal law (Gauss' law). This approach is convenient and well-known due to the symmetric nature of the distribution and its mathematical simplicity. However, the results of experimental studies show that in real conditions the distributions of such variables often have an asymmetric nature.*

*In modern calculations of structural reliability, traditionally, the asymmetry of the distribution of material resistance in most cases has a negligible effect and can be ignored. At the same time, ignoring the asymmetry in load distributions can lead to significant errors in assessing the reliability of structures. In the paper, the lognormal law was used to model asymmetric distributions, which is universal and widely used to describe physical quantities such as material strength, load, river flow, etc.*

*The results of the study are presented in the form of tables and graphs, reflecting the dependence of the reliability of structures on the safety factor. The results for symmetric (PNN) and asymmetric (PLL, PNL) distribution laws are compared. All calculations were performed using the Mathcad software package, which provides high accuracy and convenience in performing complex mathematical calculations.*

*The paper also discusses the selection of distribution parameters, which should be based on statistical data for a specific design, materials, and operating mode. It is concluded that the need to consider asymmetry depends on the value of the asymmetry coefficient and the safety factor.*

*The purpose of the study is to determine the conditions under which taking into consideration the asymmetry of the distribution of random variables is necessary to ensure the accuracy of calculations of the reliability of structures, as well as to justify the cases when the use of symmetric models is acceptable.*

***Keywords:*** *asymmetric distribution laws, structural reliability, normal distribution law,*

*lognormal distribution, safety factor.*

**Introduction.** In engineering structural reliability calculations, it is traditionally assumed that random variables, such as material resistance and applied loads, obey a normal distribution law (Gaussian law). Although this approach is convenient and widespread, it has a fundamental drawback: the normal distribution is symmetric, while real experimental data indicate a significant asymmetry of such parameters.

Studies [1–3] show that the distribution of the mass of vehicles with extreme loads has a multimodal character with several peaks corresponding to different categories of vehicles. In [4], examples of problems are given where it is necessary to consider joint distributions of loads and bearing capacity reserves, which required the construction of appropriate compositions or differences of distributions.

In this work, the lognormal law was chosen to model the asymmetry of random variable distributions. The calculations performed demonstrate that neglecting asymmetry can significantly distort the assessment of structural reliability, underestimating or overestimating real values. The convolution formulas used for the analysis allow us to obtain analytical expressions for joint distributions. The examples show that distributions for temporary loads can be asymmetric and significantly differ from the normal law, which is critical for ensuring the accuracy of the calculations.

**Scope.** The results of this study find practical application in many areas related to the design, operation and modernization of bridge structures, in particular:

- when designing bridges and other transport structures.

Refined calculation methods allow taking into consideration the asymmetric distribution of loads which is characteristic of modern transport flow. This provides a more realistic assessment of the reliability of span structures and increases the durability of structures. The use of asymmetric distribution models contributes to the optimization of structural solutions, which allows reducing material consumption without reducing the level of safety.

- operation and monitoring of the technical condition of structures.

The results of the study can be used to create monitoring systems that analyze the variability of loads in real time, identifying potential threats to their development into emergency situations.

Forecasting the residual resource of structures based on data on uneven wear of elements allows timely decisions to be made on repair or strengthening.

- analysis of transport flows and infrastructure planning.

Considering the multimodal nature of the distribution of vehicle mass contributes to the design of bridges and roads that meet modern requirements for intensity and weight restrictions.

The results of the study can be used in modeling extreme transport scenarios, such as the movement of military equipment or the transportation of heavy loads.

- modernization of existing structures

When reconstructing and strengthening structures, it is important to consider the

asymmetric nature of loads to avoid irrational overconsumption of materials and ensure the reliability of the structure during the remaining operational life.

The developed methods allow for effective assessment of the impact of changes in transport flows on structures in operation and to adjust their design parameters.

- development of regulatory documents.

The results of the study can be used to update construction codes and standards for methods for assessing the reliability of structures considering the asymmetry of load distributions.

Proposals for the introduction of new coefficients and calculation rules can be adapted for international standards and national regulations.

- risk management and assessment of catastrophic scenarios.

Models built taking into account asymmetry allow for the assessment of the impact of extreme loads, such as emergency overloads, natural disasters or man-made disasters.

They allow structures to be better prepared for such situations and reduce the likelihood of destruction.

- educational programs and scientific research.

The results obtained can be integrated into training courses for future engineers, contributing to increasing their competence in calculating the reliability of complex structures.

Further scientific developments in the field of load distribution and strength can be based on the approaches proposed in the work.

**Objective and methods.** The purpose of this study is to highlight the influence of asymmetry in distribution laws on the assessment of structural reliability, as well as to determine the conditions and coefficients under which the use of symmetric distributions can be considered acceptable. Particular attention is paid to studying the influence of asymmetry in load distributions and material resistance on the accuracy of estimating the bearing capacity reserve and determining the conditions under which simplified symmetric models can be used.

The study aims to conduct:

- analysis of the nature of load distribution and resistance based on experimental data;

- assessment of cases of possible ignoring of asymmetry in structural reliability calculations;

- development of recommendations for engineering practice regarding the consideration of asymmetry of distributions. the work used a number of theoretical, experimental and numerical methods;

- study of mathematical models of distributions of random variables, in particular normal and lognormal;

- analysis of convolution formulas for modeling joint distributions of load effects and resistance;

- development of analytical expressions for estimating the probability of limit states of structures.

Results and explanation.

According to the classical reliability theory [6,7], the reliability of a structure (or its element) is the probability that the value of the generalized safety reserve will have a positive value, i.e.:

$$P = Prob\ (S>0) \tag{1}$$

where $P$ is structural reliability; $S$ is safety reserve.

The safety reserve is defined as the difference of two random values: the generalized resistance of the element R and the generalized load effect $E$:

$$S = R\text{-}E \tag{2}$$

According to probability theory, when the laws of distribution of $R$ and $E$ values are known, we can determine the distribution law of safety reserve, which we denote by $p_s$. Taking into consideration (1), the reliability of the structure $P$ and the value $V=1\text{-}P$, which is called the probability of failure, are determined as:

$$V = \int_{-\infty}^{0} p_s(s)ds\,,\ P = \int_{0}^{\infty} p_s(s)ds\,. \tag{3}$$

The geometric meaning of the quantities $P$ and $V$ is that their values are equal to the area under the distribution curve of the strength reserve $pS(s)$. In the case when $s > 0$, this area corresponds to the reliability of the structure $P$. When $s < 0$, the area corresponds to the probability of failure $V$ (Figure 1)

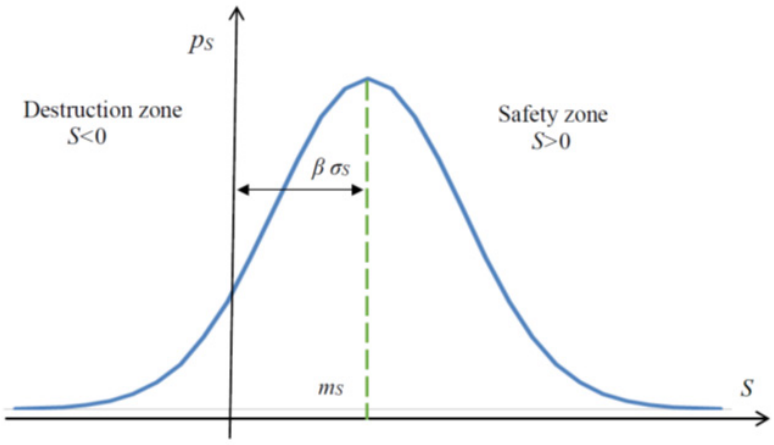


**Fig. 1. Distribution function of the safety reserve under the normal distribution law**

In most cases, the values $R$ and $E$ can be considered independent random variables. Then, under random distribution laws of $R$ and $E$, the mathematical expectation of ms

and the mean square deviation of the safety reserve σs are determined by the formulas:

$$m_s = m_R - m_E,\ \sigma_S = \sqrt{\sigma_R^2 + \sigma_E^2} \quad (4)$$

where $m_r$ , $m_e$ are mathematical expectations, $\sigma_r$, $\sigma_e$ are standards for the distribution of generalized resistance and load effect, respectively.

We denote by β the quantity called a reliability index:

$$\beta = \frac{m_S}{\sigma_S}. \quad (5)$$

The value of β was first proposed in [6]. It plays an extremely important role in the theory of reliability. As it can be seen from Figure 1, the reliability index determines the number of standards that are placed in the interval from s = 0 to s = $m_s$, and this is true for any distribution laws. Taking into account (4), the reliability index β can be written in the form:

$$\beta = \frac{m_R - m_E}{\sqrt{\sigma_R^2 + \sigma_E^2}}. \quad (6)$$

Let us denote by $\xi$ the determined value which is called a reliability index:

$$\xi = \frac{m_R}{m_E}. \quad (7)$$

Then equation (6) takes the form:

$$\beta = \frac{\xi - 1}{\sqrt{C_E^2 + \xi^2 C_R^2}}, \quad (8)$$

where $C_R = \frac{\sigma_R}{m_R}$, $C_E = \frac{\sigma_E}{m_E}$ are coefficients of variation of $R$ and $E$, respectively.

The formula for determining the reliability index (8) has an advantage over formula (6), because the coefficients of variation can be estimated even with insufficient statistical information regarding the structural resistance and the load effect. In addition, when the load changes or the cross-sectional dimensions of structural elements change, $C_r$ and $C_e$ variations remain unchanged.

In most reliability calculations, distribution laws for the random variables R and E are assumed to be in the form of a normal distribution:

$$p(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-m)^2}{2\sigma^2}},\ -\infty < x < \infty. \quad (9)$$

This law is the most studied, so it is widely used in probability theory. The main advantage of this distribution law is stability: the sum or difference of a normal distribution of random variables is also a value under a normal distribution law. Thus, if the random variables R and E have a normal distribution (9), then the safety reserve S

will also have a distribution according to the same law, and its parameters $m_s$ and $\sigma_s$will be determined according to (4):

$$p_S(s) = \frac{1}{\sqrt{2\pi}\sigma_S} e^{-\frac{(s-m_S)^2}{2\sigma_S^2}} \quad . \tag{10}$$

Considering (10), the reliability of $P_n$ structure under normal distribution laws of R and E can be written in the form:

$$P_{NN} = \frac{1}{2} + \Phi(\beta), \tag{11}$$

where $\Phi(t) = \frac{1}{\sqrt{2\pi}} \int_0^t e^{-\frac{t^2}{2}} dt$ is the Laplace function.

Figure 1 shows a graphical representation of dependence (10). As it can be seen, the normal law is symmetric with respect to the mathematical expectation *m,* which in this case coincides with the mode *M* (the value with the greatest probability). In the general case, the distribution law of a random variable can be asymmetric (Figure 2), for which $m \neq M$.

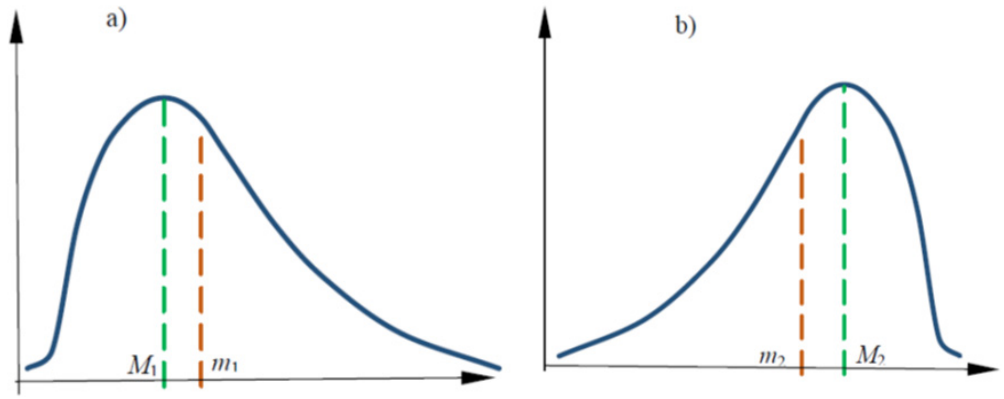


**Fig. 2. Graphs of distribution functions**
**a) positive skewness b) negative skewness**

The application of formula (11) for calculating reliability is quite simple and convenient, which led to the widespread use of the normal distribution law for resistance and load effect in the form of (9). But this law has two significant shortcomings. The first is that the argument under a normal distribution varies from -∞ to +∞, although in their physical essence both resistance and load effect are purely positive quantities. The second disadvantage is that the normal law is symmetric.

It is known that the asymmetry of the distribution is characterized by the coefficient of skewness A, which in the case of a discrete series of values is equal to:

$$A = \frac{1}{\sigma^3}\int (x-m)^3 p(x)dx. \qquad (12)$$

The distribution of a random variable can have both positive (A>0) and negative (A<0) skewness (Figure 2).

Under positive skewness (Figure 2 a), the mathematical expectation m1 will be greater than the corresponding mode M1. This means that negative deviations from the average value (for example, reduced load effects) will be more often repeated than positive ones. For the distribution with the coefficient A<0 (Figure 2 b), the situation will be the opposite. That is, load effects that are greater than average will be more often repeated. Asymmetry can be characterized both by the value of A itself and by its relation to the coefficient of a variable A/C.

Experimental studies showed that both resistance and load effects are random variables, which in most cases are distributed according to the laws of positive skewness.

In the work, the lognormal distribution was chosen to approximate the asymmetric law.

Further in the text, x will denote the value of the random variable R (resistance), y - the value of the random variable E (load effect), and s - the random value of safety reserve S.

The lognormal distribution has the form:

$$p(x) = \frac{1}{x\sqrt{2\pi\ln(1+C^2)}} e^{\frac{-\ln^2(\frac{x}{m}\sqrt{1+C^2})}{2\ln(1+C^2)}}; x > 0. \qquad (13)$$

The asymmetry coefficient for it is equal to $A = 3C + C^3$.

Distributions (13) are defined only for positive values of the argument, therefore they do not contradict the physical essence of resistance and load effects.

For the convenience of calculations and analysis of the obtained results, we introduce dimensionless quantities:

$$\bar{x} = \frac{x}{m_R}; \ \bar{y} = \frac{y}{m_R}; \ \bar{p} = pm_R. \qquad (14)$$

In dimensionless quantities (14), the lognormal distribution laws for loads and generalized resistance will take the form (the sign of the dimensionless quantity is omitted here and further):

$$p_{RL}(x) = \frac{1}{x\sqrt{2\pi\ln(1+C_R^2)}} e^{\frac{-\ln^2(x\sqrt{1+C_R^2})}{2\ln(1+C_R^2)}}, \qquad (15)$$

$$p_{EL}(y) = \frac{1}{y\sqrt{2\pi\ln(1+C_E^2)}} e^{\frac{-\ln^2(y\xi\sqrt{1+C_E^2})}{2\ln(1+C_E^2)}}, \qquad (16)$$

For the case when the strength is distributed according to the normal law, the density is denoted by $P_{rn}$

$$p_{RN}(x) = \frac{1}{\sqrt{2\pi}C_R} e^{-\frac{(x-1)^2}{2C_R^2}}, \quad (17)$$

According to probability theory, if the random variables R and E are distributed according to the laws $p_r(x)$ and $p_e(y)$, the law for the distribution of the random variable S=R-E is determined by the equation:

$$p_s(s) = \frac{d}{ds}\iint_D p_R(x)p_E(y)dxdy. \quad (18)$$

The area of integration D is the intersection of three areas:
- changes in the x argument (resistance)
- changes to the y argument (load effect)
- regions (x – y) < s.

The areas of change in x and y are determined by the accepted distribution laws. In the case of normal laws, the argument will vary from -∞ to +∞, and in the case of asymmetric distribution laws (15) and (16) from 0 to + ∞.

Using the rule of differentiation of integral functions and taking into consideration the domain D for a combination of lognormal distributions, we obtain the general density of the distribution, which we denote by $p_{sLL}$:

$$p_{SLL}(s) = \int_0^\infty p_{RL}(y+s)p_{EL}(y)dy \ . \quad (19)$$

Similarly, we obtain the distribution density for a combination of normal and lognormal laws:

$$p_{SNL}(s) = \int_0^\infty p_{RN}(y+s)p_{EL}(y)dy \quad (20)$$

Let us define the reliabilities $P_{LL}$ i $P_{NL}$, which, according to (3), are the areas under the curves (19) and (20) when s > 0, as

$$P_{LL} = \int_0^\infty p_{SLL}(s)ds, \ P_{NL} = \int_0^\infty p_{SNL}(s)ds. \quad (21)$$

Table 1 shows the results of calculations of safety and reliability indexes that depend on the safety factor ξ for the selected coefficients of variation of the generalized resistance and load effect $C_R$ = 0,1, $C_E$=0,35(the corresponding asymmetry coefficients $A_R$ = 0.3 and $A_E$=0.904).

*Table 1*

| ξ | β | $P_{NN}$ | $P_{NL}$ | Δ (%) | $P_{LL}$ | Δ(%) |
|---|---|---|---|---|---|---|
| 1,5 | 1,3130643 | 0,90541936 | 0,90164338 | 0,420 | 0,89907291 | 0,710 |
| 1,7 | 1,7990163 | 0,96399195 | 0,94975915 | 1,500 | 0,95203785 | 1,260 |
| 2,0 | 2,4806947 | 0,99344367 | 0,98206644 | 1,160 | 0,98569175 | 0,790 |
| 2,5 | 3,4874292 | 0,99975616 | 0,99676825 | 0,300 | 0,99837171 | 0,140 |
| 3,0 | 4,3386092 | 0,99999283 | 0,99938699 | 0,060 | 0,99983221 | 0,020 |
| 3,5 | 5,0507627 | 0,99999978 | 0,99987524 | 0,010 | 0,99998319 | 0,002 |
| 4,0 | 5,6443252 | 0,99999999 | 0,99997284 | 0,003 | 0,99999829 | 0,0002 |

In table 1 Δ denotes the percentage of the relative deviation of the reliability PNL and PLL (22) from the value of PNN, which is calculated according to formula (11).

As it can be seen from the analysis of the results presented in Table 1, for reliability indexes β > 2,5 the deviations of the reliability PNL and PLL from PNN are sufficiently small. This means that the asymmetry of the load effect distribution can be neglected with sufficient accuracy in this case. When β decreases from 2,5 to 1,5 percent, the deviation of the reliability PNL and PLL from PNN increases and can reach Δ ≈ 1,5%.

Since the structural reliability, according to the current DSTU [8], can vary in a small range (approximately from 1 to 0,95), the error, which is 1,5%, is quite significant.

Figure 3 presents graphs of PNN , PLL and PNL dependencies on the value of the reliability index β.

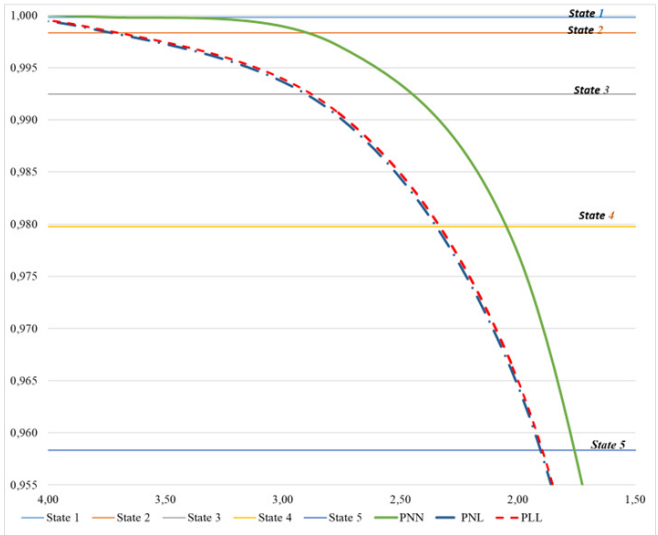


**Fig. 3 - Dependence of reliability on the reliability index β for different combinations of distribution laws for R and E**

Horizontal lines show reliability levels, which according to [8] correspond to the numbers of technical conditions: from state 1 (in operation) to state 5 (out of operation). As can be seen from the graphs above, when $\beta < 2,5$ and the asymmetry of the distribution law for the load is not taken into consideration, an number of the technical state in which the structure actually is can be overestimated . For example, if $\beta=2,2$ under the normal distribution and the reliability $P_{NN} = 0,9862$, this corresponds to the third technical state; at the same time, under the lognormal distribution, the reliability will be $P_{NL} = 0,9724$, which corresponds to the fourth technical state of the structure. Such a situation with the definition of technical state, the number of which determines the level of bridge maintenance, is quite dangerous. Especially when it comes to structures that are in 3rd or 4th technical state.

From the above table and graphs it can also be seen that the asymmetry of the material resistance at the index $A_R = 0,3$ practically does not affect the value of the calculated reliability.

The calculations performed at different values of the asymmetry coefficient showed that at $A<0,6$ (both for resistance and for load effects) the influence of asymmetry on the value of reliability can be neglected.

**Conclusions.** The paper shows that the asymmetry of the distribution of random variables that describe the load effect and resistance of structures significantly affects the accuracy of reliability calculations. In particular, when the asymmetry coefficient $A > 0.6$, it is necessary to take into account the asymmetry, since ignoring this factor can lead to significant errors in determining the operational state of the structure.

For cases where the asymmetry coefficient $A < 0,6$, the influence of the asymmetry on the calculation results is insignificant (the discrepancy does not exceed 0,5%). In such conditions, the use of symmetric models, in particular the normal distribution law, is appropriate and justified in order to simplify calculations.

It is shown that at high values of the reliability index $\beta > 2,5$, reliability calculations can be performed using a simple formula (11), which is based on the assumption of a symmetric distribution of quantities. This simplification is justified, since the errors remain within acceptable accuracy.

In cases where $A > 0,6$ and $\beta < 2,5$ , taking into account asymmetry becomes critically important. Under such conditions, it is necessary to use models that take into account the asymmetry of the distribution of random quantities of resistance and load effects. Ignoring this factor can lead to a significant underestimation or overestimation of the reliability of the structure.

The approach proposed in the work allows for accurate modeling of resistance and load effect distributions based on the lognormal law. The use of convolution formulas ensures the construction of joint distributions that adequately describe real operating states.

The results of the study can be used to improve regulatory methods for assessing reliability, develop more accurate recommendations for determining the bearing capacity margin and analyzing the durability of structures.

An important practical conclusion is the possibility of using simplified models in certain conditions when $A < 0,6$ or $\beta > 2,5$. This allows for optimization of calculations without significant loss of accuracy, which is especially important for engineering practice.

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# SIMULATION OF VEHICLE MOVEMENT AT UNREGULATED INTERSECTIONS OF PUBLIC ROADS

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***Annotation.*** *Developments in the field of computer software for modeling transport processes and their analysis represent modern software products that are becoming a powerful modeling tool. In the world practice, well-known simulation software products in the field of traffic flow organization are widely used, one of which is VISSIM (PTV AG, Germany). The PTV VISSIM simulation software can greatly simplify the work of the designer and creates a reliable platform for the design of road transport and urban planning facilities. To date, the first steps have already been taken in Ukrainian practice to address the issue of the feasibility and relevance of using transport modeling in Ukraine, especially in assessing the effectiveness of design solutions for road infrastructure. The purpose of the article was to present the results of traffic flow simulation to assess the availability and number of free traffic intervals between vehicles while driving at intersections of public roads using PTV VISSIM. The object of experimental research was an unregulated intersection of highways at the same level H-01 Kyiv-Znamianka (category II) and O100209 Uzyn - Vasyliv - Hermanivka - Trypillia (category IV). To achieve this goal, the following tasks were solved: a simulation model was developed at the experimental site (unregulated intersection); the availability and number of free traffic intervals for the existing traffic management option was assessed; measures to increase the number of free traffic intervals at the selected experimental research site were proposed and their effectiveness was evaluated.*

***Keywords:*** *reconstruction, highway, traffic interchange, road infrastructure, traffic intensity, traffic flow, free traffic interval, maximum traffic intensity, traffic flow modeling.*

**Introduction.** Unfortunately, Ukrainian practice today does not require the mandatory use of traffic modeling software, but only mentions the feasibility of their use. However, it should be noted that the first steps have already been taken to address the issue of the feasibility and relevance of using transport modeling in Ukraine, especially in assessing the effectiveness of road infrastructure design solutions. For example, with the participation of experts from the State Agency for the Restoration and Development of Infrastructure of Ukraine, the State Enterprise National Institute for Infrastructure Development, and Pro Mobility Limited Liability Company, the first edition of the Methodological Recommendations for Modeling Traffic Flows in Assessing the Effectiveness of Road Infrastructure Design Decisions was developed MR - B.2.2-37641918-928:2023 [8]. The above methodological recommendations contain a description of traffic flow modeling methods at different levels of detail (micro and

macro), as well as algorithms for collecting and compiling the necessary information for modeling using PTV GROUP software systems, but there is no mention of the mandatory use of transport modeling tools.

In the world practice, well-known simulation software products in the field of traffic flow organization are widely used, one of which is VISSIM (PTV AG, Germany). PTV VISSIM is a tool for creating traffic flow models. Therefore, for the modeling experiment, we developed a simulation model of traffic flow on sections of the public road network that will allow us to determine both the parameters of vehicle movement and traffic efficiency indicators.

**The scope of VISSIM:**

1. Evaluation of the impact of the type of road intersection on the capacity (unregulated intersection, regulated intersection, roundabout, railway crossing, interchange at different levels).

2. Design, test and evaluate the impact of traffic signal operation on traffic flow.

3. Assessment of the transport efficiency of the proposed measures.

4. Analysis of traffic management on highways and city streets, control of traffic directions both on individual lanes and on the entire roadway.

5. Analysis of the possibility of giving priority to public transport and measures aimed at priority passage of trams.

6. Analysis of the impact of traffic management on the situation in the transport network (regulation of traffic inflow, change of the distance between forced stops, inspection of entrances, organization of one-way traffic and lanes for public transport).

7. Analysis of the capacity of larger transport networks (e.g., highway network or urban street and road network) with dynamic redistribution of traffic flows (this is necessary, for example, when planning intercepting parking lots).

8. Analysis of measures to regulate traffic in railway transport and in the organization of waiting areas (e.g., customs offices).

9. Detailed simulation of the movement of each traffic participant.

10. Modeling of public transport stops and subway stations, taking into account their mutual influence.

11. Calculation of analytical indicators (more than 50 different estimates and analytical coefficients), graphing (in Microsoft Excel) of the temporary network load, etc.

The PTV VISSIM simulation software can greatly simplify the work of the designer and creates a reliable platform for the design of road transport and urban planning facilities [2-7, 10].

Unlike simpler models based on constant speeds and unchanged following behavior of vehicles in front, PTV VISSIM uses the WIEDEMANN psychophysiological model of perception. The main idea of the model is to describe the process of movement of individual vehicles in as much detail as possible, to establish a functional relationship between individual flow indicators, such as speed and distance between vehicles in the flow. The use of such models allows you to estimate the dynamics of traffic speed, delays

at the intersection, queue length and formation, etc. Therefore, different driver behavior is simulated using distribution functions for speed and distance [1].

Solving the problem of traffic flow distribution on the road network with increasing traffic intensity requires specification of the initial data on the characteristics of road conditions and traffic flows. The main volume of information is static information and relates to the description of the characteristics of the network, which is used to distribute traffic flows in the event of traffic obstacles.

Information on road conditions of a particular road network includes:

- road network layout;
- road category;
- geometric characteristics of the road network;
- road surface type and roadway condition;
- values of traffic delays;
- values of traffic intensity on the road;
- location of traffic obstacles on the road network and characteristics of each obstacle;
- location of entry and exit points for the distribution of traffic flows;
- scheme of traffic organization.

**Objective and methods.** The purpose of the simulation modeling is to assess the availability and number of free traffic intervals between vehicles while driving at intersections of public roads, as well as to analyze the effectiveness of the proposed measures to increase the number of free traffic intervals at the selected research object.

To achieve this goal, a simulation model of vehicle traffic on the selected section of an unregulated intersection of highways at the same level was developed. The intersection of the highways H-01 Kyiv-Znamianka (II category) and O100209 Uzyn - Vasyliv - Hermanivka - Trypillia (IV category) was chosen as the object of research on traffic flow parameters. For this object, we conducted field observations of vehicle traffic and obtained the actual values of time intervals between packages and between vehicles in packages during the corresponding maneuvers (left and right turns) and verified the accuracy of the proposed analytical models.

**Results and explanation.** To develop a simulation model of vehicle traffic at the intersection of national (H-01) and regional roads (O100209) near the city of Obukhiv, Kyiv region, the PTV VISSIM software package was chosen.

The main input parameters in this case are [11]:

- length of highway sections;
- width of the roadway;
- number of lanes on road sections;
- intensity of traffic flow at the entrance to the intersection of roads;
- composition of the traffic flow;
- availability of public transportation stops, etc.

The sequence of building a simulation model of vehicles at an intersection of public roads using PTV VISSIM consists of the following list of main stages, which is given in Table 1 [11].

*Table 1*

**Plan of the simulation model in PTV VISSIM (main stages)**

| No. p/n | Name and sequence of the stage | Type of work |
|---|---|---|
| 1 | Construction of an unregulated intersection of highways in one level | Images of road segments<br>Showing turns<br>Organize oncoming traffic Create acceleration and braking lanes<br>Drawing road markings |
| 2 | Entering the traffic flow | Entering data on traffic intensity<br>Determining the composition of vehicles<br>Laying routes for vehicles<br>Introduction of priority rules in conflict zones |

Before you start developing a simulation model, you need to upload the background (substrate) on which the simulation will be performed. Such a background can be an electronic map of the relevant area and scale, which is available on specialized resources such as Google Maps, SAS Planet or others. In this study, the background is a map fragment from the specialized resource Google Maps.

The first step is to model segments. Using the "Segments" object located in the "Network Objects" window, roads are drawn.

In the "Segment Attributes" window, as shown in Figure 1, you can see the length of the modeled section, name the segment, set the number of lanes for vehicles, and configure the type of road behavior displayed, the type of road surface, and the level of the multi-level interchange.

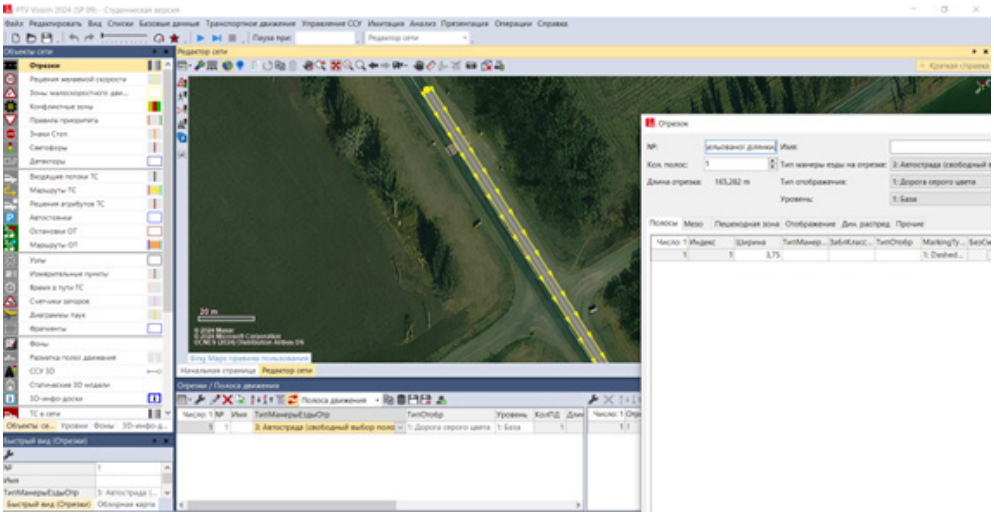

**Fig. 1. A segment of a highway**

Next, add oncoming traffic. In the drop-down menu, as shown in Figure 2, select the

“Oncoming traffic” item and activate it by pressing the corresponding key on the mouse.

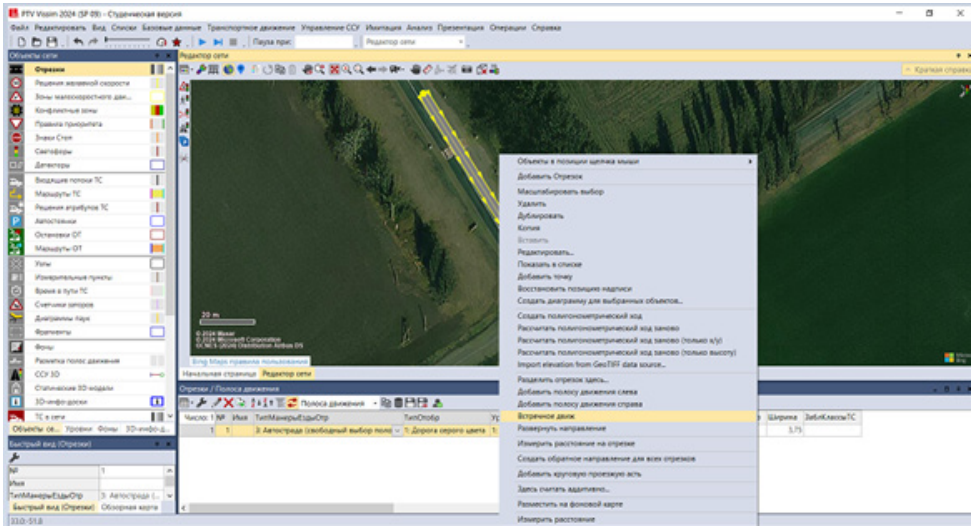

**Fig. 2. Oncoming traffic on a road section**

After that, the connecting segments are modeled. To do this, if the Segments button is activated in the Network Objects window, as shown in Figure 3, you select the initial segment and draw a connecting segment from the first (selected) segment to the second. In the dialog box, you specify the parameters of the segment and set the right turn rule: for example, from the rightmost to the rightmost lane. You can also specify the number of intermediate points.

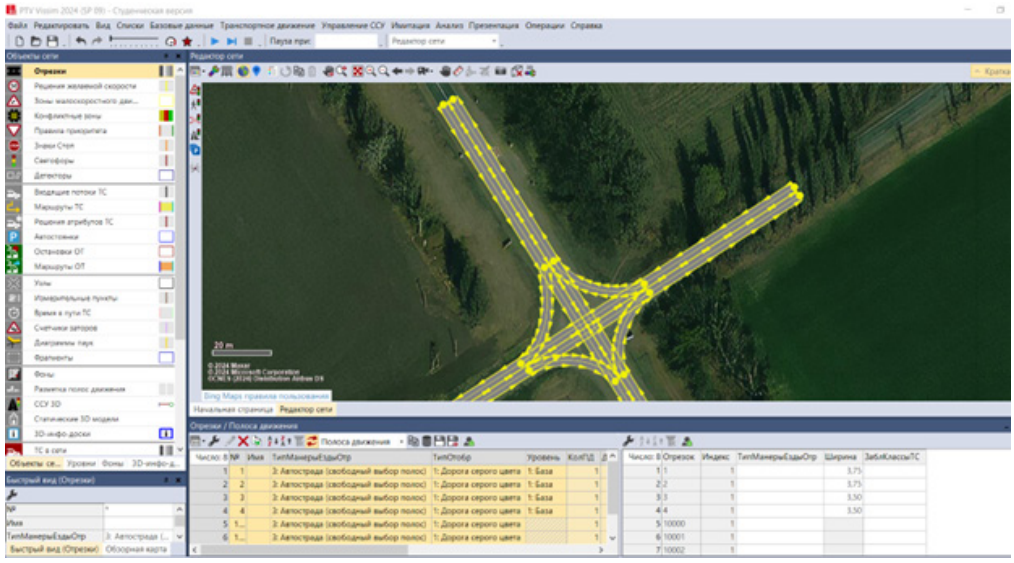

**Fig. 3. Connecting segments**

Next, you define the input flows according to the directions of movement. The “Input streams” item in the “Network objects” window is activated. Select the segment where you want to insert the input stream, most often it is highlighted in black, as shown in Figure 4.

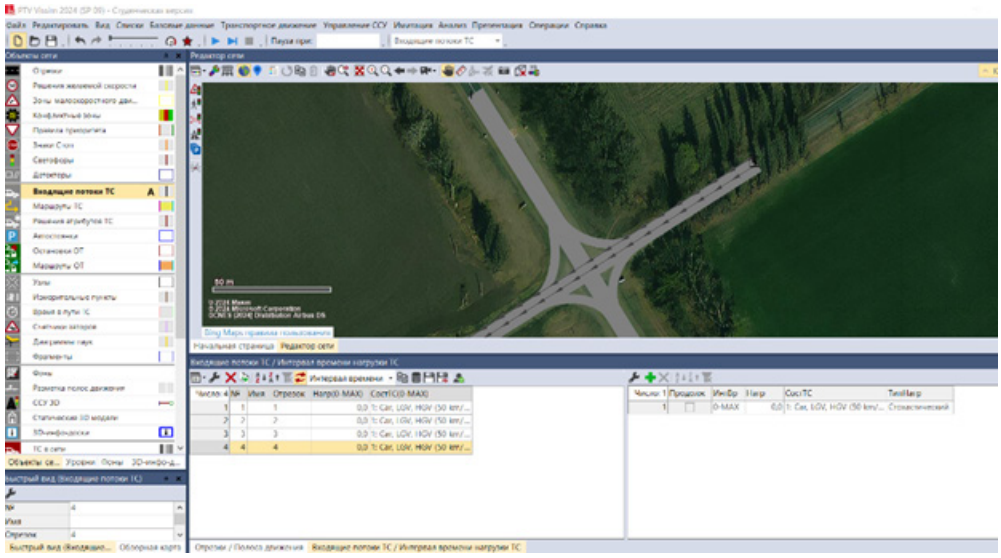

**Fig. 4. Incoming traffic flows**

After that, the intensity and composition of the incoming traffic flow is set through the Quick View menu tab, as shown in Figure 5.

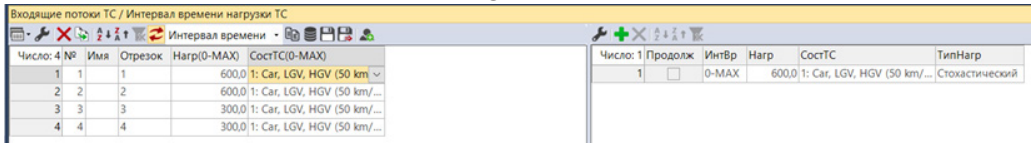


**Fig. 5. Intensity and composition of traffic flow**

Next, for each connecting segment, we build low-speed traffic zones. To do this, activate the “Low-speed traffic zones” item. Select the connecting segments (right and left turns). The construction sequence is shown in Figure 6.

After that, priority rules are introduced for vehicles passing through the conflict zones. In the “Network Objects” window, select the “Conflict Zones” item and determine the priority of traffic in the conflict zone. As a result of the modeling, they are highlighted with yellow markers on the screen, and after determining the priority - with a red and green marker, respectively, as shown in Figure 7. To determine the right of priority passage and prevent congestion in the zone of unregulated exit from the adjacent territory, in the “Network Objects” window, select the “Priority Rules” item and set the priority rules for conflicting flows.

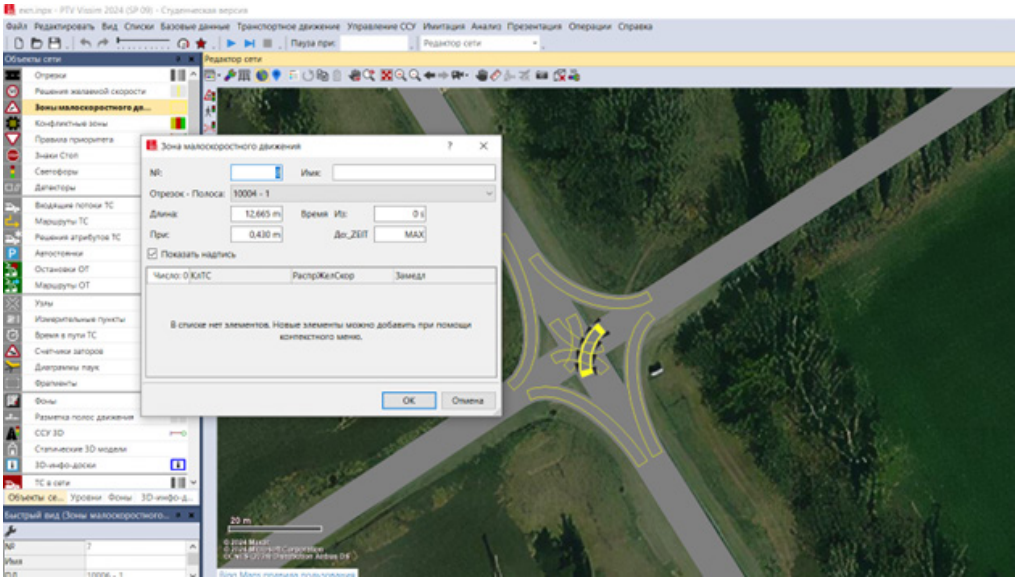

**Fig. 6. Low-speed zones**

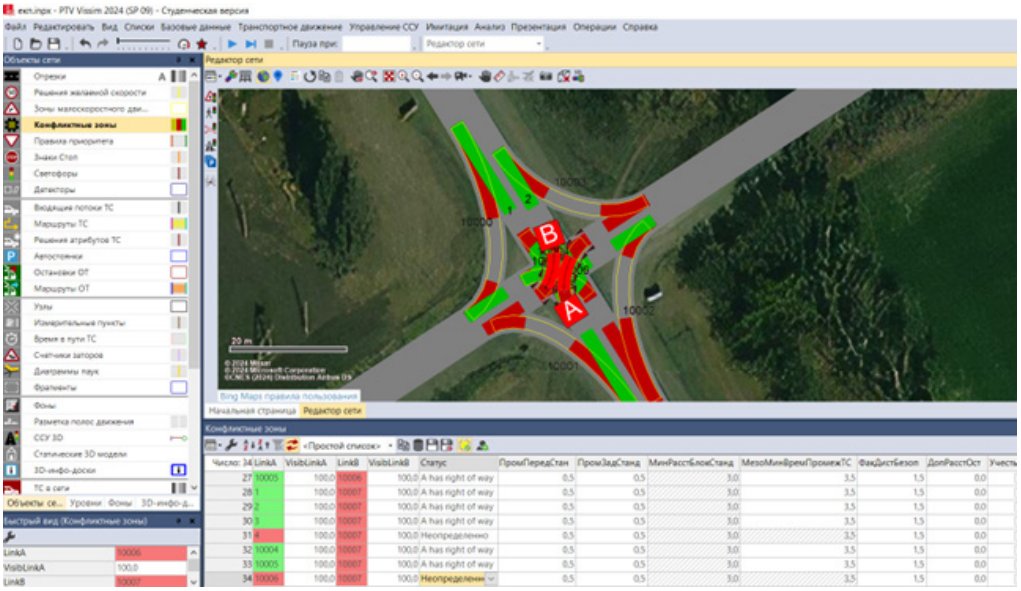

**Fig. 7. Conflict zones**

The next step is to set the routes of vehicles. In order to set a route solution, you need to activate the Vehicle Routes item in the Network Objects window. As you can see in Figure 8, the resulting route is highlighted in yellow.

If necessary, pedestrian traffic is modeled in the same way as vehicle flows are

entered into the model. To organize public transport traffic, you need to enter stops and routes with the required stops and timetable. Public transport stops can be created both on the lane and in the pocket (public transport stops in a special lane extension of the selected segment).

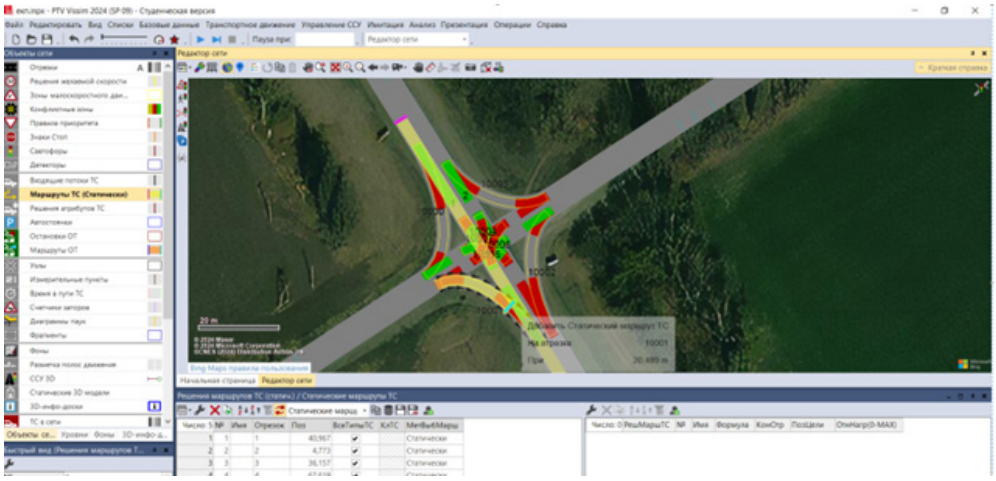

**Fig. 8. Vehicle routes**

After modeling the traffic flow at the intersection, you can start simulating the movement of vehicles on the selected object. A view of the traffic flow schedule is shown in Figure 9.

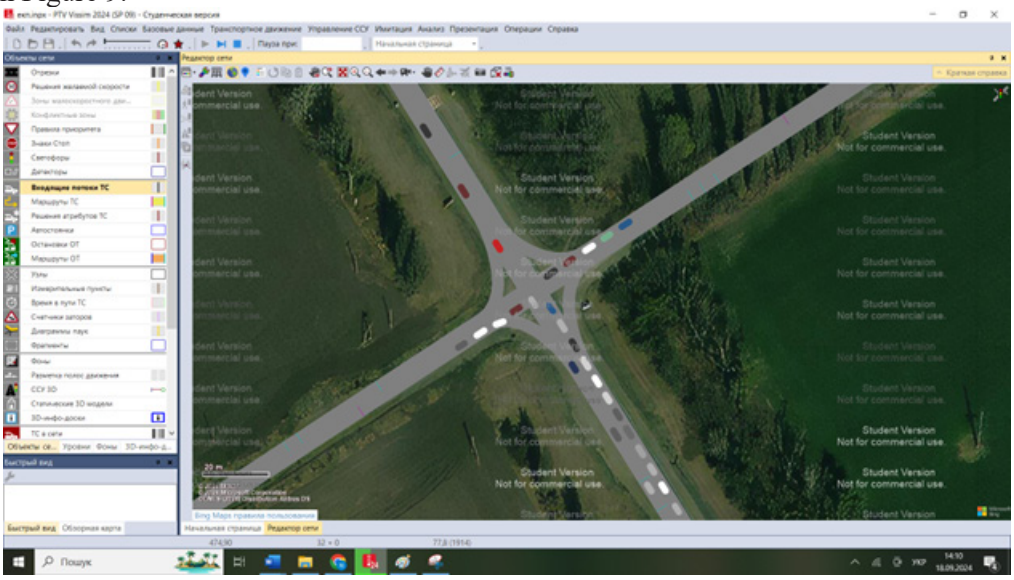


**Fig. 9. Traffic simulation**

It should be noted that the result of the simulation model is the animation of traffic in the form of a real-time graphic and the subsequent output of transport and technical parameters, such as, for example, the distribution of travel time, traffic delays, queue length, idle time, the amount of emissions of harmful substances, fuel consumption, which can be differentiated by user groups.

After simulating vehicle traffic using PTV VISSIM, average delay values for different intensities per lane were obtained and the availability and number of free traffic intervals were analyzed for the actual and maximum traffic intensity. The estimation of the availability and number of free traffic intervals (Table 2) and average delay values are shown in Table 2.

*Table 2*

**Evaluation of the availability and number of free traffic intervals for the study object**

| Existing traffic intensity Nfact, vehicle/hour | Free driving intervals, nv, car/h | Maximum traffic intensity Nmax, vehicle/hour | Actual average traffic delay, s | Average traffic delay at maximum traffic intensity, s |
|---|---|---|---|---|
| 500 | 215 | 715 | 6,18 | 18,70 |
| 600 | 150 | 750 | 6,76 | 21,85 |
| 700 | 85 | 785 | 16,59 | 22,53 |
| 800 | 45 | 845 | 23,69 | 28,66 |
| 900 | 20 | 920 | 36,53 | 29,36 |
| 1000 | 10 | 1010 | 37,83 | 40,20 |

As a result of an experimental study of traffic flow [9], the dependence of the number of free traffic intervals on the hourly traffic intensity was established (Formula 1):

$$n_{\text{в}} = 2 \cdot 10^{-14} N^{7,5303} \int_{t_i}^{t_{i+j}} t_{\text{п}_i}{}^{-0,00692N+1,331} dx, \qquad (1)$$

where $t_i$ and $t_i+_j$ are the interval of movement sufficient to perform right and left turn maneuvers without traffic complications, s;

N is the hourly intensity of one traffic lane, vehicle/hour.

With an increase in traffic intensity by 100 cars/hour or more, for the existing variant, there is a significant jump in the average delay (the ratio of the total delay time to the number of vehicles) at the facility. The main reason for this is that there is practically no possibility of making a left turn maneuver from all directions (very dense traffic).

To improve the traffic conditions, namely to reduce the average traffic delay, a simulation model of traffic at the intersection with transitional high-speed lanes for cars moving on the right along the main road was developed. A graphical representation of the traffic simulation is shown in Figure 10.

The results of the assessment of the reduction in average traffic delay after the installation of transitional high-speed lanes on the main road are presented in Table 3.

They indicate the effectiveness of the installation of transitional high-speed lanes on the main road. Their installation can significantly reduce traffic delays, which continues the effective functioning of the interchange and the road.

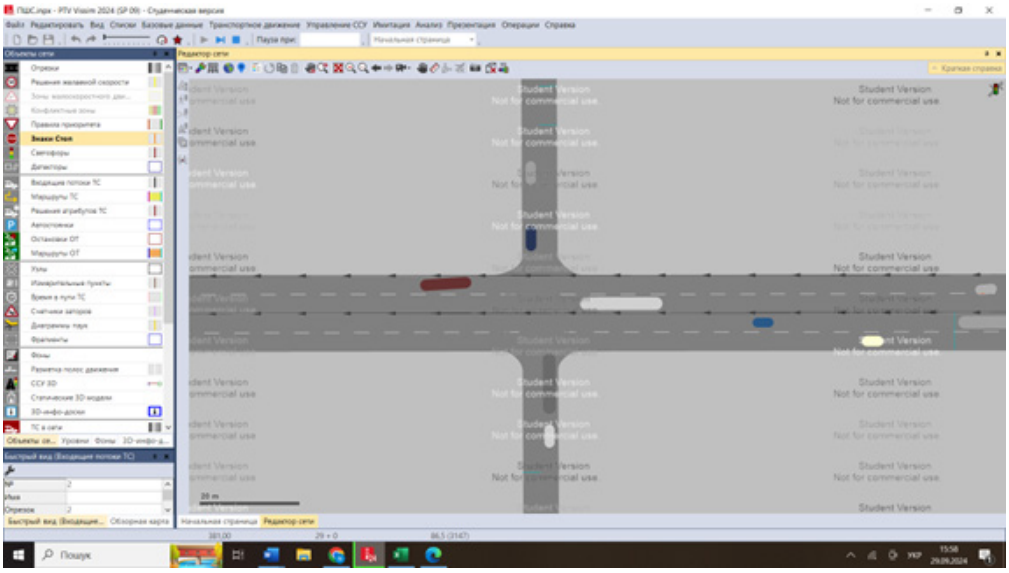

**Fig. 10. Simulation of traffic with transitional high-speed lanes on the main road**

*Table 3*

**Estimated reduction in average traffic delay after installation of transitional high-speed lanes on the main road**

| Existing traffic intensity $N_{fact}$, vehicle/hour | Maximum traffic intensity $N_{max}$, vehicle/hour | Actual average traffic delay, s | Average traffic delay at maximum traffic intensity, s |
|---|---|---|---|
| 500 | 715 | 2,65 | 3,24 |
| 600 | 750 | 3,19 | 5,46 |
| 700 | 785 | 3,26 | 4,63 |
| 800 | 845 | 6,45 | 10,29 |
| 900 | 920 | 11,31 | 13,86 |
| 1000 | 1010 | 17,87 | 19,42 |

**Conclusions.** The analysis of traffic simulations has shown that the main impact on delays is exerted by the flows of the main direction (main road). When the maximum traffic intensity is reached (i.e., when all free intervals are filled with vehicles), a significant increase in average traffic delay is observed. At actual traffic intensities of 500 to 800 vehicles per lane, there are free intervals (from 5 to 30 %), and at actual traffic intensities of 900 vehicles per lane and more, there are almost no free intervals (2 % or less). The results of calculating the availability of free intervals depending on the

intensity are shown in Table 4.

*Table 4*

**Availability of free intervals**

| Existing traffic intensity $N_{fact}$, vehicle/hour | Number of free traffic intervals, cars/hour | Availability of free intervals, %. |
|---|---|---|
| 500 | 215 | 30 |
| 600 | 150 | 20 |
| 700 | 85 | 10 |
| 800 | 45 | 5 |
| 900 | 20 | 2 |
| 1000 | 10 | 1 |

This indicates a fairly high accuracy of the developed dependence of free intervals on traffic intensity and the possibility of using it to assess the period of effective operation of a road section and make a decision on the complete reconstruction of the road or the reconstruction of only the interchange.

The results confirm the effectiveness of improving traffic conditions by arranging transitional high-speed lanes on the main road, but it should be borne in mind that the redirected traffic flows will cause additional load on the secondary road, the consequences of which are to be determined in further research.

Possible further directions for research are consideration and modeling of other measures to improve traffic management at this interchange, for example, consideration of the possibility and feasibility of arranging a roundabout at one level as a transitional type of interchange before reconstructing it into different levels.

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