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ECONOMIC SCIENCES

DIGITAL TRANSFORMATION IN ACCOUNTING AND AUDITING: IMPLICATIONS FOR EFFICIENCY AND TRANSPARENCY

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Abstract

Digital transformation represents a fundamental shift in accounting and auditing, driven by the rapid adoption of automation, ERP systems, continuous auditing, big data analytics, and digital twin technologies. This study investigates how these digital innovations reshape financial management processes, improve organizational efficiency, and enhance transparency in enterprise reporting. The research emphasizes the integration of operational and financial data through real-time processing, enabling accurate and timely decision-making, particularly in data-intensive sectors such as telecommunication enterprises. Continuous auditing combined with digital twin models provides proactive risk assessment, predictive auditing, and scenario-based analysis, allowing organizations to detect deviations and potential irregularities early. Additionally, big data analytics supports comprehensive anomaly detection, trend analysis, and strategic forecasting, further enhancing audit quality and reliability. The study also identifies critical challenges, including technological complexity, cybersecurity risks, regulatory adaptation, and the necessity for advanced professional competencies. Findings suggest that the synergistic application of multiple digital tools maximizes efficiency and transparency, strengthens internal control, and ensures more reliable and actionable financial information. From a practical perspective, organizations that adopt a strategically aligned digital approach can achieve higher operational performance, improved resource management, and enhanced stakeholder confidence. The implications of this research extend to policymakers and regulators seeking to modernize accounting standards, auditing frameworks, and governance practices in the digital economy. By synthesizing recent academic studies and professional insights, this article provides a structured understanding of the transformative potential of digitalization in accounting and auditing, highlighting both opportunities and challenges associated with its implementation.

Keywords: digital transformation, accounting automation, continuous auditing, ERP systems, digital twin, efficiency, transparency.

Introduction

Digital transformation has emerged as a strategic priority for organizations operating in increasingly complex and data-intensive environments. In recent years, accounting and auditing functions have experienced substantial changes driven by the rapid diffusion of digital technologies, including automation, data analytics, and integrated information systems. Traditional accounting models, which relied heavily on manual processing and periodic reporting, are progressively being replaced by digital platforms capable of real-time data collection, processing, and analysis.

The relevance of digital transformation in accounting and auditing is particularly evident in sectors characterized by high transaction volumes and technological intensity, such as telecommunication enterprises. In such environments, conventional accounting and audit approaches are often insufficient to ensure transparency, accuracy, and effective control. As noted by Pashayeva (2024), the digitalization of accounting and auditing in communication enterprises enables the integration of operational and financial data, thereby enhancing the reliability of financial reporting and managerial decision-making.

The transformation of auditing practices is closely linked to advancements in digital accounting systems. Continuous auditing models, supported by automated controls and real-time data access, allow auditors to

move beyond traditional ex post verification toward proactive risk assessment and monitoring. Pashayeva (2025) emphasizes that the integration of continuous auditing with digital twin technologies provides a comprehensive framework for evaluating enterprise processes and identifying deviations in a timely manner.

From a broader perspective, digital transformation in accounting and auditing contributes to improved efficiency, transparency, and accountability within organizations. International research highlights that the adoption of advanced digital tools supports more effective resource management and enhances the strategic role of accounting and auditing functions (Yerdavletova & Bimendiyeva, 2024). However, the transition to digital models also presents significant challenges, including technological complexity, regulatory adaptation, and the need for new professional competencies.

The aim of this article is to analyze the key dimensions of digital transformation in accounting and auditing, identify its practical implications, and assess its impact on organizational performance. The study synthesizes recent academic findings and professional insights to provide a structured understanding of how digital technologies reshape accounting and auditing practices. The article is organized as follows: the next section discusses the theoretical foundations of digital

transformation, followed by an analysis of digitalization in accounting systems, changes in auditing practices, sector-specific applications, and the challenges and future directions of digital accounting and auditing.

Theoretical foundations of digital transformation

Digital transformation is commonly understood as a multidimensional process that involves the integration of digital technologies into all areas of organizational activity, fundamentally altering how value is created and delivered. In the context of accounting and auditing, digital transformation extends beyond the adoption of new software solutions and encompasses changes in processes, structures, and professional roles.

Reis et al. (2018) conceptualize digital transformation as a strategic phenomenon driven by technological innovation, organizational change, and external environmental factors. Their framework emphasizes that successful digital transformation requires alignment between technological capabilities and organizational objectives. Applied to accounting and auditing, this perspective suggests that digital tools must be embedded within coherent governance and control systems to generate sustainable benefits.

Recent studies highlight that digital transformation in accounting is closely associated with the increasing use of integrated information systems, automation technologies, and data analytics. Sampaio and Silva (2025) argue that automation and artificial intelligence enhance the efficiency and accuracy of accounting processes while enabling accountants to focus on analytical and advisory functions. This shift reflects a broader transformation of the accounting profession from transaction-oriented activities to value-added services.

Auditing theory has similarly evolved in response to digitalization. The availability of large volumes of structured and unstructured data has given rise to new audit methodologies based on continuous monitoring and advanced analytics. Vasarhelyi et al. (2015) underline that big data technologies expand the scope of audit evidence and support more comprehensive risk assessments. As a result, auditing is increasingly characterized by ongoing assurance rather than periodic evaluations.

The theoretical foundations of digital transformation in accounting and auditing thus rest on the interaction between technological innovation, organizational adaptation, and professional judgment. Understanding these foundations is essential for analyzing how digitalization reshapes accounting systems and audit practices, as well as for addressing the challenges associated with the implementation of digital solutions in diverse organizational contexts.

Digitalization of accounting systems

The digitalization of accounting systems represents one of the core components of digital transformation in financial management. Traditional accounting systems, which were primarily based on manual data entry and periodic reporting, are increasingly being replaced by automated and integrated digital platforms. These systems enable real-time data processing,

reduce human error, and improve the consistency and reliability of accounting information.

One of the most significant outcomes of accounting digitalization is the automation of routine accounting operations. According to Sampaio and Silva (2025), automation technologies significantly reduce the time required for data processing and reconciliation, while simultaneously increasing the accuracy of financial records. Automated accounting systems allow enterprises to standardize accounting procedures and ensure compliance with internal and external reporting requirements.

The implementation of enterprise resource planning (ERP) systems has further accelerated the digital transformation of accounting. ERP-based accounting systems integrate financial data with operational, logistical, and managerial information, creating a unified information environment. Ionescu and Barna (2021) emphasize that ERP systems enhance transparency and traceability by linking accounting entries directly to underlying business processes. This integration supports more effective internal control and facilitates timely managerial decision-making.

Digital accounting systems also play a critical role in improving the quality of financial information. Real-time data availability enables organizations to generate up-to-date financial reports and performance indicators, which are essential in dynamic and competitive environments. Pashayeva (2024) notes that in telecommunication enterprises, digital accounting systems support the processing of large transaction volumes and complex revenue streams, thereby strengthening the accuracy and reliability of financial reporting. Moreover, challenges in implementing digital accountability frameworks in communication services highlight the need for careful design and integration of digital reporting mechanisms into existing accounting systems, ensuring both operational efficiency and regulatory compliance (Pashayeva, 2024, April)

From a broader perspective, accounting digitalization contributes to enhanced organizational efficiency and accountability. Yerdavletova and Bimendiyeva (2024) argue that digital accounting systems improve resource management by providing comprehensive and timely information for planning and control. However, the successful implementation of digital accounting solutions requires substantial investments in technology, data governance, and professional training. Without adequate organizational readiness, digitalization initiatives may fail to deliver their expected benefits.

Overall, the digitalization of accounting systems constitutes a fundamental shift in the way financial information is generated, processed, and utilized. This transformation lays the foundation for advanced auditing practices and supports the transition toward more transparent and data-driven organizational models.

Transformation of auditing practices

The transformation of auditing practices is closely linked to the digitalization of accounting systems and the increasing availability of data. Traditional audit approaches, which relied on sample-based testing and periodic inspections, are gradually being replaced by

technology-enabled models that emphasize continuous monitoring and comprehensive data analysis.

One of the most notable developments in this area is the emergence of continuous auditing. Continuous auditing refers to the use of automated procedures and real-time data access to provide ongoing assurance on financial and operational information. Pashayeva (2025) highlights that continuous auditing enhances audit effectiveness by enabling timely identification of risks, errors, and irregularities. This approach allows auditors to move from retrospective verification to proactive risk management.

The application of big data technologies has further transformed audit methodologies. Vasarhelyi et al. (2015) emphasize that big data analytics expands the scope of audit evidence by incorporating large volumes of structured and unstructured data. Advanced analytical tools enable auditors to detect patterns, anomalies, and trends that may not be observable through traditional audit techniques. As a result, audit quality and reliability are significantly improved.

Digitalization also affects the role and competencies of auditors. As auditing becomes more technology-driven, auditors are required to develop new skills in data analytics, information systems, and digital risk assessment. Quraishi et al. (2025) argue that the impact of digitalization on auditing is particularly significant in developing economies, where digital tools can enhance audit coverage and strengthen institutional accountability.

Sector-specific studies demonstrate that digital auditing practices are especially relevant in industries characterized by complex processes and high data intensity. Pashayeva (2025) shows that in telecommunication enterprises, the integration of digital auditing tools supports more effective control over revenue assurance, operational efficiency, and regulatory compliance. These findings confirm that digital transformation fundamentally reshapes the objectives, methods, and outcomes of auditing.

Despite its advantages, the digital transformation of auditing also presents challenges, including data security risks, regulatory uncertainty, and resistance to change. Addressing these challenges requires coordinated efforts by enterprises, auditors, and regulators to ensure that digital auditing practices are both effective and trustworthy.

Digital Twin and advanced technologies in accounting and auditing

Advanced digital technologies have become integral to the transformation of accounting and auditing systems, enabling organizations to move toward more predictive, transparent, and adaptive models of financial control. Among these technologies, the concept of the digital twin has gained increasing attention as an innovative tool for enhancing both accounting and auditing practices.

A digital twin can be defined as a virtual representation of physical assets, processes, or systems that is continuously updated using real-time data. In the context of accounting and auditing, digital twin technology allows organizations to model financial and operational processes, simulate alternative scenarios, and monitor

performance dynamically. Pashayeva (2025) emphasizes that the integration of digital twin models with continuous auditing frameworks enables auditors to assess enterprise activities in real time and identify deviations from expected patterns more effectively.

The implementation of digital accountability principles is critical for ensuring that the integration of digital twin models aligns with regulatory and organizational reporting standards, enhancing transparency and audit reliability (Pashayeva, 2024, April). The application of digital twin technology extends the traditional boundaries of accounting information systems. By linking financial data with operational indicators, digital twins provide a holistic view of enterprise performance. This integration enhances the relevance of accounting information for managerial decision-making and strategic planning. Pashayeva (2024) argues that in communication enterprises, where service delivery processes are complex and highly automated, digital twin-based accounting systems support more accurate cost allocation and revenue recognition.

In auditing, digital twin technology complements big data analytics and continuous auditing approaches. As noted by Vasarhelyi et al. (2015), advanced analytical tools improve the auditor's ability to process large datasets and identify anomalies. When combined with digital twins, these tools enable auditors to compare actual performance with simulated benchmarks, thereby strengthening risk assessment and audit planning. This approach reduces reliance on historical data and supports forward-looking assurance.

Artificial intelligence and automation further enhance the effectiveness of digital accounting and auditing systems. Sampaio and Silva (2025) highlight that AI-driven tools support automated classification, anomaly detection, and predictive analysis, contributing to higher audit quality and efficiency. However, the adoption of such technologies also raises concerns related to data governance, model transparency, and professional judgment. Effective implementation therefore requires clear regulatory frameworks and robust internal controls.

Overall, the integration of digital twin technology and advanced digital tools represents a significant advancement in accounting and auditing practices. These technologies enable organizations to move toward more proactive, data-driven, and resilient financial management models, while also posing new challenges that must be carefully addressed.

Digital transformation in telecommunication enterprises

Telecommunication enterprises represent a particularly relevant context for analyzing digital transformation in accounting and auditing due to their high level of technological complexity, extensive infrastructure, and large volumes of transactional data. The rapid growth of digital services and customer interactions in this sector necessitates advanced accounting and auditing solutions capable of ensuring transparency, efficiency, and regulatory compliance.

Digital transformation in telecommunication accounting is primarily driven by the need to process and analyze large-scale data generated by diverse service

offerings. Pashayeva (2024) demonstrates that the digitalization of accounting systems in mobile communication services enables more accurate revenue recognition, improved cost control, and enhanced financial reporting. Integrated digital platforms allow telecommunication enterprises to consolidate financial and operational data, thereby improving the consistency and reliability of accounting information.

Auditing practices in telecommunication enterprises have also undergone significant transformation. Traditional audit approaches are often insufficient to address the complexity and speed of operations in this sector. Pashayeva (2025) highlights that the adoption of continuous auditing and digital twin technologies enhances audit coverage and supports real-time monitoring of key risk areas. This approach is particularly effective in addressing issues related to revenue assurance, fraud prevention, and compliance with regulatory requirements.

International experience further confirms the importance of digitalization in enhancing the effectiveness of accounting and auditing in telecommunication enterprises. Pashayeva (2024) and Yerdavletova and Bimendiyeva (2024) note that digital accounting and auditing systems contribute to improved resource management and operational efficiency by providing timely and comprehensive information for decision-making. These findings are consistent with broader international research on the impact of digital transformation on organizational performance.

Despite its benefits, digital transformation in telecommunication enterprises also presents specific challenges. These include the integration of legacy systems, data security risks, and the need for specialized professional competencies. Quraishi et al. (2025) argue that addressing these challenges requires a coordinated approach involving technological investment, regulatory support, and continuous professional development.

In summary, telecommunication enterprises illustrate the transformative potential of digital accounting and auditing systems. The sector's experience demonstrates how advanced digital technologies can enhance transparency, efficiency, and accountability, while also highlighting the importance of strategic planning and effective governance in managing digital transformation.

Impact of digitalization on efficiency and transparency

Digitalization has a transformative impact on the efficiency and transparency of accounting and auditing systems by reshaping how financial information is generated, processed, and communicated. The integration of digital technologies enables organizations to move away from fragmented, manual procedures toward automated, real-time, and data-driven financial management models. This transformation significantly enhances the operational effectiveness of accounting functions and strengthens the transparency of financial reporting and assurance processes.

Table 1.

Impact of digital accounting and auditing tools on efficiency and transparency

Tool	Efficiency Impact	Transparency Impact	Accounting Implications	Auditing Implications
Accounting automation	High	Medium	Faster processing, fewer errors	Reliable supporting data
ERP systems	High	High	Integrated reporting	Strong audit trail
Continuous auditing	Medium	Very High	Ongoing data access	Risk-based assurance
Big data analytics	High	High	Data-driven decisions	Enhanced anomaly detection
Digital twin	Medium	High	Cost allocation & simulation	Predictive audits

Source: Combined application of these tools maximizes both efficiency and transparency, especially in data-intensive sectors like telecommunications (Pashayeva, 2024; Pashayeva, 2025).

Analysis and evaluation

The data presented in Table 1 illustrate the differentiated impact of key digital tools on efficiency and transparency within accounting and auditing systems. Accounting automation demonstrates a pronounced effect on operational efficiency by significantly reducing the time and effort required for repetitive tasks such as data entry, reconciliation, and routine reporting. This reallocation of human resources allows accountants to engage in higher-order analytical and strategic activities, thereby enhancing the overall agility and responsiveness of the accounting function (Sampaio & Silva, 2025). However, while automation standardizes processes and reduces error rates, its direct contribution to transparency remains moderate. The full potential for improved transparency is realized only when automated procedures are integrated into broader digital

platforms, which provide comprehensive traceability and audit trails.

ERP systems amplify both efficiency and transparency by integrating financial, operational, and managerial information into a unified platform. Such integration eliminates data redundancies, accelerates reporting workflows, and ensures consistency across organizational records, which is critical in high-volume and data-intensive sectors (Ionescu & Barna, 2021). By linking accounting entries to corresponding operational activities, ERP systems enhance the traceability of transactions, facilitating more effective internal controls and simplifying audit verification. In this context, the adoption of ERP platforms not only improves the speed and accuracy of accounting processes but also reinforces the reliability and accessibility of financial data for auditors and regulators.

Continuous auditing offers transformative improvements in transparency by enabling real-time monitoring of financial and operational activities (Pashayeva, 2025). Unlike traditional periodic audits, continuous auditing provides ongoing assurance and allows for proactive risk identification and timely corrective action. Although its efficiency gains are moderate compared to automation or ERP integration, the strategic value of continuous auditing lies in its ability to convert auditing into a forward-looking, risk-based function, which is particularly relevant in complex and rapidly evolving sectors such as telecommunications.

Big data analytics contributes substantially to both efficiency and transparency by allowing organizations to process large, heterogeneous datasets with speed and precision. These capabilities facilitate predictive analysis, anomaly detection, and informed decision-making, thereby expanding the analytical depth of both accounting and auditing functions (Vasarhelyi et al., 2015). The effectiveness of big data, however, is contingent on data quality and professional expertise, emphasizing the need for skilled personnel and robust governance frameworks.

Digital twin technology provides a virtual, real-time representation of enterprise processes, enabling simulation, scenario analysis, and predictive monitoring (Pashayeva, 2024). While the efficiency impact of digital twins is moderate due to implementation complexity, the technology markedly enhances transparency by allowing managers and auditors to observe deviations between actual and modeled performance. In telecommunication enterprises, digital twin integration supports accurate cost allocation, scenario-based planning, and predictive auditing, thus reinforcing both operational control and audit quality.

Collectively, the analysis demonstrates that the application of these digital tools in isolation produces incremental benefits, but the synergistic integration of automation, ERP, continuous auditing, big data analytics, and digital twin technologies generates compounded improvements in both efficiency and transparency. In sectors with high transaction volumes and data complexity, such as telecommunications, this integrated approach ensures reliable revenue recognition, robust internal control, and enhanced regulatory compliance (Pashayeva, 2024, 2025). Consequently, the findings underscore the necessity of a holistic, strategically aligned digital transformation that encompasses technological investment, professional competency development, and organizational change management. Such a comprehensive approach maximizes the benefits of digitalization, strengthens the strategic role of accounting and auditing, and supports evidence-based decision-making in contemporary enterprises.

Challenges and risks of digital transformation

Despite its significant benefits, digital transformation in accounting and auditing is accompanied by a range of challenges and risks that must be carefully managed. These challenges arise from technological, organizational, regulatory, and professional factors, and they can undermine the effectiveness of digitalization initiatives if not adequately addressed.

Technological complexity represents one of the most prominent challenges. The implementation of advanced digital systems, such as ERP platforms, big data analytics, and digital twin technologies, requires substantial financial investment and technical expertise. Pashayeva (2024) highlights that in communication enterprises, the integration of new digital solutions with existing legacy systems often poses significant difficulties, leading to implementation delays and increased costs.

Data security and privacy risks are also critical concerns in digital accounting and auditing environments. The increasing reliance on digital platforms and real-time data exchange exposes organizations to cybersecurity threats and unauthorized data access. Vasarhelyi et al. (2015) emphasize that the use of large datasets in auditing requires robust data governance frameworks to ensure data integrity, confidentiality, and reliability. Failure to address these risks may compromise the credibility of financial information and audit outcomes.

Organizational resistance to change constitutes another major barrier to digital transformation. The adoption of digital accounting and auditing systems often necessitates changes in workflows, responsibilities, and professional roles. Quraishi et al. (2025) note that in developing country contexts, limited digital literacy and resistance from personnel can slow the pace of digitalization and reduce its effectiveness. Addressing this challenge requires targeted training programs and strong leadership support.

Regulatory and standard-setting issues further complicate the digital transformation of accounting and auditing. Existing accounting and auditing standards may not fully accommodate digital processes, continuous auditing models, or advanced analytical techniques. Sampaio and Silva (2025) argue that regulatory frameworks must evolve to provide clear guidance on the use of digital technologies while preserving the principles of professional judgment and accountability.

In summary, while digital transformation offers substantial opportunities for improving accounting and auditing practices, it also introduces complex challenges and risks. Effective management of these issues requires a holistic approach that combines technological innovation, organizational change, regulatory adaptation, and continuous professional development.

Discussion

The analysis presented in this study demonstrates that digital transformation fundamentally reshapes accounting and auditing practices by redefining processes, professional roles, and control mechanisms. The reviewed literature consistently highlights that digitalization is not merely a technological upgrade but a comprehensive organizational transformation that affects information flows, decision-making structures, and assurance models.

One of the central findings of this discussion is the convergence between accounting digitalization and the transformation of auditing methodologies. As accounting systems become increasingly automated and data-driven, auditing practices evolve toward continuous

and analytical models. The integration of real-time accounting data into audit processes enhances audit relevance and timeliness, as emphasized by Pashayeva (2025). This convergence supports a more proactive approach to risk identification and internal control evaluation.

Another important aspect concerns the growing role of advanced technologies, such as big data analytics and digital twin models. The literature indicates that these technologies significantly expand the analytical capacity of both accounting and auditing systems. Vasarhelyi et al. (2015) and Sampaio and Silva (2025) underline that data-intensive technologies enable auditors and accountants to move beyond descriptive reporting toward predictive and prescriptive analysis. However, this shift also increases dependence on data quality, system reliability, and professional judgment.

Sector-specific evidence, particularly from telecommunication enterprises, further enriches the discussion. Studies by Pashayeva (2024, 2025) show that digital transformation is especially critical in sectors characterized by complex operations and high transaction volumes. In such environments, digital accounting and auditing systems support effective revenue assurance, transparency, and regulatory compliance. These findings are consistent with international research on digitalization in accounting and auditing within both developed and developing economies (Quraishi et al., 2025; Yerdavletova & Bimendiyeva, 2024).

At the same time, the discussion highlights persistent challenges related to digital transformation. Technological complexity, cybersecurity risks, regulatory gaps, and skill shortages remain significant barriers to effective implementation. The literature suggests that addressing these challenges requires coordinated efforts at the organizational, professional, and regulatory levels. Digital transformation, therefore, should be viewed as an ongoing and adaptive process rather than a one-time initiative.

Overall, the discussion confirms that digital transformation enhances the strategic importance of accounting and auditing while simultaneously raising new questions regarding governance, ethics, and professional responsibility. These issues warrant continued academic attention and practical experimentation.

Conclusion

This article has examined the key dimensions of digital transformation in accounting and auditing, focusing on its theoretical foundations, practical applications, and organizational implications. Based exclusively on recent academic literature, the study demonstrates that digital transformation represents a fundamental shift in the way accounting and auditing functions operate within modern enterprises.

The findings indicate that digitalization significantly improves the efficiency, accuracy, and transparency of accounting systems by enabling automation, real-time data processing, and integrated information environments. In auditing, the adoption of continuous auditing models, big data analytics, and digital twin technologies enhances audit quality and supports proactive risk management. These developments

strengthen the role of accounting and auditing as strategic tools for organizational governance and decision-making.

At the same time, the study highlights that the benefits of digital transformation are contingent upon effective implementation and governance. Technological investments must be accompanied by organizational change, regulatory adaptation, and the development of professional competencies. Without these complementary measures, digitalization initiatives may fail to deliver sustainable improvements.

The analysis of telecommunication enterprises illustrates both the transformative potential and the practical challenges of digital accounting and auditing. The sector's experience confirms that advanced digital tools can enhance transparency and accountability in complex operational environments. These insights are particularly relevant for developing economies seeking to modernize their financial management systems.

In conclusion, digital transformation in accounting and auditing is an inevitable and multifaceted process that reshapes professional practices and organizational structures. Future research should further explore the long-term implications of digitalization, including its impact on professional ethics, regulatory frameworks, and the evolving role of accountants and auditors in the digital economy.

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DETERMINANTS OF THE SHADOW ECONOMY IN SELECTED SOUTHERN EUROPEAN (EU) COUNTRIES: A MIMIC MODEL APPROACH

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Abstract

This study empirically evaluates the determinants of the shadow economy in selected Southern European Union countries over the 2013–2023 period using the MIMIC (Multiple Indicators Multiple Causes) model. Since the shadow economy is considered a latent economic phenomenon that cannot be directly observed, identifying its structural determinants is important for both the academic literature and economic policymaking. The study sample includes Cyprus, Croatia, Greece, Italy, Malta, Spain, Portugal, and Slovenia. In the model, unemployment and population growth are used as causal variables, while self-employment is employed as the indicator variable.

The empirical findings indicate that unemployment has a positive and statistically significant relationship with the shadow economy, suggesting that constraints in the formal labor market may encourage a shift toward informal economic activity. In contrast, population growth demonstrates a negative and statistically significant effect, implying that more favorable demographic dynamics may be associated with greater formal economic activity. Comparative cross-country results reveal substantial heterogeneity within the region; while Greece and Italy exhibit higher latent shadow economy index values, Cyprus and Malta display relatively lower levels.

The findings suggest that reducing the shadow economy should not be approached solely through fiscal control measures, but rather through an integrated policy framework that also incorporates labor market reforms and broader structural economic policies.

Keywords: Shadow economy, MIMIC model, Informal economic activity, Southern European Union, Economic determinants

Introduction

The shadow economy remains one of the most persistent and conceptually contested phenomena in contemporary economic analysis. Although the literature provides a range of definitions, the prevailing consensus describes the shadow economy as economic activity that generates value while remaining partially or wholly unrecorded in official national accounts; such activities typically occur outside the scope of taxation, labor market regulation, and institutional oversight [21]. The enduring nature of this phenomenon presents significant challenges for both economic analysis and policymaking [14]. On the one hand, particularly during periods of limited opportunities in the formal labor market, informal economic activity may serve as an essential mechanism for household survival and income generation. On the other hand, persistent informality undermines tax collection, distorts market competition, diminishes the effectiveness of regulatory institutions, and complicates macroeconomic governance. From this perspective, the shadow economy should be understood not merely as a set of activities absent from official statistical records, but as a structural economic challenge with far-reaching implications for fiscal sustainability, labor market efficiency, and institutional trustworthiness.

The scale and characteristics of the shadow economy are unevenly distributed across regions. While the

advanced economies of Northern Europe have generally maintained stronger institutional control over informal economic activity, Southern European countries have exhibited more persistent informal economic structures. The literature has proposed several structural explanations for this divergence, including high unemployment, fragmented labor markets, bureaucratic inefficiency, rigid regulatory frameworks, and cross-country differences in tax compliance culture. The sovereign debt crisis that unfolded after 2008 further exacerbated these structural vulnerabilities. In particular, in economies such as Greece, Italy, Spain, and Portugal, fiscal consolidation pressures coincided with deteriorating labor market conditions and declining household purchasing power. Although some degree of macroeconomic recovery was observed in subsequent years, the labor market instability and institutional distrust that emerged during the crisis persisted to a meaningful extent.

Southern Europe constitutes a particularly compelling case for analytical inquiry, as the region simultaneously reflects economic integration and pronounced structural heterogeneity. Although these countries share membership in the European Union, common regulatory frameworks, and broad mechanisms of macroeconomic coordination, they differ significantly in terms of labor market performance, demo-

graphic dynamics, economic structure, and administrative capacity. For example, Greece has long been identified in both empirical scholarship and policy discourse as an economy characterized by a comparatively large shadow sector. By contrast, smaller economies such as Malta and Cyprus warrant separate analytical consideration owing to their service-oriented economic structures and distinct regulatory environments. This internal heterogeneity underscores the limitations of treating the region as a homogeneous category; a comparative cross-country empirical analysis is therefore essential for identifying and understanding the determinants of the shadow economy.

The existing academic literature has generated important insights into the determinants of informal economic activity. Traditional explanatory frameworks emphasize tax burden, regulatory costs, unemployment, and institutional weakness as the principal drivers of shadow economic activity [22]. More recent scholarship has broadened this perspective to incorporate factors such as governance quality, demographic pressures, labor market dualism, and processes of economic transformation [14]. Nevertheless, important gaps remain in the literature. A substantial proportion of existing studies relies on large cross-country samples which, while yielding broadly generalizable findings, often do so at the expense of regional specificity. Conversely, some studies focus narrowly on single-country cases, thereby limiting the scope for comparative interpretation. Although Southern European countries are frequently represented in broader OECD and European datasets, comparative studies specifically centered on this region and employing latent variable modeling frameworks remain relatively scarce.

From a methodological perspective, measuring the shadow economy has long posed a substantial challenge, given that the phenomenon is inherently not directly observable. Direct measurement approaches, such as surveys and tax audits, are frequently constrained by data concealment, incomplete reporting, and limited cross-country comparability. Consequently, indirect estimation methods have become more widely adopted in the academic literature. Among these, the Multiple Indicators Multiple Causes (MIMIC) model is one of the most widely employed approaches for conceptualizing and estimating the shadow economy as a latent construct [20]. By modeling the unobserved shadow economy through observable economic indicators and structural determinants, this approach offers a theoretically grounded response to the measurement problem while providing a robust framework for comparative empirical analysis.

This study employs the MIMIC methodology to examine the determinants of the shadow economy in selected Southern European member states of the European Union over the period 2013–2023. The sample includes Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain. This period is analytically significant for several reasons, as it encompasses the post-sovereign debt crisis adjustment phase, the subsequent economic recovery, and the economic disruptions associated with the COVID-19 pandemic. It therefore provides a valuable context for observing the behavior of

the shadow economy under varying structural economic conditions. In the empirical specification, unemployment and population growth are included as causal variables, while self-employment serves as the observable indicator of the latent shadow economy.

This study makes three principal contributions to the literature. First, it addresses the gap between highly aggregated international analyses and single-country studies by providing a comparative regional assessment centered on Southern Europe. Second, it extends the empirical application of latent variable modeling within a European regional context characterized by significant economic and institutional heterogeneity. Third, by linking labor market and demographic structural variables to the level of the shadow economy, it offers empirical evidence relevant to policy debates concerning economic formalization, labor market resilience, and fiscal governance [1].

Literature review. Conceptual background of the shadow economy

The shadow economy remains one of the most extensively debated and conceptually complex constructs in economic theory. This complexity stems not only from the widespread prevalence of the phenomenon across economic systems, but also from the absence of a universally accepted conceptual boundary across competing theoretical frameworks. While some scholars define the shadow economy narrowly as economic activity concealed from tax authorities, others adopt a broader interpretation encompassing activities conducted outside labor market regulations, social protection systems, and administrative oversight. From this perspective, the shadow economy should not be understood merely as an issue of tax evasion; rather, it constitutes a structural phenomenon closely linked to economic formalization, institutional trust, and state governance capacity [3].

One of the most widely cited conceptual frameworks was proposed by Schneider and Enste (2000), who define the shadow economy as all legal production and service activities that generate economic value yet remain unrecorded in the official statistical system [5]. Although this framework has been widely adopted in empirical research, some scholars have argued that its conceptual boundaries may be excessively broad. For example, grouping informal labor activity, unregistered small enterprises, family-based informal production, and partially concealed income-generating activities within a single analytical category may generate theoretical ambiguity in certain contexts. Nevertheless, within the empirical economics literature, the shadow economy is generally treated as a pragmatic construct referring to income-generating activities occurring outside the formal regulatory framework [4].

The theoretical literature on the emergence of the shadow economy has developed primarily along two major explanatory perspectives. The first is grounded in rational choice economics and argues that individuals shift from the formal to the informal sector as tax burdens, regulatory costs, and administrative barriers increase. Under this view, informal economic activity represents a rational response by economic actors to the

costs and constraints imposed by the formal institutional environment [22]. The second adopts an institutional perspective, emphasizing that informal economic activity is shaped not only by economic incentives, but also by trust in public institutions, governance quality, and patterns of normative compliance. Within this framework, the shadow economy is interpreted not merely as a market response, but also as a manifestation of institutional weakness.

Labor market theory likewise provides an important explanatory framework for understanding the shadow economy. Rising unemployment, the expansion of precarious employment, and limited access to formal employment opportunities may push individuals toward informal economic activity. Particularly during periods of economic crisis, the shadow economy may function as an adaptive adjustment mechanism. From this perspective, the informal sector is not simply a by-product of tax evasion, but may also represent a broader socioeconomic response to labor market failures. This interpretation is particularly relevant in the Southern European context, where persistently high unemployment, youth labor market exclusion, and structural labor market instability have long constituted defining economic challenges.

Although the relationship between demographic variables and the shadow economy has received comparatively limited attention, scholarly interest in this dimension has grown in recent years. Population growth, migration, demographic aging, and changes in the composition of the working-age population may influence the balance between formal and informal economic activity. In some contexts, a growing and dynamic population may strengthen economic formalization through labor market expansion and rising consumer demand. Conversely, an aging and contracting population may alter the structure of economic activity and reinforce particular forms of informal employment. Although the literature has not yet reached a clear consensus on these dynamics, demographic factors are increasingly recognized as secondary but meaningful determinants of the shadow economy.

Empirical evidence from previous studies

Empirical research has produced extensive, albeit not entirely uniform, evidence regarding the size and determinants of the shadow economy. Early studies primarily emphasized the role of tax burden and state regulation in shaping informal economic activity. In his analysis of the United States, demonstrated that higher tax burdens and fiscal pressures were associated with the expansion of informal economic activity. Subsequent research extended this analytical framework to the international level [22].

Cross-country studies by Schneider et al. found that the shadow economy is systematically associated with institutional weakness, elevated tax burdens, and labor market instability [20]. Their findings suggest that even in advanced economies, the shadow economy does not disappear entirely; rather, its scale and structural composition evolve. The comprehensive international analysis conducted by Medina and Schneider broadly reinforces these conclusions, demonstrating that informal economic activity is systematically linked

to structural economic characteristics and governance quality [14].

Labor market determinants have consistently emerged as particularly important explanatory variables. High unemployment rates have been associated with the expansion of informal economic activity across numerous empirical studies. This relationship appears especially pronounced during periods of economic crisis and structural transformation, when individuals excluded from formal employment may increasingly rely on informal income-generating activities. However, some scholars have noted that this relationship is not necessarily linear, arguing that the effect may be attenuated in economies characterized by stronger social protection systems.

Empirical studies in the European context likewise provide important insights. Herwartz et al. identified significant regional disparities in the shadow economy across Europe, indicating that institutional quality and economic structure generate substantial variation even within national economies [8]. Using a MIMIC framework for Germany, Buehn demonstrated that informal economic activity is closely associated with regional economic determinants [2]. These findings further strengthened the methodological credibility of latent variable approaches in shadow economy research.

Although empirical studies specifically addressing Southern Europe do exist, they have predominantly adopted single-country analytical perspectives. Greece and Italy, in particular, are frequently identified in the literature as economies characterized by comparatively high levels of informal economic activity. Commonly cited explanations include persistent tax non-compliance, weak enforcement mechanisms, elevated self-employment rates, and fragmented economic structures. In the cases of Spain and Portugal, scholarly discussion has focused on the effects of post-crisis labor market reforms on informal economic activity. Nevertheless, comparative studies evaluating the region's major economies within a unified methodological framework remain relatively scarce.

From a methodological perspective, the MIMIC approach remains one of the dominant empirical tools in the shadow economy literature. Given the inherent challenges of direct measurement, latent variable models are widely regarded as practical and theoretically coherent alternatives. However, this methodology is not without criticism. Some researchers have emphasized that model estimates are sensitive to the choice of indicators and determinants. Nevertheless, for comparative regional analysis and the evaluation of structural determinants, the MIMIC approach continues to represent one of the most effective empirical frameworks available.

Research gap and contribution

Although the existing literature has established a substantial body of knowledge concerning the determinants of the shadow economy, several important gaps remain. The first relates to regional specificity. While large-scale international studies provide valuable generalizable insights, they may not adequately capture structural heterogeneity within specific regions. This limitation is particularly pronounced in regions such as

Southern Europe, where countries operate within a broadly shared institutional framework while exhibiting considerable economic heterogeneity.

The second gap concerns the absence of a sufficiently developed comparative regional research design. A substantial proportion of existing studies either focus on single-country cases or treat Southern Europe as a minor subgroup within broader European datasets. As a result, the systematic analysis of intra-regional variation remains limited [23].

The third gap relates to determinant selection. Although unemployment and fiscal variables have been extensively examined, the relationship between demographic dynamics and the shadow economy remains comparatively underexplored. In particular, the connection between population growth and economic formalization has yet to receive sufficient empirical clarification.

This study seeks to address these gaps directly. By providing a comparative MIMIC analysis of selected Southern European member states of the European Union, it develops a more regionally focused empirical framework for examining shadow economy dynamics.

At the same time, by evaluating the effects of labor market and demographic determinants on the latent shadow economy construct, the study contributes to both methodological advancement and policy-oriented debate [24].

Data and methodology. Data description and sample selection

This study employs a balanced panel dataset to empirically examine the determinants of the shadow economy in selected Southern European member states of the European Union. The sample comprises Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, and Spain. The selection of these countries was deliberate and informed by considerations of regional relevance, economic comparability, and data availability. Although all are members of the European Union and therefore operate within broadly shared institutional and regulatory frameworks, they exhibit substantial variation in labor market performance, economic structure, demographic dynamics, and levels of economic formalization. These differences provide an appropriate analytical setting for comparative regional investigation.

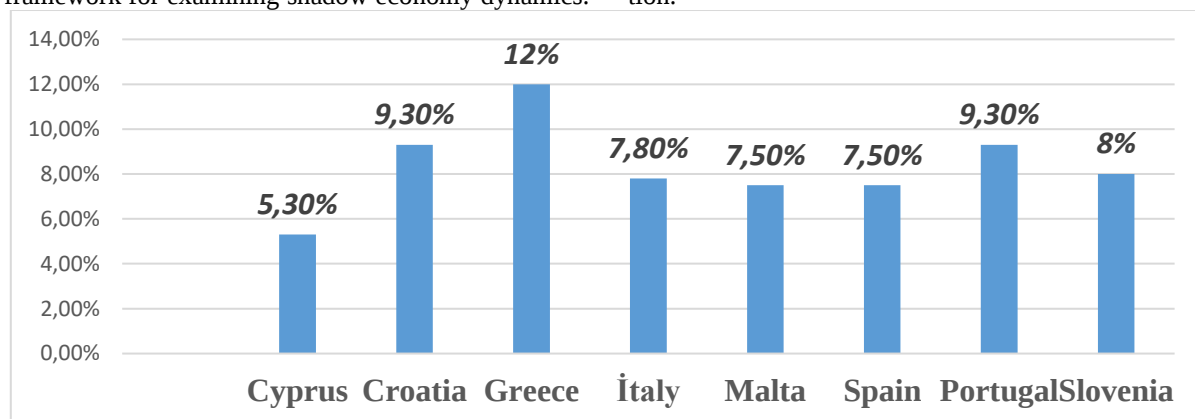


Figure 1. Shadow Economy Size (% of GDP) in in selected Southern European) countries (2023)

Analyses show that in recent years the share of the shadow economy in GDP has been increasing in some European countries. For example, in Greece this figure was 12%, in Croatia and Portugal 9.3%, and in Slovenia 8%. Although serious measures have been taken in this area at the state level, the problems have not yet been eliminated (Figure 1).

Source: <https://www.ey.com/content/dam/ey-unified-site/ey-com/en-gl/insights/tax/documents/ey-gl-shadow-economy-report-02-2025.pdf>

The study covers the period 2013–2023. The selection of this time frame is justified on both methodological and economic grounds. First, it captures the post-adjustment phase following the European sovereign debt crisis that emerged after 2008, thereby enabling the observation of structural economic changes, particularly within Southern European economies. Second, the period encompasses the economic disruptions associated with the COVID-19 pandemic and their effects on labor markets and broader economic activity. Accordingly, the selected temporal framework allows for the examination of shadow economy dynamics under varying macroeconomic conditions, spanning both

the post-crisis recovery phase and a subsequent period of renewed economic uncertainty.

The data were collected from internationally recognized open-access macroeconomic sources. Variable-specific information was obtained primarily from the World Bank and related international statistical databases. Only publicly available and standardized macroeconomic indicators suitable for cross-country comparison were included in the analysis. As the study does not involve human participants, personal data, or experimental data collection procedures, ethical approval was not required.

The balanced panel structure enhances the comparability of empirical findings while ensuring methodological consistency across observations. In total, the dataset comprises 88 observations derived from 8 countries over an 11-year period.

Variable definitions

Given that the shadow economy is inherently a latent economic construct that cannot be directly observed, its empirical estimation must rely on indirect indicators and structural determinants. In this study, consistent with the theoretical logic of the MIMIC framework, both causal variables and an observable indicator variable were specified.

The unemployment rate was included as one of the principal causal determinants. Unemployment represents a key macroeconomic indicator reflecting weakened opportunities in the formal labor market and constraints on legitimate income generation. The existing literature has extensively documented the potential for elevated unemployment to push individuals toward informal economic activity. Particularly in economic systems characterized by limited formal employment opportunities, the informal sector may function as an alternative income-generating mechanism. Accordingly, unemployment is expected to exert a positive effect on the size of the shadow economy.

Population growth was included as the second causal determinant in order to assess the potential relationship between demographic dynamics and economic formalization. Population growth may be associated with labor market expansion, increased consumer demand, and higher aggregate economic activity. At the same time, rapid demographic shifts may, under certain conditions, facilitate the expansion of informal labor markets. Given that the empirical literature has not reached a clear consensus regarding this relationship, the inclusion of this variable was considered analytically justified.

Self-employment was employed as the observable indicator of the latent shadow economy construct. Although self-employment does not inherently imply informal economic activity, it is widely used in the empirical literature as a proxy indicator for the shadow economy, particularly in economies where informal and micro-scale economic activity is more prevalent. Previous studies suggest that elevated levels of self-employment may, in certain contexts, be associated with greater informal economic intensity. For this reason, self-employment was incorporated into the model as the observed indicator variable.

The MIMIC model specification

The inherently unobservable nature of the shadow economy makes its empirical measurement methodologically challenging. Consequently, latent variable models—particularly the Multiple Indicators Multiple Causes (MIMIC) approach—have emerged as one of the most widely applied methodological frameworks in this field. The MIMIC model constitutes a specific form of structural equation modeling that enables the indirect estimation of unobservable constructs through observable variables.

In this study, the shadow economy is modeled as a latent construct using the following structural specification:

Shadow Economy = $f(\text{Unemployment, Population Growth})$

The measurement (indicator) equation is specified as follows:

Self-employment = $f(\text{Shadow Economy})$

Within this framework, the latent shadow economy is conceptualized as an unobservable construct influenced by observable economic determinants while being indirectly measured through the self-employment indicator. The general mathematical specification of the structural model is presented as follows:

$$\eta = \gamma x + \zeta$$

where:

- η denotes the latent shadow economy,
- x represents the vector of causal variables,
- γ denotes the structural coefficients,
- ζ represents the structural disturbance term.

The measurement model is specified as:

$$y = \lambda \eta + \varepsilon$$

where:

- y denotes the observed indicator variable,
- λ represents the factor loading,
- ε denotes the measurement error term.

This framework transforms the inherent challenge of the shadow economy's direct unobservability into a theoretically grounded and empirically tractable analytical model.

Estimation procedure

The empirical analysis was conducted using the R statistical computing environment. Structural equation modeling and MIMIC estimation were implemented using the lavaan package. Prior to model estimation, the structural suitability of the dataset was assessed, and the variables were subjected to preliminary examination through descriptive statistics and correlation analysis.

The model was estimated using the Maximum Likelihood (ML) estimation method. This approach is widely employed in structural equation modeling and is generally regarded as appropriate due to its statistical efficiency in parameter estimation. Model fit was assessed using multiple goodness-of-fit indices, including the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR).

To facilitate comparative analysis of the latent shadow economy index across countries and over time, standardized latent scores were computed. These scores were used for relative comparisons within the regional sample; they do not represent monetary values, but rather indicate the relative intensity of the latent construct. Higher positive values indicate comparatively greater shadow economy intensity, whereas lower or negative values reflect relatively lower levels within the sample.

This procedure enables a systematic interpretation of the findings both in terms of structural determinants and from a comparative cross-country perspective.

Empirical findings. Descriptive statistics

Table 1.

Descriptive statistics of the study variables						
Variable	N	Mean	Std. Dev.	Median	Minimum	Maximum
Unemployment Rate (%)	88	11.11	6.03	9.78	3.47	27.69
Self-employment Rate (%)	88	18.56	6.28	16.30	10.78	37.13
Population Growth (%)	88	0.35	1.14	0.09	-1.61	4.05

Note: Calculated by the author based on World Bank and Eurostat data for selected Southern European EU countries (2013–2023).

Table 1 presents the descriptive statistics, providing an initial overview of the macroeconomic characteristics of the selected Southern European Union countries over the period 2013–2023. The results reveal substantial variation across the sample, reflecting the pronounced structural heterogeneity of the region.

The unemployment rate averaged 11.11%, with a relatively high standard deviation of 6.03, indicating marked differences in labor market conditions across the selected countries. This variation likely reflects the uneven post-crisis recovery trajectories observed across Southern Europe, particularly between economies historically characterized by persistently high unemployment and those exhibiting comparatively more stable labor market performance.

Self-employment averaged 18.56%, suggesting that a significant proportion of economic activity is

concentrated in self-managed or less formally structured employment arrangements. The wide observed range, spanning from 10.78% to 37.13%, further underscores substantial structural differences in labor market composition.

Population growth remained positive on average (0.35%), although some countries experienced demographic contraction while others recorded expansion. This variation reflects differing migration dynamics, demographic aging patterns, and labor mobility trends across the region.

Overall, the descriptive findings confirm considerable heterogeneity among the selected economies, thereby reinforcing the appropriateness of applying comparative latent variable modeling to examine the determinants of the shadow economy.

Correlation analysis

Table 2.

Variable	Correlation matrix of study variables		
	Unemployment	Self-employment	Population Growth
Unemployment	1.000	0.628	-0.443
Self-employment	0.628	1.000	-0.467
Population Growth	-0.443	-0.467	1.000

Note: Author's calculations based on the compiled dataset (2013–2023).

The correlation results presented in Table 2 reveal statistically meaningful associations among the variables. A positive, moderately strong correlation ($r = 0.628$) was observed between unemployment and self-employment, suggesting that as conditions in the formal labor market weaken, individuals may increasingly resort to informal or independent income-generating activities. This finding is broadly consistent with established theoretical perspectives on the shadow economy.

Negative correlations were likewise identified between population growth and both unemployment ($r =$

-0.443) and self-employment ($r = -0.467$), suggesting that more favorable demographic dynamics may be associated with a greater concentration of economic activity within the formal sector. However, given that correlation analysis does not establish causal relationships, a more rigorous examination of these associations should be conducted using the results of the structural model.

MIMIC estimation

Table 3.

Variable	MIMIC model estimation results			
	Standardized Coefficient	Std. Error	z-value	p-value
Unemployment	0.525	0.089	5.891	0.000
Population Growth	-0.234	0.089	-2.629	0.009

The MIMIC model results presented in Table 3 identify unemployment as a significant determinant of the shadow economy in the selected Southern European countries. The standardized coefficient for unemployment is positive and statistically significant ($\beta = 0.525$, $p < 0.001$), suggesting that diminishing opportunities in the formal labor market may compel individuals to turn to informal economic activities as alternative sources of income.

By contrast, population growth exerts a negative and statistically significant effect ($\beta = -0.234$, $p = 0.009$). This finding suggests that more dynamic demo-

graphic conditions may, in certain contexts, be associated with a higher degree of economic formalization. One plausible explanation is that population growth may foster labor market expansion, increased domestic demand, and a greater concentration of economic activity within the formal sector.

The model demonstrates moderate explanatory power ($R^2 = 0.439$), indicating that approximately 43.9% of the variation in the shadow economy is explained by the determinants included in the model. Although the model fit indices appear robust, they should be interpreted with caution given the model's just-identified specification.

Table 4.

Model fit statistics	
Indicator	Value
CFI	1.000
TLI	1.000
RMSEA	0.000
SRMR	0.000
R ² (Shadow Economy)	0.439
Observations	88

Note: Estimated using maximum likelihood MIMIC modeling. Self-employment was used as the observed indicator of the latent shadow economy construct. Author's calculations.

The MIMIC estimation results presented in Table 3 indicate that both unemployment and population growth exert statistically significant effects on the latent shadow economy across the selected Southern European countries.

Unemployment exhibits a positive and statistically significant association with the shadow economy ($\beta = 0.525$, $p < 0.001$), suggesting that deteriorating labor market conditions contribute to the expansion of informal economic activity. This finding is theoretically consistent with the established shadow economy literature, which posits that individuals excluded from formal employment often turn to unregistered or informal sectors as alternative sources of income generation.

By contrast, population growth demonstrates a negative and statistically significant effect ($\beta = -0.234$, $p = 0.009$), implying that more favorable demographic

dynamics are associated with lower levels of shadow economic activity. One plausible interpretation is that population expansion may coincide with stronger labor market absorption, increased domestic demand, and higher degrees of economic formalization.

The explanatory power of the model is moderate, with approximately 43.9% of the variation in the latent shadow economy construct explained by the included determinants ($R^2 = 0.439$). Although conventional model fit indices indicate perfect fit, this result should be interpreted with caution, given that the model is just-identified (degrees of freedom = 0), meaning that fit statistics are mechanically optimized by the model specification rather than independently validating model adequacy.

Overall, the findings suggest that labor market fragility remains a central driver of informal economic activity in Southern Europe, whereas favorable demographic trends may contribute to greater economic formalization.

Country-level shadow economy index results

Table 5.

Country-level shadow economy index estimates (2013–2023)								
Year	Croatia	Cyprus	Greece	Italy	Malta	Portugal	Slovenia	Spain
2013	-0.126	-0.160	2.956	0.997	-0.605	0.330	0.014	-0.172
2014	-0.202	-0.107	2.794	0.974	-0.624	-0.015	0.202	-0.099
2015	-0.185	-0.579	2.633	0.926	-0.633	-0.222	-0.100	-0.185
2016	-0.180	-0.682	2.464	0.810	-0.701	-0.371	-0.151	-0.341
2017	-0.274	-0.856	2.189	0.765	-0.681	-0.414	-0.237	-0.348
2018	-0.335	-1.118	2.043	0.691	-0.713	-0.512	-0.252	-0.442
2019	-0.446	-1.134	2.024	0.595	-0.685	-0.517	-0.443	-0.505
2020	-0.543	-1.203	1.999	0.586	-0.702	-0.518	-0.413	-0.465
2021	-0.576	-1.224	1.966	0.536	-0.712	-0.556	-0.595	-0.466
2022	-0.696	-1.218	1.876	0.456	-0.692	-0.537	-0.648	-0.508
2023	-0.797	-1.239	1.973	0.435	-0.713	-0.585	-0.678	-0.593

Note: Higher positive values indicate relatively greater estimated shadow economy intensity, whereas lower negative values indicate comparatively lower shadow economy levels within the sample. Author's calculations based on MIMIC latent variable estimation.

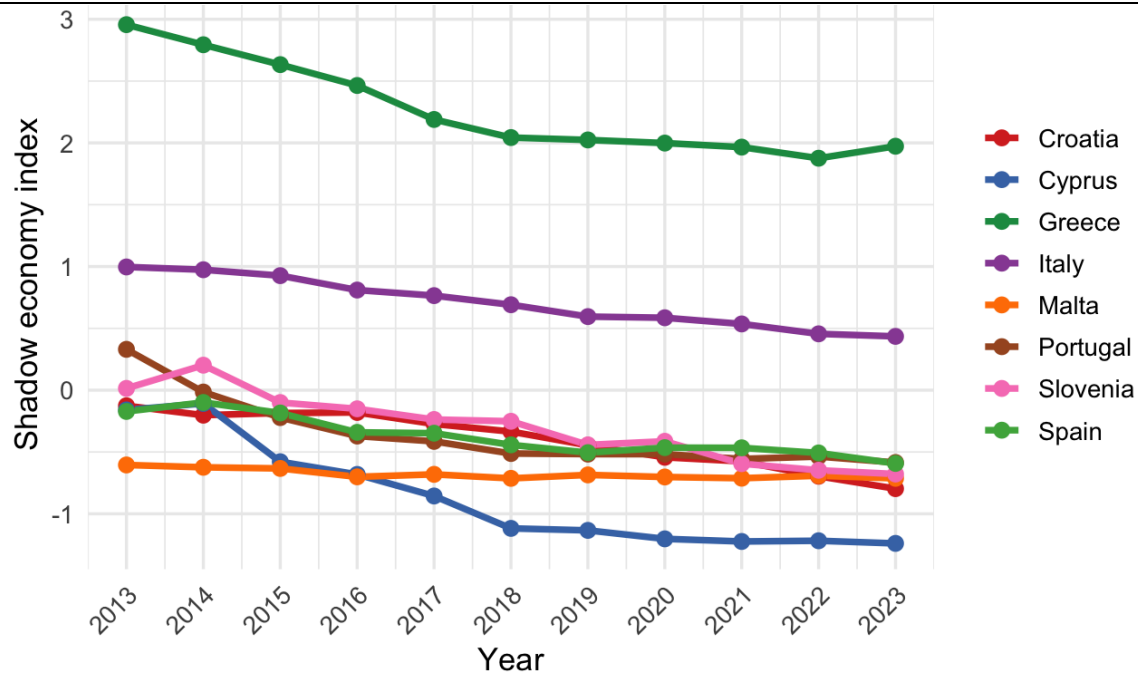


Figure 2. Country-level dynamics of the estimated shadow economy index in selected Southern European EU countries (2013–2023)

Source: Author's calculations based on MIMIC model estimation using compiled macroeconomic data for selected Southern European EU countries (2013–2023).

Note: The shadow economy index represents a standardized latent construct estimated through the MIMIC model, where self-employment serves as the observable indicator of informal economic activity. Higher positive values indicate relatively greater shadow economy intensity, whereas lower (more negative) values indicate comparatively lower levels within the sample [25,6] (Figure 2).

The country-level latent index results clearly demonstrate that the shadow economy does not exhibit a homogeneous pattern across the Southern European region. Greece consistently emerges as the country with the highest shadow economy index throughout the study period. This finding may be attributed to the country's prolonged fiscal challenges, persistently high unemployment, and the weakening of formal economic activity in the post-crisis period [16].

Italy likewise exhibits a relatively high level of shadow economy intensity, as reflected in its positive index values, although these remain lower than those observed for Greece. By contrast, countries such as Cyprus, Malta, Croatia, and Spain display comparatively

lower latent index values, suggesting that the shadow economy is shaped by heterogeneous structural and institutional conditions across the region [17].

From a temporal perspective, the shadow economy index appears to exhibit a declining trend in many countries. This pattern may reflect the strengthening of formal economic institutions, improved labor market stability, and broader economic adjustment processes in recent years. Nevertheless, the observed cross-country variation suggests that a uniform regional policy approach may be insufficient, underscoring the importance of accounting for country-specific economic conditions [18].

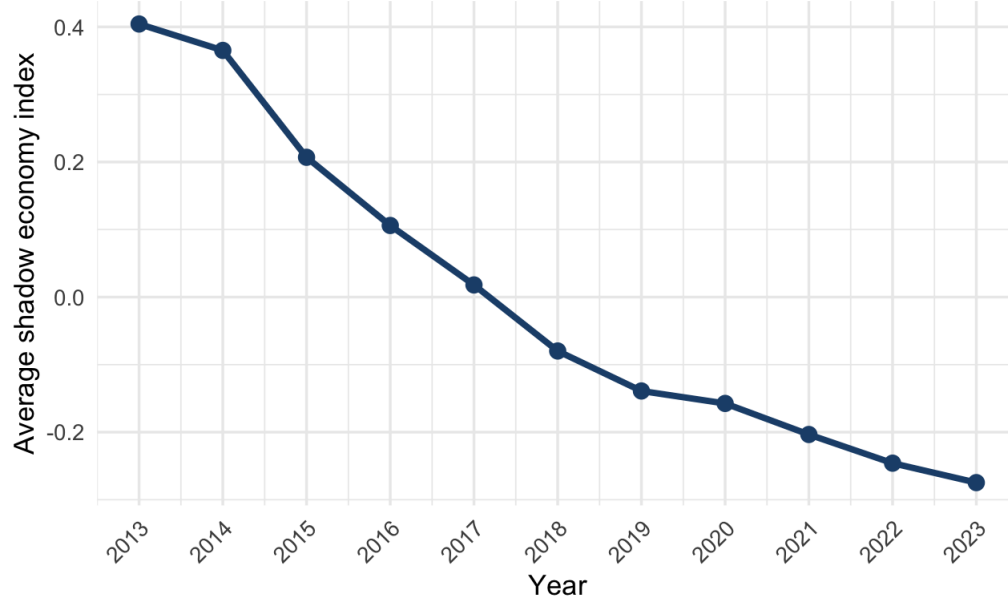


Figure 3. Regional trend of the estimated shadow economy index in selected Southern European EU countries (2013–2023)

Source: Author's calculations based on compiled macroeconomic data (2013–2023).

Note: The figure presents the annual average shadow economy index across the selected Southern European countries derived from the MIMIC latent variable estimation [15,9].

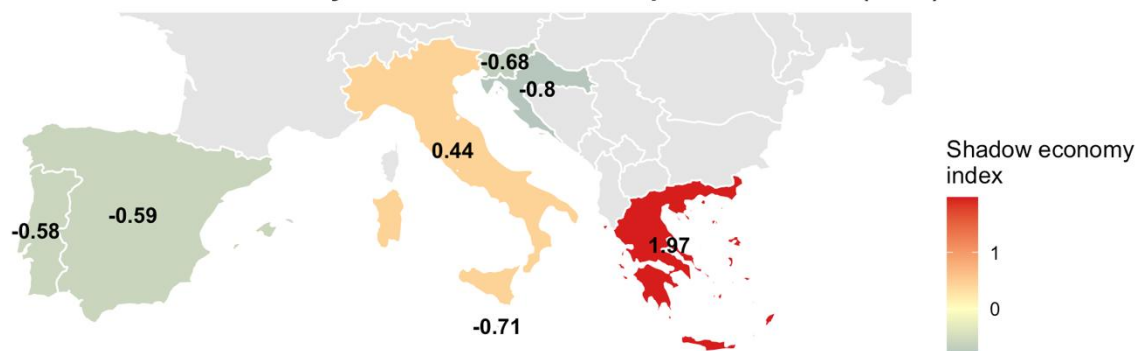


Figure 4. Geographic distribution of the estimated shadow economy index across selected Southern European EU countries in 2023

Source: Author's calculations based on MIMIC model estimation using compiled macroeconomic data (2013–2023).

Note: The figure presents country-level estimates of the latent shadow economy index derived from the MIMIC model for 2023. Higher positive values indicate relatively greater shadow economy intensity, whereas lower negative values indicate comparatively lower levels within the study sample.

Discussion

Interpretation of determinant effects

The empirical findings of this study indicate that unemployment constitutes a significant and positive determinant of the shadow economy across the selected Southern European member states of the European Union. This result is broadly consistent with the existing theoretical and empirical literature, suggesting that informal economic activity may emerge as an adaptive response to labor market constraints. Reduced employment opportunities within the formal sector may compel individuals to seek alternative, less regulated forms of income generation. This dynamic appears particularly pronounced in regions such as Southern Europe, where labor market fragility has persisted as a long-standing structural challenge.

This relationship should be understood not merely as a statistical association, but as a reflection of deeper

structural economic mechanisms. In economies characterized by persistently high unemployment, informal activity often becomes less a matter of voluntary choice and more a necessity-driven form of economic adjustment. High barriers to entry into formal employment, employment instability, and sustained youth unemployment may further intensify this process. In particular, the prolonged unemployment pressures observed in economies such as Greece and Spain during the post-crisis period lend further support to this interpretation [7].

The results also indicate that population growth is negatively and statistically significantly associated with the shadow economy. At first glance, this finding may appear counterintuitive, as more rapid population growth could, in some contexts, generate labor market pressures that encourage informal activity. However, within the context of the selected region, an alternative

interpretation appears more persuasive. More favorable demographic dynamics may be associated with labor market expansion, stronger domestic demand, and a greater capacity for economic activity to be absorbed within the formal sector. In this sense, population growth may function less as a driver of informal expansion and more as a proxy for broader economic dynamism [19].

The region's demographic structure should also be considered when interpreting this relationship. Many Southern European economies face population aging, low fertility rates, and long-term demographic decline. In this context, higher—or less negative—population growth may signal comparatively healthier structural economic conditions. Accordingly, the negative relationship identified here may be interpreted not merely as a direct demographic effect, but also as a broader indicator of economic resilience.

Nevertheless, these findings should be interpreted with caution. Within the MIMIC framework, the estimation of latent constructs is inherently dependent on the selection of indicators and structural determinants. Consequently, while the results reveal meaningful structural tendencies, they should not be interpreted as deterministic causal relationships. Even so, the findings suggest that labor market conditions and demographic structure play a substantial role in shaping the shadow economy within the Southern European context [10].

Cross-country comparative discussion

The cross-country comparison clearly demonstrates that the shadow economy is not a homogeneous phenomenon across the region. Based on the estimated latent index values, Greece appears to exhibit the highest level of shadow economy intensity, distinguishing itself markedly from the other countries in the sample. This finding is consistent with both the region's economic history and the existing literature. Greece has long been associated with persistent tax compliance challenges, elevated unemployment, post-crisis structural pressures, and comparatively weak enforcement mechanisms. In particular, the economic disruptions following the 2008 crisis may have imposed substantial constraints on formal economic activity, thereby reinforcing informal adaptation mechanisms.

Italy also exhibits relatively high shadow economy intensity, as reflected in its positive latent index estimates, although the magnitude remains substantially lower than that observed for Greece. This difference may be explained by the persistence of informal economic activity, particularly within small business sectors and in the context of regional economic dualism, despite Italy's larger and more diversified economic structure. North-south economic disparities, the prevalence of family-owned small enterprises, and administrative complexity are likely contributing factors.

Spain and Portugal display comparatively lower latent index values. These findings introduce greater nuance into the broader regional narrative surrounding the shadow economy, given that both countries also experienced significant post-crisis economic pressures. However, labor market reforms, macroeconomic recovery, and the institutional strengthening of the formal

sector over the past decade may have contributed to the relative containment of informal economic activity.

Croatia and Slovenia are characterized by comparatively lower latent intensity levels. Despite its background as a transition economy, Slovenia appears to benefit from a relatively stronger institutional framework and a more stable labor market. In Croatia, post-European Union accession formalization processes may likewise have contributed to lower levels of informal activity. In both cases, the findings underscore the importance of institutional variation within Southern Europe [11].

Malta and Cyprus exhibit the lowest latent index estimates. This pattern may be linked to the structural characteristics of their economies. In smaller, service-oriented, and administratively more manageable economic systems, formal regulatory mechanisms may be implemented more effectively. Nevertheless, these findings should be interpreted with caution, as latent variable model estimates may be more sensitive in small-economy contexts [12].

Overall, the observed cross-country differences indicate that European Union membership and a shared macro-institutional framework do not produce full homogeneity in shadow economy intensity. National economic structures, historical institutional legacies, and labor market dynamics continue to play a decisive role in shaping informal economic outcomes [13].

Policy implications

These findings carry several important policy implications. First, policy strategies aimed at reducing the shadow economy should not rely exclusively on monitoring and punitive enforcement mechanisms. If unemployment constitutes one of the principal determinants of informal economic activity, then efforts to address the shadow economy cannot be meaningfully separated from labor market policy. Expanding formal employment opportunities—particularly through the creation of sustainable jobs for young people and workers in precarious labor market segments—may represent a more effective long-term strategy.

Second, the simplification of tax and administrative systems appears critical for advancing economic formalization. High compliance costs for small and micro enterprises may incentivize a shift toward informal economic activity. In this context, digital tax administration, streamlined registration procedures, and incentive mechanisms that encourage formal business participation may play a particularly important role.

The demographic findings are likewise noteworthy from a policy perspective. If more favorable demographic dynamics are associated with lower levels of shadow economic activity, then strengthening the long-term sustainability of labor markets and preserving human capital may be regarded as indirect but strategically relevant components of formalization policy.

At the same time, the results suggest that a uniform regional policy approach may not be optimal. While institutional compliance challenges and structural labor market weaknesses may represent more pressing priorities in countries such as Greece and Italy, economies such as Malta and Cyprus may require dif-

ferent regulatory policy emphases. From this perspective, country-specific policy design appears more appropriate and potentially more effective.

Conclusion

This study empirically examined the determinants of the shadow economy in selected Southern European member states of the European Union over the period 2013–2023 using the Multiple Indicators Multiple Causes (MIMIC) framework. Given the inherently latent and directly unobservable nature of the shadow economy, unemployment and population growth were incorporated as causal determinants, while self-employment served as the observable indicator variable. This analytical framework enabled a comparative evaluation of the structural determinants of the shadow economy across the region.

The findings indicate that unemployment is positively and statistically significantly associated with the shadow economy. This result suggests that constraints within the formal labor market may encourage movement into informal economic activity and is broadly consistent with established theoretical and empirical perspectives. By contrast, the negative and statistically significant effect of population growth requires a more nuanced interpretation. Within the selected regional context, this finding may indicate that more dynamic demographic conditions are associated with greater economic formalization and stronger macroeconomic resilience.

The cross-country comparison revealed substantial heterogeneity within the region. Greece, and to a lesser extent Italy, exhibited comparatively higher latent shadow economy intensity, whereas Cyprus, Malta, Slovenia, and several other economies displayed relatively lower levels. These findings suggest that even within a shared European Union institutional framework, national economic structures, labor market characteristics, and historical institutional trajectories continue to play a significant role in shaping shadow economy outcomes.

This study contributes to the academic literature in several important respects. First, by providing a comparative empirical analysis focused specifically on Southern Europe, it helps bridge the gap between broad international studies and single-country approaches. Second, it extends the application of latent variable modeling within regional economic analysis. Third, by evaluating the relationship between labor market and demographic determinants and the shadow economy within a structural empirical framework, it offers policy-relevant evidence for broader economic governance discussions.

Nevertheless, several limitations should be acknowledged. First, the MIMIC framework is inherently sensitive to the selection of indicators and structural determinants, meaning that alternative model specifications may yield different results. Although self-employment is a widely accepted proxy indicator for the shadow economy in the literature, it does not provide a definitive distinction between formal and informal economic activity. In addition, the latent index estimates are intended for relative comparison rather

than direct monetary measurement of the shadow economy. The restriction of the sample to selected Southern European European Union countries also limits the broader generalizability of the findings.

Future research may extend this analytical agenda further. The inclusion of broader variable sets, alternative indicators, institutional quality measures, and fiscal determinants may generate deeper empirical insights. Comparative analyses involving other European regions could further enhance understanding of regional heterogeneity. The application of panel structural equation models or alternative latent variable estimation approaches may likewise offer methodological advantages.

Overall, this study demonstrates that the shadow economy should be understood not merely as a fiscal or administrative issue, but as a complex economic phenomenon closely linked to labor market structures, demographic dynamics, and institutional resilience. Accordingly, efforts aimed at reducing the shadow economy should extend beyond enforcement mechanisms and be integrated with broader structural economic policy interventions.

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STATE POLICY OF STIMULATING INNOVATIVE DEVELOPMENT OF THE ECONOMY OF THE REPUBLIC OF KAZAKHSTAN: PROBLEMS AND PROSPECTS**Kozhakhmetov Z.***Ph.D., Associate Professor, Turan-Astana University,
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Aktobe, Republic of Kazakhstan***ГОСУДАРСТВЕННАЯ ПОЛИТИКА СТИМУЛИРОВАНИЯ ИННОВАЦИОННОГО РАЗВИТИЯ ЭКОНОМИКИ РЕСПУБЛИКИ КАЗАХСТАН: ПРОБЛЕМЫ И ПЕРСПЕКТИВЫ****Кожрахметов З.***к.э.н., доцент,
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<https://doi.org/10.5281/zenodo.20448072>***Abstract**

The study analyzes the impact of state policy on the innovative development of Kazakhstan's economy. Based on statistical data and comparative analysis, a lag in key innovative indicators was revealed. A conceptual model has been proposed to strengthen state innovation policy, increase investment in R&D, develop innovation infrastructure and develop cooperation between universities, research institutes and business. The main barriers are low investment in R&D, weak cooperation between science and business, and limited commercialization of technology.

Аннотация

Исследование анализирует влияние государственной политики на инновационное развитие экономики Казахстана. На основе статистических данных и сравнительного анализа выявлено отставание по ключевым инновационным показателям. Предложена концептуальная модель укрепления государственной инновационной политики, увеличения инвестиций в НИОКР, развития инновационной инфраструктуры и развития сотрудничества между университетами, исследовательскими институтами и бизнесом. Основными барьерами выступают низкие инвестиции в НИОКР, слабая кооперация науки и бизнеса и ограниченная коммерциализация технологий.

Keywords: innovation policy; innovative development; national innovation system; economic growth; R&D; innovative activity; government regulation; Kazakhstan

Ключевые слова: инновационная политика; инновационное развитие; национальная инновационная система; экономический рост; НИОКР; инновационная активность; государственное регулирование; Казахстан

Введение. В контексте глобальных экономических преобразований инновации стали одним из важнейших факторов устойчивого экономического роста и международной конкурентоспособности. Стремительное развитие цифровых технологий, расширение наукоемких отраслей, усиление глобальной конкуренции значительно усилили роль инноваций в стратегиях развития современных экономик.

Многие страны в настоящее время переходят от ресурсных и промышленных экономических моделей к инновационному развитию. В этом процессе трансформации эффективность государственной политики играет решающую роль в формировании благоприятных институциональных условий для технологического прогресса, под-

держке научно-исследовательских и опытно-конструкторских работ, стимулировании инновационной активности в бизнес-секторе.

Теоретические основы инновационного экономического развития были сформированы в работах классических и современных экономистов, которые подчеркивали решающую роль технологических изменений в долгосрочном экономическом росте. В частности, концепцию инноваций как ключевого фактора экономического развития сформулировал Йозеф Шумпетер, который считал технологические инновации основным источником структурных преобразований в экономике. Более поздние исследования расширили эти идеи, представив концепцию национальных инновационных систем, которая подчеркивает важность институционального взаимодействия между правительством,

исследовательскими институтами и предприятиями в содействии инновационному развитию.

Современные исследования также подчеркивают важность государственной поддержки в продвижении инноваций. Государственная политика может влиять на инновационные процессы с помощью различных инструментов, включая финансовую поддержку исследований и разработок, налоговые льготы для инновационных предприятий, развитие инновационной инфраструктуры, создание благоприятных регуляторных условий для технологического предпринимательства.

Несмотря на растущее глобальное значение инновационного развития, многие развивающиеся страны и страны с переходной экономикой по-прежнему сталкиваются с серьезными проблемами в создании эффективных национальных инновационных систем. Ограниченные инвестиции в научные исследования и разработки, слабое взаимодействие между наукой и промышленностью и недостаточная коммерциализация научных исследований часто сдерживают инновационную деятельность и технологическую модернизацию экономики.

Республика Казахстан, как и многие другие страны, зависящие от ресурсов, сталкивается со стратегической проблемой перехода к инновационной экономической модели. Хотя в стране реализовано несколько государственных программ, направленных на поддержку научных исследований, технологического развития и цифровой трансформации, общий уровень инновационной активности в экономике остается относительно низким по сравнению с развитыми странами.

В связи с этим исследование роли государственной политики в стимулировании инновационного развития в Казахстане становится особенно актуальным. Понимание механизмов, с помощью которых государственная политика влияет на инновационную деятельность и технологическое развитие, может помочь выявить ключевые ограничения национальной инновационной системы и сформулировать эффективные политические рекомендации.

Целью данного исследования является анализ влияния государственной политики на инновационное развитие в национальной экономике Республики Казахстан и определение основных направлений повышения эффективности инновационной политики. Для достижения этой цели в исследовании рассматривается динамика ключевых показателей инновационной деятельности, анализируется институциональная структура национальной инновационной системы, предлагаются аналитические модели оценки инновационного развития.

Результаты этого исследования способствуют лучшему пониманию механизмов инновационной политики в странах с переходной экономикой и могут дать полезную информацию для совершенствования государственных стратегий, направленных на укрепление технологического развития и экономической конкурентоспособности.

Научная новизна исследования заключается в комплексном анализе влияния государственной инновационной политики на развитие национальной экономики Республики Казахстан с использованием сравнительного межстранового подхода, а также в разработке концептуальной модели факторов инновационной активности предприятий и предложении направлений сокращения инновационного разрыва со странами ОЭСР.

Обзор литературы. В современной экономической науке инновационное развитие рассматривается как один из ключевых факторов обеспечения устойчивого экономического роста и повышения конкурентоспособности национальных экономик. Особое внимание исследователей уделяется роли государственной политики в формировании эффективной инновационной системы и стимулировании научно-технологического прогресса.

Теоретические основы анализа инновационного развития были заложены в трудах Joseph Schumpeter [1], который рассматривал инновации как основной источник экономической динамики и структурных изменений в экономике. Согласно его концепции «созидательного разрушения», экономический рост обеспечивается внедрением новых технологий, продуктов и организационных решений, что приводит к трансформации существующих экономических структур.

Значительный вклад в развитие теории инновационной экономики внесли исследования Christopher Freeman [2], и Bengt-Åke Lundvall [3], которые разработали концепцию национальной инновационной системы. Согласно данной концепции, инновационное развитие определяется эффективностью взаимодействия между основными институциональными элементами экономики, включая государство, научно-образовательные организации, предприятия и инновационную инфраструктуру.

В рамках институционального подхода важное значение имеет теория «тройной спирали», разработанная Henry Etzkowitz и Loet Leydesdorff [4]. Данная модель описывает взаимодействие государства, университетов и бизнеса как ключевых акторов инновационного развития экономики. Эффективное сотрудничество между этими субъектами способствует ускорению процессов коммерциализации научных исследований и внедрения инновационных технологий в производство.

В последние десятилетия значительное внимание уделяется вопросам государственной инновационной политики и механизмам стимулирования инновационной активности предприятий. В исследованиях Paul Romer [5], разработавшего теорию эндогенного экономического роста, подчеркивается, что инвестиции в научные исследования, образование и человеческий капитал являются важнейшими факторами долгосрочного экономического развития.

Современные исследования показывают, что страны с высоким уровнем инвестиций в научно-исследовательские и опытно-конструкторские ра-

боты демонстрируют более высокие темпы экономического роста и технологического развития. В частности, государства Европейского союза реализуют комплексные программы поддержки инновационной деятельности, направленные на увеличение расходов на НИОКР, развитие научной инфраструктуры и стимулирование технологического предпринимательства [6,7].

В научной литературе также отмечается, что эффективность инновационной политики во многом определяется институциональной средой и уровнем развития национальной инновационной системы. Недостаточное взаимодействие между наукой и бизнесом, ограниченный доступ предприятий к финансированию инновационных проектов и слабая коммерциализация научных результатов могут существенно снижать инновационную активность экономики [8,9].

В странах постсоветского пространства проблема формирования эффективной инновационной системы остаётся особенно актуальной. Несмотря на наличие значительного научного потенциала, уровень инновационной активности предприятий в большинстве государств региона остаётся относительно низким. Это обусловлено рядом факторов, включая ограниченные инвестиции в научные исследования, недостаточную интеграцию науки и бизнеса, а также институциональные барьеры развития инновационной деятельности [10,11].

Таким образом, анализ научной литературы показывает, что инновационное развитие экономики определяется комплексом взаимосвязанных факторов, среди которых ключевую роль играют государственная политика, инвестиции в научно-технологическое развитие, уровень развития человеческого капитала и эффективность взаимодействия между основными элементами национальной инновационной системы. В этой связи исследование механизмов государственной политики инновационного развития Республики Казахстан представляет значительный научный и практический интерес.

Материалы и методы. Методологической основой исследования являются современные теории инновационного развития и концепция национальных инновационных систем. Теоретическая база работы опирается на научные подходы, разработанные в рамках институциональной экономики и экономики инноваций.

В процессе исследования использовались труды ведущих зарубежных и отечественных исследователей в области инновационной экономики, в том числе работы Joseph Schumpeter, Richard Nelson [6], Bengt-Åke Lundvall и Michael Porter [7], в которых рассматриваются механизмы формирования конкурентных преимуществ на основе инновационного развития [1,3,6,7].

Информационную базу исследования составили официальные статистические данные национальных и международных организаций, включая Бюро национальной статистики Республики Казахстан, World Bank, Organisation for Economic Co-operation and Development и World Intellectual Property Organization [8,9,10,11].

В ходе исследования применялись следующие методы научного анализа:

- статистический анализ использован для оценки динамики инновационной активности предприятий и анализа основных показателей инновационного развития экономики;

- сравнительный анализ применялся для сопоставления инновационных показателей Казахстана с аналогичными показателями развитых стран и средними значениями стран ОЭСР;

- системный подход позволил рассмотреть инновационную деятельность предприятий в контексте функционирования национальной инновационной системы;

- аналитическое обобщение использовано для выявления ключевых факторов, влияющих на инновационную активность предприятий.

Комплексное использование указанных методов позволило провести всесторонний анализ современного состояния инновационного развития Казахстана и определить основные направления повышения инновационной активности предприятий.

Результаты и обсуждение. Анализ эволюции государственной инновационной политики в Республике Казахстан демонстрирует постепенную трансформацию стратегических приоритетов от модернизации промышленности к формированию инновационной и цифровой экономики (Таблица 1).

На раннем этапе (2003-2010 годы) основное внимание уделялось созданию институциональных основ инновационного развития, включая создание технопарков и первоначальных элементов инновационной инфраструктуры. В последующие периоды (2010-2019 гг.) политические усилия сместились в сторону промышленной конкурентоспособности и роста, ориентированного на экспорт, что отражает логику структурной модернизации. Самый последний этап (2020-2025 гг.) подчеркивает цифровую трансформацию, стартап-экосистемы и технологическое предпринимательство.

Однако, несмотря на очевидную преемственность и расширение политических инструментов, эмпирические результаты свидетельствуют о том, что воздействие этой политики остается ограниченным с точки зрения поддающихся измерению результатов инновационной деятельности. Сохранение низкой инновационной активности среди предприятий свидетельствует о структурном несоответствии между разработкой политики и ее практическим осуществлением.

Эволюция государственной инновационной политики (2003–2025)

Период	Основные документы и программы	Цели	Основные результаты
2003–2010	Стратегия индустриально-инновационного развития	Формирование основ инновационной экономики, диверсификация	Создание первых технопарков
2010–2014	ГПФИИР	Модернизация промышленности	Развитие индустриальных проектов
2015–2019	ГПИИР-2	Повышение конкурентоспособности	Поддержка экспортно-ориентированных отраслей
2020–2025	ГПИИР-3	Переход к цифровой экономике	Развитие стартапов и цифровизации

Источник: составлено автором на основе данных Бюро национальной статистики РК, World Bank, OECD, WIPO

Этот вывод согласуется с теоретическими рамками национальных инновационных систем, которые подчеркивают, что одного лишь существования институтов недостаточно; их эффективность зависит от интенсивности и качества взаимодействия между субъектами. Таким образом, дело Казахстана иллюстрирует переход от институционального строительства к проблеме институциональной эффективности.

Межстрановой сравнительный анализ показателей инновационной деятельности (таблица 2) показывает существенный разрыв между Казахстаном и развитыми странами и отдельными странами с переходной экономикой по ключевым показателям инновационной деятельности.

Таблица 2

Сравнительные инновационные показатели Казахстана по сравнению с развитыми странами

Показатель	Казахстан	Россия	Беларусь	Узбекистан	ЕС	США
Доля инновационно-активных предприятий, %	11.9	14.5	12.1	10.8	40.3	45.2
Расходы на НИОКР, % ВВП	0.13	1.1	0.6	0.3	2.1	3.0
Доля инновационной продукции в ВВП, %	1.37	2.5	1.8	0.9	10.5	12.1
Кол-во исследователей на 1000 чел.	2.5	4.2	3.1	1.8	6.5	9.2
Патентная активность, кол-во/млн чел.	5	20	10	3	80	110
Высокотехнологичный экспорт, %	2.1	5.5	4.0	1.5	15.2	20.1
Венчурное финансирование, млн \$	15	250	30	5	1500	3500
Доля инноваций с участием университетов, %	12	35	20	10	45	55
Уровень цифровизации производства, %	25	60	45	20	70	85
Global Innovation Index	66	45	57	75	18	3

Источник: составлено автором на основе данных Бюро национальной статистики РК, World Bank, OECD, WIPO

Казахстан значительно отстает по расходам на НИОКР (0,13% ВВП), инновационно-активным предприятиям (11,9%), высокотехнологичному экспорту (2,1%). Напротив, страны ОЭСР и Соединенные Штаты демонстрируют значительно более высокие уровни во всех аспектах, особенно в таких показателях накопления знаний и коммерциализации, как патентная деятельность и венчурное финансирование.

Важно отметить, что этот разрыв не ограничивается объемом ресурсов, а распространяется на показатели результативности и эффективности. Это говорит о том, что проблема заключается не только в недостаточном финансировании, но и в низкой производительности инновационной системы, включая слабые механизмы передачи технологии и ограниченное участие частного сектора.

С точки зрения теории эндогенного роста (Romer, 1990) такие различия подразумевают ограниченный потенциал долгосрочного роста, поскольку накопление знаний и инновации являются ключевыми факторами устойчивого экономического роста. Таким образом, наблюдаемый разрыв

отражает более глубокие структурные ограничения, а не временные дисбалансы.

Анализ позиции Казахстана относительно стран ОЭСР (Таблица 3) подтверждает наличие ярко выраженного и многомерного инновационного разрыва.

Таблица 3

Сравнительные инновационные показатели Казахстана и стран Организация экономического сотрудничества и развития (ОЭСР)

№	Индикатор инновационного развития	Казахстан	Среднее ОЭСР	Лидеры ОЭСР
1	Расходы на НИОКР (% ВВП)	~0.13 %	~2.7 %	Израиль. Южная Корея (>4 %)
2	Доля инновационно-активных предприятий	~11–12 %	~50–55 %	Германия. Финляндия (>60 %)
3	Число исследователей (на 10 тыс. занятых)	~23	~120	Япония. Финляндия (~150)
4	Патенты (на 1 млн населения)	~40	~850	ШВА. Япония. Южная Корея
5	Доля высокотехнологичного экспорта	~5 %	~15–20 %	Южная Корея. Германия
6	Доля инновационной продукции в промышленности	~5 %	~25 %	Германия. Швеция
7	Венчурные инвестиции (% ВВП)	<0.01 %	~0.3 %	ШВА. Израиль
8	Университетские расходы на НИОКР	~0.03 % ВВП	~0.5 % ВВП	ШВА. Великобритания
9	Цифровизация бизнеса (использование цифровых технологий предприятиями)	~35 %	~70 %	Финляндия. Нидерланды
10	Рейтинг в Global Innovation Index	~80	Первая 30-ка	Швейцария. Швеция

Источник: составлено автором на основе данных Бюро национальной статистики РК, World Bank, OECD, WIPO

Этот разрыв проявляется одновременно во/в:
 - входных показателях (расходы на НИОКР, человеческий капитал);
 - механизмах пропускной способности (сотрудничество университетов и промышленности, инновационная инфраструктура);
 - показателях выпуска (патенты, высокотехнологичный экспорт, выпуск инноваций).

В нескольких измерениях разрыв достигает кратных величин (5-10 раз), особенно в патентной деятельности и доступности венчурного капитала. Такое неравенство свидетельствует об ограниченных возможностях национальной экономики по превращению знаний в коммерчески жизнеспособные технологии.

Результаты согласуются с моделью Triple Helix, которая утверждает, что эффективность инноваций зависит от синергии между правительством, академическими кругами и промышленностью. В Казахстане эта синергия остается недостаточно развитой, особенно с точки зрения коммерциализации и участия частного сектора.

Следовательно, разрыв в инновациях следует рассматривать не только как количественное отставание, но и как системный дисбаланс в структуре инновационной экосистемы.

Эмпирические результаты и концептуальные модели (рисунки 1 и 2) позволяют определить ключевые структурные детерминанты, стимулирующие высокую инновационную деятельность в Казахстане.



Рисунок 1 – Структурная схема национальной инновационной экосистемы

На рисунке 1 иллюстрируется структурная схема национальной инновационной экосистемы Республики Казахстан, отражающую взаимодействие ключевых институциональных акторов: государства, научно-образовательного сектора, бизнеса и инновационной инфраструктуры.

Схема демонстрирует логическую последовательность трансформации знаний в экономические результаты через механизм коммерциализации, что соответствует концепции «тройной спирали» инновационного развития.

Вместе с тем представленная модель носит нормативный характер и предполагает высокий

уровень координации между участниками, тогда как эмпирические данные свидетельствуют о недостаточной интенсивности таких взаимодействий в Казахстане.

Это указывает на необходимость институционального укрепления связей между наукой и бизнесом, а также повышения эффективности механизмов трансфера технологий.

На рисунке 2 иллюстрируется модель государственного стимулирования инновационного развития экономики.



Рисунок 2 – Модель государственного стимулирования инновационного развития экономики

Рычагами государственного воздействия являются:

- нормативно-правовые меры, которые предполагают законодательное регулирование, защиту интеллектуальной собственности и установление стандартов;
- финансово-экономические стимулы, которые предполагают прямую поддержку через гранты, субсидии и систему налоговых льгот;
- институциональные механизмы через создание инновационных кластеров;
- технопарков;
- центров НИОКР.

Реализация этих мер приведет к стимулированию инновационной активности через активизацию НИОКР, масштабное внедрение технологий и тотальной цифровизации процессов.

Взаимодействие этих факторов создаст усиливающий цикл высокой инновационной эффективности – достижение роста производительности и технологической модернизации и диверсификации экономики.

Таким образом, повышение инновационной активности требует комплексного подхода, включающего синхронизацию государственной политики, развитие отраслевых экосистем и стимулирование внутрифирменных инновационных инвестиций.

Одним из центральных выводов исследования является критическая роль инвестиций в НИОКР как определяющего фактора результативности инновационной деятельности и экономического роста.

Данные показывают, что интенсивность НИОКР в Казахстане остается значительно ниже международных ориентиров, что имеет несколько долгосрочных последствий:

- более медленная технологическая модернизация;
- снижение роста производительности;
- повышенная зависимость от импортных технологий;
- сохранение ресурсно-ориентированной экономической структуры.

Эти выводы согласуются с моделями эндогенного роста, в которых подчеркивается роль накопления знаний в поддержании экономического развития. В этом контексте низкие инвестиции в НИОКР не только отражают текущие ограничения, но и ограничивают будущие траектории роста.

Кроме того, анализ показывает, что одного лишь увеличения расходов на НИОКР недостаточно. Эффективность таких инвестиций зависит от взаимодополняющих факторов, включая институциональное качество, человеческий капитал и инновационную инфраструктуру.

Результаты исследования имеют важные последствия для развития и совершенствования государственной инновационной политики в Республике Казахстан.

Во-первых, увеличение инвестиций в научные исследования и разработки должно стать одним из ключевых приоритетов экономической политики.

Международный опыт показывает, что страны с более высоким уровнем расходов на НИОКР, как правило, добиваются более сильного технологического прогресса и более высоких темпов экономического роста. Поэтому увеличение государственных и частных инвестиций в исследовательскую деятельность имеет важное значение для укрепления инновационного потенциала национальной экономики.

Во-вторых, необходимо совершенствовать механизмы взаимодействия университетов, научно-исследовательских институтов, бизнес-сектора. Укрепление сотрудничества в рамках университетско-отраслевого и правительственного партнерства может значительно увеличить коммерциализацию научных исследований и ускорить распространение новых технологий.

В-третьих, требуется дальнейшее развитие инновационной инфраструктуры, включая технопарки, инновационные кластеры, институты венчурного финансирования и программы поддержки стартапов. Эти инструменты могут обеспечить благоприятные условия для развития инновационного предпринимательства и роста высокотехнологичных отраслей.

В-четвертых, особое внимание следует уделять развитию человеческого капитала и модернизации системы образования. Формирование высококвалифицированных специалистов в области науки, техники и технологий играет важнейшую роль в укреплении инновационного потенциала экономики.

Наконец, важной политической задачей остается улучшение институциональной среды и нормативной базы для инновационной деятельности. Прозрачное регулирование, защита прав интеллектуальной собственности и эффективные механизмы поддержки инновационных предприятий могут значительно повысить эффективность национальной инновационной системы.

Реализация этих мер политики может способствовать укреплению инновационного потенциала экономики Казахстана и поддержать переход страны к модели развития, основанной на знаниях.

Выводы. В целом, результаты подтверждают, что, хотя Казахстан добился прогресса в создании институциональной основы инновационной экономики, остаются значительные структурные проблемы.

Исследование показывает, что:

- инновационная политика развивалась, но остается недостаточно эффективной;
- сохраняется значительный разрыв в инновациях по сравнению с развитыми экономиками;
- структурные и системные факторы сдерживают инновационную деятельность;
- инвестиции в НИОКР играют решающую, но не исключительную роль;
- эффективность политики зависит от системной согласованности и участия частного сектора.

Эти выводы вносят вклад в литературу по национальным инновационным системам в странах с переходной экономикой и служат основой для

разработки научно обоснованной политики, направленной на содействие устойчивому, ориентированному на инновации экономическому росту.

Несмотря на полученные результаты, настоящее исследование имеет ряд ограничений, которые следует учитывать при интерпретации полученных выводов.

Во-первых, анализ инновационной активности предприятий основан преимущественно на агрегированных статистических данных, предоставляемых Бюро национальной статистики Республики Казахстан и международными организациями. Использование агрегированных показателей ограничивает возможности детального анализа инновационного поведения отдельных предприятий и отраслей экономики.

Во-вторых, исследование носит преимущественно макроэкономический характер и ориентировано на анализ общих тенденций инновационного развития. В связи с этим в работе не рассматриваются микроэкономические аспекты инновационной деятельности предприятий, включая особенности управления инновациями на уровне отдельных компаний.

В-третьих, сравнительный анализ инновационного развития основан на международных статистических базах данных, включая материалы World Bank, Organisation for Economic Co-operation and Development и World Intellectual Property Organization. Несмотря на высокую степень сопоставимости этих данных, возможны различия в методологии статистического учёта инновационной деятельности в разных странах.

Наконец, исследование ограничено временным периодом доступности статистических данных, что может влиять на полноту анализа долгосрочных тенденций инновационного развития.

Проведённое исследование позволило проанализировать влияние государственной политики на инновационное развитие национальной экономики Республики Казахстан и определить ключевые направления совершенствования механизмов стимулирования инновационной деятельности.

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HISTORICAL SCIENCES

BRIEF INFORMATION ON THE CONCEPT OF “DIVINE LIGHT” IN RELIGIOUS AND MEDICAL INTERPRETATION

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Abstract

This investigation, titled “Divine Light: The Source of Life, Health, and Strength,” is the first step in the field of treating diseases based on the shared principles of religion and medicine, without relying on conventional medical means.

Keywords: Ghafir, Surah, Al-Farabi, Hadith, Hindu, Raja Yoga

It is evident that knowledge is salvation. However, among the scholars who elevated the meaning and essence of knowledge to the highest level in human life, there were also those who remained indifferent to religious sciences. In particular, the commentary on verse 83 of Surah Ghafir in the Holy Qur'an states:

“Many philosophers who were renowned for their expertise in worldly sciences and disciplines in the past did not value religious and spiritual knowledge, and did not even consider them to be part of the realm of knowledge.”

Yet, from this same perspective, there were also great figures among the learned who believed that the relationship between knowledge, God, and religious faith is rooted in a deeper spiritual interpretation. Al-Farabi once remarked: “Religion and philosophy together form the only path that leads to truth.”

Albert Einstein echoed this sentiment, stating: “Faith in God is the greatest outcome of scientific inquiry.”

The conclusions drawn by prominent figures of science and philosophy across different eras regarding the interplay between religious belief and scientific exploration later found even clearer expression. For example, Dr. Albert Makop stated: “Engaging in scientific work has strengthened my faith in God. There is no doubt that science undeniably helps humanity gain a deeper understanding of God's power. The more discoveries a person makes in their scientific research, the stronger their faith in God becomes.”

Indeed, in compiling this treatise, when incorporating reflections and ideas quoted from sources of faith beyond Islam, we relied on the meaning of the hadith recorded in Sunan Ibn Majah (Hadith 4169):

“It is narrated from Abu Hurayrah (may Allah be pleased with him): ‘A wise word is like something a believer has lost — wherever he finds it, he has the right to take it.’”¹

Thus, the bond between religion and science, on the one hand, strengthens the spiritual dimension of faith during the process of scientific endeavor; on the

other hand, it enables the discovery of new facets of religious feeling that benefit humanity.

In this sense, we believe the time has come to turn our attention to another vital aspect of God's boundless mercy: the scientific exploration of the healing power of 'Divine Light'—a concept yet to be thoroughly studied by the scientific community.

However, before delving into this topic, we would like to remind our readers—regardless of their theoretical or practical familiarity with it—of a fundamental reality of our spiritual world. From the first moments of conscious life until their final breath, every human being inevitably turns to God, seeking health and well-being, and pleading for protection from life's misfortunes and calamities.

If we are to take a deeper look at the potential outcome of this heartfelt appeal to God — what might be described as the manifestation of 'Divine Light' — the reader's attention must first be drawn to an extremely delicate matter: human responsibility within divine blessings.

In this regard, it must first be emphasized that the divine favors granted to a servant logically demand a sense of human responsibility rooted in faith. Otherwise, a person who enjoys the unearned gift of health is essentially no different from those whom the Holy Qur'an describes as 'deaf and blind.'²

Drawing on the wisdom of this verse, we aim to highlight a truth which, though familiar in our daily lives, is often overlooked in practice. The reason for this emphasis is clear: while the verse refers directly to 'deafness and blindness' in matters of faith, there are countless instances in our daily lives where—despite knowing our actions must remain pure—we behave in ways that, even with seeing eyes and hearing ears, make us no different from the blind and the deaf.

The core point is this: when a healing verse of the Divine Word is recited, its effect appears to be closely linked to the person's mental, spiritual, and physical state of purity — to their ability to withstand satanic intrusions. The more I pondered on this matter, the

¹ ضَالَّةُ الْحِكْمَةِ الْكَلِمَةُ: "وَسَلَّمَ عَلَيْهِ اللَّهُ صَلَّى اللَّهُ رَسُولُ قَالَ: قَالَ هُرَيْرَةُ، أَبِي عَنْ بِهَا أَحَقُّ فَهُوَ وَجَدَهَا، الْمُؤْمِنُ، حَيْثُمَا

² Qur'an al-Karim. "Sūrat Fuṣṣilat", āyah 44.

more I came to the conclusion that only in such a state — one of true and thorough purity — can a supplication to God be expected to bring about the fulfillment of one's request.

Of course, when turning to God about any matter, it is not always easy to achieve a state of complete purity in the truest sense. Yet, when it is granted — even briefly — before voicing a heartfelt wish, I believe that God not only heals illness and suffering but also helps bring forth every good intention imprinted upon the servant's heart. For me, the next wondrous blessing — my pilgrimage to Hajj — became a profound testament to this very truth.

Now, I can say with certainty that such an unbelievable dream turning into reality could hardly be considered mere coincidence. For when there remains no doubt that a sincerely held intention will indeed come true, one must logically draw this conclusion: just as the sins a person commits — knowingly or unknowingly — are never overlooked by God, likewise, their righteous deeds are never left unnoticed. Moreover, even if I had not yet accomplished any truly remarkable good deeds, perhaps it was the heartfelt prayers I made in longing for the pilgrimage that were answered.

And so, only now — after this preface about sincere intentions and pure wishes — does it seem fitting to proceed directly to the analysis and interpretation of the healing power of the “Divine light” in relation to illness and suffering.

However, before speaking directly about this divine blessing, I would like to draw attention to another important point. In His Holy Book, Allah not only mentions the verses that serve as healing for His servants but also affirms that He may guide whomever He wills to the healing “Divine light.” And within this divine light lies a power that, when experienced, has been proven to bring healing to various ailments. For this reason, as tangible evidence of this reality, I intend to share with you, dear readers, the results of treatments involving the healing “Divine light,” which have been applied on several occasions.

Approximately ten years ago, I began to experience intermittent episodes of blurred vision in my left eye, which would redden from time to time. Alongside this, black spots would appear in my vision, accompanied by flashes of light — as if coming from an electric current. To relieve this condition, I used “Ciprolet,” an eye-drop medication prescribed by a doctor, and would find temporary healing, allowing me to continue my academic work. When describing the discomfort in medical terms, the doctor offered the following explanation from a clinical perspective:

“This condition is the result of elevated blood pressure, abnormal blood vessel circulation, or the aftereffects of illnesses experienced over a lifetime manifesting in the eye area.”

Following the treatment of this condition and subsequent observations, the doctor, while unable to reach any definitive conclusion, nonetheless advised me — as a precaution — to undergo an examination at an oncology clinic. However, I did not pursue that examination. Instead, starting the very next day, I began directing the healing “divine light” toward my eye

during the first three to four minutes of my regular *Raja Yoga* practice, which I had been engaged in for many years. As a result of these meditative treatments, I have continued my academic work for the past three to four years with healthy vision — without needing any eye drops or medications.

Turning now to the next case of treatment: One day, I noticed a pea-sized swelling on the right side of my cheek. Naturally, eating became uncomfortable, so I consulted an experienced dental specialist. The doctor explained that the only way to remove the problem was through surgery. I took about a week to think over this course of treatment and informed the clinic that I would return. The swelling in my cheek was described by the doctor as follows:

“Papilloma, linguistically referred to as a ‘benign tumor-like growth,’ can form when a section of tissue inside the cheek becomes damaged or irritated, for example, by being pinched between the teeth, or as a result of inflammation.”

Based on this diagnosis, surgery was deemed necessary. However, during my *Raja Yoga* sessions, I again began directing the “Divine light” to the spot where the swelling had appeared, attempting my own form of healing. A week later, I returned to the doctor and asked him to examine my cheek. To his surprise, he found that not a trace of the pea-sized swelling remained.

To be honest, it is undeniable that such extraordinary methods of healing — how they work and what their secret might be — will leave readers astonished. In fact, I first began to form an understanding of these healing secrets during my *Raja Yoga* practice in India in the 1990s.

What kind of understanding, you might ask? The practical answer to that question is this: in 1991, when I unexpectedly suffered a stroke, it was through *Raja Yoga* practice that I recovered. After regaining my health and returning to normal life, I became deeply interested in the Qur’anic verse that speaks of the “Divine light” — a blessing that may be granted to certain servants — and I began gathering and studying information about its characteristics as much as possible.

In this pursuit, I also familiarized myself with sources from other world religions that originated even before the Common Era. For example, Hindu theology teaches that “the remedies for illnesses encountered in human life are embedded within the very body of the person.” Similarly, the Daoist religious tradition of China cannot be excluded from this discussion, as it too contains references to such concepts.

Thus, from both religious and medical interpretations, all the necessary information relevant to this topic was gradually compiled. And during this process, I was fortunate to experience yet another unforgettable moment. In a conversation with academician Azizkhon Qayumov, the esteemed teacher referenced lines from Alisher Navoi's poetry — lines that, to me, seemed like the logical continuation of Hindu theology's vision of health. He offered these two lines as an example for the topic that fascinated me:

**Chun bo'ldi tabiat-i muolij,
Tanani qildi marazdan xorij.**

(When nature became the healer,
It drove illness away from the body.)

In essence, the lines of poetry highlight the notion that the remedy capable of freeing a person from illness exists within human nature itself — a thought that brought me great joy. Indeed, the prophetic insight woven into the couplet signified that the poet himself was aware of the miracles of divine healing.

For me personally, my 36 years of research on *“The Ancient History, Religious Beliefs, and Culture of the Peoples of South, Southeast, and East Asia”* proved invaluable in approaching the matter of healing from a deeper religious perspective. These studies were particularly helpful because the sources of religious teachings and beliefs across all three regions contained ample interpretive references to the concept of “Divine

light” — most notably in Hindu *Yoga Shastra*, Chinese Daoism, and, of course, Islamic Sufi thought.

If this unique direction — in many ways still unexplored or underrepresented in global discourse — truly addresses what is perhaps the most precious gift to humanity, namely the enhancement of both inner and outer well-being, then we would be sincerely grateful to hear your thoughts and reflections on the publication of this monograph. With this in mind, we remain hopeful for your positive response and kind support in helping us bring this important work to a wide audience.

Should you be interested in delving deeper into this groundbreaking approach to healing and its philosophical and historical roots, we warmly encourage you to reach out to the author at the following address:

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Abstract

This article examines the role of the mahalla institution in ensuring social stability and harmony in society. Mahalla and good neighborliness are analyzed as interconnected values rooted in the historical, cultural, and religious traditions of the Uzbek people. The study explores the historical origins of the mahalla institution, Islamic teachings concerning the rights and responsibilities of neighbors, and the development of state policies aimed at strengthening mahalla during the years of Uzbekistan's independence. Particular attention is devoted to the mahalla's function as a bridge between citizens and the state, as well as its role in promoting social solidarity, mutual assistance, and moral education. The article concludes by emphasizing the importance of mahalla and neighborly relations as unifying forces in the context of globalization and urbanization.

Keywords: Mahalla, good neighborliness, social harmony, cultural values, historical roots, Islamic teachings, state policy, stability, solidarity, civil society

The role of the mahalla institution in ensuring social stability and harmony in society is invaluable. In particular, good neighborly relations formed within the framework of the mahalla constitute an inseparable part of the national and spiritual values that have developed among the Uzbek people over centuries. Mahalla and good neighborliness are mutually complementary and harmonious social phenomena that strengthen the atmosphere of solidarity, mutual assistance, and tolerance within society.

The mahalla is one of the oldest and most stable social institutions in Uzbek society. It functions not only as a territorial unit but also as a unique school of moral upbringing, a system of social support, and a mechanism of community-based social control. Through the mahalla, people establish social connections, solve problems collectively, and transmit national values to younger generations.

As emphasized by the President of the Republic of Uzbekistan, the mahalla serves as the most important bridge between the people and the state, enabling local communities to address social problems directly:

“Throughout history, regardless of the severe trials we faced, we drew strength primarily from unity. During difficult times, our people and the members of mahalla communities stood shoulder to shoulder and overcame hardships together. Families supported other families, and neighbors helped one another. We must always remain faithful to this unique value and educate our younger generation in this spirit.”

Historical Roots of the Mahalla Institution

The mahalla institution possesses deep historical roots in Central Asia, particularly in the territory of present-day Uzbekistan. Historically, it developed not merely as a territorial community but also as a system of social governance, moral regulation, and mutual assistance.

The origins of the concept of mahalla can be traced back to ancient Eastern civilizations. Archaeological and historical sources indicate that the populations of ancient Sogdiana, Bactria, and Khorezm lived within tribal and territorial communities characterized by self-governance, collective responsibility, neighborhood

solidarity, and communal labor traditions. Local residents resolved issues related to water distribution, land use, security, and ceremonies through collective agreements. These features demonstrate the early formation of the mahalla as a social model.

With the spread of Islam in Central Asia, the mahalla acquired a deeper socio-legal and spiritual character. It evolved into a territorial community centered around the mosque. Mosques, schools (*maktab*), cemeteries, springs, and markets served as the social and cultural centers of the mahalla. Within this framework, the community provided assistance to the poor, cared for orphans and vulnerable individuals, regulated ceremonies and traditions, and mediated conflicts.

Islamic concepts such as neighborly rights, collective responsibility, charity (*sadaqah*), and almsgiving (*zakat*) significantly contributed to strengthening the mahalla institution. During this period, the mahalla became officially recognized as a social unit administered by respected community elders, often referred to as *oqsoqol* or *arbob*. The mahalla also acted as an intermediary between state authorities and the population.

Mahalla During the Soviet and Independence Periods

During the Russian imperial period, the mahalla institution survived, although its formal powers were limited. Under Soviet rule, the mahalla was often viewed as a “remnant of the old order.” Nevertheless, it continued to exist as an informal social institution through which family traditions, ceremonies, and neighborhood relations were preserved. This demonstrates the strong connection between the mahalla and the historical memory and cultural traditions of the Uzbek people.

Following Uzbekistan's independence, the mahalla gained official recognition as an important social institution. It was legally reinforced through the Constitution of the Republic of Uzbekistan and special legislation, obtaining the status of a “self-governing body of citizens.”

During the thirty-five years of independence, the development and significance of the mahalla institution

were directly emphasized three times in the official annual state programs:

2003 — “The Year of the Prosperous Mahalla”;

2022 — “The Year of Human Interests and Mahalla Development”;

2026 — “The Year of Mahalla Development and Social Progress.”

These initiatives demonstrate that strengthening the mahalla institution and enhancing its role in social protection, public stability, and civic life have become major priorities of state policy.

In 1993, Uzbekistan adopted the Law “On Self-Governing Bodies of Citizens,” which transformed mahallas into official legal institutions. The law defined their formal powers, administrative responsibilities, and social functions. Subsequently, the legislation was revised several times—in 1999, 2013, and 2021—to adapt it to contemporary reforms.

In the period referred to as “New Uzbekistan,” especially during the 2020s, the concept of “mahalla-based governance” (*mahallabay ishlash*) was elevated to the level of state strategy. This approach aims to identify and solve social problems directly at the community level and has become a fundamental mechanism in the activities of many state institutions.

In recent years, approximately one hundred normative legal acts have been adopted to strengthen the mahalla institution. These reforms addressed neighborly rights, election procedures, the authority of mahalla chairpersons, and mechanisms for interaction between society and the state. For instance, the term of office for chairpersons of citizens’ assemblies was extended from three to five years, and new procedures for conducting elections were introduced.

As a result of these reforms, millions of citizens have received social services through the mahalla system, reinforcing its role as a direct mechanism for supporting the population. Today, the mahalla effectively serves as a bridge between citizens and state authorities, facilitating social oversight and improving the identification and resolution of local social issues.

Good Neighborliness in Islamic Teachings

Historically, the mahalla institution in the Muslim societies of the East has been closely connected with the principle of good neighborliness. Neighborly relations occupy a significant place in the traditional lifestyle and worldview of the Uzbek people. Folk sayings such as “If your neighbor lives in peace, you live in peace” and “The neighbor’s right is God’s right” reflect the sacred status of neighborly relations in popular consciousness.

Human beings cannot live isolated from society. Throughout life, individuals establish social relations within the family, neighborhood, and broader community. Consequently, they acquire rights and obligations toward others. One of these obligations is the right of neighbors, to which Islam gives particular attention.

The Holy Qur’an states: “Worship Allah and associate nothing with Him, and show kindness to parents, relatives, orphans, the needy, the near neighbor, the distant neighbor, the companion at your side, the traveler,

and those whom your right hands possess. Indeed, Allah does not like those who are arrogant and boastful” (*Surah An-Nisa, 4:36*).

The Prophet Muhammad (peace be upon him) said: “Jibril continued to advise me concerning the neighbor until I thought he would make him an heir” (*Narrated by Imam al-Bukhari*).

Another narration from Abu Hurairah reports that the Prophet (peace be upon him) said: “Whoever believes in Allah and the Last Day should treat his neighbor kindly” (*Narrated by Imam Muslim*).

One of the manifestations of kindness among neighbors is the exchange of gifts during holidays and joyful occasions. The Prophet Muhammad (peace be upon him) said:

“O Muslim women! Let not a neighbor consider insignificant even the gift of a sheep’s hoof from another neighbor” (*Narrated by Imam Muslim*).

Similarly, Aisha (may Allah be pleased with her) once asked the Prophet (peace be upon him):

“To which of my two neighbors should I give a gift?” He replied: “To the one whose door is nearest to you” (*Narrated by Imam al-Bukhari*).

These narrations emphasize the ethical importance of maintaining close and compassionate neighborly relations.

Islamic history also contains many examples illustrating the significance of good neighborliness. Hasan al-Basri stated:

“Good neighborliness is not merely refraining from harming one’s neighbor, but also patiently enduring harm from them.”

Historical sources also narrate the famous story of Imam Abu Hanifa and his shoemaker neighbor, demonstrating patience, compassion, and moral guidance through neighborly relations.

Conclusion

In conclusion, the mahalla and good neighborliness cannot fully exist independently from one another. The mahalla environment strengthens neighborly ties, while good neighborliness enhances the social power and cohesion of the mahalla. Community events, collective work (*hashar*), holidays, and ceremonies bring people closer together and reinforce solidarity.

Healthy neighborly relations formed within the mahalla contribute to social stability, reduce conflicts and crime, and educate young people in the spirit of national and moral values. In the context of globalization and urbanization, when direct human interaction is gradually weakening, the values of mahalla and good neighborliness are becoming increasingly important as forces that unite society.

In particular, the mahalla plays a crucial role in encouraging youth social participation, preventing alienation and loneliness, and strengthening civic solidarity. Therefore, preserving and developing the traditions of mahalla and good neighborliness remains one of the essential conditions for ensuring social harmony and sustainable development in modern Uzbek society.

JURISPRUDENCE

HUMAN RESOURCE MANAGEMENT IN THE ALBANIAN PUBLIC ADMINISTRATION: CHALLENGES AND PROSPECTS

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Abstract

Human resource management constitutes one of the fundamental pillars for the effective functioning of public administration. In the context of the political, economic, and social transformations that Albania has undergone over the past decades, public administration has faced numerous challenges related to professionalism, efficiency, depoliticization, and the modernization of the civil service. Human resource management in the public sector is not limited solely to staff recruitment and administration, but also encompasses professional development, motivation, performance evaluation, ethics, and the strengthening of institutional capacities.

Within the Albanian context, public administration has transitioned from a centralized and politically controlled model during the communist period toward an administration that seeks to align with European standards. This transition has brought about significant legal and institutional changes, while simultaneously revealing structural issues such as nepotism, the lack of meritocracy, low levels of employee motivation, and insufficient professional capacities.

This article aims to provide a comprehensive analysis of human resource management within the Albanian public administration, focusing on the principal challenges and future development prospects. Through an analytical and comparative approach, the study will address the legal, institutional, and practical aspects of human resource administration, as well as the impact of administrative reforms on improving public service delivery.

Keywords: Public administration, human resource management, integration, civil service.

1. Introduction

Human Resource Management represents one of the most significant components of an effective and sustainable public administration system. In modern governance, the quality of public services and the level of institutional efficiency are closely linked to the professionalism, integrity, and performance of public employees. In the Albanian context, public administration has undergone substantial reforms during the last decades, particularly in the framework of European Union integration, democratization, and the establishment of the rule of law. Despite these developments, the management of human resources in the Albanian public administration continues to face numerous structural, legal, and organizational challenges.

The study examines issues related to recruitment procedures, merit-based promotion, political influence, employee motivation, professional training, performance evaluation, and administrative accountability. Particular attention is devoted to the implementation of civil service legislation and the extent to which transparency, impartiality, and professionalism are effectively guaranteed in practice.

The paper further explores the impact of digitalization, administrative modernization, and international standards on the development of public sector human resources. It argues that while Albania has adopted an advanced legal framework aligned with European principles, practical implementation remains inconsistent due to institutional weaknesses, limited administrative

capacities, and political interference in decision-making processes.

1. The Evolution of the Albanian Public Administration

The Albanian public administration has undergone several historical stages of development, evolving from a centralized administration characterized by political control and a lack of institutional autonomy during the communist regime, to the continuous contemporary efforts aimed at establishing a democratic administration based on transparency, meritocracy, equality, and aligned with European standards.

Following the collapse of the communist regime, Albania entered a new phase of political and economic reforms. Among the primary objectives was the establishment of new state institutions founded on professionalism and meritocracy, through the reform and creation of a democratic public administration reflecting a society aligned with European Union standards. The European integration process has exerted a significant influence on the reform of the Albanian public administration. The European Union has consistently required the establishment of a professional, efficient, and depoliticized administration as a prerequisite for advancing the integration process.

The first step toward establishing a transparent and efficient administration was undertaken during 1995–

1996 with the adoption of the first Civil Service Law³, although it was never effectively implemented. In 1998, within the framework of civil service reform and with the assistance of SIGMA, the OSCE, and the World Bank, a new civil service act⁴ was adopted, bringing the Albanian legal framework closer to widely accepted European standards and principles.

During the period 1999–2002, a series of by-laws were adopted, and implementing institutions were established, including: the Department of Public Administration (DAP)⁵, serving as the central managerial unit; the Civil Service Commission (KMSHC)⁶, functioning as the supervisory authority responsible for monitoring the implementation of civil service legislation and handling administrative complaints; and the Albanian School of Public Administration (ASPA)⁷, responsible for the training and professional development of public officials. These institutions continue to exercise their functions to this day.

On 12 June 2006, the Republic of Albania signed the Stabilisation and Association Agreement (SAA) with the European Union, the primary objective of which is the country's accession to the European Union. The Agreement establishes reciprocal rights and obligations while creating frameworks for cooperation across various sectors. One of these obligations consists of developing an efficient and accountable public administration, with particular emphasis on institution-building, the development and implementation of transparent and impartial recruitment procedures, human resource management, career development within the public service, continuous professional training, and the promotion of ethics and e-governance at both central and local levels of administration⁸.

For several years, Albania has maintained a well-defined strategic framework for Public Administration Reform, encompassing five principal strategies:

1. The Crosscutting Strategy for Public Administration Reform;
2. The National Crosscutting Strategy for Decentralization and Local Governance;
3. The Public Financial Management Strategy;
4. The Crosscutting Anti-Corruption Strategy;
5. The Crosscutting Strategy "Digital Agenda of Albania."⁹

2. The Legal Framework of Human Resource Management in Albania

Human resource management within the Albanian public administration is supported by a broad legal and institutional framework. The Constitution of the Republic of Albania establishes the fundamental principles governing the functioning of public administration and guarantees the rights of public employees.

The principal legal acts regulating human resource management in the public sector include:

- The Civil Service Law;
- The Labour Code;
- The Law on the Organization and Functioning of State Administration;
- The Law on Ethics in Public Administration;
- The Code of Administrative Procedures.

The Law "On the Civil Servant" represents one of the most significant legal frameworks through which the principles of meritocracy and professionalism are intended to be institutionalized within the Albanian public administration. Among other provisions, this law guarantees transparent and competitive recruitment procedures, professional training and development, as well as objective performance evaluation mechanisms.

The Department of Public Administration (DoPA) plays a central role in the management of human resources within the state administration. This institution is responsible for:

- Drafting and supervising the implementation of state policies concerning the civil service;
- Preparing draft laws and sub-legal acts related to the civil service;
- Monitoring the implementation of civil service legislation within public institutions;
- Providing opinions on every draft act proposed by other institutions concerning state administration;
- Approving and monitoring the implementation of training programs within the civil service;
- Preparing the annual recruitment plan for state administration institutions;
- Representing, together with the Ministry of Finance, the Council of Ministers in negotiations and consultations concerning the general terms of employment in the civil service with trade unions or representatives of civil servants;
- Administering the Central Personnel Register;
- Supporting and providing guidance to institutions in the implementation of the relevant legislation;
- Preparing general guidelines and manuals to ensure the uniform implementation of civil service legislation across state administration institutions;
- Submitting to the Prime Minister, upon proposal by state administration institutions, their organizational structures and staffing schemes, in accordance with the legal provisions governing budgetary system management in the Republic of Albania;
- In accordance with the legislation in force, drafting and cooperating in the development of salary

³ Republic of Albania. (1996). Law No. 8095/1996 on the Civil Service in the Republic of Albania

⁴ Republic of Albania. (1999). Law No. 8549/1999 "Status of the Civil Servant".

⁵ Department of Public Administration. (n.d.). Official website. <https://www.dap.gov.al/>

⁶ Civil Service Commission (Komisioneri për Mbikëqyrjen e Shërbimit Civil). (n.d.). Official website. <https://kmshc.al/>

⁷ Albanian School of Public Administration (ASPA). (n.d.). Official website. <https://aspa.gov.al/en/>

⁸ Republic of Albania. (2006). Law No. 9590, dated 27 July 2006, Article 111, on the ratification of the Stabilisation and Association Agreement between the Republic of Albania and the European Communities and their Member States.

⁹ Republic of Albania. (2022). National plan for European integration 2023–2025 (p. 32). December 2022.

structures for civil servants and employees of both central and local public administration¹⁰.

Furthermore, the Albanian School of Public Administration (ASPA) plays a significant role in the training and professional development of civil servants. ASPA is responsible for providing professional education through the implementation of the following programs:

- The Advanced Training Program, through which candidates for membership in the Top-Level Management Corps (TND) are prepared;
- The Continuous Training Program, through which civil servants of all categories, as well as any other individuals outside the civil service, receive ongoing professional training related to their duties and professional responsibilities¹¹.

3. Recruitment, Selection, Evaluation, and Promotion in the Civil Service

3.1. Recruitment and Selection in the Civil Service

Recruitment constitutes one of the most important functions of human resource management. A transparent and merit-based recruitment process is essential for the establishment of a professional and efficient administration.

Albanian legislation, *inter alia*, provides that admission to the civil service shall be conducted through a national competitive procedure. The selection process is based on the assessment of candidates' competencies, including written examinations, structured oral interviews, and any other appropriate forms of skills verification.

The law stipulates that first-time admission to the civil service within the executive category is conducted through an open competition procedure, which is carried out in two stages:

a) Preliminary Verification

This phase determines whether candidates fulfill the general requirements, namely: being an Albanian citizen; possessing full legal capacity to act; having proficiency in spoken and written Albanian; being in appropriate health conditions to perform the relevant duties; not having been convicted by a final court decision for the commission of a criminal offense or an intentional misdemeanor; and not being subject to disciplinary measures that have not expired according to the law. Candidates must also satisfy the specific requirements related to the level of education, professional experience, and other qualifications required for the relevant category, class, group, and position, as announced on the official website of the Department of Public Administration. This procedure is conducted by the responsible unit.

The institution responsible for organizing civil service recruitment procedures within state administration institutions is the Department of Public Administration (DoPA), whereas for Local Self-Government

Units, this responsibility belongs to the human resources unit established within the respective institution.

b) Candidate Evaluation

Following the written examination and the structured oral interview, the successful candidate is selected based on obtaining more than 70 percent of the total evaluation points awarded by the permanent admission committee.

Within the Albanian public administration, recruitment procedures are regulated by law and are based on the principles of meritocracy, transparency, and equal opportunities.

"The administration of the civil service is governed by law and is based on the principles of equal opportunities, non-discrimination, merit, transparency, professionalism, and political impartiality, while guaranteeing the stability of civil servants in office and the continuity of the civil service."¹²

Different European Union member states apply diverse approaches regarding candidate evaluation processes.

For example, the Federal Ministry for the Civil Service ensures candidate assessment through procedures based on job descriptions, performance tests (including verbal and numerical reasoning, logical thinking and problem-solving, text comprehension, and foreign language skills), as well as computer-based testing.

Meanwhile, in Slovakia, the selection process is conducted through a commission that applies several assessment methods, including oral interviews aimed at identifying managerial, analytical, and conceptual skills, strategic thinking, the ability to work under pressure, decision-making capacity, adaptability, and related competencies, as well as written examinations and mandatory assessment tests for managerial positions.

It may be argued that, in order to further strengthen credibility, professionalism, and meritocracy, the recruitment process in Albania should be improved in several directions. These improvements should include the standardization of testing procedures, increased transparency, the digitalization of recruitment processes, and the strengthening of appeal mechanisms. Furthermore, greater emphasis should be placed on evaluating candidates' professional experience, qualifications, certifications, and educational background in relation to the respective position.

In particular, performance evaluations provided by supervisors should carry greater weight—at least 60 percent of the overall assessment—compared to the evaluation of legal knowledge, which may vary according to changing circumstances and should not be considered the sole or principal determinant of a candidate's professionalism.

3.2. Performance Evaluation in the Civil Service

¹⁰ Republic of Albania. (2013). Law No. 152/2013 "On the Civil Servant," Article 7.

¹¹ Republic of Albania. (2013). Law No. 152/2013 "On the Civil Servant," Article 9.

¹² Republic of Albania. (2013). Law No. 152/2013 "On the Civil Servant," Article 5.

Regarding the evaluation of civil servants, Article 62 of Law No. 152/2013 “On the Civil Servant,” as amended, provides that:

“1. Performance evaluation is the process of verifying the overall achievement of the objectives established at the beginning of the evaluation period, as well as assessing the strengths and weaknesses of the civil servant in carrying out duties, conducted every six months. Performance evaluation aims to improve the professional skills of the civil servant and the quality of service delivery.

2. A civil servant may be evaluated at one of the following levels:

- a) ‘very good’;
- b) ‘good’;
- c) ‘satisfactory’;
- ç) ‘unsatisfactory’.

Different countries apply varying practices regarding the frequency of civil servant evaluations. States such as Hungary, Slovakia, Latvia, and Austria conduct evaluations once a year, whereas in countries such as the Czech Republic, Germany, Latvia, Poland, and Portugal, evaluations may be conducted every two or more years.

The Albanian legislation does not provide any specific provisions concerning civil servants who, as a result of receiving a “very good” evaluation, demonstrate high work performance and achievement of objectives. It may be argued that this element should be explicitly reflected in the law, as it would encourage the establishment of a stable, professional, and merit-based civil service.

The Czech Republic, within its civil service legislation, has provided that civil servants may benefit from salary supplements depending on their performance results. If a civil servant achieves outstanding results, they may receive a salary bonus not exceeding 50% of the average salary for the respective position; employees evaluated as “very good” may receive a 40% supplement, those evaluated as “good” a 30% supplement, and those evaluated as “satisfactory” a 10% supplement.

Similarly, in Latvia, civil servants receiving the highest evaluations benefit from an annual bonus amounting to 75% of their salary level, in addition to extra paid leave.

In Hungary, performance evaluations are conducted in written form and carry several legal consequences, including a salary reduction of up to 20% or a salary increase of up to 30%. In cases of poor performance, disciplinary measures may extend to dismissal from the civil service.

3.3. Promotion in the Civil Service

With regard to career development, two distinct forms may be identified: functional promotion (advancement to a higher position) and salary promotion (progression within the salary scale without movement to a different position). Within the framework of functional promotion, two additional elements of career development may be distinguished:

1. Horizontal Promotion (“parallel movement”)

This refers to the advancement of civil servants to a position within the same or a higher class, but still within the same category (for example, from Specialist III to Specialist II or Specialist I, or from Head of Unit II to Head of Unit I).

2. Vertical Promotion (“promotion in office”)

This refers to the advancement of civil servants to a position belonging to a higher category (for example, from the executive level to the lower management level, or from lower management to middle management positions)¹³.

Considering that the Law on the Civil Servant guarantees the stability of civil servants in office and the continuity of the civil service, while also being based on the principles of professionalism, it may be argued that there remains room for further improvement in this regard, particularly through the adoption of best practices implemented by European Union member states.

Germany, for example, considers the civil servant as a long-term investment from the very moment of recruitment. Every German citizen has the right to hold public office based on their abilities, qualifications, and professional achievements. The promotion of civil servants is carried out on the basis of indicators such as professional competencies, qualifications, and performance, through which civil servants may advance to higher positions within the civil service hierarchy.

The Albanian legislation recognizes the Department of Public Administration as the institution responsible, *inter alia*, for managing the Central Personnel Register (CPR), where professional data relating to civil servants are recorded. This system simultaneously serves as a comprehensive database that facilitates the orientation of civil servants toward positions corresponding to their professional experience, positive evaluations, and qualifications.

For instance, a civil servant holding a Doctor of Science degree while performing duties in a position that requires only a Bachelor’s degree should be provided with the opportunity to be positioned within an organizational structure that corresponds to their academic qualifications and professional capacities.

4. Work–Life Balance

Following recent amendments to Decision of the Council of Ministers No. 568, dated 06.10.2021, “On the approval of rules on working time and rest periods, overtime, and their compensation in state administration institutions, independent institutions, and local self-government units,” civil servants are now entitled to an annual paid leave duration of 4 (four) calendar weeks, equivalent to 22 (twenty-two) working days. The decision also introduces, among other provisions, flexibility in working hours, which were previously strictly fixed, thereby providing additional support to civil servants.

¹³ Republic of Albania. (2010). Draft conceptual document for a new Civil Service Law in Albania (p. 34). 1 October 2010.

However, based on European practices—which aim not only at public service delivery but also at ensuring broader social well-being, including that of civil servants—these recent changes remain insufficient to fully guarantee an effective work–life balance. It is therefore considered necessary to further adapt the legal framework, as European Union member states are increasingly moving towards reducing working hours or even the number of working days per week. Such reforms aim to enhance employees' well-being within their family and social life. As a country aspiring to EU membership, Albania should take further steps in this direction.

II. Methodology

The scientific methodology employed in this article is based on research, analytical, and comparative methods. These approaches have been utilized to examine the concept of the civil service mechanism, its constituent elements, and to conduct a comparative analysis of specific civil service institutions with selected practices implemented in European Union member states.

Through a qualitative and analytical approach, the study highlights the necessity of strengthening meritocracy, improving professional training mechanisms, and ensuring greater institutional independence in personnel management. The paper concludes that effective human resource management is essential not only for increasing administrative efficiency but also for enhancing public trust in state institutions and consolidating democratic governance in Albania.

III. Conclusions and Recommendations

Albania has placed particular importance on the civil service, with explicit constitutional provisions established in Article 107¹⁴. Over the years, the civil service mechanism has been progressively aligned with European legislative requirements, not only in terms of legal design but also in terms of performance and implementation. This progress is also reflected in the SIGMA Monitoring Report 2024:

“Albania remains a regional leader in public administration performance in four out of six thematic areas, particularly in public finance management, civil service and human resource management, as well as policy development and coordination for public administration reform. The appointment of a dedicated State Minister for Public Administration and Anti-Corruption in January 2024 is an important development that clarifies political responsibility for public administration reform. The attractiveness of the civil service as an employer has increased, together with satisfaction regarding salaries, following a 46% salary increase in the public sector. Working conditions affecting employee well-being (remote work arrangements, flexible working hours, consultations with employee representatives, and job

satisfaction surveys) are receiving increasing attention within the civil service. 86% of surveyed civil servants would recommend their institution as a good workplace, the highest result in the region.

Albania has made progress in establishing a stable legal framework for access to official information, and the Commissioner for the Right to Information and Personal Data Protection is an effective authority in ensuring the handling of information requests.

Albania has advanced in the digitalization of public services, with 95% of services now available through the e-Albania platform, improving online access for citizens and businesses.¹⁵

Despite these achievements, Law No. 152/2013 “On the Civil Servant,” as amended, requires further adaptation not only due to obligations arising from European Union accession but also due to broader social changes. This adaptation should follow best practices from EU member states, including:

- Standardization of testing procedures;
- Increased transparency in recruitment processes;
- Digitalization of administrative procedures;
- Strengthening of appeal mechanisms against administrative procedures;
- Greater emphasis on professional experience, qualifications, and educational level of candidates in relation to job positions, with performance evaluations by supervisors carrying at least 60 points compared to assessments of legal knowledge, which are subject to change over time and should not be considered a key determinant of professionalism;
- Strengthening of performance-based reward systems linked to evaluations, qualifications, and work experience, in order to motivate civil servants;
- Strengthening professional capacities by promoting civil servants with academic degrees into managerial structures;
- Further alignment of the legal framework with European practices, giving greater emphasis to work–life balance.

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1. ¹⁴ Public servants implement the law and serve the people.

2. Civil servants in public administration are appointed through a competitive procedure, except in cases provided for by law.

3. Guarantees of tenure and the legal treatment of public servants are regulated by law.

¹⁵ Ministry of Public Administration and Anti-Corruption. (2024). SIGMA monitoring report 2024: Albania – Regional leader in 4 out of 6 assessment areas. <https://mapa.gov.al/newsroom/raporti-i-monitorimit-sigma-2024-shqipëria-lider-rajonat-ne-4-nga-6-fushat-e-vleresimit/>

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MATHEMATICAL SCIENCES

FACE HISTOGRAMS

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Abstract

The paper proposes the concept of the Face Histogram as a technique for visualizing multivariate data using Chernoff Faces. Traditional histograms can only display one variable at a time, which is insufficient for multivariate data analysis. In contemporary data analysis, datasets often comprise multiple variables that need to be analyzed together to identify important patterns and relationships. The proposed method uses Chernoff Faces to map statistical variables to facial attributes such as eyes, mouth, and face shape. Each variable is normalized and associated with a specific facial parameter, allowing each observation in the dataset to be depicted as a unique face. The Face Histogram aids in visual pattern recognition and allows for the simultaneous comparison of several variables within a single visualization. This method is a great alternative to traditional histograms for analysis of multivariate datasets, although it reduces numerical precision.

Keywords: Chernoff Faces, data visualization, multivariate analysis, Face Histogram, statistical graphics



1. Introduction

1. Background of the Study

One way to analyze data is by way of data visualization. This is one of the main tools used by many people to analyze data as part of their statistical analysis or learning using a machine learning system. The visualizations are used to help show the data, usually in the form of distributions or relationships, using such simple graphs as histograms, bar charts and scatter plots. In most cases these graphs are for use with low dimensional data and as such do not work well for higher dimensional data.

2. Problem of the Study

In many real-world situations, observations are multivariate, meaning each observation includes several variables that will be analyzed together. As said before, traditional histograms can only represent one variable, thus, it will not be possible to detect interactions or even patterns in high dimensional data spaces by means of histograms. Often, several graphs have to be generated and analyzed by the analyst in turn which again causes problems like lack of insight and high load on memory and attention.

3. Gap in Existing Methods

Even when using multivariate visualization there are many different ways to visualize data, the majority of graphs created for multivariate data are difficult to

interpret by non-expert users. A number of strategies are in use to display multiple variables in one structure, to enable easier interpretation.

4. Purpose of the Study

A Chernoff Face is used to be used for a visualization of a statistical distribution. A Face Histogram is developed for such a purpose. The distribution of several statistical variables is encoded into the human facial features.

In the paper a method is proposed to compare multivariate observations in a straightforward way by a single display.

5. Method Overview

Each variable in the variables of a given dataset are normalized (i.e. transformed into a 0 to 100 scale) and then mapped to the features of a Chernoff Faces representation. Each face in the resulting Face Histogram represents an observation in the given data set. All the variables of the observation are displayed in parallel

on the single structure of a face, thus enabling a visually intuitive comparison of observations.

6. Contribution of the Study

The main contribution of this work is the introduction of the Face Histogram framework for improving the pattern recognition of multivariate data by exploiting the ability of humans to recognize differences on faces. The method is more interpretable than other methods but it does not try to preserve the absolute numerical values. This method is better suited for exploratory data analysis than for exact statistical reporting.

7. Paper Outline

The remaining part of this paper is organized as follows: Section 2 introduces the concept of Face Histogram and methodology of Chernoff Faces. The algorithm to build the visualization is described in Section 3. Applications of the method are discussed in Section 4. Final remarks and limitations conclude the study in Section 5. (Considered studies ([1], [3], [5], [2], [4])

8. Literature Review

Link	Author	Main idea	Connection to our work
Chernoff Faces	John Nelson	This work introduces Chernoff faces as a method for visualizing multivariate data using human facial features. Each variable is mapped to a facial attribute such as eye size, mouth curvature, or face shape. The approach leverages human sensitivity to facial expression to make complex datasets more interpretable.	Our work builds directly on this idea of encoding variables into facial features. However, we extend the classical approach by adding color encoding and additional shape transformations, improving expressiveness for multivariate datasets and allowing more flexible representation beyond standard facial mappings.
A Critique of Chernoff Faces	Robert Kosara	This critique discusses limitations of Chernoff faces, particularly issues with perceptual accuracy, inconsistent feature interpretation, and difficulty in comparing faces quantitatively. It argues that while visually appealing, Chernoff faces may not always be effective for precise data analysis.	Our approach addresses some of these limitations by introducing structured feature scaling, additional visual channels (colors and shapes), and controlled mapping rules, which aim to improve comparability between faces and reduce ambiguity in interpretation.
An application of the V-system to the clustering of Chernoff faces	Ruixia Song, Zhaoxia Zhao, Xiaochun Wang	This paper explores the use of the V-system to improve clustering of Chernoff faces, making it easier to group similar multivariate observations. It demonstrates how mathematical transformation systems can improve structure and interpretability in face-based visualization.	We extend this idea by not only clustering but also creating face histograms across countries, where each facial feature encodes statistical distributions of realworld multivariate datasets. Our work focuses more on comparative visualization across groups rather than only clustering.
Applied Multivariate Statistical Analysis	Richard A. Johnson, Dean W. Wichern	This textbook provides the theoretical foundation for multivariate statistical methods, including covariance structures, dimensionality reduction, and interpretation of high-dimensional datasets. It is a core reference for statistical modeling of complex data.	Our visualization method relies on principles of multivariate data representation described in this book. Each facial feature corresponds to a variable in a multivariate dataset, and our enhancements (color, shape, histograms) serve as an alternative visual encoding of high-dimensional statistical structures.

2. Chernoff Faces for Multivariate Data Visualization

Chernoff Faces are a graphical method to display multivariate data by making use of human facial features. Chernoff Faces were first introduced by Herman Chernoff in 1973. In Chernoff Faces every variable of a dataset is assigned to a particular feature of a face, such as the size of the eyes, the curvature of the mouth, the length of the nose, etc.

In this research a number of modifications to the Chernoff Faces have been made, leading to a so-called Face Histogram. The Face Histogram makes use of interval-based color mapping and changes in the facial features. With the Face Histogram, a number of variables can be displayed simultaneously.

3. Constructing a Face Histogram Using Chernoff Faces

3.1 Step 1: Preparing the Dataset

The first step is selecting a multivariate dataset. A multivariate dataset contains several variables for each observation. Let's take an example where four variables are used: **Example**

- GDP (Gross Domestic Product)
- Education Index
- Happiness Score
- Employment Rate

Each row in the dataset represents one country.

Table 2:

Initial Multivariate Dataset

Country	GDP	Education	Happiness	Employment
Kazakhstan	14005	0.82	6.2	65.0
Italy	40226	0.89	6.4	60.1
Japan	32476	0.93	6.1	77.0
Canada	55209	0.94	6.9	73.2

Traditional histograms would require separate graphs for each variable. The purpose of the Face Histogram method is to combine all variables into one visual structure.

3.2 Step 2: Creating Intervals

After selecting the dataset, intervals must be created. In this case GDP, happiness, education and employment index was studied globally. After that minimum and maximum values of each variables are fixed:

1. GDP → Face Shape
Minimum $\approx$ \$154 (Burundi),
Maximum $\approx$ \$138.935 (Bermuda)
2. Education Index → Eye Shape
Minimum $\approx$ 0.17 (Niger, Chad, South Sudan)
Maximum $\approx$ 0.97 (Norway, Germany, Switzerland)

3. Happiness Score → Mouth Shape
Minimum $\approx$ 1.7 (Afghanistan) Maximum $\approx$ 8.0 (Finland)

4. Employment Rate → Nose Shape
Minimum $\approx$ 35% (South Africa)
Maximum $\approx$ 85% (Switzerland, Iceland, Netherlands)

3.2.1 GDP → Face Shape

GDP connected to the overall face shape. GDP shows the general economic health and strength of a country and was picked as the main factor affecting the main structural feature of the Chernoff face. When GDP values changed, the facial outline shifted too. This helped visually set apart countries with different economic levels. Range for GDP is [\$154; \$138.935]



Figure 1: All intervals of GDP

This range was divided into 3 intervals by 3 different face shapes (see Figure 1). Each face has 6 sub-intervals by 6 colors in increasing order: violet, indigo, blue, green, yellow, red.

For example: there are 6 color intervals for first face shape (see Figure 2). If GDP falls in one certain interval, it means face edge will be the corresponding color.

If GDP is low(lies in 1st interval), then face shape is circular. If value is in 2nd interval, then face becomes oval. Finally, if GDP is high(3rd interval) face shape is wide.

3.2.2 Education Index → Eye Shape

Range for Education is [0.17; 0.97]

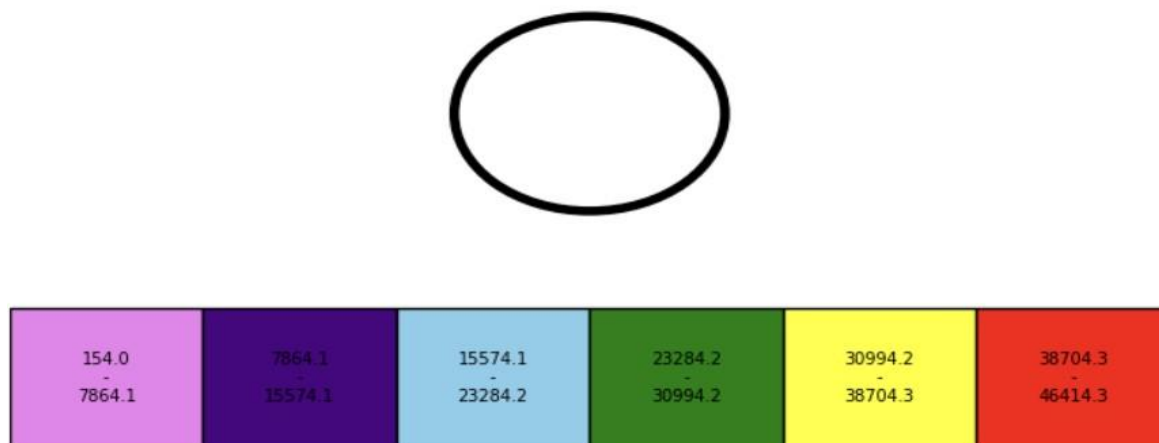


Figure 2: One interval of GDP
Education

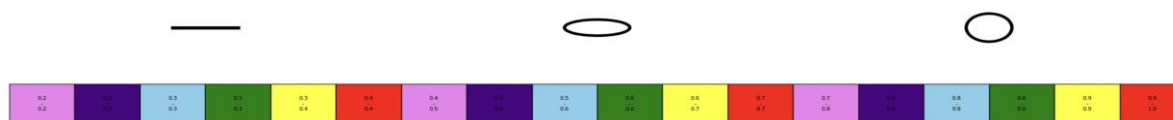


Figure 3: All intervals of Education

The same logic is applied to the eyes. If education index is low, the eyes are closed. The higher the value, the wider the eyes are opened.

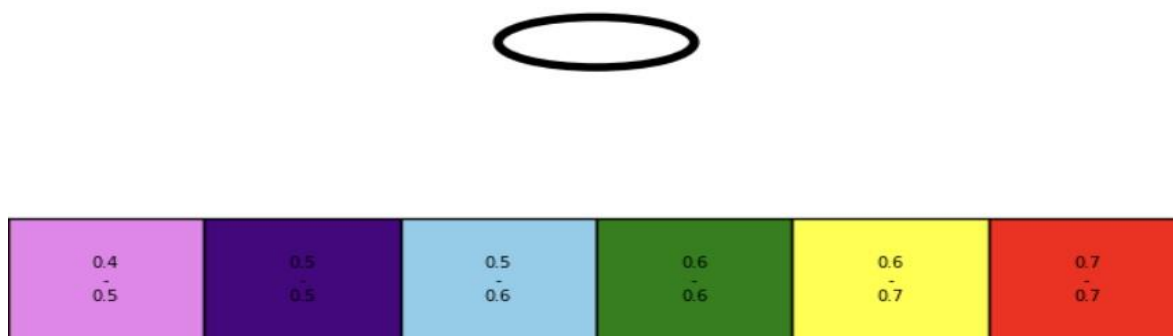


Figure 4: One interval of Education

3.2.3 Happiness Score → Mouth Shape

Range for Happiness is [1.7; 8.0]



Figure 5: All intervals of Happiness

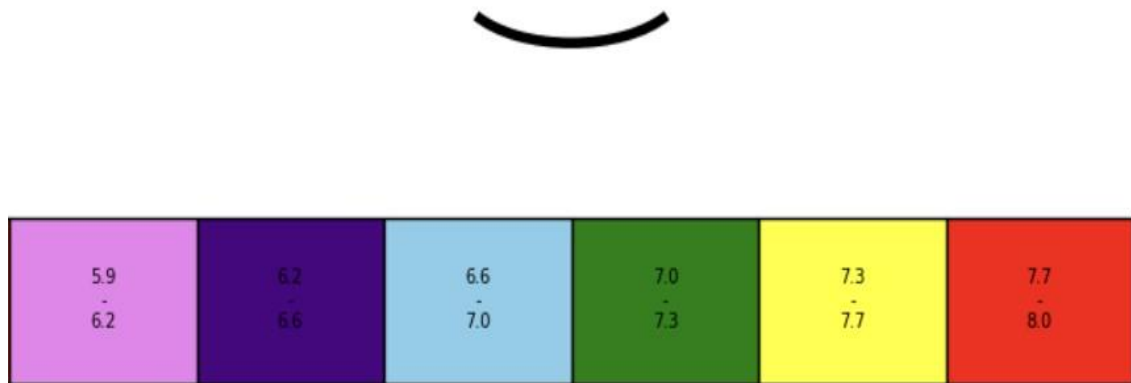


Figure 6: One interval of Happiness

3.2.4 Employment Rate → Nose Shape

Range for Employment is [%35;%85]



Figure 7: All intervals of Employment

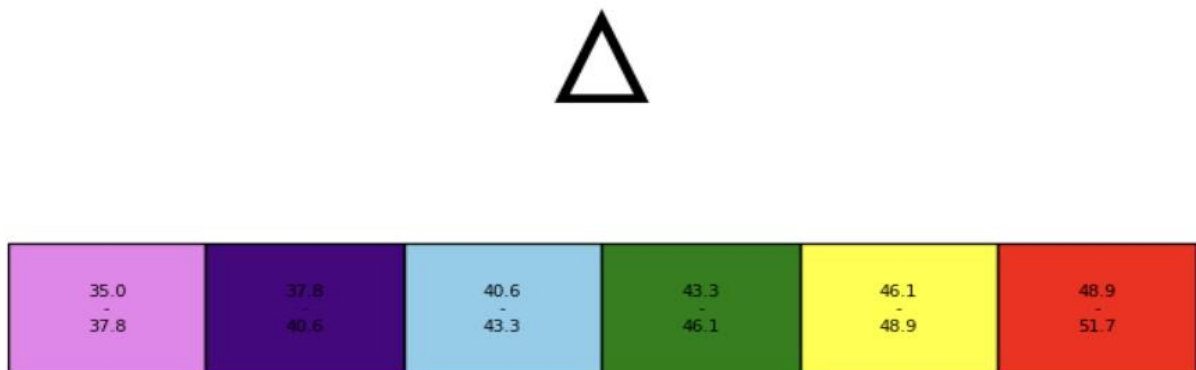


Figure 8: One interval of Employment

3.3 Step 3: Implementation and Interpretation Using Python

Creation of Chernoff faces was performed by Python via a procedure which converted basic socio-economic data into pictorial forms. In our example there

```
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib.patches import Circle, Ellipse, Arc, Polygon
```

After the division into groups, the system assigned every measurement to particular facial characteristics while following the Chernoff face model instructions. It has been observed that this linkage procedure operated inside Python by using logic rules and list positions, which connected every group type to visible parts

was chosen four countries: Kazakhstan, Italy, Japan and Canada to visualize their GDP, Education index, Happiness score and Employment rate using Face Histogram.

like the outline of the head, optical organs, nasal feature, and oral opening. Each nation was changed into a distinct facial image that holds information for the four markers at the same moment because the code processed them together.

```

# SHAPE INTERVAL
# -----

shape_index = int((value - min_val) / main_interval_size)

if shape_index > 2:
    shape_index = 2

# COLOR SUBINTERVAL
# -----

shape_start = min_val + shape_index * main_interval_size

sub_size = main_interval_size / 6

color_index = int((value - shape_start) / sub_size)

if color_index > 5:
    color_index = 5

color = COLORS[color_index]

return shape_index, color

```

Software routines in Python produced the ultimate Chernoff faces, which created picture results where a single head belongs to one nation. Graphical results were made for the purpose of looking at many socio-economic dimensions together without the need to study the digits directly. Observers state that these pictures provide a way for the eye to see differences

quickly when the user looks at the various socio-economic dimensions. Because the Python code uses specific visualization functions, the final Chernoff faces appear in a clear format that people can understand. It is often argued that the Chernoff faces allow for a faster comparison between the nations than standard tables of numbers.

Table 3:

Initial Multivariate Dataset				
Country	GDP	Education	Happiness	Employment
Kazakhstan	14005	0.82	6.2	65.0
Italy	40226	0.89	6.4	60.1
Japan	32476	0.93	6.1	77.0
Canada	55209	0.94	6.9	73.2



Figure 9: Face Histogram of Kazakhstan and Italy

Japan



Canada



Figure 10: Face Histogram of Japan and Canada

The same steps can be done to any data, any size.

4 Conclusion

The Face Histogram method makes the long-standing Chernoff Faces larger by bringing together color mapping that stays within intervals and changes to parts of the face for showing many types of data. Experts claim that the Face Histogram method lets a person see many different pieces of information at the same time because one easy-to-understand picture is produced. Since the Face Histogram method uses the shape of a face to show data and allows several pieces of information to be shown in one image.

When compared to the old-style bar charts, the Face Histogram method makes finding patterns and looking at differences between things seen much better. Even though exact counting numbers are made smaller, the Face Histogram method works well for the activities of looking at data and showing things to students in an educational institution. Because scholars hope to do more in the coming days, work will be done on making

the way features are mapped better and creating tools where people can touch and change the pictures. It has been observed that the Face Histogram method needs more ways to be understood easily by every person who looks at the data.

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MEDICAL SCIENCES

CLINICAL EXPERIENCE IN MANAGING PATIENTS WITH PULMONARY HYPERTENSION IN A CARDIAC SURGERY CENTER: RETROSPECTIVE ANALYSIS OF A CASE SERIES

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КЛИНИЧЕСКИЙ ОПЫТ ВЕДЕНИЯ ПАЦИЕНТОВ С ЛЁГОЧНОЙ ГИПЕРТЕНЗИЕЙ В УСЛОВИЯХ КАРДИОХИРУРГИЧЕСКОГО ЦЕНТРА: РЕТРОСПЕКТИВНЫЙ АНАЛИЗ СЕРИИ СЛУЧАЕВ

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Abstract

Introduction: Pulmonary hypertension (PH) is a progressive disease of the pulmonary vasculature characterized by significant morbidity and mortality. Managing patients with PH in a specialized cardiac surgery center involves comprehensive hemodynamic assessment, determination of indications for surgical interventions, and selection of specific therapy.

Objective: To conduct a retrospective analysis of clinical characteristics, results of invasive hemodynamic evaluation, and treatment approaches for a series of patients with various types of pulmonary hypertension hospitalized in a cardiac surgery center.

Methods: Retrospective analysis of a series of 10 clinical cases of patients with verified PH. All patients underwent standard clinical, laboratory, and instrumental examinations (ECG, echocardiography); right heart catheterization (RHC) with vasoreactivity testing was performed in some patients.

Results: The mean patient age was 39.8 ± 14.1 years, with males comprising 60% ($n = 6$). Pulmonary arterial hypertension (Group 1) was diagnosed in 50% ($n = 5$), PH due to left heart disease (Group 2) in 40% ($n = 4$). RHC was performed in 60% of patients ($n = 6$); mean pulmonary artery pressure (mPAP) ranged from 10 to 74 mm Hg, pulmonary vascular resistance (PVR) from <0.9 to 9.8 Wood units. Vasoreactivity testing was negative in all examined patients. Specific PAH therapy was prescribed in accordance with the 2022 ESC/ERS guidelines.

Conclusion: A comprehensive approach, including invasive hemodynamic assessment, multidisciplinary discussion, and personalized selection of specific therapy, is a key condition for the successful management of patients with PH in a cardiac surgery center.

Аннотация

Введение: Лёгочная гипертензия (ЛГ) — прогрессирующее заболевание лёгочных сосудов, характеризующееся значительной заболеваемостью и смертностью. В условиях специализированного кардиохирургического центра ведение пациентов с ЛГ сопряжено с комплексной оценкой гемодинамики, определением показаний к хирургическим вмешательствам и подбором специфической терапии.

Цель: Провести ретроспективный анализ клинических характеристик, результатов инвазивной гемодинамической оценки и подходов к лечению серии пациентов с различными типами лёгочной гипертензии, госпитализированных в кардиохирургический центр.

Методы: Ретроспективный анализ серии из 10 клинических случаев пациентов с верифицированной ЛГ. Всем пациентам проводились стандартные клинические, лабораторные и инструментальные исследования (ЭКГ, эхокардиография); части пациентов выполнена катетеризация правых отделов сердца (КПОС) с тестом вазореактивности.

Результаты: Средний возраст пациентов составил $39,8 \pm 14,1$ года, мужчины составили 60% ($n = 6$). Лёгочная артериальная гипертензия (группа 1) диагностирована у 50% ($n = 5$), ЛГ вследствие патологии левых отделов сердца (группа 2) — у 40% ($n = 4$). КПОС выполнена у 60% пациентов ($n = 6$); среднее давление в лёгочной артерии (ДЛА ср.) варьировало от 10 до 74 мм рт. ст., лёгочное сосудистое сопротивление (ЛСС) — от менее 0,9 до 9,8 ед. Вуда. Тест вазореактивности оказался отрицательным у всех обследованных пациентов. Специфическая ПАГ-терапия назначалась в соответствии с рекомендациями ESC/ERS 2022.

Заключение: Комплексный подход, включающий инвазивную оценку гемодинамики, мультидисциплинарное обсуждение и персонализированный выбор специфической терапии, является ключевым условием успешного ведения пациентов с ЛГ в условиях кардиохирургического центра.

Keywords: pulmonary hypertension, pulmonary artery pressure, pulmonary vascular resistance, right heart catheterization, Eisenmenger syndrome, specific PAH therapy, cardiac surgery

Ключевые слова: лёгочная гипертензия, лёгочное артериальное давление, лёгочное сосудистое сопротивление, катетеризация правых отделов сердца, синдром Эйзенменгера, специфическая ПАГ-терапия, кардиохирургия

INTRODUCTION. Pulmonary hypertension (PH) is a pathological condition defined as an increase in mean pulmonary artery pressure (mPAP) ≥ 20 mmHg, as determined by right heart catheterisation at rest [1]. According to the current ESC/ERS 2022 classification, there are five clinical groups of PH, differing in aetiopathogenesis, diagnostic approaches and treatment [3]. The prevalence of PH in the general population is approximately 1%, whilst among those aged 65 years and older, this figure reaches 10% or more [15]. Pulmonary arterial hypertension (PAH, group 1) is significantly less common — 15–50 cases per 1 million population — but is characterised by an extremely poor prognosis without specific treatment: the median survival without therapy does not exceed 2.8 years [13]. PAH associated with congenital heart defects (CHD) and Eisenmenger syndrome as its most severe manifestation are of particular clinical significance [8]. The diagnosis of PH requires a stepwise approach, including non-invasive methods (echocardiography, CT angiography, ventilation-perfusion scintigraphy) and mandatory invasive confirmation via right heart catheterisation (RHC) [3]. Treatment of LAH includes general measures, supportive therapy and specific medications: endothelin receptor antagonists (ERAs), type 5 phosphodiesterase inhibitors (PDE5-5), soluble guanylate cyclase stimulators (sGC), prostanoids and IP receptor agonists [3, 4].

In Kazakhstan, the problem of PH is becoming increasingly pressing due to the high prevalence of VSD, late diagnosis and insufficient availability of specific PAH therapy. The country's cardiac surgery centres play a key role in the diagnosis and treatment of this patient group, determining surgical management and patient referral pathways.

The aim of this study is to conduct a retrospective analysis of the clinical characteristics, results of invasive haemodynamic assessment and treatment approaches in a series of patients with various types of PH admitted to a cardiac surgery centre.

MATERIALS AND METHODS. A retrospective analysis was conducted of a series of clinical cases involving 10 patients with confirmed LVH who were consecutively admitted to a cardiac surgery centre in 2024. The inclusion criteria were: the presence of any

type of PH, confirmed by echocardiography and/or CPOS data; the presence in the medical records of a comprehensive description of the clinical picture, laboratory results and findings from diagnostic tests.

All patients underwent: collection of complaints and medical history, physical examination, measurement of blood pressure (BP) and SpO₂, determination of functional class (FC) according to the NYHA classification and stage of chronic heart failure (CHF) according to the ACC/AHA guidelines, determination of serum C-reactive protein (CRP) levels, electrocardiogram (ECG) recording, and transthoracic echocardiography (TTE).

Right heart catheterisation (RHCT) was performed in 6 out of 10 patients (60%) based on clinical indications. During RHP, the following were measured: pressure in the right atrium (RA), right ventricle (RV), pulmonary artery (PA), and pulmonary artery wedge pressure (PAWP); Cardiac output (CO) was calculated using the Fick method or thermodilution, pulmonary vascular resistance (PVR), pulmonary and systemic blood flow indices (Q_p, Q_s), and their ratio (Q_p/Q_s). If vasoreactivity was suspected, an acute vasodilator test was performed with inhalation of iloprost (10 µg/ml, 2 ml, 10 min).

Echocardiography was performed according to a standard protocol, assessing the dimensions and volumes of the heart chambers, left ventricular ejection fraction (LVEF) using the Simpson method, calculated pulmonary artery systolic pressure (pSAP) based on tricuspid regurgitation velocity, and assessment of right ventricular function (TAPSE, FAC).

Data were collected from the medical records of inpatients. Data are presented as absolute values, relative frequencies, means with standard deviation ($M \pm SD$) and medians with interquartile range (Me [Q1; Q3]). The study was conducted in accordance with the principles of the World Medical Association's Declaration of Helsinki. All patients' personal data have been

RESULTS. The study included 10 patients: 6 men (60%) and 4 women (40%). The mean age was 39.8 ± 14.1 years (range 21–62 years). The median age was 37.0 [28.0; 47.0] years. The clinical and demographic characteristics of the patients are presented in Table 1.

Table 1.

Clinical and demographic characteristics of patients

No.	Sex / Age (years)	SpO ₂ (%)	HR (bpm)	CRP (mg/L)	Primary diagnosis	NYHA Class	HF Stage (ACC/AHA)	CPOS
1	F / 34	97	65	1.8	Primary PH. Idiopathic PH. HF with preserved EF 58%. Bronchial asthma	III	C	—
2	F / 21	68	94	2.0	CHD: VSD. Eisenmenger syndrome. PH type 1. Cor pulmonale. HF with preserved EF 58%	III	C	—
3	M / 60	92	86	12.6	Congestive HF. Ischemic cardiomyopathy. CAD. Angina class III. HF with reduced EF 21%. INTERMACS 3	IV	D	+
4	M / 34	94	88	4.4	PAH type 2, class IV (WHO). CHD. VSD. Eisenmenger syndrome. Tricuspid regurgitation grade 4. HF with preserved EF 58%	III	C	+
5	M / 47	96	68	1.1	Sporadic HCM without LVOT obstruction. Myocardial bridge of LAD. ICD implantation. HF with preserved EF 53%	III	C	+
6	M / 43	95	93	19.3	Dilated cardiomyopathy. Status post valve surgery. Permanent AF. HF with reduced EF 12%. NYHA IV, stage D	IV	D	+
7	M / 22	99	72	0.6	CHD. ASD. Moderate PH. HF with preserved LVEF 58%, stage B. Chronic viral hepatitis C	I	B	+
8	F / 47	97	82	1.1	Idiopathic PH class III (WHO). Cor pulmonale. HF with preserved LVEF 57%. Hypertension grade 2. Post-stroke/TIA	III	—	—
9	F / 28	98	68	1.5	Primary PH. HF with preserved EF 60%. Hypertension grade 2, risk 4. Antiphospholipid syndrome?	II	C	—
10	M / 62	98	78	3.1	CAD. Prior MI. Ischemic cardiomyopathy. HF with reduced EF 21%, stage C. ICD. Hypertension grade 1. Type 2 diabetes. Obesity grade 1	II	C	+

Note: F – female; M – male; SpO₂ – blood oxygen saturation; HR – heart rate; CRP – C-reactive protein; FC – functional class; CHF – chronic heart failure; RCC – right heart catheterisation; ‘+’ – performed; ‘—’ – not performed.

According to the WHO/ESC classification, patients were categorised as follows: PAH (Group 1) – 5 patients (50%), including 3 (30%) associated with VSD and 2 (20%) idiopathic; PAH due to left-sided heart disease (group 2) – 4 patients (40%); PAH of unspecified aetiology – 1 patient (10%).

According to the NYHA functional class, patients were distributed as follows: FC I – 1 (10%), FC II – 2 (20%), FC III – 5 (50%), FC IV – 2 (20%). Thus, 70% of patients (n = 7) had FC III–IV, indicating the severity of this cohort's condition.

The median SpO₂ was 96.5% [94.0; 98.0]; a decrease in SpO₂ below 94% was recorded in 3 patients

(30%), of whom the most severe hypoxaemia (SpO₂ 68%) was observed in a patient with Eisenmenger syndrome against a background of VSD.

The median HR was 80.0 [68.0; 88.0] bpm. The mean CRP level was 4.66 ± 6.24 mg/L (range 0.6–19.3 mg/L); elevated CRP levels above the normal range were recorded in 5 patients (50%), reflecting the presence of a systemic inflammatory response against a background of chronic heart failure and concomitant pathology.

The left ventricular ejection fraction was preserved in 6 patients (60%) (EF $\geq$ 50%), moderately reduced in 1 patient (10%) (EF 53%), and significantly reduced in 3 patients (30%) (EF 12–21%).

Transesophageal echocardiography (TEE) was performed in 6 out of 10 patients (60%). Indications included: verification of the severity of left heart failure, assessment of the operability of the pulmonary valve, evaluation of haemodynamics prior to surgical intervention, and assessment of the adequacy of mechanical circulatory support.

The main haemodynamic parameters according to TEE data are presented in Table 2.

Table 2.

Results of right heart catheterisation

Parameter	Patient No. 4 (CHD VSD, Eisenmenger)	Patient No. 7 (CHD ASD)	Patient No. 5 (HCM with LVOT obstruction)	Patient No. 6 (DCM, LVAD)
PAP syst./diast. (mean), mmHg	95/62 (74)	55/28 (37)	70/30 (45)	18/6 (10)
RAP (mean), mmHg	2	14	11	1
RV pressure syst./diast., mmHg	98/15	58/4	72/8	20/10
PCWP (PW), mmHg	4	n/a	n/a	7
CO (L/min)	9.3	12.1	4.0	3.2
PVR (Wood units)	7.6	2.2	6.2	<0.9
Qp/Qs	1.3	1.6	n/a	n/a
Vasoreactivity test	Negative	Not performed	Not performed	Not performed
Conclusion	PAH high risk. CHD correction contraindicated	ASD 5.5 cm, common atrium. PAH type 1 high risk	PH type 2. Septal myectomy indicated	After LVAD, PVR normalized (<0.9 Wood units)

Note: PAP — pulmonary artery pressure; PVR — pulmonary vascular resistance; RA — right atrium; RV — right ventricle; PAP — pulmonary artery pressure; CO — cardiac output; Qp/Qs — ratio of pulmonary to systemic blood flow; n/a — not available.

Among the 4 patients who underwent a full haemodynamic assessment, the mean PVR (mean) ranged from 10 to 74 mmHg, reflecting a wide spectrum of PAH severity in the study cohort. The LSS ranged from less than 0.9 to 7.6 Wood units in patients with precapillary PH, reaching 9.8 Wood units in one patient with LAG and VSD (patent ductus arteriosus), who also underwent a vasoreactivity test with a negative result.

In patient No. 4 with PDA (VSD) and Eisenmenger syndrome in the context of CHD, a significant increase in PVR (mean 74 mmHg) and PVR (7.6 Wood units) was detected with moderate left-to-right shunting (Qp/Qs 1.3). Additionally, defects in the interatrial and interventricular septa were detected. The vasoreactivity test with iloprost inhalation proved negative (mean PVR decreased from 74 to 69 mmHg, whilst PVR increased from 7.6 to 8.2 Wood units), which ruled out the possibility of surgical correction of the VSD.

Patient No. 7, with a large (5.5 cm) atrial septal defect (ASD), was diagnosed with high-risk type 1 pulmonary hypertension (PH) with a mean PAF of 37 mmHg and a PVR of 2.2 Wood units. Patient No. 5, with hypertrophic cardiomyopathy and left ventricular outflow tract obstruction, was diagnosed with type 2 left heart failure (mean LA pressure 45 mmHg, LVEF 6.2 Wood units), which required surgical treatment (septal myectomy). In patient No. 6 with DCM and an implanted HeartMate III LVAD, normalisation of LVEF (<0.9 Wood units) was noted, confirming the adequacy of mechanical circulatory support.

Patients were treated on an individual basis in accordance with the 2022 ESC/ERS clinical guidelines. Recommendations for specific PAG therapy depending on functional class are presented in Table 3.

Table 3.

Recommendations for specific PAG therapy according to functional class (ESC/ERS 2022)

Drug / Combination	FC I (WHO)	FC II (WHO)	FC III (WHO)	FC IV (WHO)
ERAs: Bosentan, Ambrisentan, Macitentan	—	I B	I B	IIa C
PDE-5 inhibitors: Sildenafil	—	I A	I A	IIa C
Soluble guanylate cyclase stimulators: Riociguat	—	I B	I B	IIa C
Prostanoids (inhaled): Iloprost	—	IIb B	I B	I B
IP receptor agonists: Selexipag	—	I B	I B	—
Calcium channel blockers (only with positive vasoreactivity test)	—	I C	I C	—
Dual combination therapy (ERA + PDE-5i)	—	I A	I A	IIa C
Triple combination therapy	—	IIb C	IIa C	IIa C
Lung transplantation / heart–lung transplantation	—	—	I C	I C

Note: I — class of recommendation; A/B/C — level of evidence; ERA — endothelin receptor antagonists; PDE5-I — phosphodiesterase type 5 inhibitors; VRT — vasoreactive test; '—' — not indicated or no data available.

Patients with PAH (group 1, n = 5) were prescribed specific PAH therapy: patients with severe CHF (Class III–IV) and a negative vasoreactivity test received combination therapy comprising bosentan (ARA), riociguat (PGE2 agonist) and/or iloprost (prostanoid) administered by inhalation. In particular, one patient with FC IV and marked precapillary PH was prescribed a triple-combination regimen: bosentan 125 mg twice daily, riociguat 2.5 mg three times daily, and iloprost 20 µg by inhalation 6–9 times daily as required.

Patients with Group 2 PH (n = 4) received optimal medical therapy for CHF with correction of surgical valve and septal abnormalities. One patient with DCM and refractory CHF (INTERMACS 3) underwent implantation of a HeartMate III LVAD as a 'bridge' to heart transplantation.

DISCUSSION. The data obtained are consistent with current understanding of the epidemiology and clinical presentation of PH. The predominance in our series of patients with PAH associated with CHD (30%) is explained by the specific nature of the centre's cardiac surgery profile and reflects the global trend of late referral of such patients [8]. Eisenmenger syndrome represents the terminal stage of untreated PAH in VSD and is characterised by irreversible changes in the pulmonary vasculature [7, 8].

Negative vasoreactivity tests in all examined patients are consistent with the literature: true vasoreactivity in PAH is found in only 10–15% of patients, predominantly in the idiopathic form of the disease [4]. This justifies the use of combined specific therapy as the preferred approach in severe PAH (FC III–IV) [3].

Haemodynamic parameters — mean PVR ranging from 37 to 74 mmHg and LVEF ranging from 2.2 to 9.8 Wood units — meet the criteria for severe PAH and are consistent with data from major international registries, including the REVEAL Registry [18]. The use of echocardiography as the diagnostic standard allowed not only the diagnosis to be verified, but also an informed decision to be made regarding treatment strategy, including the decision against surgical correction of the mitral valve in cases of irreversible LAH.

The use of the HeartMate III LVAD in one patient with DCM and refractory CHF resulted in normalisation of the left ventricular ejection fraction (<0.9 Wood

units), which opens up the possibility of heart transplantation [6]. This case demonstrates the effectiveness of modern mechanical circulatory support strategies in overcoming post-capillary PH.

It should be noted that in patients with Group 2 PH (due to left-sided heart disease), specific PAG therapy is not indicated: the priority remains optimal treatment of the underlying disease and, if necessary, surgical correction [3]. The use of specific PAH drugs in Group 2 PH outside clinical trials is not recommended due to the lack of evidence and the risk of a worsened prognosis.

STRENGTHS AND LIMITATIONS. The strengths of this study include: real-world clinical practice at a cardiac surgery centre, the use of invasive haemodynamic assessment (CPOS) in a significant proportion of patients (60%), complete anonymisation of clinical data, and the use of modern specific PAG agents in accordance with the current ESC/ERS 2022 guidelines.

Limitations include: a small sample size (n = 10), a retrospective design, the absence of data on long-term follow-up and outcomes, and the inability to perform a comprehensive statistical analysis. The descriptive nature of the case series does not allow conclusions to be drawn regarding causal relationships. Nevertheless, the detailed description of diagnostic and therapeutic approaches is valuable in terms of sharing practical experience.

CONCLUSION

1. A retrospective analysis of a series of 10 patients demonstrated a wide spectrum of aetiologies for pulmonary hypertension in a cardiac surgery centre: PAH (group 1) accounted for 50%, and PH due to left-sided heart disease (group 2) for 40%.

2. The majority of patients (70%) had severe functional status (NYHA Class III–IV), highlighting late presentation and the need for early screening for PH.

3. Right heart catheterisation, performed in 60% of patients, is an indispensable tool for accurate haemodynamic assessment, determining the PH group and selecting a treatment strategy.

4. A negative vasoreactivity test in all patients examined justifies the need for early initiation of combined specific PAG therapy.

5. A personalised approach to treatment, based on CPOS results, functional class and comorbidities, allows for the optimisation of management of this complex patient group within a specialist cardiac surgery centre.

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TREATMENT-RELATED TOXICITY ACROSS SEQUENTIAL CHEMOTHERAPY PHASES IN PAEDIATRIC ACUTE LYMPHOBLASTIC LEUKAEMIA: A SINGLE-CENTRE RETROSPECTIVE COHORT STUDY FROM KAZAKHSTAN, 2021–2024**Baibadilova A.***First-year Master's student in Public Health, Department of Public health, Kazakhstan-Russian Medical University, Almaty, Kazakhstan***Abdrakhmanova Z.***PhD**Senior Lecturer, Department of Public health, Kazakhstan-Russian Medical University, Almaty, Kazakhstan***ТОКСИЧНОСТЬ ЛЕЧЕНИЯ НА ПОСЛЕДОВАТЕЛЬНЫХ ЭТАПАХ ХИМИОТЕРАПИИ ПРИ ОСТРОМ ЛИМФОБЛАСТНОМ ЛЕЙКОЗЕ У ДЕТЕЙ: РЕТРОСПЕКТИВНОЕ КОГОРТНОЕ ИССЛЕДОВАНИЕ В ОДНОМ ЦЕНТРЕ В КАЗАХСТАНЕ, 2021–2024 ГГ****Баибадилова А.***магистрант 1-го года обучения по специальности «Общественное здравоохранение», кафедра общественного здравоохранения, Казахстанско-Российский медицинский университет, Алматы, Казахстан***Абдрахманова З.***PhD**старший преподаватель кафедры общественного здравоохранения, Казахстанско-Российский медицинский университет, Алматы, Казахстан*
<https://doi.org/10.5281/zenodo.20448086>**Abstract**

Background: Although five-year survival in paediatric acute lymphoblastic leukaemia (ALL) now exceeds 85% in high-income settings, treatment-related toxicity remains a major cause of morbidity, treatment interruption and excess mortality, particularly in low- and middle-income countries (LMICs). Comprehensive, phase-specific toxicity data from Central Asia are scarce.

Methods: We retrospectively analysed 261 children (0–17 years) with newly diagnosed ALL treated between January 2021 and December 2024 at a single tertiary paediatric haematology centre in Kazakhstan according to an ALL-IC BFM 2009-type regimen. Toxicities were prospectively recorded and graded I–IV using the National Cancer Institute Common Terminology Criteria for Adverse Events (CTCAE v5.0) across seven sequential treatment phases (Protocol I, Protocol M, Protocol II, high-risk blocks HR-1/HR-2/HR-3, and Protocol III). Thirteen organ-system toxicity categories were assessed.

Results: The cohort comprised 152 boys (58.2%) and 109 girls (41.8%); median age was 4 years, with 67.4% aged 1–6 years. B-cell precursor ALL accounted for 84.3% of cases and 71.3% were classified as standard-risk. At least one grade I–IV toxicity event was documented in all 261 patients. The toxicity burden differed substantially across phases: grade IV haematologic toxicity affected 44.5% of patients during Protocol I and reached 83.3%, 57.1% and 63.0% during HR-1, HR-2 and HR-3 blocks respectively, but only 17.9% during Protocol M. Grade III–IV infection was the second-most-prevalent severe toxicity, peaking at 90.7% in HR-1 and 79.6% during Protocol I. Hepatotoxicity was predominantly low-grade and was the dominant adverse event during Protocol M (84.5% grade I–II). Cardiotoxicity, neurotoxicity, nephrotoxicity and pulmonary toxicity were uncommonly severe (grade III–IV <5% across phases).

Conclusions: Toxicity in our cohort followed a phase-specific pattern consistent with international BFM-type experience: induction (Protocol I) and high-risk consolidation blocks produced the highest burden of life-threatening myelosuppression and infection, whereas Protocol M was dominated by lower-grade hepatic and mucosal toxicity. These data provide the first detailed CTCAE-graded toxicity profile for paediatric ALL from Kazakhstan and may inform supportive-care prioritisation, risk-adapted dose modification and quality benchmarking for paediatric oncology services in Central Asia.

Аннотация

Введение: Несмотря на то что пятилетняя выживаемость при остром лимфобластном лейкозе (ОЛЛ) у детей в странах с высоким уровнем дохода в настоящее время превышает 85%, токсичность, связанная с лечением, остается одной из основных причин заболеваемости, прерывания терапии и избыточной смертности, особенно в странах с низким и средним уровнем дохода. Комплексные данные о токсичности по этапам лечения из Центральной Азии ограничены.

Методы: Проведен ретроспективный анализ 261 ребенка (0–17 лет) с впервые диагностированным ОЛЛ, получавших лечение в период с января 2021 по декабрь 2024 года в одном специализированном детском гематологическом центре в Казахстане по протоколу типа ALL-IC BFM 2009. Токсические эффекты регистрировались проспективно и классифицировались по степеням I–IV в соответствии с Общей терминологией критериев нежелательных явлений Национального института рака США (СТСЭ v5.0) на протяжении семи последовательных фаз лечения (Протокол I, Протокол M, Протокол II, блоки высокого риска HR-1/HR-2/HR-3 и Протокол III). Оценивались 13 категорий токсичности по органным системам.

Результаты: В исследуемую когорту вошли 152 мальчика (58,2%) и 109 девочек (41,8%); медианный возраст составил 4 года, при этом 67,4% пациентов были в возрасте 1–6 лет. В 84,3% случаев диагностирован В-клеточный предшественниковый ОЛЛ, и 71,3% пациентов отнесены к группе стандартного риска. По крайней мере одно токсическое событие I–IV степени было зарегистрировано у всех 261 пациентов. Выраженность токсичности существенно различалась между фазами лечения: гематологическая токсичность IV степени наблюдалась у 44,5% пациентов во время Протокола I и достигала 83,3%, 57,1% и 63,0% во время блоков HR-1, HR-2 и HR-3 соответственно, но составляла лишь 17,9% во время Протокола M. Инфекции III–IV степени были второй по частоте тяжелой токсичностью, достигая пика в 90,7% в HR-1 и 79,6% во время Протокола I. Гепатотоксичность преимущественно была низкой степени и являлась доминирующим нежелательным явлением во время Протокола M (84,5% — I–II степени). Кардиотоксичность, нейротоксичность, нефротоксичность и пульмональная токсичность редко достигали тяжелых степеней (III–IV <5% на всех этапах).

Заключение: В исследуемой когорте токсичность имела фазо-специфический характер, соответствующий международному опыту применения протоколов типа BFM: индукционная терапия (Протокол I) и консолидационные блоки высокого риска сопровождались наибольшей нагрузкой жизнеугрожающей миелосупрессии и инфекций, тогда как Протокол M характеризовался преобладанием гепатотоксичности и мукозальной токсичности низкой степени. Полученные данные представляют собой первое детализированное описание профиля токсичности, оцененной по CTCAE, при ОЛЛ у детей в Казахстане и могут быть использованы для оптимизации поддерживающей терапии, индивидуализации доз в зависимости от риска и оценки качества онкологической помощи детям в Центральной Азии.

Keywords: paediatric acute lymphoblastic leukaemia; chemotherapy toxicity; ALL-IC BFM 2009; CTCAE; febrile neutropenia; supportive care; Kazakhstan; Central Asia.

Ключевые слова: острый лимфобластный лейкоз у детей; токсичность химиотерапии; ALL-IC BFM 2009; CTCAE; фебрильная нейтропения; поддерживающая терапия; Казахстан; Центральная Азия.

1. Introduction

Acute lymphoblastic leukaemia (ALL) is the most common malignancy of childhood, accounting for roughly 25% of cancers diagnosed before age 15 and approximately 75–85% of all paediatric leukaemias^[1]. Risk-stratified, multi-agent chemotherapy regimens derived from the Berlin–Frankfurt–Münster (BFM) backbone — most notably ALL-IC BFM 2002 and its successor ALL-IC BFM 2009 — have driven five-year event-free survival in high-income settings above 85%^{[2], [3]}. However, the same therapeutic intensification that has improved cure rates also produces a substantial burden of acute toxicity, including profound myelosuppression, life-threatening infections, hepatic dysfunction, neurotoxicity, and asparaginase-related coagulopathy and pancreatitis^{[4], [5]}.

Recent global-burden analyses indicate that, although incidence of childhood ALL is broadly comparable across world regions, mortality and disability-adjusted life-years remain disproportionately concentrated in low- and middle-income countries, where treatment-related toxicity and infectious complications are key drivers of treatment-related mortality and abandonment^{[6], [7]}. In Central Asia, paediatric oncology services have expanded substantially over the past decade, yet detailed, phase-stratified toxicity data conforming to international Common Terminology Criteria for Adverse Events (CTCAE) standards remain limited in the published literature.

Granular characterisation of toxicity by treatment phase is important for three reasons. First, the spectrum of expected adverse events differs markedly between induction (Protocol I), high-dose methotrexate consolidation (Protocol M), reinduction (Protocol II), high-risk intensification blocks (HR-1, HR-2, HR-3) and delayed intensification/maintenance (Protocol III)^{[2], [8]}. Second,

severe toxicity events directly influence treatment delivery, dose modification, prophylactic strategies, and hospital resource utilisation^[4]. Third, comparative phase-specific data enable benchmarking against international cohorts and identification of targets for quality improvement in supportive care.

The present study reports a comprehensive, CTCAE-graded toxicity profile of a contemporary cohort of 261 paediatric patients with ALL treated at a single tertiary centre in Kazakhstan between 2021 and 2024. We describe the demographic and biological characteristics of the cohort, quantify the incidence and severity of thirteen organ-system toxicities across seven sequential treatment phases, and contextualise our findings against published BFM-based experience.

2. Materials and Methods

2.1. Study design and setting

This was a retrospective observational cohort study conducted at a tertiary paediatric haematology–oncology centre in Kazakhstan. All consecutive patients aged 0–17 years with a newly diagnosed, morphologically and immunophenotypically confirmed diagnosis of ALL, who initiated frontline treatment between 1 January 2021 and 31 December 2024, were eligible for inclusion. Patients with mature B-cell ALL/Burkitt leukaemia, mixed-phenotype acute leukaemia treated on an acute myeloid leukaemia protocol, or those who received only palliative care, were excluded.

2.2. Treatment protocol

All patients were treated according to an ALL-IC BFM 2009-type regimen, with risk stratification into standard-risk (SR), intermediate-risk (IR), and high-risk (HR) categories based on age, presenting white-blood-cell count, central nervous system involvement,

immunophenotype, cytogenetic findings (including *BCR::ABL1* and *KMT2A* rearrangements) and minimal residual disease at days 15 and 33 of induction^{[2],[8]}. Treatment phases assessed in this analysis comprised: (i) Protocol I — four-drug induction with vincristine, an anthracycline (daunorubicin), corticosteroid (prednisone or dexamethasone), and L-asparaginase; (ii) Protocol M — interim maintenance with four cycles of high-dose methotrexate (HD-MTX, 2–5 g/m²) and oral 6-mercaptopurine; (iii) Protocol II — reinduction analogous to Protocol I with dexamethasone, vincristine, doxorubicin and asparaginase, followed by cyclophosphamide/cytarabine/6-thioguanine consolidation; (iv) high-risk intensification blocks HR-1, HR-2 and HR-3, each comprising HD-MTX or HD-cytarabine, cyclophosphamide or ifosfamide, vincristine, daunorubicin or etoposide, and asparaginase, administered to high-risk patients; and (v) Protocol III — a shortened delayed intensification block used selectively.

2.3. Toxicity assessment

Adverse events were prospectively recorded by treating clinicians at every cycle and graded according to the National Cancer Institute Common Terminology Criteria for Adverse Events (CTCAE), version 5.0^[9]. Thirteen organ-system toxicity categories were assessed at each phase: haematologic, hepatic, dermatologic/mucosal, dyspeptic/gastrointestinal, performance-status decline (Karnofsky/Lansky), infection, cardiotoxicity, coagulologic, metabolic (including electrolyte disturbance and hyperglycaemia), neurotoxicity, nephrotoxicity, weight loss, and respiratory toxicity. For each patient and phase, the highest grade reached per category was recorded. Severe toxicity was defined as grade III–IV.

2.4. Statistical analysis

Categorical variables are presented as counts and percentages; continuous variables as medians and ranges. Because each patient could exhibit toxicity of

more than one grade within a category during the same phase, row percentages within toxicity-by-grade tables refer to the proportion of patients in that phase exhibiting at least one episode of that grade. Analyses were descriptive and were performed in R version 4.3 (R Foundation for Statistical Computing, Vienna, Austria) and Jamovi 2.4 (The Jamovi Project, Sydney, Australia). No imputation of missing data was performed.

2.5. Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee. Because data were extracted retrospectively from anonymised clinical records, the requirement for individual informed consent was waived.

3. Results

3.1. Cohort characteristics

A total of 261 children with newly diagnosed ALL met inclusion criteria. Demographic and clinical characteristics are summarised in Table 1. The cohort comprised 152 boys (58.2%) and 109 girls (41.8%), yielding a male-to-female ratio of 1.39:1, which is consistent with the well-documented modest male preponderance in paediatric ALL^{[1],[6]}. The median age at diagnosis was 4 years (range 0–17), with 67.4% of patients (n = 176) aged between 1 and 6 years — the well-described peak incidence window. Annual case numbers rose during the observation period from 37 in 2021 to 99 in 2024, reflecting both increased referral and the recovery of paediatric services following pandemic-related disruption.

B-cell precursor ALL was the dominant immunophenotype (n = 220, 84.3%), followed by T-cell ALL (n = 33, 12.6%); mixed-lineage, biphenotypic, and unclassified cases together accounted for 3.1%. Risk stratification yielded 186 standard-risk patients (71.3%), 61 high-risk (23.4%), 10 intermediate-risk (3.8%), 3 low-risk (1.1%) and 1 unspecified (0.4%).

Table 1.

Demographic and clinical characteristics of the cohort (N = 261).

Characteristic	n	%
Sex		
Male	152	58.2
Female	109	41.8
Age group (years)		
<1	6	2.3
1–6	176	67.4
7–12	49	18.8
13–17	30	11.5
Immunophenotype		
B-cell precursor	220	84.3
T-cell	33	12.6
Mixed / biphenotypic	6	2.3

Characteristic	n	%
Unknown / other	2	0.8
Risk group		
Standard	186	71.3
High	61	23.4
Intermediate	10	3.8
Low	3	1.1
Unspecified	1	0.4
Year of diagnosis		
2021	37	14.2
2022	69	26.4
2023	56	21.5
2024	99	37.9

3.2. Overall toxicity burden

At least one toxicity event of any grade was documented in every patient. The proportion of patients experiencing at least one grade III–IV (severe) event in each phase is summarised in Table 2. Severe toxicity was most concentrated during Protocol I (49.1% of patients with at least one grade IV event), the three high-

risk blocks (grade IV: HR-1 85.2%, HR-2 59.2%, HR-3 65.2%), and Protocol II (grade IV 34.3%). Protocol M, despite its dose-intensive HD-MTX backbone, was characterised by a substantially lower share of grade IV events (22.2%), with toxicity concentrated in grades I–II.

Table 2.

Proportion of patients (%) experiencing at least one toxicity event of each maximum CTCAE grade, by treatment phase.

Phase	n	Gr I	Gr II	Gr III	Gr IV
Protocol I	262	93.2	80.8	87.9	49.1
Protocol M	207	99.0	89.9	75.4	22.2
Protocol II	204	95.6	84.8	88.2	34.3
Block HR-1	54	88.9	92.6	94.4	85.2
Block HR-2	49	95.9	77.6	89.8	59.2
Block HR-3	46	87.0	76.1	91.3	65.2
Protocol III	29	96.6	86.2	82.8	37.9

3.3. Phase-specific toxicity profiles

3.3.1. Protocol I (induction). During Protocol I, grade III–IV haematologic toxicity was nearly universal (101 patients [38.1%] grade III; 118 [44.5%] grade IV), reflecting both leukaemic marrow infiltration at diagnosis and intensive cytoreduction by the four-drug regimen (Table 3). Grade III infection occurred in 187 patients (70.6%) and grade IV in 24 (9.1%), making infection the second-most-prevalent severe toxicity. Hepatotoxicity was predominantly low-grade (grade I 37.7%, grade II 28.7%), with severe (grade III–IV)

hepatotoxicity in 22.6%, consistent with the cumulative effect of asparaginase, dexamethasone and 6-mercaptopurine^{[5], [10]}. Dermatologic/mucosal toxicity reached grade III in 89 (33.6%) and grade IV in 5 (1.9%) patients. Coagulopathy, including grade III in 15.9% and grade IV in 5.7% of patients, reflects the well-described impact of L-asparaginase on hepatic synthesis of antithrombin and fibrinogen^{[11], [12]}. Cardiotoxicity, neurotoxicity, nephrotoxicity, and pulmonary toxicity remained predominantly low-grade.

Table 3.

CTCAE-graded toxicity during Protocol I (induction). Values are n (%) of patients in each toxicity category.

Toxicity category	Gr I	Gr II	Gr III	Gr IV	Any (Σ events)
Haematologic	8 (3.0)	31 (11.7)	101 (38.1)	118 (44.5)	258
Hepatic	100 (37.7)	76 (28.7)	51 (19.3)	9 (3.4)	236
Dermatologic	17 (6.4)	67 (25.3)	89 (33.6)	5 (1.9)	178
Dyspeptic/GI	54 (20.4)	82 (30.9)	101 (38.1)	2 (0.8)	239
Performance status	111 (41.9)	56 (21.1)	6 (2.3)	—	173
Infection	12 (4.5)	29 (10.9)	187 (70.6)	24 (9.1)	252
Cardiotoxicity	117 (44.2)	12 (4.5)	4 (1.5)	—	133
Coagulologic	65 (24.5)	64 (24.2)	42 (15.9)	15 (5.7)	186
Metabolic	144 (54.3)	76 (28.7)	19 (7.2)	1 (0.4)	240
Neurotoxicity	117 (44.2)	12 (4.5)	2 (0.8)	1 (0.4)	132
Nephrotoxicity	62 (23.4)	11 (4.2)	5 (1.9)	2 (0.8)	80
Weight loss	104 (39.3)	16 (6.0)	—	—	120
Respiratory	55 (20.8)	10 (3.8)	7 (2.6)	1 (0.4)	73

3.3.2. Protocol M (HD-MTX consolidation).

Protocol M produced the broadest spread of low-grade events but the lowest share of grade IV toxicity (Table 4). Hepatic toxicity (any grade) affected 139 of 207 patients (67.1%), with grade III–IV in 15.0%; this profile is in keeping with HD-MTX hepatotoxicity, which is typically reversible and often related to delayed methotrexate clearance and pharmacogenomic variation in

MTHFR, ABCB1 and SLCO1B1^{[13],[14]}. Mucositis (dermatologic toxicity) was prevalent (any grade 79.7%) and grade III–IV in 30.0% — consistent with HD-MTX-related epithelial injury^[15]. Infection remained an important burden, with grade III–IV in 44.9% of patients.

Table 4.

CTCAE-graded toxicity during Protocol M (n = 207).

Toxicity category	Gr I	Gr II	Gr III	Gr IV	Any (Σ)
Haematologic	125 (60.4)	102 (49.3)	88 (42.5)	37 (17.9)	186
Hepatic	120 (58.0)	55 (26.6)	25 (12.1)	6 (2.9)	139
Dermatologic	74 (35.8)	89 (43.0)	60 (29.0)	2 (1.0)	165
Dyspeptic/GI	99 (47.8)	115 (55.6)	58 (28.0)	1 (0.5)	195
Performance status	120 (58.0)	18 (8.7)	4 (1.9)	—	122
Infection	108 (52.2)	39 (18.8)	88 (42.5)	5 (2.4)	164
Cardiotoxicity	49 (23.7)	11 (5.3)	2 (1.0)	—	57
Coagulologic	35 (16.9)	8 (3.9)	2 (1.0)	2 (1.0)	44
Metabolic	137 (66.2)	24 (11.6)	3 (1.5)	1 (0.5)	146
Neurotoxicity	31 (15.0)	3 (1.5)	1 (0.5)	—	35
Nephrotoxicity	25 (12.1)	14 (6.8)	4 (1.9)	1 (0.5)	32
Weight loss	61 (29.5)	3 (1.5)	—	—	63
Respiratory	9 (4.4)	2 (1.0)	2 (1.0)	1 (0.5)	12

3.3.3. Protocol II (reinduction). Toxicity during Protocol II broadly mirrored Protocol I, with grade III–IV haematologic toxicity in 72.5% (grade III 42.7%, grade IV 29.9%) and grade III–IV infection in 69.1% (Table 5). The relatively higher rate of grade III–IV co-

agulopathy (11.3%) is again attributable to repeated asparaginase exposure^[11]. Dyspeptic toxicity remained common (grade III 26.5%), reflecting the steroid- and cyclophosphamide-driven gastrointestinal injury characteristic of reinduction.

Table 5.

CTCAE-graded toxicity during Protocol II (n = 204).

Toxicity category	Gr I	Gr II	Gr III	Gr IV	Any (Σ)
Haematologic	18 (8.8)	36 (17.6)	87 (42.7)	61 (29.9)	199
Hepatic	87 (42.7)	59 (28.9)	25 (12.3)	2 (1.0)	172
Dermatologic	27 (13.2)	61 (29.9)	48 (23.5)	2 (1.0)	138
Dyspeptic/GI	54 (26.5)	82 (40.2)	54 (26.5)	—	189
Performance status	91 (44.6)	17 (8.3)	4 (2.0)	—	112
Infection	24 (11.8)	25 (12.3)	133 (65.2)	8 (3.9)	190
Cardiotoxicity	84 (41.2)	10 (4.9)	2 (1.0)	—	96
Coagulologic	50 (24.5)	33 (16.2)	16 (7.8)	7 (3.4)	106
Metabolic	116 (56.9)	57 (27.9)	9 (4.4)	1 (0.5)	181
Neurotoxicity	71 (34.8)	9 (4.4)	3 (1.5)	—	83
Nephrotoxicity	24 (11.8)	4 (2.0)	3 (1.5)	—	31
Weight loss	82 (40.2)	6 (2.9)	—	—	88
Respiratory	14 (6.9)	2 (1.0)	3 (1.5)	—	19

3.3.4. High-risk intensification blocks (HR-1, HR-2, HR-3). High-risk patients (n = 61) experienced the greatest absolute and relative burden of severe toxicity. During HR-1, 45 of 54 patients (83.3%) developed grade IV haematologic toxicity and 49 (90.7%) developed grade III–IV infection (Table 6). Severe dyspeptic toxicity (grade III–IV) reached 51.8% in HR-1. The HR-2 and HR-3 blocks produced a comparable pattern: grade IV haematologic toxicity in 57.1% and

63.0% respectively, and grade III–IV infection in 77.6% and 84.8%. Grade III–IV pulmonary toxicity, although infrequent overall, was disproportionately observed in HR-1 (7.4%). These findings are consistent with the published BFM experience that the HR triad of HD-MTX, HD-cytarabine and ifosfamide–etoposide combinations represents the period of highest treatment-related morbidity and mortality^{[2], [16]}.

Table 6.

Severe (grade III–IV) toxicity (%) across high-risk intensification blocks.

Toxicity category	HR-1 (n=54)	HR-2 (n=49)	HR-3 (n=46)
Haematologic	96.3	89.8	89.1
Hepatic	20.4	6.1	8.7
Dermatologic	31.5	24.5	13.0
Dyspeptic/GI	51.9	36.7	30.4
Infection	90.7	77.6	84.8
Coagulologic	14.8	8.2	6.5
Metabolic	7.4	8.2	0.0
Neurotoxicity	7.4	0.0	0.0
Respiratory	7.4	2.0	0.0

3.3.5. Protocol III (delayed intensification). In the 29 patients who received Protocol III, grade III–IV

haematologic toxicity affected 82.8% and grade III–IV infection 69.0%. Hepatotoxicity remained mostly low-

grade (grade I 62.1%, grade II 37.9%; no grade IV). The smaller sample size of this phase limits statistical inference; nonetheless, the qualitative pattern was consistent with the rest of the cohort.

3.4. Cross-phase comparison of haematologic and infectious toxicity

Two organ systems — bone marrow and the infection axis — accounted for the great majority of severe toxicity in our cohort. Figure 1 (conceptual; data summarised in Table 7) shows the proportion of patients

experiencing grade III or IV toxicity in each category across all seven phases. Grade IV myelosuppression rose sharply between Protocol M (17.9%) and the HR blocks (57.1–83.3%) and remained elevated during delayed intensification. Grade III–IV infection followed a parallel trajectory, with peak rates during HR-1 (90.7%), Protocol I (79.6%) and HR-3 (84.8%). In contrast, hepatic, cardiac, neurologic and renal toxicities showed a flatter distribution, with grade III–IV rates rarely exceeding 25% in any phase.

Table 7.

Grade III + IV (severe) toxicity rates (%) by phase and organ system. Cardiac, neuro, nephro and respiratory toxicities are abbreviated for layout.

Toxicity	Prot I	Prot M	Prot II	HR-1	HR-2	HR-3	Prot III
Haematologic	82.6	60.4	72.5	96.3	89.8	89.1	82.8
Hepatic	22.6	15.0	13.2	20.4	6.1	8.7	10.3
Dermatologic	35.5	30.0	24.5	31.5	24.5	13.0	13.8
Dyspeptic/GI	38.9	28.5	26.5	51.9	36.7	30.4	24.1
Infection	79.6	44.9	69.1	90.7	77.6	84.8	69.0
Cardiac	1.5	1.0	1.0	1.9	2.0	0.0	0.0
Coagulologic	21.5	1.9	11.3	14.8	8.2	6.5	17.2
Metabolic	7.5	1.9	4.9	7.4	8.2	0.0	10.3
Neurologic	1.1	0.5	1.5	7.4	0.0	0.0	3.4
Renal	2.7	2.4	1.5	0.0	2.0	0.0	0.0
Respiratory	3.0	1.4	1.5	7.4	2.0	0.0	3.4

4. Discussion

This study provides the first comprehensive, CTCAE-graded description of acute treatment-related toxicity in paediatric ALL from a Kazakhstani tertiary centre. Three findings deserve emphasis.

First, the demographic and biological profile of our cohort — male predominance, modal age at 4 years, B-cell precursor disease in 84.3%, and standard-risk classification in 71.3% — is broadly comparable to large international BFM-based series^{[1], [2], [6]}. This supports the external generalisability of subsequent toxicity comparisons.

Second, the phase-specific toxicity pattern that we observed closely matches the spectrum reported in pooled BFM and AIEOP-BFM experience. Demidowicz and colleagues, in a 210-patient analysis of ALL IC-BFM 2002 and 2009 from a single Polish centre, reported that hepatic transaminitis, infection and mucositis dominated the non-haematologic toxicity profile, and that the introduction of ALL IC-BFM 2009 was associated with a relative shift from grade II to grade III events^[4]. Our cohort shows the same hierarchy: infection and haematologic toxicity drive severe events, while hepatic and gastrointestinal toxicity contribute the bulk of grade I–II morbidity. Severe infection rates of 70–90% during induction and the HR blocks are at the upper end of the published range and probably reflect both intensive immunosuppression and the resource-limited supportive-care environment in

which most patients in LMIC settings receive treatment^{[7], [17]}.

Third, the comparative profile of Protocol M is informative. Despite the well-known dose-dependent hepatotoxicity and mucositis of HD-MTX, our patients had the lowest share of grade IV toxicity during this phase (22.2%). This is consistent with the observation that HD-MTX-related toxicity, when monitored with leucovorin rescue, hyperhydration, alkalinisation and pharmacokinetic surveillance, is generally reversible and rarely life-threatening^{[13], [14]}. The relatively high rate of grade I–II mucositis (43.0% grade II) is in line with published rates and supports continued investment in oral-care prophylaxis and nutritional support^[15].

Coagulopathy emerged as a distinct, phase-specific toxicity. Grade III–IV coagulopathy was observed in 21.5% during Protocol I and 11.3% during Protocol II, with a near absence in Protocol M (1.9%). This pattern reflects asparaginase pharmacology: depletion of antithrombin, fibrinogen and other liver-synthesised coagulation proteins occurs almost exclusively during phases containing native or pegylated L-asparaginase^{[11], [12]}. In this context, our findings reinforce international recommendations for routine coagulation monitoring and selective antithrombin or fibrinogen replacement during asparaginase-containing phases.

Several limitations should be acknowledged. First, this is a single-centre retrospective cohort study without a formal comparator arm; toxicity comparisons are

therefore descriptive. Second, although the cohort size ($n = 261$) is among the largest reported from Central Asia, the HR blocks ($n = 46\text{--}54$) have wider confidence intervals than the standard-risk arms. Third, CTCAE grading was performed clinically rather than by independent central review; misclassification, particularly at the grade II/III boundary, cannot be excluded. Fourth, we did not link toxicity events to treatment delays, intensive-care admissions, treatment-related mortality, or long-term outcomes; analyses of these clinically important endpoints are planned in a follow-up study. Finally, pharmacogenomic correlates of toxicity (e.g., *MTHFR*, *SLCO1B1*, *TPMT*, *NUDT15*) were not assessed and represent a priority for prospective work^{[13], [14], [18]}.

Despite these limitations, our data have direct clinical and policy relevance. They provide the first robust baseline against which future quality-improvement initiatives — for example, antimicrobial stewardship, supportive-care bundles, or therapeutic drug monitoring of HD-MTX — can be evaluated. They also confirm that, in a contemporary Kazakhstani paediatric oncology setting, BFM-type therapy is deliverable with a toxicity profile consistent with international experience, while highlighting infection control as the highest-impact target for further reduction in treatment-related morbidity.

5. Conclusions

In a retrospective cohort of 261 children with newly diagnosed ALL treated according to an ALL-IC BFM 2009-type regimen in Kazakhstan between 2021 and 2024, every patient experienced at least one treatment-related toxicity event. The burden was phase-specific: severe haematologic toxicity and infection dominated during Protocol I, Protocol II and the high-risk intensification blocks, while Protocol M was characterised by lower-grade hepatic and mucosal toxicity. Cardiac, neurologic, renal and pulmonary toxicities remained predominantly low-grade across all phases. These findings provide a reproducible benchmark for paediatric oncology services in Central Asia and identify infection prevention, asparaginase-related coagulopathy management, and HD-MTX monitoring as the most actionable targets for supportive-care improvement.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of the affiliated institution.

Informed Consent Statement

Patient consent was waived owing to the retrospective and anonymised nature of the data.

Data Availability Statement

De-identified data are available from the corresponding author upon reasonable request and subject to institutional approval.

Conflicts of Interest

The author declares no conflicts of interest.

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PEDAGOGICAL SCIENCES

CULTURAL VALUES AS A FACTOR IN THE FORMATION OF INTERCULTURAL COMMUNICATION

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КУЛЬТУРНЫЕ ЦЕННОСТИ КАК ФАКТОР ФОРМИРОВАНИЯ МЕЖКУЛЬТУРНОЙ КОММУНИКАЦИИ

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Abstract

This article examines the role of cultural values in intercultural communication as a crucial prerequisite for successful interaction between representatives of different cultures. It explores the concepts of culture, cultural norms, ethnocentrism, cultural relativism, cultural identity, enculturation, and socialization. Particular attention is paid to how values determine a person's verbal and non-verbal behavior, norms of respect, distance, etiquette, attitudes toward elders, time, and personal space. The practical section of the article presents a methodological lesson designed to develop students' intercultural competence, communicative tolerance, and the ability to analyze situations of intercultural misunderstanding.

Аннотация

В статье рассматривается роль культурных ценностей в межкультурной коммуникации как важнейшего условия успешного взаимодействия представителей разных культур. Раскрываются понятия культуры, культурных норм, этноцентризма, культурного релятивизма, культурной идентичности, инкультурации и социализации. Особое внимание уделяется тому, как ценности определяют речевое и неречевое поведение человека, нормы уважения, дистанции, этикета, отношения к старшим, времени и личному пространству. В практической части статьи представлена методическая разработка занятия, направленная на формирование у студентов межкультурной компетенции, коммуникативной толерантности и умения анализировать ситуации межкультурного недопонимания.

Keywords: culture, cultural values, intercultural communication, cultural norms, ethnocentrism, cultural relativism, cultural identity, enculturation.

Ключевые слова: культура, культурные ценности, межкультурная коммуникация, культурные нормы, этноцентризм, культурный релятивизм, культурная идентичность, инкультурация.

Современное общество всё более отчётливо осознаёт необходимость изучения межкультурной коммуникации, поскольку глобализация, миграционные процессы, образовательные обмены, международное сотрудничество и расширение деловых контактов приводят к постоянному взаимодействию людей, принадлежащих к различным культурным системам. Как подчёркивают Т.Г. Грушевицкая, В.Д. Попков и А.П. Садохин, процессы модернизации и унификации не устраняют

культурных различий, а, напротив, усиливают потребность народов в сохранении собственной культурной идентичности, ценностей и традиций [1]. Межкультурная коммуникация возникает именно там, где участники общения вынуждены не просто обмениваться информацией, но и интерпретировать чужие нормы поведения, символы, речевые стратегии и ценностные установки. Поэтому проблема культурных ценностей является одной из центральных в теории и практике межкультурного

общения, что и обусловило *актуальность* данной статьи.

Научная новизна статьи состоит в комплексном рассмотрении культурных ценностей как смыслового ядра межкультурной коммуникации и как методического ресурса формирования коммуникативной толерантности у студентов. В работе предлагается практическая модель занятия, направленная на развитие у обучающихся способности анализировать межкультурные ситуации и предупреждать коммуникативные конфликты.

Методологическую основу исследования составляют теоретико-аналитический, описательный, сравнительно-сопоставительный, функциональный и методический методы. Теоретико-аналитический метод используется для раскрытия базовых понятий межкультурной коммуникации; описательный – для характеристики культурных ценностей и норм; сравнительно-сопоставительный – для выявления различий в коммуникативном поведении представителей разных культур; функциональный – для определения роли культурных ценностей в регулировании речевого и неречевого поведения; метод моделирования учебной ситуации и кейс-метод – для разработки практического занятия, направленного на формирование межкультурной компетенции студентов.

Культура в широком смысле представляет собой созданный человеком мир смыслов, норм, символов, традиций, способов поведения и форм общения. Она не дана человеку биологически. Она усваивается в процессе социализации и инкультурации, то есть включения личности в систему коллективного опыта, норм и образцов поведения [2]. Человек с раннего детства усваивает не только язык, но и способы оценки мира: что считается правильным или неправильным, красивым или некрасивым, допустимым или запретным, достойным уважения или осуждения. Следовательно, культурные ценности выступают глубинным основанием человеческого поведения. Они определяют, что для данной общности является значимым: семья, честь, индивидуальная свобода, коллективная ответственность, уважение к старшим, труд, религия, успех, гостеприимство, личная автономия, социальная иерархия или равенство.

Культурные ценности особенно ярко проявляются в коммуникации, поскольку любое общение строится не только на словах, но и на скрытых правилах их употребления. Представители разных культур могут говорить на одном языке, но по-разному понимать молчание, улыбку, прямой вопрос, отказ, комплимент, подарок, деловую встречу, личную дистанцию, жесты и формы приветствия. Так, в одних культурах прямота воспринимается как честность и открытость, в других – как грубость и нарушение этикета. В одних культурах деловое общение начинается с обсуждения личных тем, установления доверия и неформального контакта, в других – с немедленного перехода к делу. Поэтому культурные ценности выполняют регулирующую функцию: они задают правила речевого поведения

и определяют, какие формы общения считаются уместными в конкретной ситуации.

Особое значение в межкультурной коммуникации имеют культурные нормы [3]. Если ценности отвечают на вопрос, что является важным для общества, то нормы определяют, как человек должен вести себя в соответствии с этими ценностями. Обычаи, традиции, нравы, мораль, право и этикет – это формы нормативной регуляции поведения. Нормы предписывают человеку определённые модели действия: как приветствовать старших, как вести себя в гостях, как выражать благодарность, как обращаться к незнакомому человеку, как соблюдать дистанцию, как реагировать на критику или похвалу. В условиях межкультурного общения именно несовпадение норм часто становится причиной непонимания. Один и тот же поступок в разных культурах может быть истолкован противоположным образом: как вежливость или холодность, уважение или равнодушие, скромность или неуверенность, открытость или навязчивость.

Существенной проблемой межкультурной коммуникации является этноцентризм – склонность человека оценивать чужую культуру с позиций собственной культурной системы. Этноцентризм проявляется в противопоставлении «своего» и «чужого», в убеждении, что собственные нормы естественны, правильны и универсальны, а чужие – странны, нелогичны или неполноценны. Так, например, понятие «чужой» может восприниматься по-разному: как неизвестный, опасный, непривычный, недоступный для понимания или, напротив, как источник нового опыта. В межкультурной коммуникации этноцентризм опасен тем, что он мешает увидеть внутреннюю логику другой культуры. Человек воспринимает чужое поведение не как иное, а как ошибочное. Именно поэтому важнейшим условием успешного межкультурного общения становится способность выйти за пределы собственной культурной очевидности [4].

Противоположностью этноцентризма выступает культурный релятивизм. Его суть состоит в признании того, что каждую культуру необходимо понимать изнутри, в системе её собственных ценностей, норм и исторического опыта. Это не означает полного отказа от оценки любых явлений, но предполагает осторожность и исследовательскую честность: нельзя механически переносить нормы одной культуры на другую. Культурный релятивизм особенно важен в образовательной, деловой, дипломатической и научной коммуникации, поскольку помогает избежать поверхностных суждений и поспешных выводов. Он формирует уважительное отношение к иному культурному опыту и позволяет понять, почему одни и те же коммуникативные ситуации в разных обществах получают разные интерпретации.

Культурные ценности тесно связаны с культурной идентичностью. Идентичность позволяет человеку осознавать свою принадлежность к определённой группе, языку, традиции, истории и системе норм. При этом в современном мире личность всё чаще оказывается носителем нескольких

идентичностей одновременно: национальной, этнической, языковой, профессиональной, религиозной, гендерной, социальной. Межкультурная коммуникация становится успешной тогда, когда человек способен не только сохранять собственную идентичность, но и понимать идентичность другого. Нарушение этого баланса приводит к коммуникативному конфликту: человек либо замыкается в своей культурной системе, либо теряет устойчивость собственного ценностного основания. Поэтому задача межкультурной коммуникации состоит не в стирании различий, а в их осмысленном согласовании.

Культурные ценности проявляются не только в официальной сфере, но и в повседневности. Пища, одежда, жесты, порядок приветствия, отношение к гостю, распределение ролей в семье, способы воспитания детей, отношение к старшим, представления о времени и пространстве – всё это несёт ценностную нагрузку. Например, в одних культурах пунктуальность выражает уважение к партнёру, в других более важным оказывается не точное соблюдение времени, а сохранение человеческого контакта и доверительного общения. В одних культурах подарок воспринимается как знак личного внимания, в других может быть истолкован как нарушение деловой дистанции. Эти различия показывают, что ценности действуют не абстрактно, а через конкретные модели поведения. Поэтому изучение культурных ценностей должно быть не только теоретическим, но и практическим: оно помогает человеку правильно интерпретировать коммуникативную ситуацию.

Ниже мы приводим небольшой сценарий занятия по межкультурной коммуникации с целью сформировать и развить у студентов культурные ценности.

Методическая разработка занятия

Тема: Культурные ценности в межкультурной коммуникации

Дисциплина: Русский язык / Межкультурная коммуникация. Уровень: B2–C1

Формат: практическое занятие с элементами мини-лекции, анализа кейсов и групповой дискуссии. Продолжительность: 90 минут

Цель занятия - сформировать у студентов представление о культурных ценностях как основе межкультурного общения и научить анализировать коммуникативные ситуации с учётом различий в нормах, ценностях, стереотипах и моделях поведения представителей разных культур.

Задачи занятия. Образовательные: раскрыть понятия «культура», «культурные ценности», «культурные нормы», «энкультурация», «аккультурация», «культурная идентичность»; показать связь культурных ценностей с речевым и неречевым поведением; познакомить студентов с основными стратегиями аккультурации: ассимиляцией, сепарацией, маргинализацией и интеграцией.

Развивающие: развивать умение анализировать межкультурные ситуации; формировать навык аргументированного высказывания на русском языке; развивать критическое мышление и способность видеть ситуацию с позиции другой культуры.

Воспитательные: формировать уважительное отношение к культурному многообразию; предупреждать этноцентричное восприятие «чужой» культуры; развивать коммуникативную толерантность.

Ожидаемые результаты.

К концу занятия студент должен уметь: *объяснять*, что такое культурные ценности; *приводить* примеры культурных ценностей в повседневной коммуникации; *различать* культурную норму и индивидуальную привычку; *анализировать* причины межкультурного недопонимания; предлагать коммуникативно корректные стратегии поведения в межкультурной ситуации.

Ход занятия.

1. Организационный этап.

Преподаватель сообщает тему занятия и задаёт проблемный вопрос: Почему люди из разных культур иногда не понимают друг друга, даже если говорят на одном языке?

Студенты предлагают ответы: разные традиции, нормы поведения, религия, жесты, отношение ко времени, семейные роли, этикет, статус, дистанция общения.

2. Вводная мини-лекция.

Преподаватель объясняет основные положения темы.

Культура – это не только искусство, литература, национальная одежда или кухня. В широком смысле культура включает нормы, ценности, верования, обычаи, традиции, знания и модели поведения, которые человек усваивает в обществе. Культура не является врождённой: человек осваивает её в процессе социализации, то есть через семью, школу, общество, язык, религию, традиции и повседневные практики.

Преподаватель записывает на доске схему:

Культура → ценности → нормы → поведение
→ коммуникация

Затем объясняет: ценности отвечают на вопрос: что важно? Например: семья, свобода, честь, успех, старшие, личное пространство, гостеприимство.

Нормы отвечают на вопрос: как надо поступать?

Например: как приветствовать, как обращаться к старшим, когда можно спорить, как выражать несогласие.

Коммуникация показывает, как эти ценности и нормы реализуются в речи, жестах, дистанции, интонации, молчании, этикете.

3. Работа с ключевыми понятиями.

Студенты получают задание: соотнести термины и определения.

Термин	Определение
Культурные ценности	Представления общества о важном, значимом, достойном
Культурные нормы	Правила поведения, принятые в обществе
Энкультурация	Усвоение человеком культуры с детства
Аккультурация	Приспособление к новой культуре
Культурная идентичность	Осознание принадлежности к определённой культуре
Этноцентризм	Оценка чужой культуры через нормы своей культуры
Интеграция	Вхождение в новую культуру без отказа от своей

После выполнения задания преподаватель обсуждает ответы со студентами.

4. Анализ коммуникативных ситуаций.

Студенты делятся на группы. Каждая группа получает кейс.

Кейс 1. Пунктуальность. Студент из одной страны пришёл на встречу ровно в 10:00. Его партнёр из другой культуры пришёл в 10:25 и не считает это нарушением. Первый студент воспринимает это как неуважение.

Вопросы: Какие культурные ценности столкнулись? Это личная невежливость или различие культурных норм? Как можно избежать конфликта?

Кейс 2. Прямой отказ. Один участник переговоров прямо говорит: «Нет, мы не согласны». Другой воспринимает это как грубость, потому что в его культуре отказ принято выражать косвенно.

Вопросы: Почему возникло недопонимание? Какую роль играет речевой этикет? Как можно переформулировать отказ мягче?

Кейс 3. Уважение к старшим. Молодой специалист на совещании активно спорит с пожилым коллегой. В одной культуре это воспринимается как профессиональная уверенность, в другой – как неуважение к возрасту.

Вопросы: Какая культурная ценность здесь важна? Как связаны возраст, статус и коммуникация? Как сохранить свою позицию и не нарушить этикет? После обсуждения каждая группа представляет решение.

5. Практическое задание «Ценности моей культуры».

Студенты индивидуально заполняют таблицу.

Культурная ценность	Как она проявляется в поведении?	Возможное недопонимание с другой культурой
Уважение к старшим	Обращение на «Вы», уступание места, внимательное слушание	В другой культуре это может восприниматься как чрезмерная дистанция
Гостеприимство	Приглашение домой, угощение, настойчивое предложение еды	Гость может почувствовать давление
Семья	Важность мнения родителей и родственников	Представитель индивидуалистической культуры может счесть это зависимостью
Скромность	Не принято открыто хвалить себя	В другой культуре это может выглядеть как неуверенность
Коллективная поддержка	Помощь родственникам и друзьям	Может восприниматься как нарушение личных границ

После заполнения 2–3 студента зачитывают свои примеры.

6. Речевая практика.

Студенты составляют мини-диалоги по моделям.

Ситуация 1: Вы хотите отказаться от приглашения, но не хотите обидеть собеседника.

Ситуация 2: Вы не поняли культурную норму и хотите уточнить её вежливо.

Ситуация 3: Собеседник нарушил привычную для вас норму поведения, но вы хотите избежать конфликта.

Полезные речевые формулы: Правильно ли я понимаю, что в вашей культуре принято...? Извините, я могу уточнить один момент? В моей культуре это обычно воспринимается иначе. Возможно, я неправильно понял ситуацию. Мне важно уважительно отнестись к вашей традиции. Давайте

найдем вариант, который будет удобен для обеих сторон.

7. Рефлексия.

Преподаватель задаёт вопросы: Что сегодня было для вас новым? Какие культурные ценности чаще всего становятся причиной недопонимания? Почему важно не оценивать чужую культуру только через нормы своей культуры? Какая стратегия аккультурации кажется вам наиболее продуктивной?

Контрольные вопросы:

Что такое культурные ценности?

Чем культурные ценности отличаются от культурных норм?

Как ценности влияют на речевое поведение?

Что такое энкультурация?

Что такое аккультурация?

Какие стратегии аккультурации выделяются в теории межкультурной коммуникации?

Почему интеграция считается наиболее продуктивной стратегией?

Что такое этноцентризм?

Почему межкультурное общение требует эмпатии?

Как можно предупредить межкультурный конфликт?

Домашнее задание.

Написать мини-эссе на тему:

«Какие культурные ценности моей страны могут быть непонятны представителям другой культуры?». Объём: 180–220 слов. В эссе необходимо: назвать 2–3 культурные ценности; объяснить, как они проявляются в общении; привести пример возможного недопонимания; предложить способ избежать конфликта.

Таким образом, культурные ценности являются смысловым ядром межкультурной коммуникации. Они определяют мировоззрение человека, регулируют его речевое и неречевое поведение, формируют представления о норме, этикете, уважении, допустимой дистанции, способах выражения

согласия и несогласия. Непонимание ценностных оснований чужой культуры приводит к коммуникативным сбоям, стереотипам и конфликтам; напротив, знание этих оснований создаёт условия для диалога, взаимного уважения и эффективного взаимодействия. Межкультурная коммуникация требует не отказа от собственной культуры, а способности видеть её как одну из возможных систем смыслов. Только в этом случае встреча культур становится не источником отчуждения, а пространством взаимного обогащения.

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PHARMACEUTICS

WHAT THE ASSORTMENT OF STUDENT PHARMACY KITS CAN TELL US

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Abstract

Objective. To study the assortment of home medicine kits of medical students in their junior and senior years.

Research materials and methods. An anonymous online survey of students from four medical universities in the Republic of Belarus ($n = 507$). The questionnaire included information on the students' gender, age, medication group, medications stored in their home medicine kits, and the names of individual medications. Statistical processing of the results was performed using Microsoft Excel and Statistica 10.0; absolute and relative values were described, and differences were assessed using appropriate criteria ($p < 0.05$).

Results. Over-the-counter symptomatic medications predominated in home medicine kits. The percentage of students reporting having antibiotics in their medicine cabinets reaches 35-40% by the fifth year ($p < 0.001$). The percentage of students having prescription medications in their home medicine cabinets increased from 28.2% in the first year to 57.1% in the fifth year ($p < 0.001$), as well as cardiological medications, 18.2% and 52.0%, respectively ($p < 0.001$). At the same time, the percentage of antiallergic (antihistamine) medications did not change significantly (~83.5%). Bandages and antiseptics were present in ~80% of students; and the most commonly used medications were paracetamol and ibuprofen (in >90%). When choosing medications, students relied on their personal positive experience of using them, with its importance tending to increase from the junior to the senior year of university. Students with higher academic achievement were more likely to include antibiotics in their medicine cabinet than students with lower GPAs.

Conclusions: Medical education undoubtedly influences the composition of a medicine cabinet: For example, from junior to senior year, there is an increase in the purchase of antibiotics and prescription medications. However, medical education also encourages the purchase of medications without consulting a doctor, due to confidence in one's own knowledge. This necessitates developing students' respect for the professional competence of healthcare workers. In other words, when choosing a treatment, students should follow a doctor's advice rather than self-medicate.

Keywords: medicine cabinet, medical students, self-medication, antibiotics

INTRODUCTION

A home medicine cabinet reflects a person's actual health problems or the anxiety of someone who doesn't currently have a confirmed medical diagnosis but fears illness and protects themselves by purchasing medications and storing them in their home medicine cabinet. University students are no exception in this regard, and their tendency to self-medicate is high, a global practice [1-5]. As medical students gain knowledge, particularly in pharmacotherapy, they undoubtedly change their preferences, choosing what they believe are the optimal medications for their medicine cabinet. However, as research shows, for example, pharmaceutical education does not at all preclude self-medication [3]. At the same time, there are certain established patterns in the use of certain medications that are difficult to change (for example, "paracetamol is the best medicine for reducing elevated body temperature during infectious diseases"). Furthermore, students with different levels of training in pharmacology and pharmacotherapy will differ in their choice of specific medications for their home medicine cabinets. The reason is simple: if a student doesn't know the best medicine for a given condition,

they will purchase the one they know. Therefore, studying the home medicine cabinets of Belarusian medical students in their junior and senior years seems practically significant for obtaining information, in particular, on the presence and prevalence of self-medication.

RESEARCH MATERIALS AND METHODS

Data was collected through an anonymous online survey using the Google Forms platform. A total of 507 students (88.6% female, 9.3% male) participated. The study included students from Grodno State Medical University, Vitebsk State Medical University, Gomel State Medical University, and the Belarusian State Medical University. The study was conducted in accordance with the ethical standards of the World Medical Association's Declaration of Helsinki. All respondents provided voluntary informed consent to participate; selection was conducted randomly by sending questionnaires to email addresses. Statistical data processing was performed using Microsoft Excel and Statistica 10.0, with descriptions of absolute and relative values.

RESULTS AND DISCUSSION

The proportion of students with antibiotics in their home medicine cabinet is high and consistently increases from approximately 20% to 35-40% by the fifth year ($p < 0.001$). Thus, there is a significant tendency to self-medicate with antibiotics, which is a problem in other countries as well, at a similar rate (46%) as in Belarus [4]. Another study also noted a similar trend [3]. Moreover, almost half of the students' use of antibiotics was based on their confidence in their effectiveness against viral infections. This study also noted that female students with experience self-medicating with antibiotics were more likely to use antibiotics [5]. These findings indicate that, as they progress through their studies, Belarusian students perceive antibiotics as a standard element of treatment for any infection, including the most common ones, i.e., viral infections. This demonstrates a lack of understanding that such a practice leads to the spread of antibiotic resistance and shows that medical education in itself, while providing general knowledge about diseases and medications, in the absence of independent clinical practice, does not prevent the presence of antibiotics in home medicine cabinets and self-medication with them [4-6]. Research shows that during the educational process the volume of medical knowledge continuously increases, especially when studying clinical medicine in the senior years, however, as indicated above, this does not exclude the tendency of a significant number of students to self-medicate. [7]. During the survey, it was found that the presence of emergency supplies increased from 49.6% in the 1st year to 77.9% in the 5th year ($p < 0.001$). This increase indicates a qualitative change in the structure of the first aid kit, and not simply an increase in the number of drugs. In the senior years, a focus on probable emergency conditions appears, and the range of medications "in case of complications" expands, likely reflecting a shift from a predominantly theoretical to a clinical mindset. Self-medication is most evident in the acquisition and storage of prescription drugs. The proportion of students with prescription medications without a doctor's prescription increases from the first to fifth years, respectively, from 28.2% to 57.1% ($p < 0.001$). These figures indicate not only a change in the contents of the first-aid kit, but also a transformation in students' behavioral attitudes. As students move to senior years, confidence in their own knowledge increases, dependence on external recommendations (teachers, doctors) decreases, and the tendency to independently make decisions about the initiation and algorithm of pharmacotherapy increases. On the one hand, this reflects the formation of an autonomous model of medical behavior, without which it is impossible to imagine a physician's work. On the other hand, this may be accompanied by the risk of irrational use of drugs, a decrease in criticality to self-medication, both in practice and in its content [8]. Cardiological drugs are studied in depth in older years. This is reflected in the fact that the frequency of the presence of such drugs in the medicine cabinet increases from 18.2% in the first year to 52.0% ($p < 0.001$) in the fifth. However, it would probably be an oversimplification to

explain such an increase solely as a result of the learning process. A student can acquire such knowledge during part-time work in medical institutions (this is a common practice for medical students), and involvement in the treatment of elderly relatives. This leads, among other things, to the acquisition of more modern and selectively acting drugs. The fast-acting ACE inhibitor captopril was most often present in students' medicine cabinets, which indicates the presence of hypertension in students, requiring periodic elimination of high blood pressure. Thus, the first aid kit begins to reflect not only the knowledge, but also the beginnings of the clinical experience of the future physician, who selects a drug based on clinically oriented thinking [9]. Antiallergic (antihistamine) drugs demonstrate a stable level of purchase and use (83.5%), without significant fluctuations during the course of study at the university, which is easily explained by the presence of allergies in students already in the first year, with its persistence in older years, and the wide knowledge of such drugs among the population, the ease of their prescription, the unambiguous clinical response to them ("works - does not work"). Therefore, their presence in the student's first aid kit does not depend on the level of training and the course of study of the student and, given the high probability (e.g., seasonal hay fever, etc.) of the manifestation of allergic reactions in the future, a supply of such drugs is always available for students with allergies [10]. As noted above, as the course of study progresses and the transition from the junior to the senior year, the tendency to purchase and self-medicate with antibiotics increases. In other words, more educated students tend to self-medicate with drugs that are less well known to the general population than with well-known antipyretic and analgesic drugs (ibuprofen, paracetamol). Personal experience can be considered the most important factor in drug selection, making the most frequently prescribed and personally tested drugs popular among the population [9-12]. A general description of the structure of the home medicine cabinet, according to an analysis of data from a survey of medical university students ($n = 507$), showed that the structure of the home medicine cabinet is predominantly formed by symptomatic therapy and over-the-counter drugs. This model is consistent with global trends in self-medication described in a number of pharmacoepidemiological studies, for example, according to data from C M Hughes et al., the prevalence of self-medication in the general population exceeds 50%, with the main share being analgesics, anti-cold and gastrointestinal drugs.[11] Among the means for treating and dressing wounds, the most common category turned out to be dressings (adhesive tape, bandages) and antiseptics (chlorhexidine, hydrogen peroxide), which were present in the overwhelming majority of respondents (~80%). This corresponds to international recommendations for the composition of first aid kits, where antiseptics and dressings are the basic components.[13] The high prevalence of these products can be explained by their versatility of use, low cost, and the absence of the need for a prescription. In Eastern European countries, such a first aid kit structure is typical, which is associated with the historically established practice of

self-treatment of wounds. Of the painkillers and antipyretics, as noted above, paracetamol and ibuprofen were most often present in first aid kits (>90%). This is fully consistent with international recommendations. The World Health Organization recommends paracetamol and NSAIDs as first-line drugs [14], and the Cochrane Database notes them as the most common OTC analgesics. [15]. The study by Moore et al. confirms that these drugs dominate the structure of analgesic consumption. [16]. Drugs for the treatment of colds in medicine cabinets are represented, first of all, by nasal decongestants (in approximately 75–80% of respondents) – symptomatic agents for rhinitis, which is quite rational, given that the treatment of ARVI in the overwhelming majority of cases is symptomatic [17]. Although the therapeutic value of such treatment is questionable (and long-term treatment is even harmful, leading to drug-induced rhinitis), the situation with similar drugs in other countries is similar [17]. Drugs for the treatment of gastrointestinal disorders are represented in the questionnaires, first of all, by sorbents (~70%). Moreover, the World Health Organization's international recommendations for the treatment of acute diarrhea emphasize rehydration rather than sorbents [18]. Replenishing lost fluid and electrolytes, and sometimes (in non-infectious diarrhea) loperimide, are the mainstay of diarrhea treatment [18, 19]. Thus, the high prevalence of sorbents reflects the established opinion in post-Soviet medicine about their value. Sedatives, hormonal, and cardiac medications: approximately 60% of respondents indicated having the above-mentioned medications in their medicine cabinet. Research shows that in post-Soviet countries, the use of over-the-counter sedatives is widespread, especially those of herbal origin, such as valerian, motherwort, and peony [20]. It should be noted that phenobarbital-containing drugs (such as “Valocordin”, “Corvalol”) are also classified as sedatives in Belarus, although similar combination drugs with barbiturates (phenobarbital) are controlled and restricted for use in most countries of the world [21]. Of the ophthalmological drugs, moisturizing drops were the most common (~60%). Literary sources confirm the high prevalence of dry eye syndrome, especially when using digital devices [22]. First Aid Supplies: most students (~70–75%) do not have specialized first aid supplies in their home medicine cabinets. This indicates a lack of preparedness for emergency situations, despite their medical education.

CONCLUSION

The study results show that the structure and contents of medical students' medicine cabinets change significantly during their studies. The presence of antibiotics and prescription medications increases as students become more familiar with clinical conditions, i.e., by their fifth year of university studies. At the same time, the presence of antiallergic (antihistamine) medications in the medicine cabinets does not change significantly from junior to senior year (~83.5%), reflecting the specific nature of their use for allergic reactions, which tend to recur and require students to always have a medication from this group on hand. The high prevalence of dressings, antiseptics, analgesics, antipyretics, and

symptomatic remedies for acute respiratory viral infections is consistent with international practices, while the predominance of sorbents for gastrointestinal disorders reflects regional specificities in the Soviet Union. Unfortunately, however, medical education also encourages students to purchase medications without consulting a doctor, due to their confidence in their own knowledge. This necessitates developing students' respect for the professional competence of healthcare professionals. In other words, when choosing a treatment, students should follow a doctor's advice rather than self-medicate.

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PHILOLOGICAL SCIENCES

TURKISM AND ITS CHARACTERISTICS IN LITERATURE OF THE TURKIC PEOPLES OF THE 20TH CENTURY

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Abstract

The article examines the reflection of the idea of Turkism in the literature of the Turkic peoples in the 20th century. The issues of Turkism as nationalism and its defensive nature in the struggle for ethnic-national existence, as well as the Turkish mentality are touched upon. In the Soviet period, some propaganda issues were brought to the fore in the appropriation of the literature of the Turkic peoples of the same ethnic origin. Thus, the characteristic features of the phenomena of ethnic thinking were purposefully distorted.

The 20th century is characterized as the awakening of national consciousness and the widespread spread of the ideas of Turkism in the literature of the Turkic peoples. During this period, ethnic consciousness was gradually replaced by national consciousness, and attention began to increase to national factors.

In general, the study shows that the history of each ethnos passes in merciless struggles for its own existence and preservation. Among the means of struggle, the factors that constitute ethnic identity, in particular, the literary factor, are of great importance.

Keywords: Turkism, Jadidism, National Conscience, Turkic Literature, 20th Century.

THE IDEOLOGY OF TURKISM AS A MEANS OF ETHNIC SELF-PRESERVATION

The formation of the Turkic ethnic group, its self-affirmation was followed by wars and conflicts. The history of each group is spent with relentless struggles to preserve its existence. In all cases, the ethnic groups struggle not only physically, but they also fight to preserve their existence. Among the means of struggle, the factors constituting ethnic uniqueness, including the factors of literature and culture are of great importance.

The Tsarist Russia began to fulfill the policy of changing ethnic uniqueness according to the well-thought comprehensive action plan after it enslaved the Turkic people in the 19th century. Various movements such as Jadidism, Qadimism, and Enlightenment began in the socio-political, literary, and cultural life of the Turkic people which is based on the Turkist ideology. In the new period, Turkism was the means of self-preservation.

JADIDISM AND QADIMISM: STRUGGLE FOR NATIONAL EDUCATION

Jadidism began to develop among the Turkic people of Russia from the second half of the 19th century. The Tsarist Russia adopted the policy of training pro-Russian intellectuals in the countries they had invaded. That's why they increase their focus in the field of education. They focused on consistently implementing their comprehensive action plan in order to get into contact with the people of the countries they had invaded, to make easy the process of managing them, and most importantly, to form the Turkic intellectuals according to the educational principles of the dominant ethnic group, that is to change their ways of thinking as a result. So, the Jadid movement prospered widely in the socio-political life of the Turkic people. The process of return to the national thinking was taking on a wide

scale among the Turkic Muslim people of Russia. Establishment of the schools of new type and their gaining influence gave rise to the diversity of opinions and positions among the Turkic intellectuals. Besides the followers of the schools of new type, there were also intellectuals who believed in the importance of preserving the traditional educational methods, and they started the counterpropaganda. They were called Qadimists because they advocated the old traditions. While Qadimists endeavored to keep the traditional educational system, the Jadids tried to give it up completely.

If we accept Jadidism as the phenomenon of the 2nd part of the 19th century, we cannot overlook other movements of that period, especially the Enlightenment. Both Jadidism and Enlightenment are based on ethnical and national interests and prefer upbringing and education in solving actual problems. Enlightenment prefers to educate the nation, while Jadidism prefers the salvation of the nation.

Beginning from the late 19th and early 20th centuries, the renaissance of the national conscience and Turkism developed into two directions: 1) The Turkism of the intellectuals of the period which implied the spiritual unity of the Turkic world; 2) Focus on the national factors as the national conscience replacing the ethnic conscience beginning from the 17th and 18th centuries. Jadidism in Tatarstan and Central Asia politicized by gaining Turkist and nationalist behavior. The Jadids really disturbed the Tsarist Russia and the Bolshevik regime. The Jadid movement in later stages of its development had become a great political power inside the empire. In the early 20th century, unlike the Tsarist reactionism in his fight against Jadidism, the Bolshevik regime not only prevented the Jadidism, destroyed them, draw them to his side or made them to run away from the country, but it also endeavored to delete them

from the history of the Turkic peoples, to move the influence of Jadids away from the socio-political, scientific and cultural, literary and philosophic thought by creating an image of the enemy in them for around a century as well.

THE RISE OF TURKIST IDEOLOGY IN TURKEY: GOKALP, YURDAKUL AND SEYFETTIN

In those times, Turkism lived its renaissance in Turkey. In 1908, as a result of the revolution of Young Turks, monarchy turned into constitutional monarchy. The thought of Ottomanism began to grow stronger. In his paper published in *Peyman* in 1909, Ziya Gokalp (1876-1924) wrote that "Ottoman does not mean Turk", and called the countries covering a wide area which speaks Turkic, Turan.

As the Ottoman empire was declining in early 20th century, it does not only lose his lands in Europe, but even the existence of Turkey as a state was in danger. Under these circumstances, the ideas of Turkic solidarity began to develop in Turkey. The Turkists of this time came together in the societies of *Türk Yurdu* (Turkish Homeland) and *Türk Ojaghi* (Turkish Hearth). At this time, Ziya Gokalp (1876-1924) was one of the leading figures of the Turkist movement and the central figure in field of Turkist theory. Z. Gokalp has developed and demonstrated the necessity of creating Turkic unity and has taken practical steps in order to realize it. Ziya Gokalp who was one and the first of the well-known thinkers of Turkey, has systematized knowledge on Turkic ideology for the first time. *The Essentials of Turkism* by him was the program of Turkism. The ideologist who gives the definition "Turkism means elevating the Turkic nation" explains the essence of Turkism, comments on the matters like Turkism in language, aesthetics, morals, law, religion, economy, politics, and philosophy.

In Turkish literature, alongside with Z. Gokalp, there were also other representatives of the Turkist ideology such as Mehmet Emin Yurdakul and Omer Seyfettin. M. Yurdakul (1869-1944) known as "the first national poet of Turkey" tried to instill the national identity in the people.

The late 19th and early 20th centuries are referred as awakening of the national conscience in the national literature and formation of the Turkic literature. One and the first of the prominent members of the national poetry in Turkish literature was M.E. Yurdakul. In M. Emin's works, the life in Turkey in the end of the 19th century and the beginning of the 20th century was reflected realistically. The poet has shouted in his loud voice that his language is Turkish language, and his nation is Turkish in a fully conscious manner for the first time among all Ottoman poets.

This time was an extremely hard period for Turkey that was under the attack of invaders. Just in this time, M. Emin managed to influence their psychology by emphasizing the immortality of Turkic spirit, and the fact that it would not submit to the slavery.

In the period of national independency movement in Turkey (1918-1922), M. Emin, as a real patriotic poet of his own nation, chanted the feelings, griefs, sor-

rows of his motherland. M.E. Yurdakul entered the history of the Turkish literature as the founder of Turkish national poetry, with his socio-political activities and literary works, he played a significant role in awakening of social ideas in the national formation of Turkish people and in its national culture.

Turkist ideas were further promoted in O. Seyfettin's (1884-1920) works. Omer Seyfettin created his works during the period of National literature. Omer Seyfettin was an ardent supporter of national language and literature. The paper called "Yeni lisan" ("New Language") by the writer was a kind of concept of the National literature. His tendency to create literature without using unnecessary words, flashy sentences, embellishment was also characteristic for his stories. What topics has the writer who was one of the brightest representatives of the simplification of language and Turkish storytelling written about? He has written about Turkish lifestyle, Turkish women, Turkish children, Turkish peasants, importance of the passing of Turkish customs and traditions to the future generations, the wars waged by the Turkish people, their valor, determination, dignity, the bravery of Turkish soldiers, being martyr in the sake of land, never forgetting the formula of "he who does not oppress is oppressed", the love for language, religion, motherland, and nation, vigilance against the ones who are dividing the Turks, the Turkist ideal and aim...

The ideological movements of the time, including Ottomanism, Islamism, Westernism, Turkism, greatly influenced undoubtedly on the works written in the time of National literature. In O. Seyfettin's short stories, the ideas of Turkism have been advocated more widely. In his paper "Ideology of Turkishness" he writes: "...The nation we belong to is "Turkishness". It means that the Turkish people have two kinds of life: 1. Personal, i.e. the individual life of each Turkish person. 2. Common, i.e. the national life, Turkism which is lived by all Turkish people together... To strengthen this common life, to prepare an unbreakable future for them is the "Ideology of Turkishness" (Teymur 1992: 79). As a real Turkish writer, O. Seyfettin always tried to protect the interests of Turkish people.

TURKISM IN AZERBAIJAN: THE LEGACY OF HUSEYINZADE AND GASPIRALI

In the beginning of the 20th century, Azerbaijan had the ideologies of Turkism and Azerbaijanism, and Turkism was occurring around A. Huseynzade and the journal *Füyuzat* found by him. We read the following about A. Huseynzade's participation and services to social, political and national matters of Turkey in Z. Gokalp's *Essentials of Turkism*: "Ali bey who came from Russia to Istanbul, explained the essentials of the Turkism in medical school. His poem "Turan" was the first discloser of the ideal Turanism." (Göyalp 1991: 28).

Ali bey Huseynzadeh was the ideologist of Azerbaijani romanticism in 20th century who put forward the common Turkic literary language systematically, who seriously developed this idea advocated it in his works. It was no coincidence that Ismail Gaspirali openly admitted the newspaper *Hayat* ("Life") to be the successor of *Terciman*, as well as Ali bey Huseynzade to be

his spiritual successor (Kəngərli 2004: 163).

After *Hayat* closed, Ali bey Huseynzade took over the director and main writer of a journal called *Fuyuzat* which was also published with the financial support of Z. Taghiyev. The complete set of this journal published until November of 1906 is a valuable source to understand Huseynzade's political and philosophical thoughts and to analyze his writing style. The most striking aspect in Ali bey's struggle in *Fuyuzat* is to contribute and support to defend the Turkism, and purity and unity of Turkic people against Iranism that tried to attract Azeri Turks near, especially via sectarianism for over some hundred years, and Russicism that began to influence relatively recently, for about 50-60 years (Akçura 2010: 210).

Turkism was associated with the name of Ismail Gaspirali at the time. In the times when the Turkic speaking peoples living in a vast territory within Tsarist Russian Empire, in their eternal and everlasting lands, but suffering under the Russian bondage in need of education, progress, science, culture, and eventually, unity, Ismail Gaspirali appeared on the stage of history with his *Terciman* and his motto "Unity in language, thought, and deed." He explained that the Turkic people scattered from the Altai to the Urals, from Central Asia to the Caucasus, from the Volga to the Balkans belong to the same values and it is time for them to own it (Seyfettin 1993: 4). The idea of necessity of a united common literary language has been put forward for the first time by Ismail Gaspirali in the 80's of the 19th century. According to Gaspirali, the identity of a nation begins from its language, and the Turkic peoples must speak the same language, i.e. the common Turkic literary language in order to get to know and love each other, to understand their own national identity, to become a united, strong nation. This kind of an ideal became the ideological basis for the thought of creating the common Turkic language prospered among the Turkic peoples of Russia and Turkey. Gaspirali fulfilled his motto "Unity in language, thought, and deed" via *Terciman*. The struggles of the newspaper *Terciman* in forming a united language for the Turkic world was praiseworthy. The newspaper *Terciman* became the most extraordinary phenomenon in the Turkic world after Hasan bey Zardabi's newspaper *Akinchi*. During its 35 years of publication (1883-1918), it has been the most popular Turkist and Islamist publication that strived to bring together and to elevate the Turkic people living in various parts of the world.

Ismail bey Gaspirali was one of the most prominent Jadids that played a matchless role in creating new way of thinking among the Muslim peoples of Russia. M.A. Rasolzade wrote the following in the newspaper *Istiklal*: "At the time, Ismail bey was the leader of Jadids and *Terciman* was their publication. The most significant one of the innovations that was issued by *Terciman* was the simplified common Turkic language. A Turkic that was understood by the educated people of every Turkic country. *Terciman* gave all its energy to teaching simplified Turkic to all Turkic people, explained the feeling it spread by the motto "Unity in language, thought, and deed" towards the end of its life. Although according to its existence today, the motto

"Unity in language, thought, and deed" is very far from realization as it was imagined by the whole Turkism which intended to unite all Turkic peoples around into a single Turkic state, *Terciman* that make this motto his banner, has undoubtedly played its historical role successfully (Tahirli 2009: 2).

TURKISH LITERATURE IN CENTRAL ASIA DURING THE SOVIET REGIME AND THE BOOK "AZ-YA"

The Jadid movement was dominant in Central Asia as a politicized form of Turkism.

The invasion of most of the Turkic people by the Bolsheviks after Tsarist Russia make the situation more complicated. The Turkic peoples who had relative independence and freedom in the early times like Azerbaijanis, Kazakhs, Turkmens, Uzbeks, Tatars, Bashkirs and so on, were subjected to ruthless surveillance in all fields, especially in literature, culture and arts. In the Soviet period the policy of the Bolshevik-Communist regime of creating the Soviet person in accordance with the model of Russian person prevailed. First of all, by falsifying the history of the Turkic people, they were being separated from their past, and their memory was being erased. The dangerous aspect that was not clear, was that the process of separating the Turkic people from each other began to be replaced by the process of alienation. The interesting point is that alienation was not only conducted between Turkey or the Turkic people outside of the USSR in general and the Turkic people within the empire, but they also paid special attention to implementing it among the Turkic people within it. An analogous situation was also realized in literary life. The power of an artistic word was also used against the people themselves: the historical past was demonstrated in a distorted way, the artistic analysis of the national peculiarities forbidden, instead of ethnic person, political person, i.e. Soviet person was glorified, etc. The artists wrote before the Soviet regime and thinking about the fate and future of their people and country were subjected to spiritual and physical repression. The officers of literature of the regime spiritual poisoning the artists who do not conform to their demands, began to physically destroy them in 1937. The Turkic people lost many of their intellectuals during this process of genocide. The men of letters of the Turkic people subjected to repression, Cho'lpon, A. Qodiriy, A. Ibrahimov, M. Zhumabayev, Shakarim, and the others; apart from the physical destruction, the survivors were under control till the end, e.g., M. Auezov.

A strict censorship regime was applied and the Turkist personalities were referred as the enemies of the people. And the literature of the people taught in Soviet times used to be selected according to ideological and political criteria. Nevertheless, both the literature lived on, and the verbal art continued to be taught. There were objective and subjective insufficiencies, but like the other people, in the literature of the Turkic peoples, the works distinguished by their artistic value and for demonstrating national interests. The artists like A. Qodiriy, Cho'lpon in Uzbekistan, Ch. Aytmatov in Kirghizstan, M. Auezov, O. Suleymenov in Kazakhstan, N. Sarykhanov in Turkmenistan, M. Jalil in Tatarstan tried to conscientiously serve to their own people.

In the Soviet period, Turkism was preserved thanks to the power of ethnic potential of the people. As we have mentioned before, the center of gravity of Turkism was literature. Oljas Süleymenov's works are the best examples of this.

Any other Turkic poet cannot be imagined who felt the ethnic longing of the Turkic people like him, it is the longing for the deserts, steppes, and this longing has an intimate character: Oljas seems like a horseman going from east to west along the old Turkic steps... (Cəfərov 2006: vol.4, 303).

Az-Ya has a special place among O. Süleymenov's works. The work has a special importance for its original reproach to the history of Turkic people, their language, and their socio-political and historical reputation. The book *Az-Ya* consisting of three parts, expresses an objective attitude to every questions within the scientific and national historical principles, draws interest for learning the national aesthetical values and literary cultural history of the Turkic people who have ancient history, and at the same time for shedding light on some points of the cultural and political histories of a lot of people living in Eurasian territory (Quliyev 2025: 628).

The biggest significance of *Az-Ya* was its great influence on the national awakening of the Turkic people. And this work was born from the necessity of conveying the truths about fate of the Turkic people to the future generations. He said the following in one of his speeches: "I came across with the unexpected facts: it seems that the languages seemingly far from each other had historical relationships. For example, the Russian and Turkic languages. Everything began with my research on *The Tale of Igor's Campaign*. How many old Turkic words this work had. But many others did not like my arguments and examples. They used to say that Turkic and Russian are far from each other. They called me as a Pan-Turkist." (Akimova 2016: 10).

It is known from the history that the Turkic ethnic groups had not tried to assimilate the members of other ethnic groups purposefully. Where is ethnic groups who could not stand against the power of the Turkic language and thought had given up some of their ethnical and national factors voluntarily.

Literature has a unique role and importance in the fight against ethnic and national assimilation. Preservation of the language, the literary description of the historical facts and ethnical and national specificities in the novels like *Abay* by M. Auezov, *Bygone Days* by A. Qodiriy, *Turbulent Kur* by I. Shykhly, as well as in the works in various types and genres written by the artists of the second half of the twenty century, was the expression of Turkism. Literature is one of the main bases of strengthening and activating the resistance energy in the ethnic group.

The fact that the Turkic people had the same ethnic

origin, the same mythological, religious and philosophical views, the same lifestyle and way of thinking, the same customs and traditions, has led their literary and moral values to emerge from the same source. This commonness among the literatures of the Turkic peoples may be referred not as only typological similarity, but firstly as common characteristics. All of these once again prove that the studies on the literature of the Turkic people does not only stem from political, but also from national requirements.

CONCLUSION

In modern times, Turkism develops in two directions in the history and literature of the Turkic people. The first direction is continuous theoretical searches and their aim to strengthen the connection between the Turkic peoples. The second one is to continue the traditional Turkism in literature, culture and art. All these serves to the purpose of promoting Turkism and bringing the Turkic people together in terms of moral values.

The modern Turkic states have the potential to have a say among the countries of the world. They do not need to come together within a border to do it. Close friendly connections, political, economic, literary and cultural relations are sufficient to ensure the connections between the people. Therefore, great work is done toward the further enrichment of the common Turkic culture and the improvement of the literary and cultural ties today. In modern times, systematic work is being done in a large scale in order to prevent the closeness between the Turkic peoples and strengthening alienation between them. Despite this, by finding shelter in their Turkic pride, the Turks manifest their national existence in all fields, as well as literature with great determination and will. Behind this will stand the national and moral values that they cherished with great love.

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PHYSICAL SCIENCES

PLANET EARTH IS DESIGNED MUCH MORE COMPLEX THAN IS EXPLAINED BY MODERN SCIENTIFIC KNOWLEDGES

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Abstract

The article argues that, in accordance with the corrected version of the special theory of relativity (STR), the planet Earth is much more complex than this is explained by modern scientific knowledge. The Earth is probably a three-dimensional spiral structure in four-dimensional space. You can verify this by traveling round-the-world trip by plane. Such flights make time travel into the past and into the future possible. This will allow, for example, to anticipate and prevent disasters, bring back to life people who died as a result of accidents and crimes, and also solve many other problems. However, the version of STR taught in all physics textbooks denies the feasibility of time travel for people on Earth. And therefore no one has made such journeys before.

Keywords: special theory of relativity; relativistic formulas; physical reality of imaginary numbers; Multiverses; universes and antiuniverses; anti-time; external and internal time; time zones on Earth; time travel

1. Introduction: fundamental mistake of the authors of special theory of relativity

Created the 20th century by Joseph Larmor [1], Nobel laureate Hendrik Anton Lorentz¹⁶ [2], Jules Henri Poincaré [3], Nobel laureate Albert Einstein¹⁷ [4], and other talented scientists, the special theory of relativity (STR) are rightly considered the outstanding scientific achievement of the 20th century due to their use of principle of relativism. However, at the beginning of the twentieth century, science lacked much of the knowledge necessary to create STR. Because of this, the missing knowledge had to be replaced with postulates that turned out to be partially incorrect. Therefore, this STR itself turned out to be largely incorrect [5]-[9].

And most importantly, all the relativistic formulas obtained in it turned out to be incorrect

$$m = \frac{m_0}{\sqrt{1 - (v/c)^2}} \quad (1)$$

$$\Delta t = \Delta t_0 \sqrt{1 - (v/c)^2} \quad (2)$$

$$l = l_0 \sqrt{1 - (v/c)^2} \quad (3)$$

and others, in which m_0 is the rest mass of a moving body;

m_0 is the relativistic mass of a moving body;

Δt_0 is the rest time of a moving body;

Δt is the relativistic time of a moving body;

l_0 is the rest length of a moving body;

l is the relativistic length of a moving body

The creators of STR made this fundamental mistake without understanding that the argument v in formulas (1)-(3) according to Newton's first law is the fourth¹⁸, in addition to length, width and height, spatial dimension [10]-[21]. Albert Einstein also failed to use the concept of four-dimensional space in STR. But he managed to preserve the special theory of relativity, introducing into it the principle of not exceeding the speed of light. Although, as it turned out later, this postulate turned out to be incorrect. But in the process of searching for truth in science, this is acceptable.

2. The special theory of relativity taught in physics textbooks is incorrect.

From the principle of not exceeding the speed of light, which is in fact a postulate, that this STR drew the conclusion that imaginary numbers are physically unreal. But a postulate is merely an assumption. Consequently, a conclusion drawn from a postulate is also merely an assumption, which has no evidential value. Therefore, the assertion regarding the physical unreality of imaginary numbers could simply have been called a postulate. However, the authors of the version of the STR, taught in textbooks, ignored this fact, as they needed to explain the relativistic formulas in some way. And to do so, they had to at least give the impression that the principle of not exceeding the speed of light had been proven. And since these textbooks are still used in the educational process, it follows that the goal was achieved.

Therefore, further in the article we will continue to explain that the version of STR studied in textbooks is incorrect. [22]-[54]. Let us recall that the problems of the authors of STR began from the very beginning due to their inability to explain the relativistic formulas (1)-(3) published in 1905. After all, no one would need a

¹⁶ Who received his Nobel Prize in Physics in 1902 for explaining the Zeeman effect.

¹⁷ Who received his Nobel Prize in Physics in 1921 for his services to theoretical physics and especially for his research into the photoelectric effect.

¹⁸ Not to be confused with the fourth dimension in four-dimensional space-time (Minkowski space).

theory that even its creators could not explain. And relativistic physicists have still not been able to explain these formulas, since all the quantities $m(v)$, $\Delta t(v)$, $l(v)$ in these formulas in the hyper-light range of speeds $v > c$ took on values measured by imaginary numbers incomprehensible to physicists. Therefore, as not to explain relativistic formulas in the superluminal range of speeds, the principle of the non-exceeding of the speed

of light was used in the STR.

However, yet in 1897, Charles Proteus Steinmetz published [55] a theory of linear electrical circuits of alternating current, in which the imaginary resistances $-j/\omega C$ of capacitors and $+j\omega L$ ¹⁹ of inductors were de facto recognised as physically real. This provided experimental proof of the physical reality of imaginary numbers.

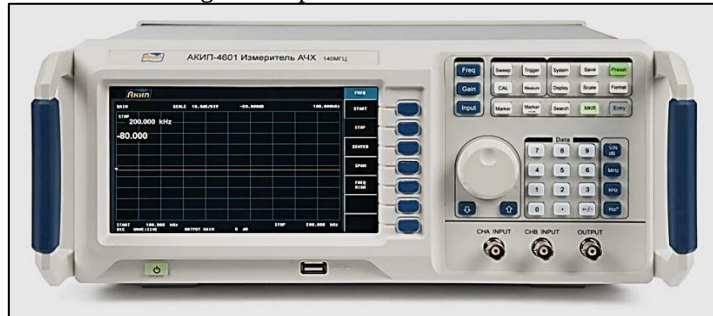


Fig. 1. In any radio engineering laboratory there are devices called frequency response meters, which already by their very existence prove the physical reality of imaginary numbers

Therefore, for more than half a century, the radio industry has been mass-producing frequency response meters²⁰ (Fig. 1), which by their very existence prove the physical reality of imaginary numbers, since you can only measure what actually physically exists. And such devices measured frequency characteristics, mathematically described using imaginary numbers.

But even if any of the relativist physicists were to learn that Charles Proteus Steinmetz had already proven the physical reality of imaginary numbers, this would not save the STR. For it turns out that the relativistic formulas are not correct, since, in the superluminal speed range $v > c$, function (1) describes a physically unstable process that cannot exist in nature. Therefore, relativistic physicists did not really need any proof of the physical reality of imaginary numbers. On the contrary, in order to refuse to explain their relativistic formulas in the hyperluminal speed range $v > c$, they needed the principle of not exceeding the speed of light. And this is precisely why proof of the physical unreality of imaginary numbers was needed. Which, however, do not exist in nature.

This is why Albert Einstein continued to work on developing available for use version of the STR. He therefore argued that there is no known physical process in nature that is described using imaginary numbers. On this basis, he introduced into STR a postulate known as the principle of the non-exceeding of the speed of light. From this, it was concluded that there was no need to explain formulas (1)–(3) in the superluminal range of velocities $v > c$. And when Cherenkov radiation [56] was discovered, refuting the claim that there is no known process in physics in which anything moves at a speed exceeding the speed of light, the STR was saved by the clarification that the principle of the

non-exceeding of the speed of light referred to processes in a vacuum.

And later, at the Large Hadron Collider (costing \$10 billion), the widely publicised OPERA [57] experiment was conducted over 15 years²¹ (between 2003 and 2018), involving over a hundred of the most eminent physics professors, the aim of which was to prove the physical reality of imaginary numbers. In 2011, the OPERA collaboration even announced the successful completion of this experiment. But six months later, at the same Large Hadron Collider, the OPERA experiment was refuted by the ICARUS experiment. This created the impression that the principle of the non-exceeding of the speed of light is irrefutable. And it is in this form that the generally accepted version of STR is now presented in all physics textbooks in all countries.

However, articles [58]–[75] have been published, including five articles in 2008–2010²² [58]–[62], containing descriptions of radio engineering experiments that successfully proved the physical reality of imaginary numbers. Moreover, these publications also contain descriptions of well-known physical processes²³ – a tsunami, the ringing of bells, music created by a piano, and even a swing swinging on the playground after a push from parents – proving the physical reality of imaginary numbers.

Thus we live not only in the visible and tangible world described by real numbers, but also in existing invisible and intangible world – one far less familiar to us – described by imaginary, complex and hypercomplex numbers.

3. A corrected version of the special theory of relativity.

3.1. Corrected relativistic equations

¹⁹ In radio engineering and electrical engineering, the imaginary unit is conventionally denoted by the letter j , as the letter i is used to denote electric current

²⁰ Also called frequency response analyzers

²¹ And for any radio engineering experiment proving the physical reality of imaginary numbers, one day is more than enough for one engineer

²² That is, even before the publication in 2011 of the message about the supposedly successful completion of the OPERA experiment

²³ Contrary to Albert Einstein's assertion that there are no processes in nature that can be described using imaginary numbers,

Since we have just have proven the physical reality of imaginary numbers in the most indisputable manner, we shall now explain formulas (1)–(3) in full. And since people tend to understand visual information better, Fig2a,b,c show the graphs of formulas (1)–(3). As can be seen, these graphs in the sub-light speed range $v < c$ differ significantly from the graphs in the hyper-light speed range $v > c$. It therefore becomes clear that the same processes cannot occur in the sub-light and hyper-light speed ranges v . And for the same processes to occur in these ranges, the graphs of formulas (1)–(3) must be identical, as shown in Fig2d,e,f. To achieve this, since the velocity v in formulas (1)–(3) is the

fourth spatial dimension, the factor²⁴ i^q must be introduced

$$m(q) = \frac{m_0 i^q}{\sqrt{1 - (v/c - q)^2}} = \frac{m_0 i^q}{\sqrt{1 - (w/c)^2}} \quad (4)$$

$$\Delta t(q) = \Delta t_0 i^q \sqrt{1 - (v/c - q)^2} = \Delta t_0 i^q \sqrt{1 - (w/c)^2} \quad (5)$$

$$l(q) = l_0 i^q \sqrt{1 - (v/c - q)^2} = l_0 i^q \sqrt{1 - (w/c)^2} \quad (6)$$

where $q(v) = [vq/c]$ – the “floor” function from discrete mathematics defined for

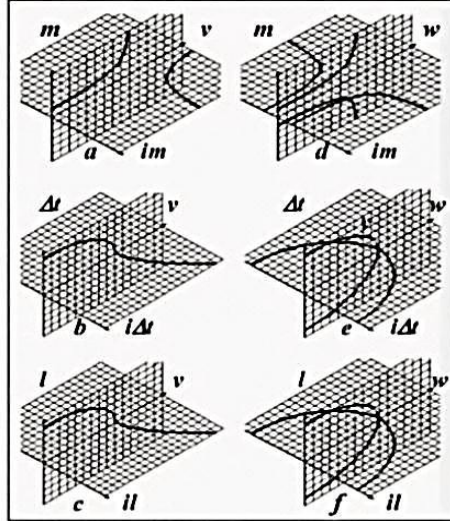


Fig. 2. Graphs of the functions $m(v)$, $\Delta t(v)$ and $l(v)$ corresponding to the existing and corrected versions of the STR in the subluminal $v < c$ and superluminal $v > c$ velocity ranges

the argument vq/c which constitutes the fourth spatial dimension;

$w = v - qc$ – the velocity that is local to all universes.

And since the fourth spatial dimension v is a vector quantity, the formulas (4)–(6) must be revised once again. To this end, three factors i^q , i^r and i^s must be introduced into formulas (4)–(6)

$$m(q, r, s) = \frac{m_0 i_1^q i_2^r i_3^s}{\sqrt{1 - [v/c - (q + r + s)]^2}} \quad (7)$$

$$\Delta t(q, r, s) = \Delta t_0 i_1^q i_2^r i_3^s \sqrt{1 - [v/c - (q + r + s)]^2} \quad (8)$$

$$l(q, r, s) = l_0 i_1^q i_2^r i_3^s \sqrt{1 - [v/c - (q + r + s)]^2} \quad (9)$$

where $q(v) = [v_q/c]$ – the “floor” function in discrete mathematics of the argument v_q/c , which

is one of the orthogonal coordinates q of the fourth spatial dimension v ;

$r(v) = [v_r/c]$ – the “floor” function of discrete mathematics of the argument v_r/c , which is the other orthogonal coordinate r of the fourth spatial dimension v ;

$s(v) = [v_s/c]$ – the “floor” function of discrete mathematics of the argument v_s/c which is yet another orthogonal coordinate s of the fourth spatial dimension v ;

v_q, v_r, v_s – projections of the velocity vector v onto the orthogonal co-ordinates q, r, s (see Fig. 3).

²⁴ In the theory of functions of a complex variable, the function i^q is defined only for integer values of the argument q . However, his definition can be extended as follows. For integer values of the argument ... -2, -1, 0, +1, +2, +3, +4, +5, ... the function i^q is equal to ... -1, -i, +1, +i, -1, -i, +1, +i, ... But for the same integer values of the argument ... -2, -1, 0, +1, +2, +3, +4, +5, ... the same values ... -1, -i, +1, +i, -1, -i, +1, +i, ... is also equal to the function $e^{iq\pi/2}$, which, in accord-

ance with Euler's formula $e^{iq\pi/2} = \cos(q\pi/2) + i\sin(q\pi/2)$, is defined also for non-integer values of the argument q . Therefore, definition of the function i^q can be extended to any values of the argument q by the formula $i^q = \cos(q\pi/2) + i\sin(q\pi/2)$, analogous to Euler's formula. The resulting formula will allow the value of the function i^q to be determined for any values of the argument q , including non-integer values. And it will be required in astro-geophysical studies of portals, which will be discussed further on.

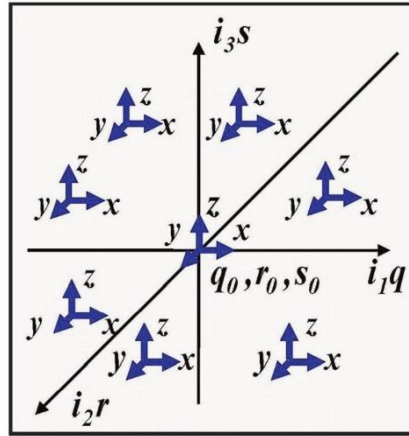


Fig.3. The six-dimensional space of the hidden Multiverse, where q, r, s are the coordinates of mutually invisible parallel universes and anti-universes, and x, y, z are the coordinates of the material content of these parallel universes and anti-universes

This formula i^q (as well as the formulas i^r and i^s) in formulas (7)–(9), which defines the nature of each universe, for integer values of the argument $q(v)$, equal to ... 0, 1, 2, 3, 4, 5, ..., successively takes the values ..., +1, +i, -1, -i, +1, +i, ... and so on. Its value²⁵ $q(v) = 0$ in formulas (7)–(9) for the sublight speed range $v < c$ corresponds (since $i^0 = 1$) to our visible universe, which we shall call, for the sake of clarity, the tardion²⁶ universe. The value $q(v) = 1$ in the superluminal speed range $2c > v > c$ corresponds (since $i^1 = i$) to some other, already invisible universe, as it lies beyond the event horizon. For the sake of clarity, we shall therefore call it the tachyon²⁷ universe. Then the value $q(v) = 2$ in the velocity range $3c > v > 2c$ will correspond (since $i^2 = -1$) to an invisible tachyon anti-universe. The value $q(v) = 3$, in the velocity range $4c > v > 3c$, will correspond (since $i^3 = -i$) to an invisible tachyon anti-universe. The value $q(v) = 4$ in the speed range $5c > v > 4c$ will correspond (since $i^4 = +1$) to another (and therefore also invisible) tardion universe. The value $q(v) = 5$ in the velocity range $6c > v > 5c$ will correspond (since $i^5 = +i$) to another tachyon universe. And so on.

Consequently, nature contains not only our visible universe—which, as stated in the generally accepted version of STR, corresponds to equations (1)–(3) but also a multitude of other mutually invisible²⁸ universes and anti-universes that correspond to equations (7)–(9). And these mutually invisible universes and anti-universes, together with our visible universe, form an invisible Multiverse [76]–[84], which we have therefore called the hidden Multiverse.

3.2. Explanation of the phenomena of dark matter and dark energy by the existence of universes and antiuniverses of the hidden Multiverse

Therefore, having explained the meaning of the basic concepts we need, it would seem time to clarify the structure of the hidden Multiverse. However, at present, no explanation of the structure of the Multiverse can be considered convincing unless it explains the

phenomena of dark matter and dark energy [85]–[90], discovered in the XX century. Which are so named because they are so obscure, as not a single chemical element has been detected in them, and also because they do not emit, absorb, reflect, or refract electromagnetic radiation and, therefore, are invisible. The persistent search for dark matter and dark energy, which account for more than 95% of all mass-energy contained in the hidden Multiverse, at the Large Hadron Collider exclusively in the microcosm of our only visible universe also seems inconsistent with common sense.

A more logical assumption is that dark matter and dark energy [85]–[90] are everything except our visible universe, mutually invisible universes and antiuniverses, the hidden Multiverse. In this case, dark matter is neighboring to our visible universe invisible universes and anti-universes, and dark energy - the remaining invisible universes and anti-universes of the hidden Multiverse. Therefore, the phenomena of dark matter and dark energy will be a gravitational shadow²⁹ on our visible universe from the remaining mutually invisible universes and antiuniverses included in the hidden Multiverse. This assumption explains all the incomprehensibility of the phenomena of dark matter and dark energy simply and clearly. That's why we will use it.

Then, assuming that over the billions of years of its existence, the mass-energy of all universes and anti-universes of the hidden Multiverse, due to the presence of a huge number of portals between them according to the law of communicating vessels, has been largely averaged, it becomes possible, using the data obtained by the WMAP and Planck spacecraft, to determine the structure of the hidden Multiverse. And according to data obtained by the WMAP spacecraft [96], the mass-energy of our visible universe (actually, our hidden Multiverse) consists of 4.6% baryonic matter, 22.4% dark matter and 73.0% dark energy. And according to more recent data obtained by the Planck spacecraft [97], the mass-energy of our visible universe (again, ac-

²⁵ If we start counting the value of q from our visible universe.

²⁶ The term "tardion universe" is borrowed from Isaac Asimov's short story "Take a Match."

²⁷ The term "tachyon universe" is borrowed from Isaac Asimov's short story "Take a Match."

²⁸ Because they are all beyond the event horizon

²⁹ And therefore, like our shadow on a sunny day, they do not contain a single chemical element..

tually, our hidden Multiverse) consists of 4.9% baryonic matter, 26.8% dark matter and 68.3% dark energy. As you can see, these data differ little from each other, which proves their truth. Therefore, it is permissible to assert that:

- our hidden Multiverse according to data obtained by the WMAP spacecraft, it consists of $100\% / 4.6\% = 21.8^{30}$ parallel universes and antiuniverses, and according to data obtained by the Planck spacecraft, it consists of $100\% / 4.9\% = 20.4$ parallel universes and antiuniverses;
- dark matter, according to experimental data obtained by the WMAP spacecraft, consists of $22.4\% / 4.6\% = 4.9$ parallel universes and antiuniverses, and according to data obtained by the Planck spacecraft, it consists of $26.8\% / 4.9\% = 5.5$ parallel universes and

antiuniverses;

- dark energy, according to experimental data obtained by the WMAP spacecraft, consists of $73.0\% / 4.6\% = 15.9$ parallel universes and antiuniverses, and according to data obtained by the Planck spacecraft, it consists of $8.3\% / 4.9\% = 13.9$ parallel universes and antiuniverses;
- and our visible universe, of course, is only one.

3.3. The structure of the hidden Multiverse

Fig. 4 shows an example, corresponding to the results of calculations of the possible structure of the hidden Multiverse. In this structure of the hidden Multiverse, the distribution of material content in each invisible universe and antiuniverse will be determined by some func-

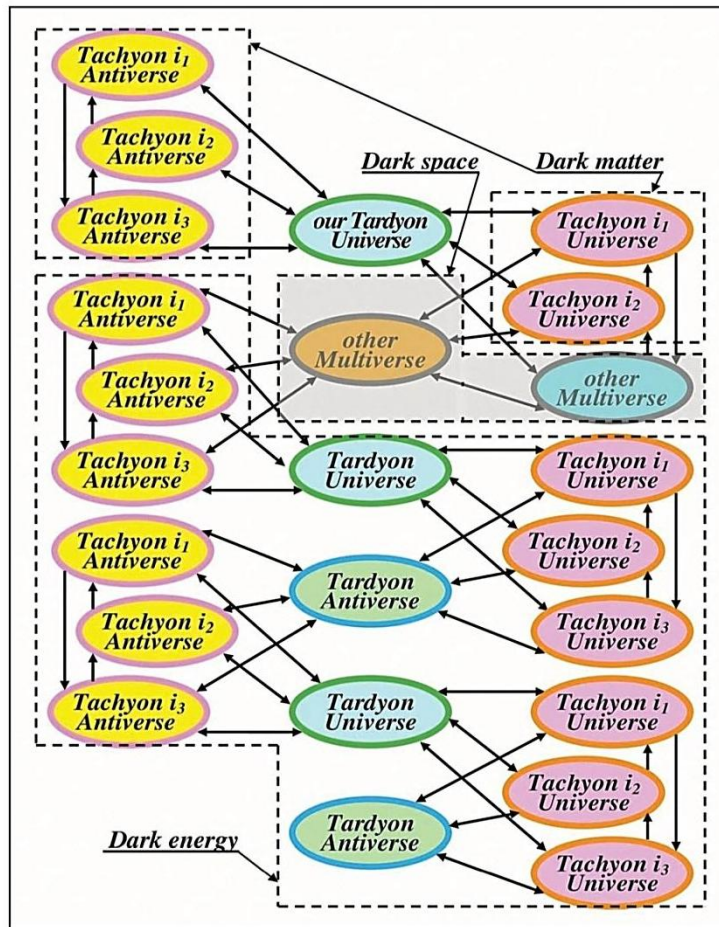


Fig. 4. An example of the structure of the hidden Multiverse, corresponding to the principle of physical reality of hypercomplex number

tion $f_{q,r,s}(x, y, z)$, and the coordinates of these universes will be determined by the quantities $i_1 q, i_1 r, i_3 s$. Those. such a hidden Multiverse will be six-dimensional and it will be described by the quaternion $f_{q,r,s}(x, y, z) + i_1 q + i_1 r + i_3 s$, in which the imaginary units i_1, i_2, i_3 are related by the relations [98]-[100]

$$i_1^2 = i_2^2 = i_3^2 = -1 \quad (10)$$

$$i_1 i_2 i_3 = i_2 i_3 i_1 = i_3 i_1 i_2 = -1 \quad (11)$$

$$i_1 i_3 i_2 = i_2 i_1 i_3 = i_3 i_2 i_1 = 1 \quad (12)$$

This is exactly what Lisa Randall predicted³¹: “We may be living in a three-dimensional pocket of higher-dimensional space.”

³⁰ Naturally, the number of universes and antiuniverses is an integer, and a non-integer number was obtained only due to experimental errors, including due to failure to take into account unknown factors influencing the result of the experiment.

³¹ Lisa Randall is a professor in the Department of Physics at Harvard University and a member of the American Academy of Arts and Sciences and also the National Academy of Sciences of the United States.

From formulas (10)-(12) it follows that such a hidden Multiverse has a helical structure, and its mutually invisible universes and antiuniverses (in addition to our visible universe) form dark matter and dark energy. In this case, it is possible to move into the tardion antiuniverse from the tardion universe and into the tardion universe from the tardion antiuniverse in various, but not arbitrary, ways, but only in such a way (see Fig. 4), in which the value of i^q will successively take the values $\dots +1, +i_1 \oplus +i_2 \oplus +i_3, -1, -i_1 \oplus -i_2 \oplus -i_3, +1, \dots$ and etc., where $\oplus$ is the symbol of the logical operation of discrete mathematics 'exclusive OR'. In this case, different trajectories of movement from one universe (or antiuniverse) to another can differ only due to the replacement of some tachyon universes from i_1, i_2, i_3 with others and some tachyon antiuniverses from i_1, i_2, i_3 with others. Consequently, tachyon universes i_1, i_2, i_3 in the hidden Multiverse are located parallel to each other. Tachyon antiuniverses i_1, i_2, i_3 are also located parallel to each other for the same reasons. And therefore, in the hidden Multiverse, when transitioning from any tardion universe to a tardion anti-universe and then to another tardion universe, parallel universes and antiverses must alternate in the following sequence - 'tardion universe', 'one of the tachyon universes', 'tardion anti-universe', 'one of the tachyon anti-universes', 'tardion universe', 'one of tachyon universes', etc.

Moreover, portals in such a structure of the Multiverse are not only bidirectional, corresponding to formula (10) and shown by two-way arrows, but also unidirectional, corresponding to formulas (11), (12) and shown by one-way arrows. And since the structure of our hidden Multiverse, as shown in Fig. 4, is open in some places, then in these places it is connected to other Multiverses through the corresponding portals. And all together they collectively form the Hyperuniverse.

3.4. How can we be convinced of the real physical existence of invisible universes and antiuniverses?

However, in science, any evidence, even the most seemingly impeccable one, can be trusted only if it is confirmed experimentally. And such experimental evidence of the existence of invisible parallel universes³² and antiuniverses shown in Fig. 4 adjacent to our visible universe can be two hundred thousand anomalous zones [101]-[104], existing on Earth, serving as entrances to portals leading to planets of various star systems. Most of the portals probably lead to astronomical objects in our universe and even in our solar system. A smaller number of portals connect us with other universes and anti-universes of the hidden Multiverse. And, perhaps, some portals even connect us with astronomical objects in other Multiverses of the Hyperverses. All these possible options in Fig. 4 are shown. The classification of anomalous zones after astro-geophysical studies of the corresponding portals will help determine where each portal leads.

And the possible distrust of the claim that anomalous zones are entrances to portals can presumably be

eliminated by astronomical observations [105]-[122] of the star sky in anomalous zones. This would require comparing on computer of maps of the starlit sky observed in anomalous zones and somewhere outside of anomalous zones. Moreover, some observatories are already in anomalous zones. For example, the Main Astronomical Observatory of the National Academy of Sciences of Ukraine, which is located 12 km from the center of its capital, Kyiv in Goloseyevo Forest. And if such differences are found, it is evidence that the corresponding portal to this anomalous zone leads to another planet in our solar system or further afield. After all, the starry sky is different for every planet.

4. Time Travel on Earth

4.1. Where are the anti-matter and the anti-time located?

And now we can explain the problem that is inexplicable in the version of STR studied in textbooks - where exist antimatter, the existence of which this version of STR does not deny. It is clear that she cannot be in our hidden Multiverse, because her annihilation with matter would make our universe no longer exist.

However, it exists. In 1995 CERN performed a sensational experiment that produced nine antihydrogen atoms lasting about 40 billionth parts of second. And just one gram of such an antihydrogen would have cost \$662.5 trillion. So the existence of antimatter has even been proven experimentally. But where does it exist then? After all, in all physics textbooks it is claimed that nature has our only visible universe. Therefore, the experiment at CERN can also be considered as proof that the version of the STR studied in textbooks is incorrect.

And in accordance with formulas (7)-(9) of the corrected version of STR, anti-matter in nature exists in the invisible tardyon and tachyon antiuniverses of the hidden Multiverse. Moreover, in these invisible tardyon and tachyon anti-universes, anti-time and anti-space [105]-[122] also exist.

4.2. Time Travel on Earth, Inner Time and Outer Time

The existence of antitime makes it possible, in accordance with formulas (8) and (9), due to travels in space, also travels in time. But since the portals, the universes and anti-universes of the hidden Multiverse, are still unexplored, time travel in space is now inaccessible to us. Therefore, further we will consider only the possibility of time travel on Earth [10]-[21]. As the presence of time zones on Earth also makes time travel possible due to space travel.

However, although official modern science admits the possibility of time travel in some exotic situations in the special³³ and general³⁴ theories of relativity, as well as in quantum physics³⁵, it still claims that time travel of people on Earth, either now or in the distant future, will never be possible.

Nevertheless, time travels by people on Earth are now already carried out by airplane flights, since, upon landing at any airport, millions of air passengers

³² I.e. such that do not intersect

³³ For example, in the "twin paradox"

³⁴ For example, in the ultra-high gravity region of a black hole's event horizon

³⁵ For example, as a result of teleportation of not information, but of physical objects.

Table 1.

Examples of business jet characteristics that can be used for time travels

Aircrafts	Maximum range	Cruising speed	Hourly rates	Seats
Citation Latitude	5 300 km	815 km/h	3 500 €/hour	8
Citation Longitude	7 400 km	910 km/h	5 000 €/hour	12
Challenger 300	5 700 km	850 km/h	4 900 €/hour	8
Challenger 350	5 926 km	850 km/h	4 000 €/hour	9
Challenger 600	5 500 km	850 km/h	4 600 €/hour	12
Challenger 3500	6 297 km	985 km/h	5 500 €/hour	10
Falcon 20	4 200 km	987 km/h	3 900 €/hour	8
Falcon 50/50EX	5 600 km	850 km/h	4 900 €/hour	8-10
Global 5500	10 927 km	900 km/h	8 000 €/hour	16
Gulfstream G150	5 200 km	850 km/h	3 900 €/hour	6-8
Gulfstream G200	5 000 km	870 km/h	6 200 €/hour	8
Hawker 850 XP	4 800 km	750 km/h	3 400 €/hour	6-8
Hawker 900XP	5 400 km	865 km/h	3 700 €/hour	6-8
Hawker 4000	5 280 km	890 km/h	5 400 €/hour	10
Learjet 70	3 815 km	967 km/h	3 500 €/hour	7
Legacy 450	5 370 km	860 km/h	3 300 €/hour	8
Praetor 600	7 400 km	850 km/h	6 000 €/hour	12

Table 2.

The value of external time at different latitudes

Location of departure and arrival airfields	Geographic coordinates of the airfield	Size of 24 time zones for a round-the-world flight	Size of one time zone.
Santiago de Chile	33,45° S.	33422 km	1393 km
Buenos Aires	34,60° S.	33021 km	1375 km
Melbourne	37,82° S.	31339 km	1306 km
New York City	40,72° N.	30456 km	1269 km
Reykjavík	64,15° N.	17616 km	734 km
Murmansk	69,58° N.	14424 km	601 km
Kirkenes	69,73° N.	14376 km	599 km
Longyearbyen (Spitsbergen, Norway)	78,13° N.	8184 km	341 km
Alert, (Canada)	82,5° N.	5230 km	218 km

always change their watches to a local time other than time at the airport of departure. Thus confirming time travel. And refuting the erroneous statements of the incorrect version of STR studied in textbooks.

And when explaining time travels on Earth, it is necessary to take into account the existence in nature, in addition to internal time, which we always use, also of external time, which we have never used before. And which are generated by different circumstances and have different peculiarities. Internal time can be called

biological human time, since one second is one contraction of the human heart. And it cannot flow backwards. A person cannot return to his youth. But external time is generated by the rotation of the Earth around its axis. One revolution of the Earth is 24 time zones. Therefore, by changing the direction of our movement in space, we can move both into the past and into the future external time. Consequently, time travel is always movement only in external time.



Fig. 5. One of the business jets

Time travels can be very useful, since traveling into the future will allow, for example, to recognize and avoid unforeseen disasters, accidents, natural disasters, etc. in advance. And traveling to the past will allow the same situations in the present to be corrected by visiting the past. Even, for example, to bring back to life people

who died as a result of an accident, a terrorist attack³⁶ or for other reasons [141]-[151].

And although time travel on Earth is not currently used due to the fact that it always occurs together with long-distance travel, this problem is completely solvable. To do this, the aircraft must make a round-the-world trip around the north or south pole and land after 24 hours of outside time at the same airfield from which the journey began. Thus eliminating the unnecessary factor of space in time travel.

And there are many aircraft models suitable for use in time travel. They are called business jets³⁷ (see Fig. 5). There are currently 22,000-24,000 business jets in operation on Earth. Table 1 shows the flight performance characteristics of some business jets. And Table 2 shows airfields quite close to the North Pole³⁸ that can provide the shortest routes for round-the-world flights.

Moreover, time travel can be accomplished not only on airplanes. Time travel on airplanes is only needed if a person needs to travel to the past or future. And if it is necessary to transmit information to the past or future, then radio communications can be used, like airplane flights, using round-the-world communication lines³⁹

4.3. The structure of planet Earth differs significantly from the structure corresponding to modern scientific knowledge

Thus, time travel on Earth is physically possible and currently appears to be technically feasible [152]-[162], since suitable aircraft and acceptable flight routes exist. However, neither they nor other aircraft ever made the round-the-world flights we needed, because there was no need for them. Indeed, any airfield farthest from the airfield from which the plane took off is located where the antipodes live, i.e. at a diametrically opposite point on Earth. And this is only half of a trip around the world. The distance to other airfields is shorter. Therefore, the possibility of a round-the-world flight still needs to be confirmed by actually carrying out such a flight.

As we cannot make such a flight, let's take a round-the-world air trip in our minds. Let's start with the initial situation, i.e. from a completely understandable trip around the world, during which two identical planes will simultaneously take off from the same airfield in two opposite directions - one to the west, the other to the east. If they fly at the same speed, then, provided that the Earth does not rotate, everything will be clear. They will arrive at the same airfield from which they departed at the same time. But if we take into account that the Earth rotates, then these planes will not arrive at their airfields at the same time. One of them will fly through

$$T_1 = 2\pi R / (V + \Delta V) \text{ hours,} \quad (13)$$

and the other through

$$T_2 = 2\pi R / (V - \Delta V) \text{ hours,} \quad (14)$$

where R is the radius of the circle on the Earth's surface at the latitude at which airplanes will fly in a swarm;

V – aircraft flight speed relative to the stationary Earth;

ΔV is an increase or decrease in the flight speed of aircraft relative to the surface of the Earth due to its rotation around its axis.

From formulas (13) and (14) it follows

$$(T_2 - T_1) = 4\pi R \Delta V / (V^2 - \Delta V^2) \quad (15)$$

Consequently, both planes will be able to arrive at the same airfield from which they departed simultaneously only if $\Delta V = 0$, i.e. when the Earth does not rotate around its axis. And since the Earth always rotates, the planes in the experiment under consideration will inevitably arrive at their airfields in the same internal time, but at different external times. Those, to different spaces. And not to the airfield from which the planes took off. All three of these airfields will be different. Moreover, all these airfields and the settlements surrounding them are inhabited. All these airfields and near them will have their own life, repeating our life in the very recent past and future. And all these airfields, settlements and everything else exist, regardless of whether you flew into them or not. Therefore, when you fly into the past or future, you will be able to meet yourself.

But such flights to twin airfields will allow for quasi-round-the-world flights, providing time travel, since these airfields differ slightly.

So where are they located? Naturally, on the same Earth as you and me. Only the Earth, it turns out, is not structured like a globe, as we always assumed. A is a three-dimensional (i.e., volumetric) spiral-shaped structure. Using most likely the same fourth spatial dimension that was mentioned at the beginning of the article. But in order to fully know and understand all this, serious scientific research will naturally be needed. But to fully know and understand all this will require serious scientific research.

5. Conclusion

Thus, the actually existing physical world is largely turned out to be different from the way it is explained in the version of STR studied in physics textbooks. But although over the past hundred years since the creation of this STR, much has been demonstrably refuted, the content of the sections of physics textbooks that present it has not essentially changed.

And main difference STR from classical physics is its use of the ingenious principle of relativism. But all the relativistic formulas obtained in this STR using the principle of relativism turned out to be incorrect. And even the creators of this theory themselves could not explain them. Moreover, these formulas were not explained until very recently, since their explanation given in textbooks using an incorrect postulate, called

³⁶ Perhaps President Kennedy could have been saved in a similar way after the assassination attempt.

³⁷ A business jet is a small private jet aircraft for transporting a limited number of passengers (usually from 6 to 20) on an individual order for businessmen, officials and VIPs; it is characterized by a higher level of comfort, the ability to take

off/land from small airfields and high speed, allowing you to quickly get to anywhere in the world

³⁸ Since the existing airfields are further from the south pole. But, probably, such airfields can be created in Antarctica.

³⁹ But also with its transmission around the north or south pole.

the principle of not exceeding the speed of light, is incorrect.

Therefore, Albert Einstein, in his version of STR, in order to make it explainable, had to prove not physical reality, but, on the contrary, the physical unreality of imaginary numbers. And for this it was necessary that this physical unreality of imaginary numbers should follow from something indisputably true. And as such an initial supposedly indisputably true truth, a postulate was used, called the principle of not exceeding the speed of light.

But when creating and using such a chain of reasoning, the fact was ignored that Charles Proteus Steinmetz back in 1897⁴⁰, in his proposed interpretation of Ohm's law, had essentially already proven the physical reality of imaginary numbers. And since then, radio engineers have never had the slightest reason to doubt its truth, since when the frequency of a sinusoidal voltage applied to any electrical LCR circuit changes, the amount of current flowing through it always changes. This fact, which occurs in the practical activities of radio engineers literally at every step, is an extremely simple, absolutely understandable and irrefutable proof of the physical reality of imaginary numbers.

Albert Einstein also ignored the fact that the physical reality of imaginary numbers is also proven by the existence of processes known to everyone in nature - tsunamis, Indian summers, bell ringing, music created by a piano, and even swings swinging on the playground after a push from parents - described using imaginary numbers.

Nevertheless, Albert Einstein still needed to somehow doubt this in his proposed version of STR. Otherwise, it would be necessary to admit that the creators of this version of STR are unable to explain the obtained relativistic formulas in the hyperluminal speed range $v > c$. And then this theory, which even its creators could not explain, would naturally be of no use to anyone. That is why a postulate, was introduced into the STR, called the principle of not exceeding the speed of light, from which a conclusion was made about the physical unreality of imaginary numbers, which was not confirmed by any experiments. This made it possible not to explain relativistic formulas in the hyperluminal speed range $v > c$. Therefore, despite the fact that Albert Einstein was nominated for the Nobel Prize 66 times for the creation of STR, due to the lack of any experimental evidence of its truth, he never received it for his version of this theory.

In order to prove the denial of the physical reality of imaginary numbers in the incorrect version of special relativity, relativistic physicists had to undertake enormous and costly efforts. In particular, to create at least illusion of the impossibility of refuting the STR's assertion of the physical unreality of imaginary numbers, on the Great Hadron Collider (worth ten billion dollars) a collaboration OPERA, which included more than one hundred of the most authoritative professors-physicists, for almost 15 years (2003-2018) was the unsuccessful physical experiment OPERA, which aimed to prove the physical reality of imaginary numbers but failed to do

so. And thereby supposedly proved the impossibility of refuting the assertion about the physical unreality of imaginary numbers. In 2011, it was even announced that the OPERA experiment had been sensationally successful, but then half a year later in 2012, the OPERA experiment was refuted by another ICARUS experiment on the same Large Hadron Collider

Therefore, physicists are still ignoring publications that cite simple and comprehensible radio-technical experiments successfully proving the physical reality of imaginary numbers and explaining that if the imaginary numbers were, as claimed in the incorrect version of STR, physically unrealistic, there should be no radio nor computer technics.

Moreover, because of the assertion of the physical unreality of imaginary numbers and thus of the existence in nature of our only visible universe, it has become apparent that there was no place for antimatter and tachyons in this only visible universe. Although their existence in nature was not denied. And where they are located is explained only by the corrected version of the open source software.

It also transpired that, because of the assertion of the physical unreality of imaginary numbers and therefore of the existence in nature of our only visible universe, the phenomena of dark matter and dark energy had never been and would never be explained, because the dark matter and dark energy are, according to the corrected version of the STR, all reciprocally invisible universes and antiuniverses existing outside our visible universe in the hidden Multiverse.

More than 200,000 anomalous zones have been discovered on Earth, which are entrances of portals to the planets of not only our Solar System, but also other star systems in the hidden Multiverse and even in the Hyperverses. And it also proves the existence of other universes and antiuniverses. Moreover, in the existence of these invisible outside the portals of universes can be ascertained by astronomical observations of the star sky in portals. But these low-cost astronomical observations, which would allow for sensational scientific discoveries of other universes and anti-stellar ones, are still not being made, probably because of the fear that invisible neighboring universes and antuniverses ones will be discovered. And then the version of the STR studied in textbooks on physics would have to be undeniably disbelieved.

The version of STR taught in physics textbooks also leads to the conclusion that time travel is impossible for humans. Although, in fact, millions of air passengers already make such time travel every day, as evidenced by the fact that passengers of planes reset their clocks to local time after landing. However, since such time travel by air passengers occurs simultaneously with long distances travel, it is currently not used. The article explains how, through quasi-round-the-world flights, time travel may become physically and technically feasible.

Less-expensive radiotelephone time travel is also possible, and once it's in demand, it could be implemented quickly and inexpensively. This would make it

⁴⁰ That is, before the creation in 1905 of the version of STR that is now studied in all physics textbooks

possible to communicate and exchange information with people (including oneself) in the past or future relative to our own time.

And, finally, among other things, such quasi-round-the-world time travel will prove that our Earth is much more complex than is explained by modern science. It is probably a three-dimensional spiral structure⁴¹ in four-dimensional space, the existence of which follows from Newton's first law.

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⁴¹ A one-dimensional spiral is, for example, the well-known Archimedes spiral. A two-dimensional spiral of Archimedes is a medical bandage or medical plaster in three-dimensional

space. And our Earth is a three-dimensional Archimedes spiral made in a similar way in four-dimensional space, the existence of which follows from Newton's first law.

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ON THE TEMPERATURE AND NATURE OF HEAT TRANSFERS IN RADIATIVE HEAT TRANSFER

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Abstract

This paper examines the nature of temperature and heat transfer during radiative heat exchange and proposes an alternative interpretation of thermal phenomena. The authors review the historical development of theories of heat, from caloric theory to wave and molecular-kinetic approaches, and argue for reconsideration of several fundamental concepts related to temperature and heat. Based on the proposed model of matter as a self-contained rotating spherical vortex (“atom-vortex”), the paper suggests that temperature is determined by the rotational state of matter and that heat transfer is associated with photons interpreted as carriers of heat and mass transfer. A relationship between emitted heat, temperature, and rotational motion is proposed, and radiative heat transfer is interpreted within this framework. The authors conclude that the presented results motivate a revision of conventional views in thermodynamics and heat-transfer theory.

Keywords: temperature; heat; heat transfer; radiative heat exchange; thermal radiation; photon; caloric theory; molecular-kinetic theory; atom-vortex model; thermodynamics; electromagnetic radiation; heat–mass transfer

In modern physics, there is still no unified understanding either of the nature of temperature T or of the nature of heat Q [1–3]. A correct understanding of the nature of heat is of fundamental importance, since the correct understanding of a large branch of physics depends on it. The material theory of heat that existed until the middle of the 19th century viewed heat as the motion of a certain substance in the form of “imperceptible particles” — corpuscles much finer than air and moving rapidly through space, whose propagation was considered identical to the rectilinear propagation of light [4]. Based on this theory, measuring instruments were developed that made it possible to begin quantitative (calorimetric) studies of thermal phenomena (J. Black, 1762). This theory was later discarded and replaced by wave and molecular-kinetic theories of the nature of heat.

The foundations of the science of temperature were laid by the work of M. V. Lomonosov [5] two and a half centuries ago. Nevertheless, these ideas have still not been considered by mainstream science, accepted officially, or developed further.

In the present work, from the standpoint of the model proposed by the authors - according to which the fundamental form of existence of a liquid homogeneous substance is a self-contained rotating spherical vortex [6–7] - several basic concepts concerning the nature of temperature and heat are reconsidered.

For several centuries, there was a struggle between two hypotheses concerning the nature of heat: the **material** and the **kinetic** theories. The material theory of heat regarded heat as a form of motion of “imperceptible particles” — the motion of corpuscles of a certain substance.

This theory was developed by F. Bacon (1561–1626), P. Gassendi (1592–1655), R. Descartes (1596–1650), R. Boyle (1627–1691), R. Hooke (1635–1703), E. Mariotte (1620–1684), J. Locke (1632–1704), I. Newton (1643–1727), N. Lémery (1645–1715), C. Wolff (1679–1765), H. Boerhaave (1668–1738), G.

Hamberger (1697–1755), P. Musschenbroek (1692–1761), and L. Euler (1707–1783).

Quantitative studies of caloric (heat substance) were carried out by G. W. Krafft (1701–1754), G. W. Richmann (1711–1753), J. Black (1728–1799), I. Wilcke (1732–1796), L. de Morveau (1737–1816), A. Lavoisier (1743–1793), C. L. Berthollet (1748–1822), P. S. Laplace (1749–1827), A. F. de Fourcroy (1755–1809), J. B. J. Fourier (1768–1830), P. L. Dulong (1785–1838), A. Petit (1791–1820), N. L. S. Carnot (1796–1832), and B. P. E. Clapeyron (1799–1864).

Their work led to the establishment, by the 1770s, of the basic calorimetric concepts: the unit for measuring the quantity of heat (the calorie introduced by Wilcke), heat capacity, specific heat capacity, and the heat of fusion and vaporization. The English chemist Joseph Black was the first, in 1754–1755, to clearly distinguish between the concepts of **quantity of heat** and **temperature**, defining temperature as an indicator of the degree of heating measured by a thermometer. To relate these concepts, he introduced the concept of **specific heat capacity** (1760): the amount of heat required to raise the temperature of a unit mass of a substance by one degree. Heat capacity differed from one substance to another. It turned out to be a characteristic property of matter rather than of heat itself. Black discovered not only that the melting point of ice remains constant, but also that thermometer readings stay unchanged at one and the same temperature despite the input of heat, until all the ice has melted. From this, he arrived at the concept of **latent heat of fusion**. Using the calorimeter he invented in 1762, Black carried out, during 1759–1763, the first measurements of the heat capacities of substances and of the latent heat of fusion of ice and the evaporation of water.

In 1787, the French chemists Claude Louis Berthollet (1748–1822), L. Guyton de Morveau (1737–1816), A. Lavoisier, and A. Fourcroy proposed a special name for the unit of measurement of the quantity of heat -**calorique** (“caloric,” or heat substance).

Only almost one hundred years later (in 1852) was the unit of quantity of heat legalized and later given the name **calorie**. However, the state of physical experimentation at that time did not make it possible to determine what kind of substance it actually was.

The period from the end of the 18th century to the beginning of the 19th century was enriched by other important discoveries, whose true significance, according to the authors, has still not been fully appreciated. It was during this period that the doctrine of “**radiant heat**” began to take shape. The term “radiant heat” and the first observations of heat rays belong to the Swedish chemist **C. W. Scheele** (1742–1786), who, in his *Chemical Treatise on Air and Fire* (1777), along with reporting the discovery of oxygen, also discussed heat rays. He introduced the concept of **thermal radiation** (“radiant heat”) and investigated thermal radiation. Scheele pointed out that air is not heated by heat rays and that a glass mirror does not reflect heat rays. In doing so, he confirmed an earlier observation by **Lambert** that glass blocks heat rays. The beginning and middle of the 19th century were also marked by other landmark discoveries in physics which, if correctly interpreted, could have directed the development of physics in a completely different direction.

The beginning and middle of the 19th century were also marked by the appearance of other landmark discoveries in physics which, if interpreted correctly, could have redirected the development of physics along an entirely different path.

First, important manifestations of the interrelation of thermal phenomena with other phenomena were discovered - primarily their relationship with light. The connection between light and heat had long been noted. These questions were studied by **G. B. della Porta** (1582–1666), **P. del Buono** (1625–1659), **E. Mariotte** (1620–1684), **J. G. Schultze** (1687–1744), and **P. Bouguer** (1698–1758). In 1777, **J. Lambert** (1728–1777) conducted experiments on the propagation of heat along a rod and demonstrated that “**heat rays**,” like light rays, propagate in straight lines and that their intensity changes inversely with the square of the distance. **M. van Marum** (1750–1837), in 1786, established a connection between heat and the electric spark. **M. A. Pictet** (1752–1825) carried out the first more complete investigations of the properties of thermal radiation (1790). **P. Prevost** (1751–1839), based on Pictet’s experiments, proposed his theory of the “equilibrium of fire” - thermal equilibrium. **W. Nicholson** (1753–1815), in 1802, discovered the luminous effect of electric current. **A. F. de Fourcroy** (1755–1809), in 1800, discovered the heating effect of electric current. **F. W. Herschel** (1738–1822), in 1800, discovered infrared rays in the solar spectrum. **V. V. Petrov** (1761–1834), in 1802, discovered the electric arc and carried out a series of experiments using it to melt metals and burn various substances. **J. Ritter** (1776–1810), in 1801, established that silver chloride blackens under the action of radiation belonging to the invisible part of the spectrum — later recognized as the discovery of ultraviolet rays. **J. Leslie** (1766–1832) obtained relative values for the emissive power of various bodies (with

respect to soot) and, in 1804, demonstrated that radiation depends on direction. **H. C. Ørsted** (1777–1851), in 1820, discovered the magnetic effect of electric current (revealing the vortex state of matter). **K. Matteucci** (1811–1868), in 1833, showed that heat rays interfere with one another. **J. D. Forbes** (1809–1868), in 1833, confirmed the interference of heat rays using an apparatus with two Fresnel mirrors and, in 1834, observed the polarization of thermal radiation. **J. C. A. Peltier** (1785–1845), in 1834, discovered the phenomenon of heat release or absorption during the passage of electric current. **M. Melloni** (1798–1854), in 1833, constructed a thermomultiplier; in 1835, he proposed that heat rays and light rays have the same nature and differ only in wavelength; in 1836, he confirmed the existence of polarization of thermal radiation; and in 1841, demonstrated the identity of thermal and light rays.

In 1841, **J. P. Joule** (1818–1889) established the law of the heating effect of electric current, and in 1843 carried out the first measurement of the mechanical equivalent of heat. In 1842, the law of the heating effect of electric current was also discovered by **E. H. Lenz**. **J. R. von Mayer** (1814–1878), in 1842, was the first to formulate the law of equivalence between mechanical work and heat and calculated the mechanical equivalent of heat. Independently of him, J. Joule reached the same discovery in 1843, and in 1847 **H. Helmholtz** expanded the scope of this law, extending its application beyond mechanical and thermal energy to include other forms of energy.

However, the scientific community reacted in a particular way to the results of M. Melloni’s work on radiant heat. By that time, the corpuscular theory of light, whose origins had been laid by the founder of optics - the Arab scholar **Ibn al-Haytham** (Latinized: **Alhazen**) (965–1039) - had been replaced by the wave theory of Young and Fresnel. Supporters of the wave theory of light believed that light consisted of oscillations of the ether. The wave theory of light had already become almost universally accepted; therefore, the complete identity of thermal rays and light rays was interpreted as proof of the **wave nature of heat**. On this basis, all thermal effects were explained, and at the same time the **caloric theory** (the concept of heat as a substance) was abandoned.

Thus, the concept of the existence of a material (substantial) medium composed of corpuscles - “*imperceptible particles*”, much finer than air and moving rapidly, accompanying light and propagating in straight lines similarly to light - on the basis of which measuring instruments were created that made it possible to begin quantitative (calorimetric) studies of thermal phenomena, was abandoned and replaced by the concept of the **kinetic nature of heat**, i.e., the **molecular-kinetic theory of J. Bernoulli**, whose development he began in 1738 (Section X [8]). It was this theory that formed the foundation of the modern understanding of the nature of heat.

However, neither the wave theory nor the molecular-kinetic theory of heat is capable of explaining:

- a) the physical nature of temperature;
- b) the physical nature of heat;

c) the rectilinear propagation of radiant heat — its principal property;

d) the ability of heat to propagate through a vacuum.

Earlier, in our works [6–7, 9], we showed that any charge Q - gravitational, electrostatic, or magnetic - as a carrier of interaction consists of flows of substance emitted by a body, i.e., vortex-like stream structures composed of flows of isolated convective cells - photons of a specific wavelength - carrying the mass inherent to them and the corresponding quanta of action.

The existence of an identity between light rays and thermal rays, established by **Melloni** in 1835–1842, allows one to assert that the carrier involved in thermal interactions is caloric - responsible for heat transfer and measurable by calorimetric methods - which, according to the authors, was unjustifiably discarded in the middle of the 19th century and replaced by Schrödinger's wave function in 1926. It is precisely this “caloric”, which provides heat and mass transfer during radiative heat exchange across different regions of the electromagnetic spectrum, that is considered to be a photon moving in a straight line and which, according to modern views, is regarded as massless.

Let us return to the law of the heating effect of electric current established by **J. Joule** in 1841 and confirmed by **E. H. Lenz** in 1842. This law states that the quantity of heat Q released during the passage of a current J through a conductor with resistance R over a time interval t is:

$$Q = J^2 R t \quad (1)$$

Let us express the current $J = Q/t$ and the resistance $R = U/J$ in equation (1) through the quantity of charge found by us in [6]:

$$Q = \sqrt{m v_m^2 r_m} \quad (2)$$

where m is the mass of the substance of a liquid rotating spherical atom-vortex, v_m is the speed of azimuthal rotation around its own axis, r_m is the radius of the atom-vortex. Substitution gives:

$$Q = \varphi \cdot m v_m^2, \quad (3)$$

where

$$\varphi = c/v_R, \quad (4)$$

here the dimensionless factor φ characterizes the degree of excitation of the radiating medium and c is the speed of light, v_R is the speed of current propagation through a conductor with resistance R .

The resulting expression (3) represents the law of radiation of heat from an atom-vortex. From it, it follows that the quantity of heat released Q is directly proportional to the square of the azimuthal rotation speed around the atom-vortex axis, i.e., proportional to twice the kinetic energy of rotation of the vortex forming the atom. According to the authors, this demonstrates how correct **M. V. Lomonosov's** assertion was that the release of heat is connected with the rotational motion of individual “imperceptible particles” - atoms forming matter. Dividing in expression (3) the product of mass by the square of the azimuthal velocity by the **Boltzmann constant** k , one can directly proceed to determining the temperature of the atom-vortex in degrees:

$$T = m v_m^2 / k. \quad (5)$$

It should also be noted that already at that time M. V. Lomonosov stated: “There must exist a greatest and final degree of cold, which should consist in the complete cessation of the rotational motion of particles” [10]. Applying this thesis to the formulas obtained above (3–5) shows that, in the absence of rotational motion of an atom or of a larger body, radiation also ceases, i.e., the atom or body becomes cold, neutral, non-interacting - that is, “dark.”

Table 1.

Mass Values of Photons of Different Wavelengths

Radiation type	Symbol	Mass	Wavelength, λ	Frequency ν	Class
γ -radiation	γ	10^{-27} g	$\sim 10^{-11}$ cm	$\sim 10^{21}$ s $^{-1}$	Photons
X-ray radiation	γ_{ret}	10^{-30} g	$\sim 10^{-8}$ cm	$\sim 10^{18}$ s $^{-1}$	
Ultraviolet rad.	γ_{uv}	10^{-32} g	$\sim 10^{-6}$ cm	$\sim 10^{16}$ s $^{-1}$	
Visible light	γ_v	10^{-33} g	$\sim 10^{-5}$ cm	$\sim 10^{15}$ s $^{-1}$	
Infrared radiation	γ_{if}	10^{-35} g	$\sim 10^{-3}$ cm	$\sim 10^{13}$ s $^{-1}$	
Radio radiation	γ_{rad}	10^{-37} g	$\sim 10^{-1}$ cm	$\sim 10^{11}$ s $^{-1}$	
Relic radiation	γ_{rel}	$10^{-40} \div 10^{-43}$ g	$\sim 10^2 \div 10^5$ cm	$\sim 10^8 \div 10^5$ s $^{-1}$	

The identity of thermal and light rays, established by the works of **M. Melloni** in 1835–1842, makes it possible to consider that heat-mass transfer is carried out by caloric particles — photons of different wavelengths. *This makes it possible to calculate the number of photons involved in heat transfer.* Since the energy carried by a photon of a given wavelength is determined by

$$E_{\phi\lambda} = m_{\phi\lambda} c^2,$$

the number of photons carrying it will be equal to

$$N_{\phi\lambda} = Q/E_{\phi\lambda}.$$

The total amount of emitted heat over all wavelengths is determined by the equation:

$$Q = \sum_{\lambda} Q_{\lambda} = N_{\phi\lambda} \cdot m_{\phi\lambda} \cdot c^2 \quad (6)$$

Using Planck's constant $h = m c \lambda$ one can calculate the mass of a photon of any wavelength. The results of these calculations are presented in Table 1.

It follows from Table 1 that, as temperature decreases and the radiation shifts from the ultraviolet to the infrared region, the mass of the emitted photon also decreases. The smallest photon mass corresponding to relic (background) radiation is not relic radiation left over from the Big Bang, but rather indicates that this

radiation originates from extremely weakly heated bodies.

The mechanism of radiation emission by matter from a rotating vortex was considered earlier by us in works [6–7]; therefore, due to the limited scope of this article, it is not discussed here. Thus, all of the above allows the following conclusions to be drawn:

- Heat–mass transfer is carried out by caloric particles — photons of different wavelengths.
- A direct relationship has been established between the amount of heat released Q , and consequently the temperature T , and the speed of the azimuthal self-rotation about its own axis of the radiating substance - atom-vortices - which, according to the authors, confirms the material nature of heat.
- Temperature T is an energetic criterion of the rotational (rotation about its own axis) state of individual masses of matter [9].
- A non-rotating mass is cold -neutral, does not radiate and, consequently, neither emits nor interacts; that is, such a mass is “dark.”

The obtained results require a revision of the principles of modern heat physics and thermodynamics in which heat participates.

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SOCIAL SCIENCES

ACCESSIBILITY CHALLENGES AND INTERVENTION MODELS IN SOCIAL WORK WITH PERSONS WITH PHYSICAL DISABILITIES

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Abstract

Disability is one or more impairments a person possesses at birth or later in life. People might face disability at any stage of life, and it could impact their social life tremendously. In this analysis, the research was conducted with 15 disabled individuals employing the in-depth interview methodology within the framework of qualitative methodology in Baku (Azerbaijan), and they were suggested solutions that they preferred for their predicaments.

Due to this research, accessibility problems of disabled people over fifty were investigated. The outcomes of this assessment can be utilized in governmental and non-governmental organizations when developing intervention models. Additionally, these abilities impact the formation of social workers' approach methods to this process. Concomitantly, this research is valuable for the literature regarding disabled individuals.

Keywords: disability; physical impediment; accessibility problems; Azerbaijan; in-depth interview method

Introduction

Every individual is in possession of equal rights with others in either social or physical life. However, there are some disadvantageous groups that cannot leverage it. One of those groups is individuals with physical impediments. It is claimed that 12 percent of the world's population consists of disabled people, meaning that there are over 1 billion disabled people. It is known that 93 million are children and 720 million are adults (WHO, 2020). According to the information provided by the statistical information system of people with international disabilities, of the 2.511.950 people with physical impediments living in the world, 1.414.643 are males and 1.097.307 are females (ASHEYHGM, 2021).

Throughout the history, the acceptance of disabled people has been a challenge. This situation hampers the living standards of physically disabled individuals, causing hardship as a result. It was once restricted to having their social surroundings and even a family and child (Lipson

and Regers, 2000, 73-74). Along with the social problems, psychological adversities also rise. Therefore, disabled individuals are compelled to face psychosocial issues (Aykurt, 2020, 428).

At a certain point in life, people irrefutably experience disability. This happening occurs either in their own or acquaintances' lives (Abdullayev, 2023). Disability varies depending on the source and cause. Those

are divided into three sections: before birth, during birth, and after birth. The reasons for before birth; drug usage, parents being relatives, illnesses during pregnancy, genetic reasons, the alcohol or drug addiction of a mother, the traumas gained during pregnancy, stress, diet, and unhealthy diet might be the cause. The reasons during birth; births that do not occur under normal conditions, traumas, incorrect practices, etc. can be the factor. The causes after birth may be accidents occurring in work settings, traffic accidents, household incidents, earthquakes, terrorism, wars, industrial accidents, etc (Koca, 2010).

It is observed that the obstacles that physically disabled people encounter are overcome by time. Currently, we can see that individuals with physical impediments possess opinion articulation of freedom in international and national policies and are represented in many areas of society (WHO, 2011). Nevertheless, this does not confirm that problems are fully alleviated. Still predicaments such as being outcasted by certain groups, not being endorsed by family and social surroundings, not considering disabled individuals in city planning, lack of sufficient knowledge of employees working in the service and transportation sectors, insufficiency of economic support, limitations in academic life, problems in bilateral relations due to disability are experienced (Jensen ve Karoly, 2008).

Another handicap that obstructs the life quality of disabled people is the accessibility issue. Resources and

services should be available for every individual. Absence of this condition leads to the discrepancy, and it is related to the previously mentioned setting (Duranton and Guerra, 2016: 18). In the Modern Age, accessibility barriers are prevalent in urban areas where a high concentration of people exist. One of the core challenges in urban design is the fact that there are confined or no layouts suitable for people with disabilities (Evans, 2009). Disabled individuals face such hurdles every day. Thus, the prioritization of the resolutions for the highlighted problems is of a great essence.

The Objective of the Research and Analysis Reasons

The greatest handicap experienced by disabled people in the process of adaptation to society lies in their competency to move freely in social life. If an individual encounters physical barrier in his or her surroundings, these questions the full participation in the environment. In conjunction with the physical reasons, psycho-social causes are led as a result, which contributes to the disadaptation of an individual positively. While investigating those adversities, we can observe that infrastructure issues are hurdles that have been faced since the past and still remain one. Subsequently, it maintains the relevance of the matter and leads to research in this field.

The infrastructure problems of individuals dwelling in Azerbaijan are at a severe level. The sparse of audible traffic lights, the lack of lanes for wheelchairs on the roads, the absence of rules to ensure the movements of disabled people on buses and subways, and the presence of written signs for people with hearing disabilities mainly in the center of the city, and other predicaments make this study relevant in Azerbaijan. Unfortunately, there is no empirically based answer to some of the inquiries that arise in such an environment. For instance, how does a disabled person navigate? What would they want to have access to? The answers to these questions may seem obvious at first sight. However, the empirical proofs are required to be certain. The goal of this study, therefore, is to investigate the issues related to infrastructure experienced by people with physical disabilities and formulate solutions. The major element in identifying resolutions to a hindrance is that researching the problem through individuals experiencing it will assist us in uncovering more optimal and accurate approaches.

One of the major factors that augment the worth of ongoing research is that we cover a country that has bounded empirical information in the relevant literature. A few minutes of searching in scientific databases posits that no article on the indicated topic has been issued in Azerbaijan implementing the methodology for the current study. In an article that is relatively pertinent to our topic, the stress levels of individuals with impairments in 9 CIS countries were quantitatively examined (Stickley et al., 2021). Therefore, the study with a distinct objective does not provide the information that current research can offer. Furthermore, the outputs of our study may be constructive for those researching MDB settings as well as scholars studying disability concerns in this geographical area.

Previous Research

The infrastructure issues confronted by people with disabilities have been the subject of research worldwide for a lengthy period. Likewise, a boost of interest in this matter is observed in Azerbaijan. By implementing quantitative research methodology regarding the infrastructure of disabled people, Musasoy (2022) conducted a survey. In a survey conducted among the population, more than 60% of individuals with disabilities reported that they encounter adversities with infrastructure. The magnitude of addressing these challenges is underscored. Unlike the present research, his study did not specifically provide resolutions; it simply identified and presented the predicament. The investigation of a problem is as essential as the determination of its solutions. Therefore, resolving the adversity is not adequate. The innovation of strategies to resolve the issues is also required.

If we consider the global scale, the infrastructure barriers encountered by disabled individuals are studied in more than one state of America by Eisenberg et al. (2022). This study examined cities with infrastructure for people with disabilities utilizing special air transport and cities with unsatisfactory infrastructure. As a result, no difference was discovered among the cities. In the current study, the interviews were conducted with disabled individuals, and the impact of infrastructure problems on them was investigated simultaneously, unlike the former research.

Danso et al. (2019) examined the handicaps experienced by people with visual impairments in infrastructure. The challenges at transport hubs and in the metro were discussed. In this study, questionnaires were administered to 4 respondents, including metropolitan employees and engineers. This study was conducted in the Kumasi metropolitan region in Ghana. In contrast to the present study, it is evident that it solely investigated infrastructure concerns occurring in the metropolitan area. Meanwhile, merely 4 people, consisting of metro specialists and an engineer, are involved in the study as respondents. The investigation of other aspects of infrastructure (roads, sidewalks, overpasses, etc.) was disregarded in the study. The absence of such instances renders the examination of these components of the subject matter unavoidable.

Phillips (2002) reflected on the challenges during the Soviet period in his study. He mentioned the neglect of disabled individuals and the obstruction of their active movements. Simultaneously, it is pinpointed that although reforms are underway in Ukraine regarding people with impairments, disabled individuals still encounter infrastructure and employment-related problems that hinder their comfortable movement. Unlike the present research, no survey or questionnaire was employed in the methodology section, making it inevitable to conduct a study investigating the infrastructure issues of disabled individuals in the post-Soviet countries.

Stickley et al. (2021) conducted research studying the psycho-social problems of individuals with physical impairments in post-Soviet countries including Ukraine, Azerbaijan, Armenia, Georgia, Kazakhstan,

Kyrgyzstan, Belarus, Moldova, and Russia. In this research, 18 thousand people were involved as respondents, and their psycho-social issues were studied. The study drew attention to the psychological problems of people with disabilities. The reason for this was revealed to be inappropriate conditions. Here, the infrastructure challenges of people with impairments were examined within the psychosocial problems.

Since the above problems are not explicitly addressed, it is vital to research them, considering the individuals may not perceive underlying causes and impacts to be endearing.

Methodology

A qualitative method was employed in this study. Due to the utilization of qualitative research methodologies encompassing interview and document analysis, a cohesive and accurate portrayal of notions and phenomena in the natural environment is exhibited. The common traits of qualitative research are natural settings, direct data gathering, thorough descriptions, process orientation, inductive data analysis, participant standpoint, and flexibility (Fraenkel and Wallen, 2006).

In this study, a qualitative research model was used. The study was conducted in the capital of Azerbaijan, Baku. A semi-structured questionnaire was designed by the scholar to determine the deficiencies and unveil approaches. The interview consisted of open-ended questions. Therefore, attaining the resolution of predicaments becomes straightforward. The meetings were conducted both online and face-to-face, depending on the participants' conditions. Fifteen physically disabled individuals were involved in the sessions. The snowball sampling method was used to assess the respondents. Initially, individuals exhibiting four specific characteristics were selected, and subsequent participants were recruited through their networks.

The study group for this research comprises disabled individuals ranging in age from 18 to 29.

To ensure confidentiality, unique code numbers were assigned to each respondent. The interviews were audio-recorded with the consent of the respondents with disabilities.

Participants who did not consent to audio recordings had their responses documented manually. Given the sensitive nature of research, interviews were conducted in settings where participants felt at ease. To elicit more comprehensive responses, the questions were clarified and complemented with examples. The duration of the interviews ranged from 25 to 30 minutes and were conducted between May 21 and June 5.

The interview commenced with revealing reasons why individuals with physical disabilities refrain from going outside, the hindrances they tackle when navigating outdoors, and the challenges faced when moving independently. Additionally, the underlying causes of these adversities and potential solutions were addressed. The interview questions:

When did you acquire your disability?

How does your physical disability impact your life?

How does your physical impairment influence your emotional well-being? How do you usually spend your leisure time?

Have you encountered accessibility barriers due to your disability? If so, what specific barriers have you faced?

What strategies or approaches do you use to manage those challenges?

What recommendations would you suggest for eliminating or mitigating these problems?

Findings and conclusion

In this section, the core information about the interviewed physically impaired individuals between the ages of 18 and 29 is provided. In adherence to ethical considerations, code names were used to describe the respondents.

Table 1.

Information on Demographic Characteristics of Interviewees

No	Age	Gender	Education	Marital Status	Disability type
K1	29	F	Bachelor degree	Single	Visual
K2	20	F	Secondary education	Single	Orthopedic
K3	29	F	Secondary education	Single	Orthopedic
K4	29	M	Secondary education	Single	Orthopedic
K5	19	M	Bachelor's degree student	Single	Hearing
K6	28	M	Associate's degree	Married	Hearing
K7	27	M	Secondary education	Married	Hearing and speech
K8	21	F	Bachelor's degree student	Single	Orthopedic
K9	24	M	Bachelor's degree student	Single	Speech
K10	26	M	Bachelor's degree student	Single	Orthopedic
K11	23	F	Secondary education	Single	Speech
K12	21	M	Bachelor's degree student	Single	Orthopedic
K13	26	M	Master's degree	Single	Visual
K14	27	F	Secondary education	Single	Speech
K15	22	F	Secondary education	Single	Speech

Source: Compiled by the authors based on field interview results.

Findings related to the timing of disability onset

The initial occurrence of this situation is as pivotal as the circumstances faced by individuals with impairments. In this context, when disabled people were

asked about the time and reasons for their current condition, their responses were as follows: two respondents linked their condition to genetic factors, one respondent

to premature birth and its complications, and two others to injuries stemming from medical flaws during delivery. The remaining respondents were born with disabilities and were identified within the first year of life. Both visually impaired K1 and K13 reported that their condition occurred at birth, which they cannot recall. K1 explicitly stated being born blind in one eye and losing vision in the other over time.

"This situation happened during the delivery. I do not remember. There was some vision until the age of three". (Respondent 1)

"I was born with my disability. Initially, there was no vision. Afterward, I had surgery in Iran. Then my eyes were able to see a little. During operation, the electricity of the building went off, and the wound was closed in lamplight since the generator was not functioning". (Respondent 13)

K2, K3, and K6 mention that the reason for the arousal of this situation is the violation by the doctor.

"My back was injured when I was born. The injury occurred after the birth. The doctor damaged my spine during delivery". (Respondent 2)

"The day I opened my eyes to the world, the doctor injured my spine during

birth". (Respondent 3) "When I was a child, I got the wrong vaccine, and it went wrong. I do not recall". (Respondent 6)

K5 and K7, both hearing impaired, state that they were disabled since childhood and that their parents recognized the situation at a later stage.

"I do not remember. My mother felt that I could not hear when I was six months". (Respondent 5)

"I have been like this since birth. My parents brought me to the doctor because I could not speak". (Respondent 7)

The conclusions regarding the influence of disability on individuals' personal lives

The respondents report not recalling the onset of disability since it commenced either before the delivery or at a very young age. When they fully comprehended their situation, they delivered that the experience was initially quite distressing. They were disheartened by others' reactions, especially how people stared at them, in addition to the reluctance of their peers to spend time with them and the mockery they faced. Nevertheless, the limited timeframe of these events and the unlikelihood of such situations occurring again were disclosed. K11 articulated the situation in this way.

"I do not know. I was around seven when I fully realized the situation and it happened when my friends and I were enrolled in different schools. It made me feel upset". (Respondent 11)

Among the respondents, K5 reported the parents being more upset about the condition, and under this circumstance, K5 supported them.

"I cannot recall. Not me yet, my mother was feeling sad. I was stimulating my mother. When everyone was embarrassed to take off their hearing aids, I was not". (Respondents 5)

Respondent 8 highlighted the difficulty of the situation and the lengthy period taken to embrace it. The respondent later pinpointed that she recovered after the

psychologist's efforts to make the respondent attend social events and invitations.

"It was very challenging at first. I could not start going to kindergarten and never could. When I went outside, some children laughed, some mocked, and the bullying lasted for a while. I was in a depression in an elementary school. Then I went to a psychologist.

Afterward, he encouraged me to participate in events". (Respondent 8)

Respondents 10 and 11 report being aware of the situation early on, and, thus, they did not experience any psychological or other damage.

"I realized it earlier than usual. I embraced it as a part of mine and knew I would overcome it. The diagnosis was not introduced to me as a severe one. My family supported me a lot. My feet were paralyzed. I was facing difficulty writing, reading, and reading in different languages. My psychological condition was ideal. I was doing exercises. At the age of nine, I began walking by holding onto one side. I was taking a certain number of steps". (Respondent 10)

Although a resilient individual, the disability condition leaves an impact on the person's life. Considering that the sessions were conducted only once, individuals would refrain from elaborating on the current influences and consequences of their disability. While fostering trust was prioritized during the interviews, it is believed that establishing such a connection during one session was challenging.

Findings Regarding the Analysis of the Feelings Caused by Physical Disability in the Individual

As a response to how their disability impacts their feelings, many participants mentioned that they perceive their condition as a normal part of life and make peace with it. They noted experiencing vast adversities during childhood and facing times of emotional struggles that remain a part of the past. Some participants indicated that since they were born with this condition, they were not feeling distressed yet society's lack of knowledge on this topic made them upset. Nonetheless, not all interviewees have fully embraced their situation, and acknowledged sometimes not feeling emotionally well. Other participants reported that they have encountered no notable challenges, either because of their childhood or having this condition since birth. K4 expresses the situation in this manner.

"Since it comes from birth, I do not feel any change. I just had a reclusive stance, and I overcame it over time". (Respondent 4)

Among participants, K1 reported being tardy at work due to the disability, and this situation frustrated this participant.

"I try my impairment not to influence my feelings. However, it sometimes does. We do our work at a slower pace. I felt a sense of sorrow because of my disability". (Respondent 1)

Respondent K14 indicated being a child when the situation was comprehended thoroughly and not feeling well. The participant expressed how scary the situation was at some points and cried over it occasionally. Nevertheless, currently, K4 accepts the condition and states that it is not of great essence.

"I was around seven I understood my condition deeply, yet I cannot recall. I remember children pushing me and saying they did not want to play with me. At that moment, I ran home sobbing. It sometimes scared me. Currently, it does not mean anything". (Respondent 14)

The Findings regarding the Analysis of Leisure Time Utilization of Physically Disabled Individuals

The participants commonly engage in activities analogous to their hobbies. In conjunction with that, some cannot spare time during the day to value their idle time. The majority of individuals articulate that they spend time constructively and partake in activities that yield personal advantages. Their satisfaction from this situation is observed.

Participant K8 asserts utilizing leisure time efficiently and allocating time to socialize, unlike in the participant's childhood.

"I listen to music and sometimes walk...now socializing. Despite the childhood now socializing". (Respondent 8)

Meanwhile, K15 states engaging in calming endeavors during idle time.

"I draw pictures. It pacifies me. Spending time with my friends, listening to music". (Respondent 15)

The other participant, K2, reports possessing an occupation and completing half of the tasks remotely and the other half in the workplace whilst watching TV shows during spare time. Moreover, K2 mentions participating in social projects.

"I work either during the day or at home, or I am called to projects. I watch TV shows in my free time". (Respondent 2)

According to the given answers, although sometimes difficult to implement for them, respondents productively spend their time during idle hours or at weekends. Within this framework, it is blatant that along with the encountered handicaps, numerous joyful moments were experienced, and the vitality of those moments in their lives is undeniable.

The Findings regarding Accessibility and Service Access Problems Experienced by Individuals due to Physical Disability

Whilst examining the answers provided by respondents, the accessibility and service access challenges faced by physically disabled individuals were identified. When allocating those problems into sections, typical predicaments are observed in public transportation, ramps, sidewalks, and with social service workers.

Respondent K1 elucidates the adversity of moving on paths, and the absence of distinct signs for people with visual impairments at the subways and commuter stops. Furthermore, K1 reported encountering a problem when trying to obtain a health document at one of the entities.

"I have difficulties moving on the roads. There are many ups and downs. I face challenges getting on and off the bus. There are no raised letters on subways. When I went to receive a health report from an institution, whose name I do not want to mention, in the service sector, one of the employees disrespected me because of my disability". (Respondent 1)

Another respondent, K7, expresses concern that employees in the service field do not adequately treat individuals with physical impairments and that the ramps are excessively elevated. Meanwhile, some restaurants and cafes lack elevators.

"They disregard us. I have difficulties comprehending this. This situation can also occur with the officer talking to us. Ramps are impractically elevated, and I face challenges. We cannot find elevators to go upstairs at some restaurants and cafes". (Respondent 7)

Respondent K1 remarks on the impediments experienced at passenger terminals and aboveground crossings.

"The entrance doors for disabled individuals at busses are not opened. We have to wait for the door. The width of the sidewalks is very narrow, and it is not feasible to move there with wheelchairs. Don't they also erect electricity poles on those narrow sidewalks?... There are elevators in the aboveground passages, yet we cannot find the employee who is responsible for functioning the elevators". (Respondent 8)

Respondent K15 highlights experiencing challenging moments whilst interacting with social service employees and the handicap stemming from workers not knowing sign language.

"I go to a sector that is designed for assisting disabled people yet there is no one capable of communicating in sign language. There are even no signs for us. This situation is very troublesome". (Respondent 15)

The Findings on Coping with the Accessibility and Service Access Problems Experienced by Individuals due to Physical Disability

It is detected that the participants tackle such unfavorable situations more than anticipated. Whilst some seek to discern alternatives to evade those adversities, others face challenges in order to overcome and unveil solutions for them.

Respondent K2 lengthens the commute duration to discover novel options if moving on the sidewalks is not viable. Under such circumstances, requesting for assistance from other people is observed.

"When I cannot move on sidewalks, I search for different ways. Even if it is grueling and time consuming. As a last option, I move on the roads that cars pass. When the elevator is not present or broken, I ask for other people's help. I appreciate their help". (Respondent 2)

Respondent K3 is in a dilemma concerning the thoughts. Initially, he advocates for the benefits provided by online services, but subsequently, she argues that this standpoint is not the most appropriate.

"I utilize online services. I might be thankful to the pandemic for this. However, this is also not a suitable approach. We should benefit from the services face to face so that they see the problem and manifest an effort to solve it. Once I had difficulty using the service. The employee told me to leave, and that the rest of the work would be done with my mother. By saying - "If the way the service is provided does not suit me, you have to adjust it" - I

demanded my right". (Respondent 3)

Speech-impaired K6 articulated encountering service accessibility problems since other people do not comprehend sign language and utilizing the notes of the mobile phone to communicate in this situation.

"My sole solution is to write. I always keep notes on my phone open. I write down what I want to deliver". (Respondent 6)

While tackling such predicaments, Respondent K7 tries to solve the problem by communicating and standing aside. However, some problems, as K7 indicates, are not resolved by conversation.

"I stand at one side on the bus. I try to deliver my thoughts by talking to people, yet it sometimes does not work. I do not have any solutions for the problems of elevator and ramp". (Respondent 7)

The Findings regarding the Solutions for the Accessibility and Service Access Problems Experienced by Individuals due to Physical Disability

According to the participants' responses, strategies for addressing the encountered hardships in accessibility and service fields are categorized under the following headings: Augmenting the involvement rate of disabled people in social life, ensuring adequate representation in places, providing training on ethical behaviours for service workers, and designing equal conditions in settings where people spend their leisure time (cafes, restaurants, shopping malls, etc.).

Respondent K1 articulated that prioritization of active participation in social life and the existing challenges would be resolved in advance if taken into consideration.

"When we sit at home, the problems stay still. I suggest being more present in society to highlight and solve the problems. When we are seen around more, the faster the solutions are proposed". (Respondent 1)

Respondent K5 perceives mutual understanding as an effective strategy for problem-solving. A physically impaired individual should observe others and behave accordingly, whilst society should also adopt an appropriate approach toward them. He believes that well-structured projects can lead to this accomplishment.

"Disabled individuals should be attentive. They should consider the people around them. On the other hand, other people should be aware of the disability of individuals in front of them.

This can be achieved through projects, as I believe". (Respondent 5)

By insisting on the layout of the city, Respondent K13 proposes that serious adjustments concerning urban design ought to be undertaken by accountable individuals.

"Government or other entities plan laws and projects. A scarce fraction of people participating in the planning process are disabled people. Therefore, we need to be represented more when such laws or projects are endorsed". (Respondent 15)

Discussion

In this research, the interview methodology is employed to study the predicaments and their solutions in several directions. Although some outcomes exhibit similarities with the former research results, certain divergences are also detected.

In Musasoy's (2022) survey regarding the integration of physically impaired individuals into society, 28,2% of disabled people point to infrastructure issues as a reason for their unemployment and 38,4% of them underscored that transportation is not conducive to their disabilities. In contrast to this, interviews were included in the methodology of the current study, resulting in obtaining a deeper understanding of the matter. The present findings share commonalities with Musasoy's research and in both studies, findings suggest that people with disabilities struggle with social integration.

Considering physically disabled individuals, Eisenberg et al. (2022) analysed the cities with high infrastructure by utilizing advanced technical aids in the research. The photos and videos of areas were recorded to juxtapose them. The findings revealed that in the vast regions, the infrastructure is not fully optimal for active movements of disabled people. Nevertheless, the infrastructure conduciveness was investigated based on the responses provided by physically impaired individuals. The major distinction lies in the fact that, within this research, the pathways to overcoming the challenges and potential resolutions are delineated by qualified scholars. The findings yielded in the present study are more accurate considering the concreteness of the investigated area. Moreover, current research is more precise and solution-oriented, whereas Eisenberg et al.'s paper presents findings with a general scope.

Danso et al. (2021) studied the infrastructure concerns of physically impaired individuals. This scholarly investigation was commenced after securing the requisite endorsements and targeted employees within the designated metropolitan zone. Therefore, the same situation was reflected in the present study as superiority, and the focus group, unlike the former research, was individuals with physical impairments. Additionally, the expanded recognition of areas, including the infrastructure, is perceived as another advantage of current research. Philips (2002) contrasted the disabled people in the Soviet and Independence periods. The insights indicated the upgraded life quality in the Independence period, yet the infrastructure issues remain unchanged. The present research involved the concrete participation of respondents, and the collected verbal inputs were incorporated. Since Ukraine and Azerbaijan are post-Soviet countries, the findings from both studies are analogous. The current study, however, can be considered advanced due to the veracity and meticulousness of the outcomes. The justification for this is that Philips researched the contemporary condition via resources reflecting the situation rather than direct interaction with disabled individuals. A more refined methodology for exploring a problem is to derive insights from the communication of individuals directly influenced by it.

Stickley et al. (2021) studied the reasons for the impact of disability on depression. The research conducted in the post-Soviet geographical zones targeted 18 thousand of physically impaired individuals, and the concern of infrastructure is presented as one of the underlying causes of depression. As a result, investigating the issue and offering corresponding solutions hold

considerable significance. The current research thoroughly explores the infrastructure problems experienced by disabled individuals and the applicable solutions are proposed.

Concurrently, the prevailing social stigma against people with impairments is mirrored in the institutions designed to assist them. Furthermore, recent studies emphasize that social change and inclusive development are closely associated with equal participation opportunities for disadvantaged groups in educational and social environments. In particular, innovative and socially oriented approaches contribute to strengthening social integration and improving accessibility conditions for individuals with disabilities (Jafarova, 2026). Additionally, the transformation of modern societies through innovation and social awareness has increased the importance of inclusive policies aimed at supporting vulnerable populations and ensuring their active participation in public life (Jafarova, 2026).

Conclusion

The active engagement of physically disabled individuals in social life is a fundamental pillar in the construction of the welfare state. Toward the end of the previous century, the initiatives of the United Nations and the European Union regarding education, rehabilitation, and employment of people with disabilities elevated the visibility of these concerns. Providing the involvement of disabled individuals is a key parameter for the realization of this objective. To facilitate this, both the infrastructure and the level of preparedness among individuals with disabilities need to be robust. The infrastructure-related issues play a pivotal role in stimulating the participation of disabled individuals in social dynamics and navigating independently. The failure to provide inclusive infrastructure in metro systems, public buildings, elevated walkways, and other infrastructure causes hindrance to access to education, healthcare, employment, and social integration. The responses gathered from comprehensive meetings with physically impaired individuals indicate that disabled people are unable to navigate as they desire. The vitality of public transportation, crossings, and metro stations in the lives of disabled people is highlighted, and the sole way to foster social interaction outside is the resolution of pinpointed issues. Transportation and urban infrastructure are essential for physically impaired individuals. They reported that buses, overpasses, subways, and the flaws in vast buildings and roads from an infrastructural perspective are not inclusive.

Recommendations

According to the responses provided by the participants, the categorization of the proposed recommendations would include the following: There are accountable employees stationed at the elevators of overpasses. When the employees are absent, orthopedically impaired individuals are refrained from utilizing this service. Regarding this matter, the elevators should be directly available for use by individuals with disabilities without the need for attendants. The presence of audible traffic signals in specific areas of the city, while absent in others poses obstacles for visually impaired individuals. The availability of this technology across the city should be considered. In the waiting points for public

transport, the information should be provided by raised letters for individuals with visual disabilities. The ramps fail to meet the requirements of standards. They should not be over 18 degrees.

Individuals utilizing wheelchairs frequently encounter this problem. Addressing this issue with careful consideration is of great magnitude in attaining resolution.

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TECHNICAL SCIENCES

FORMATION OF STRUCTURE FORMATION AND STRENGTH OF ARBOLITOBETON COMPOSITES UNDER THE INFLUENCE OF LONG-TERM LOADS BASED ON ACTIVE IRON-SULFUR COMPOUNDS

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БЕЛСЕНДІ ТЕМІР-КҮКІРТ ҚҰРАМДЫ ТҮТҚЫРЛАР НЕГІЗІНДЕ ҰЗАҚ МЕРЗІМДІ ЖҮКТЕМЕ ӘСЕРІНЕ АРБОЛИТОБЕТОН КОМПОЗИТТЕРІНІҢ ҚҰРЫЛЫМ ТҮЗУІ МЕН БЕРІКТІГІНІҢ ҚАЛЫПТАСУЫ

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Abstract

The article examines the problems of obtaining iron-sulfur viscous substances by the method of mutual neutralization and detoxification, as a result of their mechanochemical processing, as well as the stages of formation and solidification of arbolitobeton composites prepared on the basis of oil production and metallurgical industry waste under long-term load conditions. The method of mutual neutralization and detoxification of toxic components of industrial waste by mechanochemical processing at low temperatures was used to obtain iron-containing astringents. If the oxidative properties are performed by pyrite annealing, then the regenerating properties are acquired by technical elemental sulfur.

Аннотация

Мақалада темір-күкірт құрамды тұтқыр заттарды өзара бейтараптандыру және детоксикациялау әдісі арқылы, олардың механохимиялық өңдеу нәтижесінде алу мәселелері, сондай-ақ мұнай өндіру және металлургия өнеркәсібі қалдықтары негізінде дайындалған арболитобетон композиттерінің құрылым түзу және қату сатылары ұзақ мерзімді жүктеме жағдайында зерттеледі.

Темір-күкірт құрамды тұтқырларды алу үшін өнеркәсіптік қалдықтардың уытты компоненттерін төмен температурада механохимиялық өңдеу арқылы өзара бейтараптандыру және детоксикациялау әдісі қолданылды. Тотығу қасиеттерін пирит күйдірілдісі атқарса, қалпына келтіруші қасиетке техникалық элементтік күкірт ие болады.

Keywords: iron-sulfur, arbolitobeton, mechanochemical processing.

Кілт сөздер: темір-күкірт, арболитобетон, механохимиялық өңдеу

Кіріспе

Құрылыс көлемінің үнемі артуына байланысты құрылыс материалдары мен бұйымдарына деген сұраныс та күннен-күнге өсіп келеді. Осыған орай, құрылыс конструкцияларының, әсіресе қоршаушы элементтердің массасын азайту үрдісі байқалуда. Бұл жеңіл бетондарды, соның ішінде төмен тығыздықпен ($550-650 \text{ кг/м}^3$) және жергілікті жоғары беріктікпен (тиісінше $3,0-5,0 \text{ МПа}$) сипатталатын жеңіл арболитобетон композиттерін қолдану есебінен жүзеге асырылады [1-5].

Алайда аталған еңбектерде жоғары тұтқыр зат шығыны кезінде дайын материалдың салыстырмалы түрде төмен беріктігі мәселесі шешілмеген. Сондай-ақ бұйымдардың қалыптан босату беріктігін алу мәселесі толық шешілмеген, соның салдарынан оларды қосымша түрде жылы жерде

кемінде 7 тәулік (жаз мезгілінде) және 7 тәуліктен артық (қыс мезгілінде) ұстау қажеттілігі туындайды.

Соңғы уақытта өндірістік қалдықтардың көлемін азайтып, оларды барынша тиімді пайдалануға мүмкіндік беретін технологиялық процестер мен схемаларды әзірлеуге ерекше көңіл бөлінуде [5-10]. Бұл, әсіресе, өнеркәсіп пен ауыл шаруашылығы қалдықтары мол өңірлер үшін өзекті мәселе болып табылады. Мұндай өңірлерге Қазақстанның батыс және шығыс аймақтары жатады, мұнда жыл сайын металлургия, мұнай-химия және тау-кен өнеркәсібінен шыққан көп тоннажды улы қалдықтар жиналып, қоршаған ортаны ластауда [10-12].

Бұл қалдықтарды, әсіресе мұнай-газ өндірістерінің қалдығы болып табылатын техникалық күкіртті қайта өңдеу және пайдалану құрылыс материалдары өндірістерінде екінші реттік шикізатты қолдану мүмкіндігін зерттеу тұрғысынан үлкен қызығушылық тудырады.

Әдеби дереккөздерге жасалған талдау мен алдыңғы тәжірибелік-зертханалық жұмыстардың нәтижелері техникалық күкірт негізінде жоғары тиімді құрылыс материалдарын алудың және олардың өндіріс технологияларын әзірлеудің өзектілігін көрсетеді. Осы себепті, құрылыс материалдарының құрамында қолданылатын күкіртқұрамды уатты қалдықтарды детоксикациялау бойынша қосымша эксперименттік зерттеулер жүргізу, сондай-ақ ұзақ уақыт әсер ететін жүктеме жағдайында темір-күкіртқұрамды арболитобетон композиттерінің беріктік түзілуін, деформация және бұзылу механизмін зерттеу қажет.

Шешілмеген ғылыми мәселелерді талдай отырып, осы зерттеудің мақсаты – механохимиялық өңдеу әдәсі арқылы темір-күкіртқұрамды тұтқыр заттарды әзірлеу, сондай-ақ ұзақ мерзімді жүктеме әсеріндегі арболитобетон композиттерінің құрылым түзілуі мен қату сатыларын зерттеу болып табылады.

Мақсатқа жету үшін келесі міндеттер қойылды: арболитобетон композиттері құрамында қолдану үшін механохимиялық өңдеу әдісімен алынған темір-күкіртқұрамды тұтқыр заттардың құрамын әзірлеу және олардың қасиеттерін зерттеу.

Материалдар мен тәжірибелік-зертханалық жұмыстарда қолданылған әдістер

Тәжірибелік-зертханалық зерттеулер жүргізу үшін мемлекеттік стандарт ГОСТ 31108-2003 талаптарына сәйкес келетін Шымкент цемент зауытының 500 маркалы портландцементі пайдаланылды.



Зерттеулер барысында сондай-ақ Қазақстан кәсіпорындарының өндірістік қалдықтары – шламдар мен қатты заттар қолданылды. Қосымша қоспа ретінде бұрынғы «Фосфохим» АҚ кәсіпорнының пиритті күйдіріндісі пайдаланылды.

Пиритті күйдіріндінің химиялық құрамы (массалық үлесі, %):

CaO – 10,5%;

SiO₂ – 19,7%;

Fe₂O₃ – 66,1%;

Al₂O₃ – 2,3%;

MgO – 1,2%;

Басқа түрлі қоспалар – 0,2%.

Модификациялаушы қоспа ретінде техникалық күкірт қолданылды – бұл Қазақстан Республикасының Атырау облысындағы жоғары күкіртті мұнай кен орнын қайта өңдеу нәтижесінде алынған екіншілік өнім. Сұрып нөмірі - №9998, мемлекеттік стандарт 127.1-93 бойынша.

Техникалық күкірттің химиялық құрамы:

Күкірттің массалық үлесі – 99,060%;

Күлдің массалық үлесі – 0,400%;

Органикалық заттардың массалық үлесі – 0,053%;

Судың массалық үлесі – 0,010%.

Зерттеулерде қолданылған өндірістік қалдықтардың сыртқы түрлері – техникалық күкірт (а) және пиритті күйдірінді (б) – 1-суретте көрсетілген.

Темір-күкірт құрамды арболитобетон композитін алу үшін органикалық толтырғыш ретінде Ақтөбе облысының қамыстарынан алынған ұсақталған талшықтар пайдаланылды (2-сурет).

Ұсақталған қамыс талшығының химиялық құрамы төмендегідей:

Целлюлоза – 39,1%;

Лигнин – 19,2%;

Пентозандар – 17,7%;

Полисахаридтер – 24%.



1-сурет. Техникалық күкірттің (а) және пиритті күйдіріндінің (б) сыртқы түрлері



2-сурет. Ұсақталған қамыстың сыртқы түрі

Пиритті күйдірінді мен техникалық күкірт негізіндегі темір-күкірт құрамды қоспаларды цементпен бірлескен механо-химиялық белсендіру

Зерттеу жұмыстарын жоспарлау барысында ғылыми гипотеза іске асырылды, оған сәйкес қоспа бөлшектерінің әрқайсысын қосымша белсендіру әсеріне жеткізу үшін олар бірлескен ұнтақтау әдісімен өңделді. Нәтижесінде, химиялық қасиеттері жағынан бір-біріне қарама-қарсы сипатты қатты қалдықтардың өзара детоксикациясы жүзеге асты.

Темір-күкірт құрамды қоспалардың құрамын алдын ала анықтау және оларды белсендіру бойынша тәжірибелік жұмыстар жүргізу кезінде ұнтақтау ЛШМ-750 шарлы диірмені құрылғысында орындалды. Бұл процесте негізгі әсер ету механизмдері – үйкеліс пен соққы күші.

Шарлы диірменнің техникалық сипаттамалары төмендегідей:

- Ұнтақтау принципі – үйкеліс;
- Біліктердің диаметрі – 45мм, ұзындығы – 170мм және 370мм;
- Айналу жиілігі – 100-750 айн/мин;
- Орнатылатын барабандардың массасы – 12 кг дейін;
- Қуат тұтынуы – 300Вт;
- Габариттік өлшемдері – 1000x325x265 мм;
- Жалпы салмағы – 35кг.

Техникалық күкірт мен пиритті күйдірінді цемент ерітіндісімен бірге механохимиялық белсендіру әдісімен өңдеу мүмкіндігін және оның темір-күкірт құрамды қоспаның қасиеттері мен

темір-күкірт цемент тасының беріктігіне әсерін зерттеу үшін үш компонентті тұтқыр қоспаның ерітіндісін кезең-кезеңімен зерттеу әдістемесі қабылданды.

Осы процестердің дәйекті түрде өтуін талдау нәтижесінде бастапқы тұтқыр материалдың белсенділігін арттыру себептері анықталды.

Үлгілер келесі технологиялық тізбектілікпен дайындалды:

- Пиритті күйдірінді мен техникалық күкірт негізіндегі темір-күкіртқұрамды қоспаларды фракциялық құрамы мен меншікті беті бойынша дайындау және мөлшерлеу;

- Портландцементті дайындау және мөлшерлеу;

- Байланыстырғыштың жалпы массасынан белгілі мөлшерде суды дайындау және араластыру;

- Пиритті күйдірінді мен техникалық күкірт негізіндегі темір-күкіртқұрамды қоспаларды 100:200, 100:250, 150:250 массалық қатынаста диірменге тиіп, №008 електе 8-10% қалдықпен сипатталатын ұсақтыққа дейін ұнтақтау және 20 минут бойы араластыру;

- Темір-күкіртқұрамды қоспаға 67-70% цемент және су-цемент қатынасы В/Ц=0,6 болатындай жетпейтін су мөлшерін қосу;

- Темір-күкіртқұрамды қоспаларды цементпен бірлесе 10 минут бойы бірге ұнтақтау;

- Диірменді тоқтатып, күкіртқұрамды байланыстырғыш қоспаны түсіру.

Шарлы диірменде ұнтақталғаннан кейінгі темір-күкіртқұрамды құрғақ қоспалар компоненттерінің меншікті беттері 1-кестеде келтірілген.

1-кесте. Темір-күкіртқұрамды компоненттердің меншікті беттері

Күкірт қоспасы, %	Пиритті күйдірінді, м ² /кг	Цемент, м ² /кг	Күкірт, м ² /кг
18	298	400	583
12	297	420	577
13	265	450	602

Темір-күкірт құрамды байланыстырғыштарды алу әдістері

Темір-күкіртқұрамды цементтік тастың беріктік сипаттамаларына техникалық күкірт қоспасының әсерін анықтау бойынша зерттеу жүргізу үшін 100x100x100мм өлшемді үлгілер дайындалды. Су-цемент қатынасы 0,385 болған

жағдайда күкіртқұрамды ерітінді қоспасының жайылуы дірілдеткіш үстелді 200мм деңгейінде қамтамасыз етілді.

Бастапқы және активтендірілген байланыстырғыштардың сипаттамалары 30515-97, 31108-2003 және 7473-2010 мемлекеттік стандартына сәй-

кес анықталды. Күкіртқұрамды байланыстырғыштардың созылу және иілу кезіндегі беріктік шектері 40x40x160мм өлшемдегі үлгі-балкаларда ИП-2710 аспабы арқылы анықталды.

Одан әрі әзірленген темір-күкіртқұрамды байланыстырғыштардың құрамдары бойынша темір-күкіртқұрамды арболитобетон үлгілері дайындалады. Темір-күкіртқұрамды байланыстырғыштардың әзірленген құрамдары 2-кестеде келтірілген.

2-кесте. Темір-күкіртқұрамдарды байланыстырғыштардың әзірленген құрамдары

Техникалық күкірт, %	Пиритті күйдірілді, %	Цемент, %	Су, %	Тығыздық, кг/м ³
18	18	64	30	1580
12	18	70	30	1585
13	20	67	30	1590

Қорытынды

Қоспа құрамына техникалық күкіртті енгізу темір-күкіртқұрамды тұтқырлардың беріктік сипаттамаларына оң әсер етіп олардың сығылуға беріктік шегін 73,5МПа-ға дейін арттырды. Темір-күкіртқұрамды керамзитбетондармен салыстырғанда, темір-күкіртқұрамды арболитбетонның жылжымалылығы айтарлықтай төмен, бұл бірдей кернеу деңгейінде сіресу деформациясының азаюына әкеледі.

Қаржыландыру: Бұл зерттеу жұмысын Қазақстан Республикасы Ғылым және жоғары білім министрлігі ғылым комитеті қаржыландырды (ЖТН АР25794879 Қамыс-қабатты құрылыс материалын алу үшін байланыстырушы ретінде полиэтилен пленкасының қалдықтарын кәдеге жарату).

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METHODS FOR STABILIZING KAZAKHSTAN'S POWER SYSTEM WITH THE INTEGRATION OF RENEWABLE ENERGY SOURCES**Shinali Baizhan Azamatuly***PhD student at the Institute of Energy and Green Technology, Almaty University of Power Engineering and Telecommunications (Almaty, Kazakhstan)*<https://doi.org/10.5281/zenodo.20448103>**Abstract**

This article examines modern methods for stabilizing the power system with an increasing share of renewable energy sources. Particular attention is paid to the current state of renewable energy in Kazakhstan in 2024–2025, as well as the technical challenges arising from the integration of solar, wind, and energy storage systems. It is shown that an increasing share of inverter energy resources leads to a decrease in the natural inertia of the power system, increased complexity of frequency and voltage regulation, and the need for new control methods. The article analyzes the capabilities of grid-following and grid-forming inverters, revealing their advantages and limitations. It is concluded that the most promising approach is a hybrid model, in which grid-following inverters provide efficient power output, while grid-forming inverters perform the system-forming functions of stabilizing voltage, frequency, and inertia-like response.

Keywords: renewable energy sources; RES; Kazakhstan's power system; power system stabilization; grid-following inverters; grid-forming inverters; virtual inertia; energy storage systems; Smart Grid; frequency stability; voltage stability.

The relevance of this topic is determined by the fact that the integration of variable renewable energy sources—primarily wind and solar generation—requires not only the construction of new facilities but also changes in power system management methods. The IEA emphasizes that as the share of solar and wind generation increases, the power system goes through several phases of renewable energy integration, and each phase creates new technical challenges that require special measures to maintain the reliability and efficiency of the grid. NREL defines renewable energy integration as the practice of developing efficient methods for transmitting variable renewable energy to the grid while maintaining or improving the stability and reliability of the power system.

The objective of the study is to analyze methods for stabilizing the power system during the integration of renewable energy sources and compare the capabilities of grid-following and grid-forming inverters. Research methods: literature review, comparative analysis, systems analysis, and analysis of statistical data on renewable energy in Kazakhstan for 2024–2025. The scientific novelty lies in the generalization of modern approaches to stabilizing a power system with a high share of renewable energy sources and the comparison of the capabilities of GFL and GFM inverters as applied to the conditions of the Kazakhstan power system.

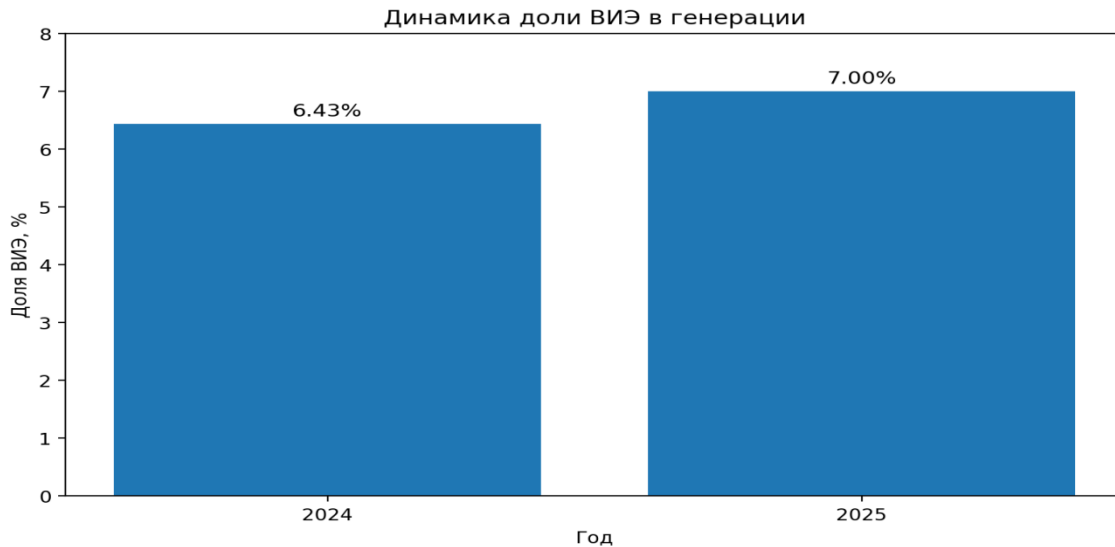
This topic is particularly significant for Kazakhstan, as KEGOC's strategy explicitly states the objective of ensuring the reliable operation of the Unified Electricity System of Kazakhstan amid the energy transition and the integration of renewable energy sources into the system. The Ministry of Energy of the Republic of Kazakhstan also sets a goal of achieving a 15% share of renewable energy sources by 2030, including the development of renewable energy projects with energy storage systems.

As of 2024–2025, the use of renewable energy sources in Kazakhstan has transitioned from the stage

of point projects to a more sustainable electricity sector, however, RES still retain a supporting rather than a core role in the country's energy balance. In 2024, RES facilities generated 7.58 billion kWh, which accounted for 6.43% of all electricity generation; the installed capacity reached approximately 3.03 GW, and about 153 facilities were in operation. Wind power plants made the largest contribution - 4.51 billion kWh, followed by solar power plants - 1.89 billion kWh, small hydroelectric power plants - 1.18 billion kWh, while bioelectric power plants had a minimal share - about 1.58 million kWh. In 2025, the growth continued: according to data published with reference to the Ministry of Energy of the Republic of Kazakhstan, the generation of renewable energy sources reached 8.62 billion kWh, that is, an increase of 13.7% compared to 2024, and the share of renewable energy sources in total generation was about 7%. The installed capacity of renewable energy sources by the end of 2025 reached 3.537 GW, of which 1.909 GW were wind power plants, 1.313 GW were solar power plants, about 314 MW were small hydroelectric power plants, and 1.77 MW were bioenergy [1]. Thus, in Kazakhstan in 2024–2025, it was wind energy that developed most dynamically, which is associated with the natural and climatic potential of the steppe regions and the state's focus on large wind power plant projects. At the same time, the growth of renewable energy requires the parallel development of flexible generation, energy storage, digital control, and grid infrastructure, as the increasing share of solar and wind generation increases the demands on power system stability, power balancing, and generation forecasting. The government's goal of increasing the share of renewable energy to 15% by 2030 and commissioning at least 8.4 GW of new renewable energy capacity by 2035 demonstrates that the sector will expand, but its continued effectiveness depends not only on the construction of new plants but also on the technological stabilization of the power system [1].

Indicator	2024	2025
Renewable Energy Generation	7.58 billion kWh	8.62 billion kWh
Share of Renewable Energy in Total Generation	6.43%	about 7%
Installed Renewable Energy Capacity	3.03 GW	3.537 GW
Wind Energy	4.51 billion kWh	5.38 billion kWh
Solar Energy	1.89 billion kWh	2.04 billion kWh
Small Hydropower	1.18 billion kWh	about 1.2 billion kWh
Bioenergy	1.58 million kWh	about 2.8 million kWh

Dynamics of the share of renewable energy sources in generation



Consequently, Kazakhstan is demonstrating steady growth in renewable energy sources, but the transition to a higher share of renewable generation requires not only capacity expansion but also a comprehensive modernization of the power system—developing storage, flexible capacity, grid-forming inverters, forecasting, and digital dispatch control.

Today, the main problem with renewable energy sources is their variable and inverter-based nature. Traditional power systems relied on synchronous generators, which have mechanical inertia. Replacing some of these generators with solar and wind turbines connected via power electronics reduces the natural inertial frequency support. As a result, the power system becomes more sensitive to sudden changes in load, generation, emergency outages, and power fluctuations.

The concept of inverter-based energy resources deserves special attention. NREL emphasizes that solar, wind, and battery systems are connected to the grid through inverters, making grid-forming inverters - inverters that can not only follow grid parameters but also shape voltage and frequency - increasingly important for the future energy system.

It should be noted that the main methods for stabilizing a power system using renewable energy sources are: 1. Grid-forming inverter control. This is one of the most promising approaches. Grid-forming inverters can operate as voltage sources, maintain frequency and voltage, provide synchronization, and contribute to grid stabilization. NREL research considers grid-forming inverters a key approach for power systems with a high proportion of inverter sources.

2. Virtual synchronous generator/virtual inertia. The VSG/VSM method simulates the behavior of a synchronous generator: the inverter is given an algorithm that allows it to respond to frequency changes like a traditional rotating machine. Reviews of grid-forming control indicate that droop control, virtual synchronous machine, and synchronverter are the most common control strategies.

3. Droop control. Droop control allows active and reactive power to be distributed among multiple sources without constant centralized communication. This method is especially important for microgrids, stand-alone power systems, and hybrid renewable energy + storage systems.

4. Energy storage systems. Battery storage systems can smooth out fluctuations in renewable energy generation, participate in primary frequency regulation, support voltage, provide power reserves, and increase grid flexibility. IRENA considers grid flexibility a key requirement for the energy transition and renewable energy integration.

5. Smart Grid, digital control, and forecasting. Accurate forecasting of solar and wind generation, digital monitoring, automated load management, the use of PMUs/WAMS, SCADA, EMS, and intelligent algorithms are essential for grid stabilization. KEGOC's strategy also includes the implementation of modern, innovative, and digital technologies, including the Smart Grid.

6. Increasing grid flexibility. Flexible resources include storage systems, hydroelectric power plants, fast-start gas-fired power plants, demand response, in-

terconnections, grid redundancy, and grid modernization. The IEA emphasizes that as the share of renewable energy increases, targeted measures are needed for each phase of integration, including flexibility, network infrastructure, and operational solutions.

Therefore, the purpose of this article is to substantiate and describe a set of methods for stabilizing a power system with a high share of renewable energy sources based on the use of grid-forming inverters, virtual inertia, energy storage systems, and intelligent control algorithms. To achieve this goal, it is necessary to analyze the impact of solar and wind generation on the frequency and voltage stability of the power system; examine modern methods for stabilizing power systems with a high share of renewable energy sources; compare the capabilities of grid-following and grid-forming inverters; and determine the prospects for applying these methods in the power system of Kazakhstan.

As we know, in power systems with a high share of renewable energy sources, the difference between grid-following and grid-forming inverters becomes fundamental, since it is no longer just a matter of connecting solar, wind, and battery installations to the grid, but rather the ability of inverter resources to contribute to maintaining power system stability. Grid-following inverters (GFLs) have historically been a more common and technologically mature solution for renewable energy sources: they operate as controlled current sources, synchronized with the existing grid voltage, typically via a PLL mechanism, and perform well in the areas of active power generation, MPPT, current regulation, reactive power compensation, and operation in strong grids.

However, their key limitation lies in their dependence on an external grid reference signal: with reduced inertia, a drop in short-circuit power, voltage distortions, or operation in weak grids, GFL inverter stability deteriorates, and large numbers of such devices can exacerbate frequency and small-signal stability issues.

In 2024-2025 studies, the transition from grid-following to grid-forming control logic is considered a natural response to the growing share of inverter energy resources in the power system. In a 2024 NREL presentation, B. Kroposki directly links the need for GFM inverters to the rapidly increasing number of inverter-based resources "from Solar PV, Wind, and Batteries" in the grid—that is, solar, wind generation, and battery energy storage systems [2]. Unlike grid-following inverters, which are primarily synchronized with the existing grid voltage and "follow" grid parameters, grid-forming inverters are capable of more actively participating in the formation of the power system's reference parameters—voltage, frequency, inertial-like response, and oscillation damping.

B. Bahrani, M. H. Ravanji, B. Kroposki, et al., in a 2024 article, emphasize that GFM control allows the inverter resource to respond to changes in the system "nearly instantaneously," that is, almost instantly, helping to stabilize the grid during disturbances [3]. Therefore, GFM inverters have broader stabilization capabilities: they can maintain local frequency and voltage, operate in weak grids and microgrids, provide island

operation, participate in black start, and improve system performance with reduced inertia and a high share of renewable energy sources.

In a 2025 review by M. V. Kaiser and C. Fan, grid-forming converters are characterized as a technology necessary for "reliable, stable, and resilient operation" of power systems transitioning to low-inertia and inverter-dominated configurations [4]. At the same time, the researchers emphasize that the transition to GFM does not mean a complete abandonment of GFL: the future power system will likely be hybrid, where grid-following inverters will retain their role as efficient power sources, while grid-forming inverters will take on system-forming functions.

However, hybridity creates new challenges: S. Chen, Y. Wang, M. Yang, et al. (2025) show that in hybrid systems, a GFL inverter can act as an "excitation source" of forced oscillations for GFM inverters [5]. Consequently, the advantage of GFM inverters lies not simply in a more complex control scheme, but in the qualitatively different role of renewable energy sources in the power system: renewable generation ceases to be only an alternating power source and becomes an active tool for maintaining stability.

At the same time, as B. Bhowmick, M. A. Akwa, and S.-Y. Kim show, even modern hybrid-compatible GFM inverters require solutions to problems of coordination, current limitations, and fault ride-through, since the replacement of synchronous generators with renewable energy sources creates "low-inertia power systems" with increased vulnerability to frequency instability [6].

Summarizing the scientists' opinions, it can be noted that the widespread deployment of inverter resources—primarily solar, wind, and storage—requires a shift from a simple "grid-following" logic to a more active role for inverters in shaping its parameters. Grid-forming inverters (GFMs) offer broader stabilization capabilities in this regard: they operate closer to the voltage source, can maintain local frequency and voltage, provide an inertia-like response, dampen oscillations, operate in weak grids, microgrids, and island modes, and, if equipped with energy storage, participate in black start and system restoration after failures.

NREL notes that GFM inverters are becoming necessary due to the growing share of inverter-based resources in the power system, and also notes that, in practice, it is beneficial to deploy GFMs primarily in the weakest sections of the grid and that the combination of GFMs and storage maximizes their potential. In a 2024 IEEE Power & Energy Magazine review, GFMs are considered a key resource for renewable-rich power systems because they are able to respond almost instantly to system changes and help stabilize the grid, while conventional IBRs without grid-forming functions lack a number of capabilities, including autonomous operation and participation in blackout recovery.

At the same time, GFM inverters cannot be considered a simple, one-size-fits-all solution. They still face challenges in terms of current limitations during faults, configuring droop control, virtual synchronous machine, and virtual oscillator control algorithms, coordination with GFL inverters, interaction with existing

relay protection, and preventing new types of oscillations. GFM technologies are essential for the stable and reliable operation of low-inertia systems, but require further development of topologies, control strategies, small-signal stability modeling, and inverter-grid interactions. It is particularly important that the power system in the near future will be neither fully GFL nor fully GFM, but a hybrid. In systems where GFL and GFM operate simultaneously, a GFL inverter with MPPT can act as a source of forced oscillations, inducing GFM inverter modes, requiring specialized compatibility analysis and parametric tuning. Therefore, the most rational strategy for renewable energy sources is not to completely abandon GFL inverters, but to combine them with GFM resources and energy storage. GFLs remain effective for mass generation and cost-effective power delivery to a stable grid, while GFMs must perform system-forming functions—maintaining voltage, frequency, inertia-like response, resilience of weak nodes, and recovery from disturbances.

This is confirmed by studies of the coordination of GFL and GFM storage systems for virtual inertia, where differences in synchronization and frequency response mechanisms require coordinated control, but with proper configuration, can achieve the desired overall inertia effect. Practical results from the PNNL/IEEE PESGM also show that replacing GFL batteries with GFM batteries in power systems with a high concentration of inverter-based resources improves the voltage profile, active power during and after a fault, and increases the permissible renewable energy output from a local area. Therefore, when comparing the capabilities, we can conclude: GFL inverters remain technologically mature, economical, and effi-

cient in a strong grid, but rely on pre-established voltage and frequency; GFM inverters are more complex and expensive in terms of control and system coordination, but they ensure the transition of renewable energy from a passive power source to an active element of power system stabilization.

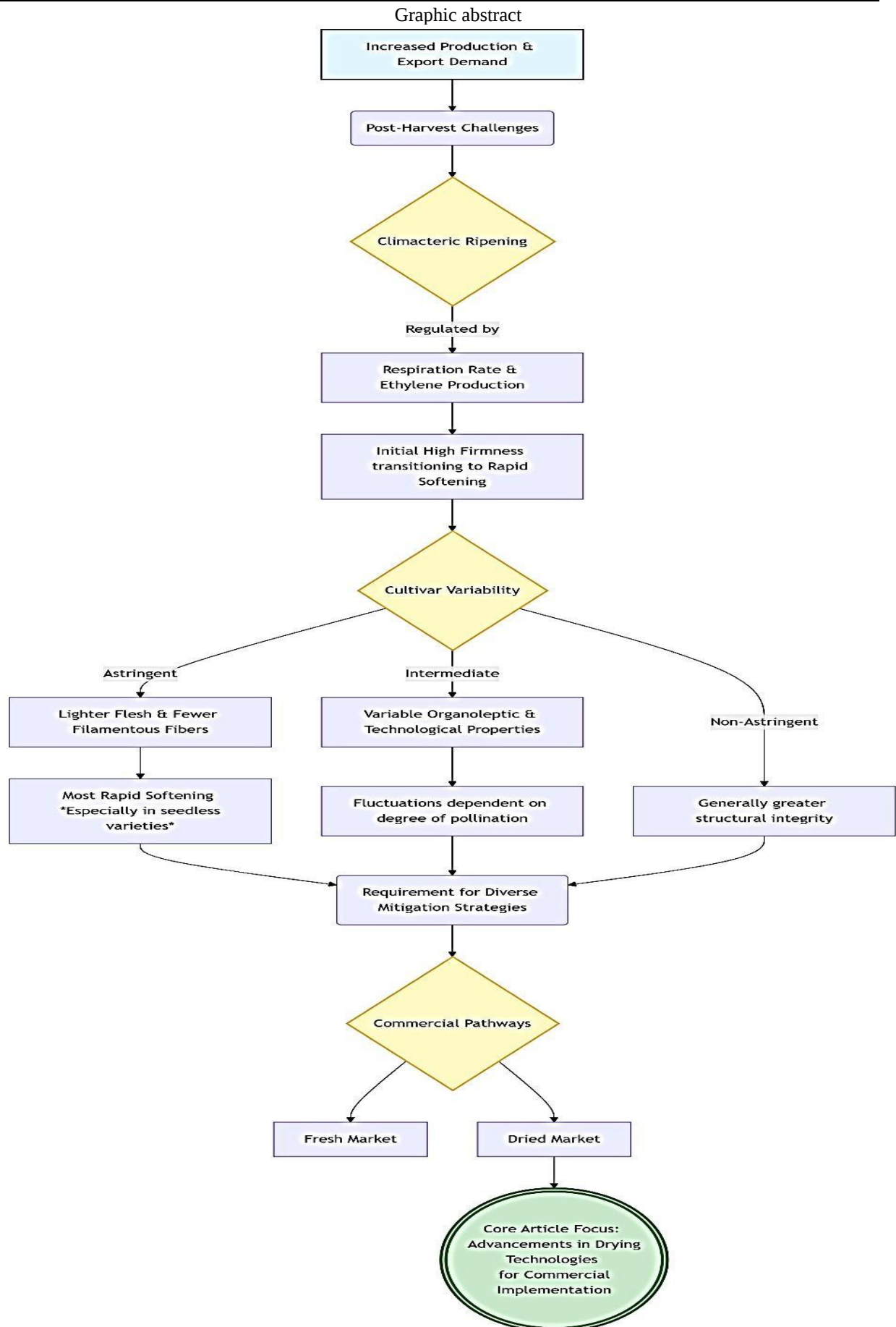
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PRODUCTS FROM DRYING PERSIMMONS OF VARYING DEGREES OF MATURITY**Hafizov S.***Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan***Hafizov Gh.***Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan*<https://doi.org/10.5281/zenodo.20448105>**Abstract**

The production of dried persimmons is a dynamically developing segment of the dried fruit market, especially in countries with a high level of fresh persimmon cultivation (Azerbaijan, China, Uzbekistan). Due to the high concentration of fruits during drying (about 300 grams of dried fruit is obtained from 1.5 kg of fresh fruit), production volumes in terms of fresh product are very significant. Currently, the possibility of using this fruit as a raw material for obtaining not only natural dried persimmons, but also other products from its drying is being actively studied. This article provides a brief updated overview of the potential industrial use of persimmon fruits in this area, focusing on the suggestions of the authors of this article.

Keywords: Freshly harvested hard persimmon fruits, aged softened persimmon fruits, processed by drying.



Introduction

Recently, research on persimmon fruits has primarily focused on their physiological functions, including their antioxidant, lipid-lowering, anti-atherosclerotic, antitumor, and antiviral activities [1-2]. Nevertheless, thousands of tons of persimmons are discarded annually due to high production volumes, stringent quality standards, and consumer expectations regarding shape, size, and color [3]. Furthermore, the persimmon has a limited shelf life; as a seasonal and perishable fruit, it presents significant challenges for storage and transportation [4-5]. Although typically firm at harvest, the fruit undergoes rapid softening after one to two weeks of storage under ambient conditions; as senescence progresses, structural integrity diminishes and handling becomes increasingly difficult [6]. Consequently, post-harvest losses can account for up to 20% of the total annual production volume [7-8].

Inadequate post-harvest handling, microbial contamination, and high respiration rates are primary factors contributing to the short shelf life of perishable commodities. Therefore, effective preservation techniques are essential to mitigate spoilage and extend shelf life. Preservation encompasses the processes applied to perishable commodities to maintain their quality and consumer acceptability over extended periods [9].

A significant increase in persimmon production, coupled with a higher proportion of fruit intended for export, has necessitated the adaptation of post-harvest technologies to ensure the fruit reaches the end consumer in optimal condition. As the persimmon is a climacteric fruit, its ripening during storage is regulated by respiration rate and ethylene production. Depending on the cultivar, the fruit may initially be astringent or non-astringent. At the time of commercial harvest, persimmon flesh is typically very firm across all varieties, but it subsequently undergoes rapid softening, which poses significant challenges during transport. The flesh of astringent varieties is generally lighter than that of

non-astringent varieties. However, astringent varieties possess fewer filamentous fibers to support their structural integrity; consequently, during post-harvest senescence, seedless astringent fruits soften more rapidly than less astringent fruits containing one or more seeds. Furthermore, numerous intermediate varieties exist, whose organoleptic and technological properties fluctuate annually based on the degree of pollination. This variability requires growers to adopt diverse strategies to mitigate post-harvest losses. Commercially, persimmons are predominantly marketed either fresh or dried. This article provides a concise, up-to-date overview of recent advancements in persimmon drying technologies, intended to inform growers and commercial enterprises seeking to implement projects in this sector.

Traditional drying method

Air drying is the oldest and simplest method for persimmon dehydration; the process is terminated at a moisture content of approximately 50% (yielding semi-dried persimmons) or continued until the moisture content reaches 35% or lower [10-11].

The production and consumption of semi-dried and dried persimmons are traditional in Asian countries such as South Korea, China, and Japan, employing various processing methods to yield high-quality, shelf-stable products with desirable organoleptic properties [12-13].

In Azerbaijan (and neighboring Georgia), firm, ripe fruits are selected for this traditional drying method. The fruits are carefully peeled while leaving the stems intact, which are then used to tie them with strong threads, ensuring no physical contact between individual fruits. The resulting strings are suspended under a canopy (Fig. 1, A). During the drying process, some producers periodically massage the fruits to improve their final shape and accelerate surface sugar crystallization (Fig. 1, B). The drying process typically requires one month; however, the fruits are occasionally left suspended until March.



Figure 1. Stages of the traditional drying method: (A) - Peeled fruits suspended on threads for air-drying under a canopy; (B) - Dehydrated persimmons exhibiting characteristic surface sugar crystallization.

Bundles of dried persimmons tied with threads (Fig. 1) are sold in Georgian markets at a relatively low price, starting from 3.5 GEL (\$1.10) per kg. However, prices for seedless dried persimmons (typically produced from the "Hachiya" cultivar) are twice as high, starting at 7.5 GEL (\$2.30) per kg. For comparison, the cost of prunes, which are also popular in Georgia, starts at 10 GEL (\$3.03) per kg.

Prices for dried persimmons and prunes in Azerbaijan are largely comparable to those in Georgia.

In these markets, dried persimmons attract notably less consumer interest compared to dried apricots, raisins, and plums. This is partly due to the product's inconsistent appearance; although typically sold as

whole, peeled fruits, their visual characteristics vary significantly from batch to batch.

Producers often delay the sale of dried persimmons until a white, fluffy efflorescence of sugar crystals develops on the surface. However, this practice increases the risk of microbial contamination [14].

Although this traditional drying method is well-established, research has investigated how the final product's qualitative characteristics vary depending on the persimmon cultivar and cultivation region. Notably, Spanish researchers have identified the physicochemical and microstructural changes occurring during the natural drying of "Rojo Brillante" persimmons harvested at two different maturity stages [15]. Fruits at the

first maturity stage had a lower average weight (195.3 g) compared to those at the second stage (252.0 g). A moisture content of 50%, classifying the persimmon as semi-dried, was reached after 21 and 28 days for the 195.3 g and 252.0 g fruits, respectively. Drying induced slight browning, resulting in color degradation. Dehydration also led to a significant decrease in soluble tannin content; by the 28th day of drying, the fruits had completely lost their astringency.

The natural canopy drying of whole persimmons is a traditional practice in Asian countries (e.g., China, South Korea, and Japan), yielding a product with desirable organoleptic and nutritional properties that is consumed and produced on an industrial scale. The standard preparation involves removing the calyx and skin, followed by suspending the fruit on threads. In China and Japan, the partially dried fruits are manually kneaded toward the end of the process to ensure uniform moisture distribution and to shape the final product [16].

González et al. [1] applied this drying method to "Rojo Brillante" persimmons, comparing the properties of naturally astringent fruits with those pretreated with CO₂ to remove astringency prior to drying. After 20 days, a natural reduction in soluble tannin content occurred; ultimately, both the initially astringent and the pretreated non-astringent fruits exhibited similar final concentrations (20-30 mg/100 g). Furthermore, the flesh of the untreated astringent fruits retained an orange hue, whereas the CO₂-treated fruits exhibited browning. Consequently, pretreatment to reduce astringency is unnecessary when utilizing this drying method.

Villena et al. [17] analyzed the physicochemical and microstructural changes during the natural drying of "Rojo Brillante" persimmons harvested at an early maturity stage (S1) and a late maturity stage (S2). Water loss induced shrinkage, leading to the formation of a secondary epidermis and the gelation of the internal flesh. Compared to S2 fruits, S1 fruits developed a thicker secondary epidermis and a smaller internal gelated region, resulting in a firmer final product. Microstructural analysis revealed the degradation of parenchyma cells in both the secondary epidermis and the internal flesh following drying, with S1 exhibiting a more rapid rate of degradation than S2. Consequently, the final characteristics of the dried persimmon are highly dependent on the maturity stage at harvest.

Although dehydration under a canopy or in direct sunlight remains one of the most common methods for drying persimmons [1], it presents hygiene concerns; furthermore, the drying period can extend to several weeks under uncontrolled environmental humidity [18].

A successful dehydration process relies on a slow, consistent application of heat to ensure uniform drying [9]. Modern, advanced drying techniques involve either the use of mechanical dehydrators [20-21] or sun drying intensified by solar air heaters [22-23].

Drying persimmons with the concentration of solar energy using solar air heaters

On an industrial scale, solar drying is utilized for persimmon dehydration, resulting in an extended shelf

life [24], reduced microbial spoilage [25], enhanced quality, and the retention of nutritional properties [26-27]. Hanif et al. [28] and Senadeera et al. [24] reported that increasing slice thickness and decreasing drying temperature influence the vitamin C content in persimmons. They concluded that to maximize vitamin C retention, persimmons should be dried at temperatures below 50 °C with a slice thickness of 1.0 cm.

Another study demonstrated that elevating the drying temperature reduced fungal infections by up to 22.1%, while the application of honey was more effective than aloe vera gel in decreasing the aflatoxin content of the dried fruit [29]. Similarly, the exogenous application of a 10.0% persimmon peel extract aided in preserving the nutritional and mineral composition of the fruit. Furthermore, this peel extract demonstrated superior efficacy in maintaining nutritional value when compared to commercially available synthetic preservatives [26,30]. Bolek and Obuz [31] pretreated fruit samples with sodium metabisulfite prior to drying at various temperatures; they observed the highest rehydration capacity and ascorbic acid retention at 50 °C. Moreover, during storage, control treatments exhibited the maximum activity of mesophilic aerobic bacteria, whereas the treated samples displayed the lowest activity, indicating the antimicrobial efficacy of sodium metabisulfite.

Blanching duration and drying temperature significantly impact hourly moisture loss and overall drying time. The shortest drying time and highest rehydration values were achieved with a 5-minute blanching period [26].

Pretreatment of persimmons with nitrogen or carbon dioxide demonstrated that both gases contribute to preserving texture and nutritional quality after three weeks of storage; nitrogen-treated fruits exhibited a superior visual appearance, while carbon dioxide-treated fruits possessed superior organoleptic taste properties [32].

Sun-dried persimmons (dehydrated for 12 hours at 60 °C) contained lower polyphenol levels than fresh fruit, although differences in the concentrations of trace elements, minerals, and dietary fiber were insignificant [27].

Persimmons pretreated with citric acid exhibited the highest contents of dry matter, glucose, fructose, and vitamin C. Additionally, sulfur treatment significantly influenced the physicochemical characteristics and volatile profile of the dried fruits, resulting in the identification of approximately 45 aromatic compounds [3].

A study investigated the individual and interactive effects of varying temperatures, alongside natural and artificial preservatives, on the drying kinetics and organoleptic characteristics of the 'Fuyu' persimmon cultivar. The fruit was harvested from the experimental orchard at Peshawar

Agricultural University, Khyber Pakhtunkhwa, Pakistan (34.02° N, 71.48° E, elevation 359.0 m) [34]. Harvested fruits were washed, blanched in water at 70 °C, and arranged on the trays of a solar dryer. The experimental design incorporated two factors: drying temperature and food preservatives (two natural and

three artificial). Three temperature regimens (40, 45, and 50 °C) and five preservative treatments were evaluated: a 25% honey solution, a 25% aloe vera solution, a 2% sodium benzoate solution ($C_7H_5NaO_2$), a 1% potassium metabisulfite solution ($K_2S_2O_5$), and a 2% citric acid solution ($C_6H_8O_7$). An experimental setup was constructed, comprising a forced convection solar dryer equipped with a flat-plate solar collector, a drying cabinet, and an exhaust fan (Fig. 2).

The total drying duration was approximately 13.0 hours. An evaluation of the drying temperatures indicated an hourly moisture loss of 8.2% at 50 °C, followed by 6.8% at 45 °C, with the minimum loss (6.1%) recorded at 40 °C. Regarding the preservatives, the highest hourly moisture loss (7.8%) occurred in persimmons treated with the 2% citric acid solution, while the

lowest (6.4%) was observed with the 1% potassium metabisulfite solution. Overall, the maximum hourly moisture loss (9.3%) was recorded at a drying temperature of 50 °C combined with the 2% citric acid treatment, whereas the minimum (6.1%) occurred at 40 °C with the 25% honey solution treatment. The individual and interactive effects of drying temperature and preservatives also significantly influenced the pH of the dried persimmons. The highest (6.32) and lowest (6.13) pH values were observed at drying temperatures of 45 °C and 50 °C, respectively. Sugar and vitamin C contents, alongside titratable acidity, peaked in samples subjected to the citric acid pretreatment and dried at 50 °C.



Figure 2. Experimental setup of the forced-convection solar dryer utilized for persimmon dehydration, comprising a flat-plate solar collector, a drying cabinet, and an exhaust fan [34].

Consequently, the temperature of the air utilized in the dehydration process is a primary factor dictating the drying rate. Excessively high drying temperatures can cause thermal damage to the product or induce the undesirable phenomenon of "case hardening." Furthermore, elevated temperatures can lead to the significant degradation or complete destruction of beneficial chemical constituents. Therefore, strict limitations must be imposed on the drying temperatures applied to most food commodities. Conversely, raising the temperature accelerates the dehydration process and enhances the microbial safety of the final product.

The use of special devices with a forced change of factors affecting the intensity of drying

Persimmon Chips

Although the comparable yield in mass between naturally and artificially dried persimmons may create an illusion of economic advantage for natural drying, the functional versatility of natural drying is significantly lower. This is particularly true regarding its potential to yield novel products with targeted functional properties.

In recent years, crisp fruit snacks have gained increasing popularity among modern consumers [35]. However, persimmon snacks produced via natural drying are unlikely to satisfy consumer demand for a crisp texture.

Freeze-drying yields a crisp product rich in biologically active compounds [1]. Furthermore, this method achieves superior retention of these bioactive compounds compared to alternative drying techniques.

However, freeze-drying is a highly time-consuming, energy-intensive, and costly process [36]. Additionally, prior to freeze-drying, pretreatment is necessary to eliminate astringency, as naturally astringent samples retain high concentrations of soluble tannins and consequently exhibit an excessively astringent mouthfeel [37]. Conversely, persimmon chips dried utilizing a combination of hot air and microwave drying demonstrated similar color, texture, flavor, and overall acceptability to their freeze-dried counterparts [38].

Because every individual drying process possesses inherent limitations, combining multiple methods represents a practical strategy for producing high-quality dried products, effectively bridging existing quality gaps [39]. While microwave drying is rapid and highly efficient, its primary challenges include high operating costs and process control difficulties stemming from rapid and uneven heating, which can result in localized overheating during dehydration [40].

Fruits utilized for chip production must be sufficiently firm to withstand mechanical peeling and slicing by electric processing equipment. In small-scale operations, an abrasive peeling machine (e.g., Hitrees), with a capacity of up to 1000 kg per shift, can be utilized for this purpose (Fig. 3, **A**). For slicing, an electric food processor, such as the "Robot Coupe CL50 Ultra," with a processing capacity of 5 kg of fruit per minute, is highly suitable (Fig. 3, **B**); this specific model is equipped with a large-volume feed hopper possessing a surface area of 139 cm².



Figure 3. Mechanical equipment utilized in the preparation of persimmons for chip production: A- Abrasive peeling machine; B -Electric food processor used for slicing.

Soluble tannins are responsible for the astringency of persimmon fruits, and Gonzalez et al. [1] reported that consumer perception of astringency directly correlates with the soluble tannin content in persimmon snacks.

Firm persimmons are typically astringent, and their slices rapidly darken upon exposure to atmospheric oxygen.

Addressing this issue, the Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan has developed a technology for producing natural chips. This method allows for the near-complete preservation of the color of persimmon slices, while simultaneously improving their flavor profile [41].

Fig. 4 provides a visual representation of this process.

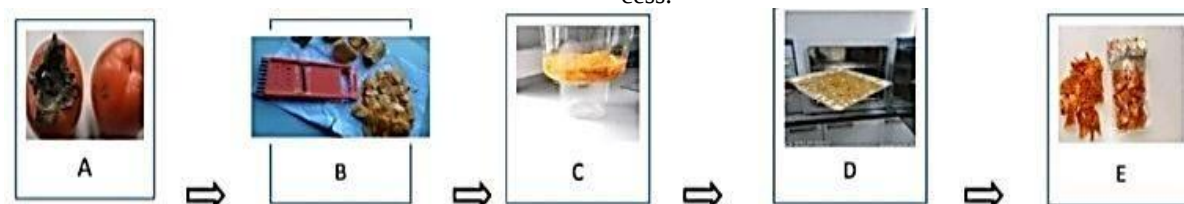


Figure 4. Sequential process to produce natural chips from firm persimmons - the stages illustrate: (A) raw fruit selection; (B) peeling and slicing; (C) pre-treatment for color preservation; (D) dehydration; and (E) the final packaged product.

The fruits (Fig. 4, A) are first washed, and the peduncle is removed from each fruit along with the calyx. Subsequently, the fruits are cut into distinct segments (typically 4 or 8, depending on the fruit's size). The waste generated during this initial processing is negligible, not exceeding 20 g per 1 kg of raw material.

These segments are then sliced to a thickness of 2–3 mm and immediately immersed in a prepared aqueous solution comprising 1 part citric acid, 2 parts sodium chloride (table salt), and 40 parts water (Fig. 4, B; Fig. 4, C). When utilizing an electric food processor for this operation, the solution is dispensed directly into the slicing receptacle.

With each subsequent batch, a fresh volume of the acid-salt solution is added to replenish the mixture. The residual solution remaining after processing four consecutive batches of slices is repurposed for the preparation of other canned fruit products.

The treated slices are carefully extracted using a slotted spoon and arranged on grates to drain excess solution.

The slices treated with the acid-salt mixture are arranged in a single layer on extruded mesh grids with 5 × 5 mm square apertures. Mesh grids are utilized instead of solid aluminum baking trays to prevent the slices from adhering to the surface during dehydration. A single grid measuring 35 cm × 35 cm accommodates 600 g of processed slices.

The grids containing the slices are transferred to mobile racks and loaded into a drying chamber (Fig. 4, D). Dehydration is conducted at a temperature of 70–72 °C and is completed after 3 hours, at which point the

residual moisture content of the product decreases to 11%.

The yield of dried slices from 1 kg of 'Hiakume' persimmons (average fruit weight 268 g; waste components consisting of a peduncle and calyx weighing 2.7 g, and 3 seeds weighing 3.3 g) is 216 ± 0.4 g. To impart a crisp texture, the slices undergo a secondary microwave drying phase to achieve a final moisture content of 5–6%.

The dried slices are packaged in resealable plastic bags (Fig. 4, E), wherein they retain their original organoleptic characteristics (including color) for six months or longer.

This preservation of quality is illustrated in Fig. 5, which depicts the appearance of three samples of the aforementioned persimmon chips after six months of storage at temperatures not exceeding 10 °C.

The results indicate that while all three samples retained the color of the raw material well, the chips produced from slices pre-treated with Solution 1 (comprising 1 part citric acid, 2 parts sodium chloride, and 40 parts water) prior to dehydration exhibited the most attractive visual appearance. Subsequent chemical analysis confirmed the superiority of Sample 1; it demonstrated greater vitamin C retention and a lower concentration of polyphenols-particularly the astringent forms-compared to the other two samples.

In conclusion, the pretreatment of persimmon slices with stabilizing solutions, coupled with a combination of hot air and microwave drying, enables the production of high-quality persimmon snacks while simultaneously conserving time and energy.



Figure 5. Visual comparison of 'Hiakume' persimmon chips following pretreatment in various stabilizing solutions: (1) citric acid, table salt, and water (1:2:40 ratio); (2) table salt, granulated sugar, and water (1:10:20 ratio); and (3) citric acid, table salt, and water (1:2:80 ratio).

Natural dried persimmon without flavoring additives

A study investigated the effect of four drying methods on the total concentration of biologically active compounds in persimmons and the *in vitro* bioavailability of total phenolic content (TPC). The results indicated that ultrasound-assisted vacuum drying, infrared drying (ID), and hot air drying (HAD) enhanced the bioavailability of TPC. Conversely, the bioavailability of lyophilized (freeze-dried) samples did not differ significantly from that of fresh persimmons. This increase in bioavailability was attributed to the thermal treatment applied during dehydration, as heat facilitates the release of biologically active compounds from the food matrix. Consequently, ID and HAD exhibited the highest bioavailability, as these drying methods impose the greatest thermal load [42].

Park et al. [43] conducted dehydration experiments on wafer-thin persimmon slices, achieving complete drying in 12 hours at 60 °C.

Pretreating persimmons with hot steam prior to dehydration resulted in a final dried product that was more astringent than the fresh fruit [44].

Due to pronounced inter-varietal differences, developing a single, universal pretreatment method for persimmon dehydration is considered impractical. For certain cultivars, a pretreatment consisting solely of epidermal peeling is sufficient. For other cultivars, slicing prior to drying is preferable; these slices may be dried directly or subjected to preliminary soaking in stabilizing solutions to enhance the final flavor and texture of the dried persimmons [14].

From a processing standpoint, firm persimmons are easier to handle, segment, and arrange on drying trays. However, at this maturity stage, the fruit's astringency remains at its peak; consequently, it is challenging to produce premium dried fruit from raw materials

that are not fully ripe and have not yet developed optimal organoleptic properties.

Furthermore, firm persimmons require peeling prior to drying, resulting in physical losses and a reduced yield of the target product. Across various cultivars, the usable flesh of under-ripe, firm persimmons accounts for only 49.70% to 85.79% of the total fruit mass [45], with the remainder discarded as peeling waste.

Conversely, fully senescent, softened persimmons develop a tender texture and superior flavor profile that eliminates the necessity of peeling. Following any mechanical disruption of its integrity (which, at this stage of ripeness, must be performed manually), the flesh retains its original color for an extended period without significant browning. The softened fruit can be manually scored with a sharp knife, making several longitudinal incisions from the apex toward the calyx while leaving the base intact. The segments are then gently separated to resemble an open flower, and the fruit is dehydrated in this configuration.

Fig. 6 illustrates the core components of the dehydration technology for aged, softened persimmon fruits developed at the Research Institute of Fruit and Tea Growing of the Ministry of Agriculture of the Republic of Azerbaijan [46, 47, 48].

According to this technology, the preparation of aged, softened fruits for drying proceeds as follows.

First, each fruit (Fig. 6, A) is carefully washed under running water and scored with a sharp knife from the apex to the base, creating 4–8 approximately equal segments. These segments remain attached at the basal end where the calyx is located, and the fruit is then placed on a wire mesh baking tray. Subsequently, these interconnected segments are gently spread apart to create substantial interstitial spaces, giving the fruit the appearance of an open flower with 4–8 "petals" (Fig. 6, B).



Figure 6. Sequential dehydration process for aged, softened persimmons. The stages illustrate: (A) whole washed fruits; (B) fruits scored and expanded into attached "flower-like" segments to facilitate drying; (C) dehydrated fruits on the mesh drying tray; (D) close-up of the fully dried product; and (E) the final packaged fruit.

The dehydration of aged, softened persimmons in this configuration is conducted in a single layer at 70–72 °C for 9.5–10.5 hours, achieving a final moisture content of 24%.

The dried fruits (Fig. 6, C) are manually separated into sections, which may consist of paired segments connected at the base (Fig. 6, D); during this step, the

peduncles and calyces are removed. The dried segments are then packaged in resealable plastic bags (Fig. 6, E). Alternatively, plastic containers with hinged lids may be utilized for this purpose.

The resulting fully dried persimmon product is stored at a temperature not exceeding 10 °C to optimally preserve its initial color, which closely resembles that of the raw material.



Fig.7. Fully dehydrated 'Hachiya' persimmon segments demonstrating the development of surface sugar efflorescence (crystallization) after 6 months of storage at ambient temperature with continuous air exposure.

The yield of the final product from 1 kg of aged, unpollinated (seedless) 'Hachiya' persimmons (average fruit weight 205.5 g) was 284 g; waste generated from trimming the dried fruits (calyx and peduncle) amounted to 15 g.

The shelf life of the fully dried persimmon is 6 months. After this period, a white efflorescence consisting of sugar crystals typically develops on the surface of the segments (Fig. 7).

The yield of the final product from 1 kg of partially pollinated (containing 1–2 seeds) aged 'Hiakume' persimmons (average fruit weight 290 g) was 280 g.

Table.

The component composition of 100% dried persimmons obtained after aging Hachia and Hiakume persimmons until completely softened (g/100 g of air-dry product).

100% dried persimmon	Water	Mono saccharides	Sucrose	Titrated acids (in terms of citric acid)	Total polyphenols, (Mg/100 g)	Vitamin C, (Mg/100 g)
"Hachiya"	24.0±1.0	49.45±2.06	8.70±0.36	1.18±0.05	280.0± 11.67	7.79±0.33

The table with a detailed description of the biochemical evaluation of the finished samples shows that the concentration of simple sugars and polyphenols in natural air-dry persimmon "Hachiya" is significantly higher than in natural air-dry persimmon "Hiakume". This compositional variance provides a rationale for recommending each variety to distinct consumer demographics based on specific dietary profiles.

Conclusion

Thus, in recent years, global persimmon production has increased concurrently with a growing interest in the study of the fruit's nutritional composition, bioactive compounds, and postharvest technologies.

To mitigate post-harvest losses, the utilization of surplus persimmons for dehydration is of particular interest.

A review of the current state of the field demonstrates that the potential to optimize persimmon drying technologies has been, and continues to be, extensively investigated. Of specific interest are recent developments aimed at enhancing the organoleptic properties of dried persimmons, alongside the establishment of appropriate hygienic standards and optimal product forms for consumer presentation.

As evidenced by these technological advancements, adhering to a processing paradigm that utilizes firm fruits during the primary commercial harvest, followed subsequently by aged, softened fruits, can significantly extend the operational season for dried persimmon production.

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**LEGAL FRAMEWORK FOR THE ORGANIZATION OF BUILDING MATERIALS PRODUCTION
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**ПРАВОВЕ ЗАБЕЗПЕЧЕННЯ ОРГАНІЗАЦІЇ ВИРОБНИЦТВА БУДІВЕЛЬНИХ МАТЕРІАЛІВ
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Abstract

The article presents an analysis of the current state of building materials production under wartime conditions, as well as the prospects for the development of this sector during the period of post-war reconstruction of Ukraine's national economy. It is noted that the volume of building materials production has objectively decreased due to the destruction of production capacities as a result of military actions, as well as the location of major industrial enterprises in temporarily occupied territories.

It has been established that, during the hostilities, approximately 138 million square meters of buildings were destroyed, and 26 thousand square kilometers of roads were damaged, which has led to a significant increase in demand for building materials. At the same time, the cost of construction materials has risen substantially due to the devaluation of the national currency, disruptions in logistics chains, and increased energy prices.

Shortages of cement, concrete, dry construction mixtures, mineral wool, PVC profiles, flat glass, and electrical products may pose serious challenges to the recovery of the national economy. However, this situation simultaneously creates significant potential for future investment. It is emphasized that the current decline in building materials production is not critical, although demand from construction companies has decreased fivefold. Nevertheless, once reconstruction begins, all available production capacities will be required, and their expansion will become necessary, leading to rapid growth in the construction materials market.

In response to legislative changes aimed at enhancing public safety and improving the energy efficiency of buildings and structures, trends have been identified indicating increased demand for energy-efficient construction materials and modular reinforced concrete shelters. Under conditions of effective management, it is possible to generate added value from domestic production of building materials, which could create approximately 180,000 jobs—exceeding pre-war levels [2].

The study also analyzes the production of building materials in the relatively safe (“rear”) Ivano-Frankivsk region in 2023 compared to 2022, as well as industry trends in 2024, highlighting positive performance dynamics for most enterprises. In order to significantly increase production volumes of building materials based on local raw materials, it is proposed to utilize abandoned industrial facilities, which are present in nearly all territorial communities of the region, for the establishment of socially important production capacities. This approach should incorporate scientific and technological advancements, innovation, and best international practices.

Particular attention is paid to the legal aspects of industry regulation under martial law. The study examines state deregulation measures, simplification of permitting procedures, implementation of European quality standards, and mechanisms for stimulating demand through state reconstruction programs. It is concluded that there is a need to maintain a balance between easing business conditions and ensuring strict compliance with safety and environmental standards for construction products.

Анотація

У статті проведено аналіз стану справ з виробництвом будівельних матеріалів в умовах війни, а також перспективи розвитку цієї галузі в період відбудови народного господарства України. Відзначено, що обсяги виробництва будівельних матеріалів об'єктивно зменшилися через руйнування виробничих потужностей внаслідок воєнних подій, а також знаходження великих підприємств на окупованих територіях. Підтверджено, що за час бойових дій було зруйновано 138 млн квадратних метрів будівель та пошкоджено 26 тисяч квадратних кілометрів доріг, що призвело до підвищення попиту на будівельні матеріали. У свою чергу, вартість будівельних матеріалів значно зросла, через девальвацію гривні, логістичні проблеми та здорожання енергоносіїв. Дефіцит цементу, бетону, будівельних сумішей, мінеральної вати, ПВХ-профілів, листового скла, електротехнічної продукції може створити значні виклики для відновлення народного господарства, але це є важливим потенціалом для інвестування на перспективу. Звернута увага, що в нинішній ситуації зниження виробництва будівельних матеріалів не є критичним, хоча попит від будівельних організацій зменшився в п'ять разів. Про те, коли розпочнеться відновлення, всі потужності будуть потрібні, їх необхідно буде збільшувати і ринок будівельних матеріалів буде стрімко зростати. У відповідь на внесені законодавством зміни щодо підвищення безпеки населення і покращення енергоефективності будівель і споруд визначено тенденції щодо підвищення попиту на енергоефективні будівельні матеріали та модульні залізобетонні укриття. За умови ефективного управління ми можемо формувати додану вартість від виробництва будівельних матеріалів на території України, що дозволить створити близько 180 тисяч робочих місць - більше, ніж до війни. Проаналізовано виробництво будівельних матеріалів в «тиловій» Івано-Франківській області за 2023 рік в порівнянні з 2022 роком і тенденції роботи галузі в 2024 році і відзначено позитивну динаміку роботи більшості підприємств. З метою значного збільшення обсягів виробництва будівельних матеріалів з місцевих сировинних ресурсів запропоновано використовувати покинуті виробничі приміщення, які є практично у всіх територіальних громадах області під організацію потужностей соціально важливої продукції з використанням науково-технічного прогресу, інновацій та передового досвіду.

Особливу увагу в дослідженні приділено правовим аспектам регулювання галузі в умовах воєнного стану: проаналізовано заходи державної дерегуляції, спрощення дозвільних процедур, імплементацію європейських стандартів якості та механізми стимулювання попиту через державні програми відбудови. Зроблено висновок про необхідність балансу між спрощенням умов ведення бізнесу та дотриманням суворих норм безпеки й екологічності будівельної продукції.

Keywords: building materials; martial law; market; production; scientific and technological progress; innovation; imports; legal framework; deregulation; European standards.

Ключові слова: будівельні матеріали; воєнний стан; ринок; виробництво; науково-технічний прогрес; інновації; імпорт, *правове забезпечення, дерегуляція, європейські стандарти.*

Постановка проблеми. Базовою галуззю будівельного комплексу є промисловість будівельних матеріалів. До війни серед країн Центральної Європи Україна була одним з найбільших вироб-

ників і експортерів різноманітних будівельних матеріалів, які виробляються з природної сировини (будівельний камінь, кам'яні облицювальні матеріали, вогнетривкі глини, каолін, кварцити тощо) та хімічним способом (покрівельні матеріали,

пластмаси, смоли, клейкі речовини, полістиролові й кумаринові плити та ін.). Обсяг виробництва будівельних матеріалів складав 16 млрд. доларів із понад 130 тисячами працюючих в цій галузі. Щорічно ринок зростає на 10% і Україна поставляла на експорт 5% продукції, при цьому повністю забезпечуючи свої потреби. Повномасштабне вторгнення Росії значно вплинуло на зниження попиту на будівельні матеріали в прифронтових регіонах і складнощі з релокацією підприємств. Водночас, 90% будівельних матеріалів, необхідних для відбудови можуть вироблятися в Україні. У «тилових» областях, зокрема, Івано-Франківській, є наявний потенціал потужностей з виробництва будівельних матеріалів. На основі існуючих промислових підприємств, а також з використанням покинутих виробничих приміщень, які є практично у всіх територіальних громадах області, з необхідною їх реконструкцією і впровадженням досягнень науково-технічного прогресу, інновацій є можливість значно збільшити обсяги, розширити асортимент будівельних матеріалів в основному з місцевих сировинних ресурсів. Все це повинно здійснюватися під відповідальним керівництвом місцевих територіальних громад, районних й обласної військових адміністрацій відповідно до Закону України «Про правовий режим воєнного стану».

У цих умовах ключову роль відіграє здатність держави створити гнучке, адаптивне та ефективне правове поле, яке дозволить виробникам швидко відновити потужності, релокувати підприємства у безпечні регіони та забезпечити потреби ринку якісною вітчизняною продукцією.

Аналіз досліджень публікацій. З означеної проблематики існує ряд публікацій, які носять загально інформаційний і рекомендаційний характер. Серьогіна Н.В., Пашинов В.О. та Петренко О.В. проаналізували загальний стан галузі виробництва будівельних матеріалів на прикладі окремих груп, визначили зовнішні та внутрішні фактори впливу на обсяги виробництва будівельної продукції [1, с.117].

Т. Одаренко, розглядаючи передумови й перспективи розвитку будівельного комплексу України, оцінює промисловість будівельних матеріалів, як комплекс галузей у складі важкої промисловості, які виготовляють матеріали, деталі й конструкції для всіх видів будівництва (цементу, азбестоцементних виробів, збірних залізобетонних і бетонних конструкцій та виробів, стінових матеріалів, будівельної кераміки, будівельних матеріалів та виробів з полімерної сировини, нерудних будівельних матеріалів, пористих заповнювачів тощо) [2, с.44].

О. Латишева стверджує, що така ситуація обумовлена збільшенням ступеню зношення основних засобів, зменшенням обсягів введення нових основних засобів, зниженням рентабельності діяльності виробництв будівельної продукції [3, с.71. На думку окремих авторів, проблеми й перешкоди розвитку виробництва будівельних матеріалів сповільнюють соціально-економічний розвиток

країни, погіршують їх конкурентну позицію. Проте оцінці розвитку виробництва будівельних матеріалів України в умовах воєнного стану поки що не приділено достатньо уваги. Також питання комплексного правового забезпечення саме організації виробництва будівельних матеріалів, з урахуванням новітніх законодавчих змін періоду воєнного стану та курсу на євроінтеграцію, потребують додаткового ґрунтовного дослідження.

Мета статті - аналіз тенденцій та перспектив розвитку виробництва будівельних матеріалів України в умовах воєнного стану, а також передумов і факторів, що сприятимуть розвитку ринку будівельних матеріалів в період відбудови.

Аналіз проведено на прикладі «тилової» Івано-Франківської області по виробництву промислової продукції, що використовується в будівництві.

Виклад основного матеріалу. З період повномасштабної війни галузь по виробництву будівельних матеріалів зазнала значних збитків. За даними Всеукраїнської спілки виробників будівельних матеріалів, щонайменше 70 великих будівельних підприємств, понад 300 середніх і близько однієї тисячі малих було зруйновано внаслідок бойових дій, а також в даний час знаходяться на окупованих територіях. Аналітики відзначають, що руйнування підприємств будівельної галузі триває, тому виробникам і постачальникам будівельних матеріалів потрібно шукати нові логістичні ланцюжки. Така тенденція спостерігається і в 2024 році [6, с.44].

Протягом 2022-2023-2024 років втрат зазнали різні сегменти промисловості будівельних матеріалів, зокрема металопрокату, скла та сухих будівельних сумішей. Від валютного ринку залежить вартість імпортованих будівельних матеріалів в Україні, так і собівартість їх виробництва із закордонної сировини і на іноземному обладнанні. У відповідь на загрози воєнного часу відбулися зміни в законодавчих документах щодо підвищення безпеки людей і покращення енергоефективності будівель і споруд. У ДБН В.2.6-31:2021 змінилися вимоги до мінімально допустимих значень приведенного опору теплопередачі огорожувальних конструкцій будівель і споруд з їх підвищенням в середньому на 28%.

Внесені зміни до закону України №2486-IX регламентують вимоги до улаштування об'єктів цивільного захисту при проектуванні і будівництві нових будівель і споруд.¹ На ринку будівельних конструкцій з'явилися модульні залізобетонні укриття, призначені для захисту людей під час надзвичайних ситуацій військового характеру. Нові вимоги призвели до зміни технологій виробництва окремих будівельних матеріалів, що також вплинуло на здороження собівартості продукції. В результаті поступового відновлення виробництва будівельних матеріалів в Україні помітно не лише зростання цін на ринку будівельних матеріалів, але також підвищення рівня заробітної плати працівників цієї галузі [13, с.9].

Вартість будівельних матеріалів в період воєнного часу зросла більше як вдвічі, порівняно з довоєнними цінами.

Одним із головних матеріалів для відбудови народного господарства України є цемент. За даними Асоціації «Укрцемент», потреба цементу в роки відбудови становитиме щонайменше 14 млн. тон на рік. До такої потреби необхідно готувати потужності цементної промисловості України. Зокрема, мова йде про будівництво клінкерних печей для збільшення потужностей по виробництву цементу понад 2,4 млн. тон на рік. Цементна сировина і цементна промисловість розміщена по всій території України. В довоєнний період збільшилася частка високоякісних сортів цементу і щорічно зростали його обсяги. Свого часу на території України утворилися великі зони виробництва цементу: південно-східна (Донецька область), південна (Миколаївська область), західна (Рівненська, Хмельницька, Львівська, Івано-Франківська області).⁴²

В умовах війни підприємства цієї галузі на сході і півдні нашої держави майже не працюють або працюють на окупованих територіях

Основне навантаження по виробництву цементу для будівельної галузі взяли на себе підприємства, які розміщені в «тилових» областях Західної України, зокрема ПрАТ «Івано-Франківськ цемент». Також великий попит прогнозується на бетон, цеглу, металоконструкцію, скло, теплоізоляційні та облицювальні матеріали. У сучасному будівництві спостерігається підвищений попит до застосування енергоефективних будівельних матеріалів, зокрема виготовлених по інноваційних технологіях з використанням місцевих сировинних ресурсів в «тилових» областях [1, с.23]. Серед інноваційних технологій можна відзначити розробку ТОВ «Енергетичні інноваційні технології» «Конструкції огорожуючі для захисту від ударної хвилі та уламків» згідно Технічних умов ТУ У 13.2.6 – 23,6 – 36216527 – 001:2024 р., які набрали чинності 30.10.2024 р.

Такі конструкції можна виготовляти на одному із підприємств в «тиловій» Івано-Франківській області, або для організації виробництва перепрофілювати одне із виробничих приміщень, які в даний час не використовуються. Важливим являється організація виробництва композитної терасної дошки типу «PolyWood» з використанням відходів деревообробної промисловості, а також відходів продукції рослинництва агропромислового комплексу і наповнювачів місцевого хімічного підприємства

В даний час більшість українських інвесторів готуються до відбудови і активно прораховують вартість проектних і будівельно-монтажних робіт, але очікують завершення воєнних дій і справедливого миру. Для міжнародних інвесторів виробництво будівельних матеріалів України може розглядатися, як пріоритетний для інвестицій та надання допомоги постраждалим від війни економіці. Міжнародні фінансові інституції планують залучатися до відбудови народного господарства

України. Ключовими критеріями фінансування повоєнного будівництва в Україні будуть швидкість та прозорість реалізації проектів, тому міжнародні організації вже сьогодні починають налагоджувати партнерство з виробниками будівельних матеріалів.

При цьому у пріоритеті стають підприємства, які працюють з європейськими технологіями і матеріалами, що дозволяє створювати сучасні енергоефективні та архітектурно привабливі будівлі і споруди.

Забезпечення будівництва матеріалами вітчизняного виробництва підтримає після воєнне ослаблене народне господарство України через зростання виробленої доданої вартості, організацію робочих місць та збільшить надходження до місцевих бюджетів, а також зменшить потребу фінансування із державного бюджету за рахунок інвестицій міжнародних фінансових організацій.

Аналіз виробництва будівельних матеріалів в «тиловій» Івано-Франківській області за 2022-2023 роки і тенденції в 2024 році.

Промислове виробництво в області охоплює широкий спектр видів діяльності, одним із яких є випуск будівельної продукції. Виробництво промислової продукції, що використовується в будівництві забезпечують більше ста підприємств регіону.

У виготовленні виробів із деревини у 2023 році порівняно з попереднім роком спостерігається зменшення окремих видів продукції, зокрема обсяги виробництва виробів столярних та конструкцій будівельних з деревини зменшилися на 5,4%; деревини, уключаючи планки та фриз для паркетного покриття підлоги, незібрані, у вигляді погонажу уздовж будь якого з ребер, торців чи площин, стругана або нестругана, шліфувана або з'єднана в шип(крім хвойних порід та бамбука)-на 23,1%; виробництво вікон, дверей балконних та їх рам – на 31%; деревини хвойних порід у вигляді погонажу профільованого уздовж будь якого з ребер чи площин, уключаючи планки та фриз для паркетного покриття підлоги, незібрані-на 35,7%.

У 2024 році порівняно з аналогічним періодом минулого року зменшилося виробництво вікон, балконних дверей і їх рам (у 5,8 раза); деревини хвойних порід у вигляді погонажу профільованого уздовж будь якого з ребер чи площин, уключаючи планки та фриз для паркетного покриття підлоги, незібрані (на третину). Водночас, за вказаний період зросло виробництво деревини, уключаючи планки та фриз для паркетного покриття підлоги, незібрані у вигляді погонажу уздовж будь-якого з ребер, торців чи площин, стругана або нестругана, шліфувана або з'єднана в шип (крім хвойних порід та бамбука)-в 1,7 рази; виробів столярних та конструкцій будівельних з деревини-на 4,4%.

На підприємствах з виробництва гумових і пластмасових виробів у 2023 році зросло вироб-

⁴² Закон України від 29.07.2022 №2486-IX «Про внесення змін до деяких законодавчих актів України щодо забезпечення вимог цивільного захисту під час планування та

забудови територій. Верховна Рада України. Законодавство України: сайт.URL: <https://zakon.rada.gov.ua/laws>.

ництво вікон та їх рам, дверей та їх коробок і порогів з пластмас-на 20,7%. Спостерігається також зростання у виробництві будівельних елементів, які використовуються для спорудження підлог, стін, перегородок, стель, дахів т. ін [2, с.38].

У січні–серпні 2024р. порівняно з аналогічним періодом 2023 року зросло виробництво гіпсових сумішей, що складаються з кальцинованого гіпсу або сульфату кальцію; клінкерів цементних; портландцементу; блоків та цегли з цементу, бетону або каменю штучного для будівництва (на 2,2–49,3%); розчинів бетонних, готових для використання (на 6,6%); плиток, плит, черепиці та виробів подібних з цементу, бетону або каменю штучного (крім блоків та цегли для будівництва) (на 14,9%); цегли невогнетривкої керамічної будівельної (крім виробів з борошна кам'яного кремнеземистого чи ґрунтів діатомітових) (на 17,6%); елементів конструкцій збірних для будівництва з цементу, бетону або каменю штучного (на 18,7%) [5, с. 46].

Виробництво будівельної продукції в області демонструє змішану динаміку, що може бути пов'язано як з внутрішніми, так і з зовнішніми чинниками економічного характеру (Коба, 2020, с.353). Упродовж останніх трьох років намітилася позитивна динаміка у виробництві портландцементу, клінкерів цементних, каменю дробленого, а також дверей, плиток і плит керамічних, елементів і збірних конструкцій для будівництва з цементу, бетону чи каменю штучного, розчинів бетонних, сумішей асфальтових для дорожнього покриття, листів профільованих холоднодеформованих, зі сталі нелегованої [4, с. 19]. Водночас зменшилися обсяги у виробництві цегли керамічної будівельної, виробів столярних і конструкцій будівельних, з деревини, пісків будівельних (глинисті, каолінові, полевошпигитові), крім кременистих і металонасних пісків.

У «тилових» областях, зокрема, в Івано-Франківській області, необхідно провести інвентаризацію виробничих приміщень колишніх промислових підприємств, які з різних причин припинили свою діяльність, і перепрофілювати їх на організацію виробництва будівельних матеріалів [7 с. 199]. Для прикладу, це приміщення Хриплинського промислового вузла в м.Івано-Франківську, приміщення і територія бувшого заводу ТОС «Барва» в с.Ямниця, приміщення покинутих хімічних виробництв в м. Калущі, заводів сільсько-машинобудування і електрооснастки в м. Коломий, бувших лісокомбінатів і багато ін. Практично в кожній територіальній громаді є приміщення, які можна перепрофілювати під виробництва необхідних будівельних матеріалів. Щодо кадрового забезпечення доцільно працевлаштувати випускників спеціалізованих ліцеїв, коледжів, вищих навчальних закладів на створених виробництвах з відповідним бронюванням на період воєнного стану.

Таким чином, для збільшення виробництва будівельних матеріалів потрібних обсягів і асортименту необхідно:

- активізувати розвиток й використання досягнень науково-технічного прогресу, інновацій, передового досвіду в галузі як способів дій, модернізації основних засобів і предметів праці та якості працівників, що забезпечить створення необхідної кількості, потрібного асортименту та високої якості продукції;

- розвивати нові організаційні форми у галузі, ріст соціально-економічних дій і рішень, цілеспрямованого й активного впливу фахівця на виробничі та логістичні процеси;

- зменшити залежність галузі від зовнішніх умов і процесів, відмовитись від надмірної централізації й локалізації щодо енергозабезпечення, використання місцевих сировинних ресурсів;

- підвищити вимоги до цивільного захисту та життєзабезпечення працівників на виробництві і місцевого населення.

Правове забезпечення цієї сфери наразі розвивається у двох паралельних, але взаємозалежних напрямках: перший — максимальна дерегуляція та спрощення умов ведення бізнесу для виживання галузі; другий — імплементація європейських стандартів якості з огляду на майбутню масштабну відбудову за кошти міжнародних донорів.

Для запобігання колапсу будівельної галузі держава здійснила низку кроків щодо лібералізації законодавства. Ключовим документом стала Постанова Кабінету Міністрів України № 722 від 24.06.2022 р. «Деякі питання здійснення дозвільних та реєстраційних процедур у будівництві в умовах воєнного стану».² Цей нормативно-правовий акт дозволив перевести значну частину процедур у декларативний формат. Для виробників будівельних матеріалів це означає можливість швидшого запуску нових виробничих ліній (зокрема при релокації підприємств на захід України, наприклад, в Івано-Франківську область) без тривалих бюрократичних затримок [11, с.99]. Також Законом України «Про внесення змін до деяких законодавчих актів України щодо забезпечення умов для відновлення та розвитку України» було суттєво спрощено процедури зміни цільового призначення земельних ділянок для розміщення промислових об'єктів, що є критично важливим для будівництва нових заводів з виробництва будматеріалів. Виробництво будівельних матеріалів (бетону, цегли, щебеню, скла) безпосередньо залежить від видобутку корисних копалин місцевого значення. В умовах воєнного стану парламент виніс низку змін до Кодексу України про надра.⁴³

Спрощено процедури отримання спеціальних дозволів на користування надрами, зокрема для видобутку піску, глини та вапняку, що дозволяє уникнути дефіциту базової сировини. Крім того, на законодавчому рівні врегульовано питання використання відходів від руйнувань (будівельного сміття,

⁴³ Постанова Кабінету Міністрів України № 722 від 24.06.2022 р. «Деякі питання здійснення дозвільних та реєстраційних процедур у будівництві в умовах воєнного

стану». <https://zakon.rada.gov.ua/laws/show/722-2022-%D0%BF#Text>

що утворилося внаслідок обстрілів) як вторинної сировини для виробництва нових будівельних матеріалів, що вирішує як екологічну проблему, так і проблему дефіциту ресурсів.

Попри війну, Україна не відмовилася від курсу на євроінтеграцію. Відтепер виробник зобов'язаний складати декларацію показників будівельної продукції та наносити відповідне маркування (національний знак відповідності або маркування СЕ). Це створює певні правові та фінансові виклики для вітчизняних виробників у період війни, адже вимагає модернізації лабораторій та проходження нових процедур оцінки відповідності. Проте дотримання цих правових норм є обов'язковою умовою для участі компаній у великих інфраструктурних проєктах відбудови, які фінансуватимуться європейськими фондами.

Висновки. Виробництво будівельних матеріалів під час воєнного стану є складним видом діяльності. Однак, незважаючи на труднощі, воно відіграє важливу роль в ритмічному забезпеченні капітального будівництва необхідними ресурсами особливо в період відбудови народного господарства України.

Впровадження результатів досліджень і конкретних пропозицій дасть можливість активізувати роботу існуючих виробництв, організувати нові потужності і поповнити дефіцит в будівельних матеріалах, який виник через зруйновані агресором аналогічні підприємства на сході і півдні нашої держави, здійснювати реконструкцію існуючих та будівництво нових виробничих приміщень, відновлювати й модернізувати інженерну інфраструктуру, розвинути будівництво житла, об'єктів соціально-культурного призначення, організувати додаткові робочі місця, в т.ч. для тимчасово переміщених осіб, поповнити місцеві бюджети і в цілому бюджет України.

Перспективи подальших наукових розвідок у цьому напрямі можуть бути зосереджені на розробці механізмів **гармонізації українських стандартів** виробництва будматеріалів із вимогами Європейського Союзу в контексті повоєнного відновлення. Особливої уваги потребує дослідження правового регулювання **державно-приватного партнерства** для стимулювання інвестицій у відбудову зруйнованих потужностей. Також доцільним є вивчення юридичних аспектів впровадження **екологічних («зелених»)** технологій та рециклінгу будівельних відходів, що утворилися внаслідок бойових дій.

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PERSONAL LLM AND AI AGENTS ON LOCAL EQUIPMENT: ARCHITECTURE, BENCHMARKING AND IMPLEMENTATION FEASIBILITY ASSESSMENT**Smidovych L.**

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ПЕРСОНАЛЬНІ LLM ТА ШІ-АГЕНТИ НА ЛОКАЛЬНОМУ ОБЛАДНАННІ: АРХІТЕКТУРА, БЕНЧМАРКІНГ ТА ОЦІНКА ДОЦІЛЬНОСТІ ВПРОВАДЖЕННЯ**Смідович Л.**

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Abstract

Most systems based on large language models operate via cloud servers, and this is unacceptable for organizations with sensitive data. At the same time, open models (LLaMA, Qwen, Mistral) already allow you to run billions of parameters on a regular video card thanks to quantization. The article describes a prototype of a desktop AI agent that runs locally via Ollama. The system has its own ReAct loop instead of LangChain, two-layer memory with background classification on a separate small model, a set of tools for working with notes and files, and built-in benchmarking on 29 test prompts. We compared four models on a single GPU (RTX 3090, 24 GB). Qwen 2.5 14B turned out to be the best in terms of speed and quality, and Mistral Nemo 12B was unable to correctly call the tools at all. For an ordinary user, a cloud subscription is still more profitable, but for a company with 50+ employees, a local solution pays for itself in a year.

Анотація

Більшість систем на базі великих мовних моделей працює через хмарні сервери, і для організацій з чутливими даними це неприйнятно. Водночас відкриті моделі (LLaMA, Qwen, Mistral) вже дозволяють запускати мільярди параметрів на звичайній відеокарті завдяки квантизації. У статті описано прототип десктопного ШІ-агента, який працює локально через Ollama. Система має власний цикл ReAct замість LangChain, двошарову пам'ять з фоновією класифікацією на окремій малій моделі, набір інструментів для роботи з нотатками і файлами, та вбудований бенчмаркінг на 29 тестових промптах. Ми порівняли чотири моделі на одному GPU (RTX 3090, 24 ГБ). Qwen 2.5 14B виявився найкращим за балансом швидкості і якості, а Mistral Nemo 12B взагалі не зміг коректно викликати інструменти. Для звичайного користувача хмарна підписка поки що вигідніша, але для компанії з 50+ працівниками локальне рішення окупається за рік.

Keywords: Large Language Models, AI agent, quantization, Ollama, benchmarking, RAG, ChromaDB, local deployment.

Ключові слова: Великі мовні моделі, ШІ-агент, квантування, Ollama, бенчмаркінг, RAG, ChromaDB, локальне розгортання.

1 Вступ

За три роки з моменту запуску ChatGPT мовні моделі з експериментальної технології перетворились на робочий інструмент. За різними оцінками, ChatGPT має близько мільярда активних користувачів на місяць [1, 2]. Claude, Gemini та десятки менших сервісів додають ще стільки ж. Люди пишуть листи, аналізують документи, генерують код, і рідко замислюються над тим, куди йдуть їхні дані.

А йдуть вони на сервери OpenAI, Google чи Anthropic. Для особистого листування це прийнятно. Для юридичної фірми, яка завантажує дого-

вори клієнтів, або лікарні, яка передає медичні записи, це може бути порушенням законодавства про захист персональних даних. Навіть якщо провайдер обіцяє не використовувати дані для тренування, юридичний ризик залишається, бо дані фізично знаходяться на чужому сервері.

Паралельно з'явилися відкриті моделі. Meta випустила LLaMA [3], Mistral AI зробили Mistral [4], Alibaba Cloud представила Qwen [5]. За якістю вони наближаються до закритих аналогів, а квантизація (GGUF, GPTQ, AWQ) дозволяє стиснути модель у 3-4 рази без помітної деградації [6, 7]. Мо-

дель з 14 мільярдами параметрів, яка у повній точності займає 28 ГБ, після квантизації поміщається у 9 ГБ відеопам'яті.

Ми вирішили перевірити, чи можна зібрати на цій базі повноцінного ШІ-агента, який працюватиме автономно. Не просто чатбот, а систему, яка запам'ятовує контекст, працює з файлами, шукає по документах, і при цьому нічого не відправляє в інтернет. А заодно побудувати інструмент для порівняння моделей, щоб зрозуміти, яка з них підходить для яких задач.

Далі ми спершу оглянемо наявні рішення і покажемо, чого їм бракує (розділ 2), потім розберемо архітектуру самого агента (розділ 3) та методику тестування з результатами (розділ 4), а під кінець чесно порахуємо, кому таке локальне розгортання справді має сенс (розділ 5).

2 Аналіз існуючих рішень

Перш за все варто розмежувати чатбот та агента. Wang та співавтори у своєму огляді [8] виділяють чотири складові LLM-агента: профіль (хто він і що вміє), пам'ять (що він знає про користувача), планування (як розбиває задачу на кроки), та дії (що робить). Yao та співавтори [9] запропонували конкретний паттерн для організації дій, ReAct, де модель по чергово думає і діє, перевіряючи себе через зовнішні джерела замість того, щоб покладатись на «внутрішні знання».

Для запуску моделей локально є кілька варіантів. Ollama [10] обгортає llama.cpp [11] у зручний інтерфейс: одна команда завантажує і запускає модель з GPU-прискоренням. Він також підтримує native function calling, тобто модель може у стандартному форматі попросити викликати зовнішню функцію. vLLM потужніший для серверного використання з continuous batching, але для десктопного застосунку на Windows це надлишкове.

Серед фреймворків для побудови агентів найвідоміший LangChain [12]. Ми спробували його

на початку і відмовились. API змінюється між версіями, залежностей десятки, а коли щось ламається, дебажити через п'ять шарів абстракції складно. AutoGen від Microsoft цікавий для мультиагентних сценаріїв, але для одного помічника надлишковий.

Є і готові десктопні застосунки. Jan дає офлайн чат, але без пам'яті між сесіями, без інструментів, без RAG. По суті красивий інтерфейс до Ollama. LM Studio аналогічний, плюс закритий код. AnythingLLM найближчий до того, що ми робимо: є RAG, є щось схоже на агентний цикл, є Docker. Але бенчмаркінгу немає, автоматичної класифікації пам'яті немає, профілів з різними наборами інструментів теж.

У роботі [15] Zheng та співавтори показали, що велика мовна модель може оцінювати відповіді інших моделей з якістю, порівнянною з людською оцінкою. Ми використали цей підхід у системі бенчмаркінгу: Qwen 2.5 32B виступає суддею для менших моделей.

3 Архітектура

3.1 Що ми обрали і чому

Рантайм Ollama, мова Python, інтерфейс PySide6 (Qt6), зберігання ChromaDB + SQLite [13, 14]. Агентний цикл написаний з нуля, приблизно 250 рядків. Це менше, ніж один файл конфігурації LangChain для аналогічної задачі.

Моделей у системі шість, кожна зі своєю роллю (табл. 1). Основна робоча модель, Qwen 2.5 14B, займає 9 ГБ відеопам'яті і залишає достатньо місця для KV-cache навіть при довгих діалогах. Qwen 2.5 3B працює у фоні як класифікатор, вирішуючи чи є у розмові щось варте запам'ятовування. nomic-embed-text перетворює текст у вектори для семантичного пошуку. А Qwen 2.5 32B ми завантажуємо окремо, коли треба оцінити якість відповідей менших моделей.

Таблиця 1.

Моделі та їх ролі у системі

Модель	VRAM	Роль
LLaMA 3.1 8B	4.9 ГБ	Тестована (швидка)
Mistral Nemo 12B (Q4 K M)	7.5 ГБ	Тестована
Qwen 2.5 14B	9 ГБ	Основна
Qwen 2.5 32B (Q4 K M)	19 ГБ	LLM-judge
Qwen 2.5 3B	1.9 ГБ	Класифікатор
nomic-embed-text	274 МБ	Ембедінги

Все тестувалось на одній машині: RTX 3090 (24 ГБ), 32 ГБ DDR5, Windows 11.

3.2 Як працює агентний цикл

Користувач пише запит. Контролер збирає промпт: бере системне повідомлення профілю, шукає релевантні факти з пам'яті (до 3 глобальних і 3 профільних), додає фрагменти з бази знань якщо вона є, та історію розмови. Все це йде в Ollama через streaming.

Модель може відповісти текстом, а може вирішити що їй потрібен інструмент. Тоді вона формує tool_call прямо у стрімі. Контролер переходить його, виконує (наприклад створює нотатку

або читає файл), повертає результат, і модель продовжує. Максимум 8 таких ітерацій, щоб не заиклитись.

Пам'ять працює на двох рівнях. Короткочасна, це просто останні повідомлення з SQLite з ковзним вікном, щоб не переповнити контекст моделі. Довгочасна зберігається у ChromaDB: окремо глобальні факти (ім'я, мова, алергії) і окремо факти конкретного профілю (деталі проекту, преференції). Після кожної пари повідомлень фоновий потік на Qwen 3B аналізує розмову і вирішує, чи є там щось варте збереження. Користувач нічого не робить і навіть не знає, що класифікація відбувається.

3.3 Інструменти і RAG

Інструментів сім: п'ять для нотаток (створити, список, прочитати, видалити, пошукати) і два для файлів (прочитати, переглянути директорію). Файлові операції обмежені робочою текою, дозволені тільки текстові формати, максимум 100 КБ на читання, таймаут 30 секунд.

Бази знань прив'язані до профілів. Markdown файли розбиваються на шматки по ~2000 символів з перекриттям і індексуються у ChromaDB. При запиті система знаходить три найбільш схожих фрагменти і додає їх у промпт. Якщо файл у тепі змінився, переіндексовується тільки він, а не вся база.

4 Бенчмаркінг

4.1 Як ми тестували

Ми зібрали 29 тестових промптів у п'яти категоріях. Speed (5 штук) для чистого заміру швид-

кості. Quality UA (8 штук) для перевірки українською: переклади, ділові листи, граматики. Code (5 штук): Python, SQL, regex. Reasoning (6 штук): арифметика, логіка, послідовності. Tool Use (5 штук): чи модель викликає правильний інструмент з правильними аргументами.

Оцінювання тривале. Для Reasoning і Tool Use працює автоматична перевірка: правильна відповідь або ні. Для Quality UA і Code оцінює Qwen 2.5 32B як суддя [15], від 1 до 5. І якщо автоматична оцінка сумнівна, є ручна, вона має найвищий пріоритет. Перший запит кожної моделі відкидається, бо він включає час завантаження у VRAM і псує статистику. Між моделями VRAM очищується через keep_alive=0.

4.2 Що вийшло

Результати зведено у табл. 2.

Таблиця 2.

Результати порівняння моделей

Модель	tok/s	TTFT, мс	VRAM, ГБ	Quality UA	Tool Use
LLaMA 3.1 8B	525	141	16.5	2.5-3.0	часткова
Mistral Nemo 12B	50	228	19.7	3.0-3.5	0/5
Qwen 2.5 14B	134	131	18.2	3.5-4.0	найкраща
Qwen 2.5 3B (фонова)	470	97	6.8	—	—

LLaMA 3.1 8B очікувано найшвидша, 525 токенів на секунду. Але з українською у неї проблеми: може перейти на російську посеред речення або зробити граматичну помилку, якої носій мови б не зробив. Оцінка LLM-judge 2.5-3.0 з 5.

Qwen 2.5 14B повільніший (134 tok/s), зате з українською працює краще за всіх: 3.5-4.0 з 5. Час до першого токена 131 мс, тобто відповідь починає з'являтися миттєво. Для інтерактивного діалогу це комфортно.

Mistral Nemo 12B здивував. Повільний (50 tok/s), займає найбільше VRAM (19.7 ГБ), і головне, взагалі не зміг викликати інструмент. Нуль з п'яти. Модель генерувала текстову відповідь замість того, щоб сформулювати структурований виклик. Для нас це означає, що для агентних сценаріїв підтримка function calling у конкретній моделі важливіша, ніж кількість параметрів.

5 Кому це потрібно

Якщо чесно, звичайному користувачу поки що ні. Підписка на ChatGPT Plus коштує 20 доларів на місяць і дає кращу якість. Відеокарта RTX 3090 коштує 1000-1500 доларів на вторинному ринку, і навіть після цього локальна модель поступається за якістю.

Для бізнесу розрахунок інший. Компанія з 50 працівниками платить за ChatGPT Enterprise приблизно 36 000 доларів на рік. Сервер з GPU коштує одноразово. Після першого року різниця стає відчутною, а дані при цьому нікуди не йдуть. Ми визначили чотири конкретних сценарії: корпоративний асистент з RAG по документації, HRпомічник для онбордингу (покриває 70-80% типових питань), контроль якості на виробництві через мультимодальні моделі, та медичний попередній скринінг.

Є ще один аргумент на користь локальних рішень, і він пов'язаний з часом. Qwen 2.5 72B вже конкурує з LLaMA 3.1 405B при п'ятикратно меншому розмірі [5]. Якість відкритих моделей росте швидше, ніж вимоги до заліза. Те, що сьогодні дає GPT-4 [16], через два-три роки зможе модель на звичайній відеокарті. Залізо при цьому не змінюється.

6 Висновки

Ми побудували працюючого ШІ-агента, який запускається на одній споживчій відеокарті і працює без інтернету. У ньому є власний цикл ReAct замість LangChain, двошарова пам'ять з фоновною класифікацією, інструменти в пісочниці, профілі зі своїми базами знань і вбудований бенчмаркінг, що сам оцінює якість відповідей. Серед існуючих локальних рішень (Jan, LM Studio, AnythingLLM) такої комбінації немає. З чотирьох тестованих моделей Qwen 2.5 14B показав найкращий баланс. Mistral Nemo 12B не підтримує виклик інструментів, що робить його непридатним для агентних задач. Для бізнесу з чутливими даними рішення окупатиметься менш ніж за рік. Далі планується мультимодальність, мультикористувачський режим і QLoRA дотренування.

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